HANDBOOK

2019

Boston Children's Hospital
Boston Medical Center
Boston Combined Residency Program

Harvard Medical School

Boston University School of Medicine

Vital Signs in Children

Normal Heart Rates (beats/min)		
Age	**Awake rate**	**Sleeping rate**
Neonate	100-205	90-160
Infant	100-180	90-160
Toddler	98-140	80-120
Preschooler	80-120	65-100
School-aged	75-118	58-90
Adolescent	60-100	50-90

Normal Respiratory Rates (breaths/min)	
Age	**Rate**
Infant	30-53
Toddler	22-37
Preschooler	20-28
School-aged	18-25
Adolescent	12-20

Fahrenheit-Celsius Conversion			
F	**C**	**F**	**C**
105	**40.6**	**99**	**37.2**
104	**40.0**	**98**	**36.7**
103	**39.4**	**97**	**36.1**
102	**38.9**	**96**	**35.6**
101	**38.3**		

Normal Blood Pressures (mm Hg)			
Age	**Systolic**	**Diastolic**	**MAP**
Birth (12h, <1000 g)	39-59	16-36	28-42
Birth (12h, 3 kg)	60-76	31-45	48-57
Neonate (96h)	67-84	35-53	45-60
Infant (1-12 mo)	72-104	37-56	50-62
Toddler (1-2 y)	86-106	42-63	49-62
Preschooler (3-5 y)	89-112	46-72	58-69
School-aged (6-7 y)	97-115	57-76	66-72
Preadol. (10-12 y)	102-120	61-80	71-79
Adolescent	110-131	64-83	73-84

Def. of Hypotension by Systolic BP & Age	
Age	**Systolic BP (mmHg)**
Term neonate (0-28 d)	<60
Infants (1-12 mo)	<70
Children (1-10 yo)	<70 + (age in years x2)
Children (>10 yo)	<90

Pre-ductal SpO2 Target			
1 min	**60-65%**	**4 min**	**75-80%**
2 min	**65-70%**	**5 min**	**80-85%**
3 min	**70-75%**	**10 min**	**85-95%**

Modified Glasgow Coma Scale for Infants and Children			
	Child	**Infant**	**Score**
Eye opening	**Spontaneous** **To speech** **To pain** **None**	**Spontaneous** **To speech** **To pain** **None**	**4** **3** **2** **1**
Best verbal response	**Oriented, appropriate** **Confused** **Inappropriate words** **Incomprehensible sounds** **None**	**Coos and babbles** **Irritable, cries** **Cries in response to pain** **Moans in response to pain** **None**	**5** **4** **3** **2** **1**
Best motor response	**Obeys commands** **Localizes painful stimulus** **Withdraws in response to pain** **Flexion in response to pain** **Extension in response to pain** **None**	**Moves spontaneously and purposely** **Withdraws in response to touch** **Withdraws in response to pain** **Abnormal flexion posture to pain** **Abnormal extension posture to pain** **None**	**6** **5** **4** **3** **2** **1**

Department of Pediatrics

Boston Children's Hospital
Boston Medical Center

Third Edition

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Note: *This handbook is also available in print. For a hardcopy, please contact Erin Elbel.*

Dear BCRP,

This is the third edition of the BCRP Handbook and the first printed version in several years. It is based upon contributions from generations of residents past. It is intended to be an on-the-fly reference for residents that sharpens clinical knowledge, bolsters clinical efficiency, and ultimately improves patient care. **ALL CLINICAL INFORMATION CONTAINED HEREIN IS SUBJECT TO CHANGE. Medication dosing, in particular, depends on indication and clinical situation**. Please double-check using evidence-based resources (i.e. clinical pathways, UpToDate, Lexicomp) before entering orders. Essentially, trust no one but Pharmacy Ed.

In addition to the resident authors of yesteryear and the many resident and faculty reviewers listed below, we are indebted to several other key players:

- First and foremost, thank you to **Laura Chiel**, whose unwavering belief in this project moved it past the finish line.
- Thank you to **Ted & Kate**, who supported the printing of this book for all residents, and to our faculty advisor, **Carolyn Marcus**.
- Thank you to the 26 residents who made personal donations to ensure this book could be printed in color and to the resident reviewers who provided invaluable suggestions and feedback.
- Finally, we owe an inestimable debt to **Alex Hyszczak**, our copy editor, who immediately grasped the vision of this book all the way from Arizona and combed through every page, table, and figure, ensuring both beauty and organization.

We hope you enjoy using this book as much as we enjoyed making it.

BCRP Handbook 3.0 Editors,
Erin Elbel & Zach Winthrop

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Toxicology	Shannon Byler	Katherine O'Donnell

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Calling for Help

BCH

Name	Medical Assist Team	ICU Eval	ICU STAT	Code Blue	
How to Call	**Call 5-5555 and state "Medical Assist Team to floor # and room #"**	**Page EVAL (3825) w/ your extension.** ICU will call back w/i 30 mins	**Call 5-5555 and state "ICU STAT to floor # and room #"** *("5 to stay alive")*	**Call 5-5555 and state "Code Blue to floor # and room #"**	
When to Call	A **NON-HOSPITALIZED person who is able to verbalize what is wrong**, NOT complaining of trouble breathing or chest pain (if trouble breathing or CP, call Code Blue.)	NON-time critical, to ask "What level of care does this patient need?" ****Discuss w/ attending of record first****	**Time critical: pt may need to go to the ICU now.** Call when you think "I really wish the ICU were here right now." **Notify attending ASAP, but do not delay call**	**Serious medical emergencies, need for immediate resuscitation, cardiopulm. arrest** (includes patients/family/ visitors/staff)	
Who Comes	• Gen Peds Seniors • ED RN • COPP • Critical Care Transport Team (if available) • 2 Security Officers	ICU Fellow only	• ICU Fellow • ICU Charge RN • RT • Gen peds seniors • DOM	• ICU Fellow • ICU Attending • Anesthesia • ICU Charge RN • ED RN • RT x2 • Pharmacist Social Worker	• Chaplain • Critical Care Transport Team • COPP • Security x7 • Gen peds Seniors

BMC

Name	Anesthesia Stat	ICU Eval	Code Blue
How to Call	**4-7777:** Ask for anesthesia stat	**6789**	**4-7777:** State: your name, phone number, building/room #, **adult vs. pediatric** patient, specific issue
Who Comes	Anesthesia fellow	PICU Senior Resident, PICU Attending	PICU Senior (Attending if in house), PICU Charge RN, RT and RN supervisor

PALS: Vital Signs in Children

Normal Heart Rates (beats/min)

Age	Awake Rate	Sleeping Rate
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PALS: Color-Coded Length-Based Resuscitation Tape

Equipment	GRAY 3-5 kg	PINK Small Infant 6-7 kg	RED Infant 8-9 kg	PURPLE Toddler 10-11 kg	YELLOW Small Child 12-14 kg
Resuscitation bag		Infant/child	Infant/child	Child	Child
Oxygen mask (NRB)		Pediatric	Pediatric	Pediatric	Pediatric
Oral airway (mm)		50	50	60	60
Laryngoscope blade (size)		1 Straight	1 Straight	1 Straight	2 Straight
ET tube (mm)		3.5 Uncuffed 3.0 Cuffed	3.5 Uncuffed 3.0 Cuffed	4.0 Uncuffed 3.5 Cuffed	4.5 Uncuffed 4.0 Cuffed
ET tube insertion length (cm)	3 kg 9-9.5 4 kg 9.5-10 5 kg 10-10.5	10.5-11	10.5-11	11-12	13.5
Suction catheter (F)		8	8	10	10
BP cuff	Neonatal #5/ infant	Infant/child	Infant/child	Child	Child
IV catheter (ga)		22-24	22-24	20-24	18-22
IO (ga)		18/15	18/15	15	15
NG tube (F)		5-8	5-8	8-10	10
Urinary catheter (F)	5	8	8	8-10	10
Chest tube (F)		10-12	10-12	16-20	20-24

Equipment	WHITE Child 15-18 kg	BLUE Child 19-23 kg	ORANGE Large Child 24-29 kg	GREEN Adult 30-36 kg
Resuscitation bag	Child	Child	Child	Adult
Oxygen mask (NRB)	Pediatric	Pediatric	Pediatric	Pediatric/adult
Oral airway (mm)	60	70	80	80
Laryngoscope blade (size)	2 Straight	2 Straight or curved	2 Straight or curved	3 Straight or curved
ET tube (mm)	5.0 Uncuffed 4.5 Cuffed	5.5 Uncuffed 5.0 Cuffed	6.0 Cuffed	6.5 Cuffed
ET tube insertion length (cm)	14-15	16.5	17-18	18.5-19.5
Suction catheter (F)	10	10	10	10-12
BP cuff	Child	Child	Child	Small adult
IV catheter (ga)	18-22	18-20	18-20	16-20
IO (ga)	15	15	15	15
NG tube (F)	10	12-14	14-18	16-18
Urinary catheter (F)	10	10-12	12	12
Chest tube (F)	20-24	24-32	28-32	32-38

PALS: Respiratory Emergencies

FYI Medications to Avoid in Children w/ Neuromuscular Disease	Recall that the use of succinylcholine for intubation of children w/ neuromuscular diseases may trigger life-threatening conditions, such as hyperkalemia or malignant hyperthermia. Several commonly used drugs, such as aminoglycosides, have intrinsic neuromuscular blocking activity that can worsen respiratory muscle weakness.

The Management of Respiratory Emergencies Flowchart summarizes general management of respiratory emergencies and specific management by etiology. Note that this chart does not include all respiratory emergencies; it provides key management strategies for a limited number of diseases.

Management of Respiratory Emergencies Flowchart

- Airway positioning
- Suction as needed
- Oxygen
- Pulse oximetry
- ECG monitor (as indicated)
- BLS as indicated

Specific Management for Selected Conditions

Upper Airway Obstruction

Croup	Anaphylaxis	Aspiration Foreign Body
• Nebulized epinephrine • Corticosterioids	• IM epinephrine (or autoinjector) • Albuterol • Antihistamines • Corticosteroids	• Allow position of comfort • Specialty consultation

Lower Airway Obstruction

Bronchiolitis	Asthma	
• Nasal suctioning • Bronchodilator trial	• Albuterol ± ipratropium • Corticosteroids • Subcutaneous epinephrine	• Magnesium sulfate • Terbutaline

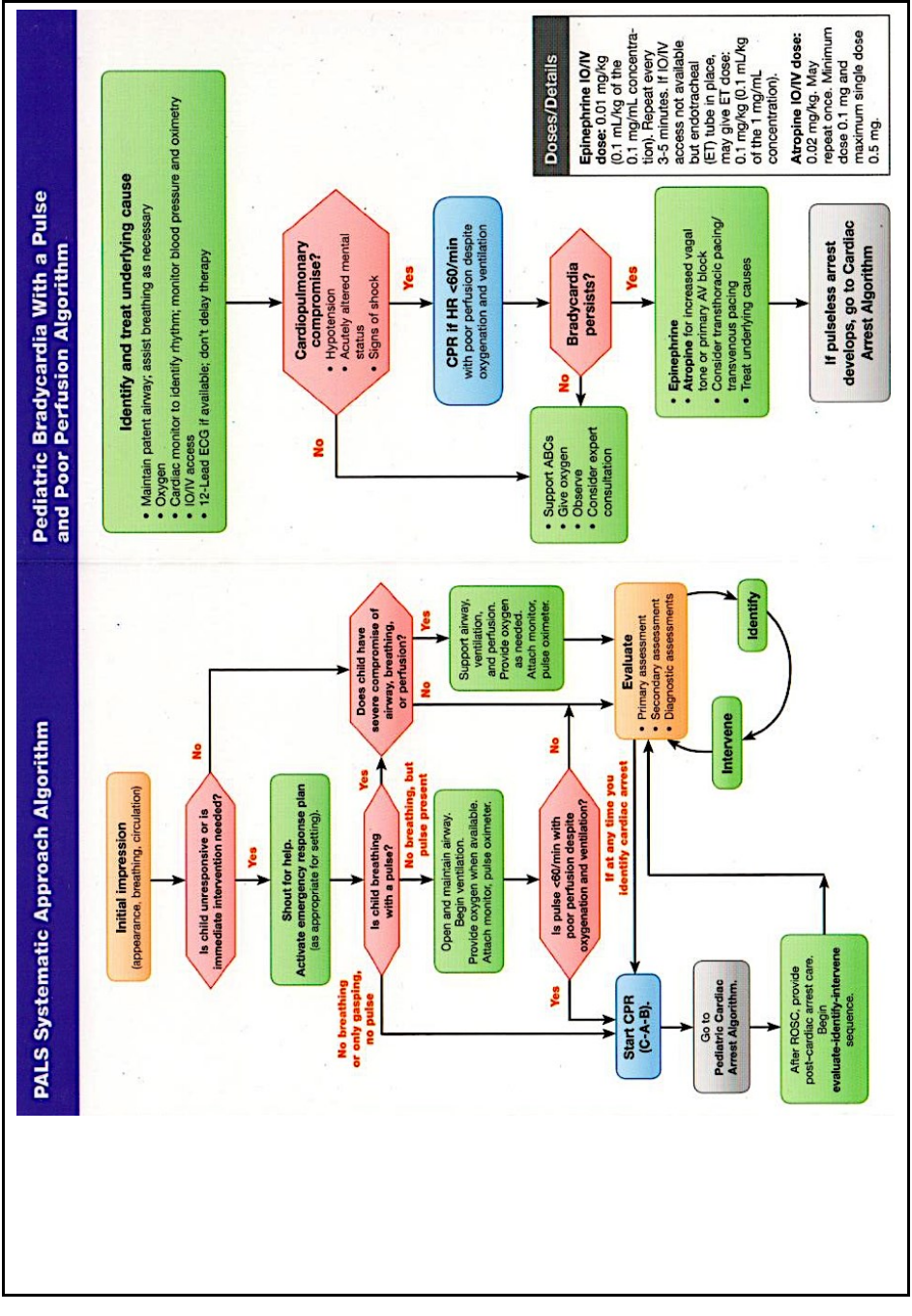
Lung Tissue Disease

Pneumonia/Pneumonitis Infectious Chemical Aspiration	Pulmonary Edema Cardiogenic or Noncardiogenic (ARDS)
• Albuterol • Antibiotics (as indicated)	• Consider noninvasive or invasive ventilatory support w/ PEEP • Consider vasoactive support • Consider diuretic

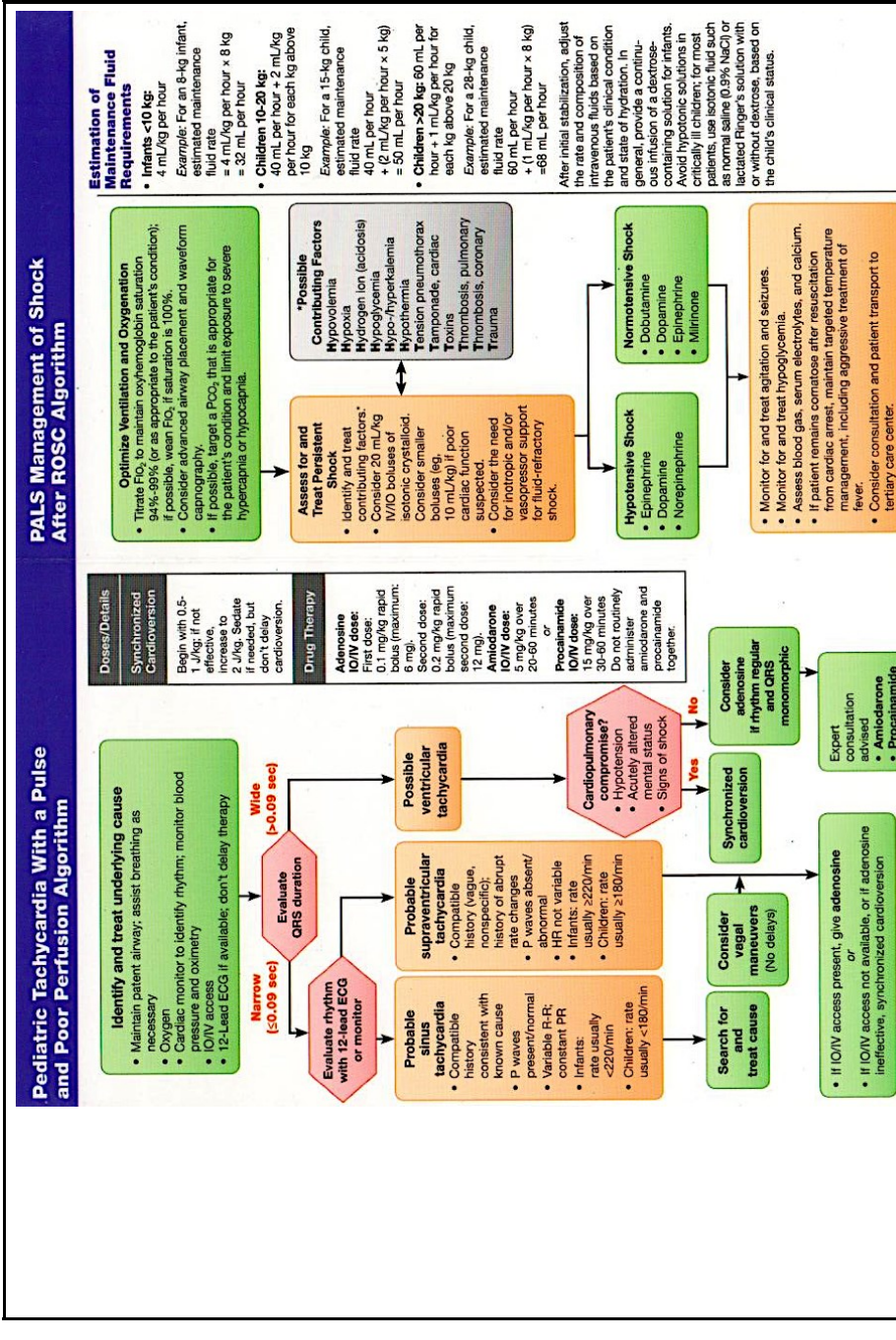
Disordered Control of Breathing

Increased ICP	Poisoning/Overdose	Neuromuscular Disease
• Avoid hypoxemia • Avoid hypercarbia • Avoid hyperthermia	• Antidote (if available) • Contact poison control	Consider noninvasive or invasive ventilatory support

PALS: Systemic Approach & Bradycardia w/ Poor Perfusion



PALS: Tachycardia w/ Poor Perfusion and Mgmt of Shock after ROSC



PALS: Recognition and Management of Shock

Recognition of Shock Flowchart

	Clinical Signs	Hypovolemic	Distributive	Cardiogenic	Obstructive
A	Patency	Airway open and maintainable/not maintainable			
B	Respiratory Rate	Increased			
	Respiratory Effort	Normal to increased		Labored	
	Breath Sounds	Normal	Normal (± crackles)	Crackles, grunting	
C	Systolic Blood Pressure	**Compensated Shock → Hypotensive Shock**			
	Pulse Pressure	Narrow	Variable	Narrow	
	Heart Rate	Increased			
	Peripheral Pulse Quality	Weak	Bounding or weak	Weak	
	Skin	Pale, cool	Warm or cool	Pale, cool	
	Capillary Refill	Delayed	Variable	Delayed	
	Urine Output	Decreased			
D	Level of Consciousness	Irritable early Lethargic late			
E	Temperature	Variable			

Management of Shock Flowchart

• Oxygen • Pulse oximetry • ECG monitor	• IV/IO access • BLS as indicated • Point-of-care glucose testing

Specific Management for Selected Conditions

Hypovolemic Shock

Nonhemorrhagic	Hemorrhagic
• 20 mL/kg NS/LR bolus, repeat as needed • Consider colloid	• Control external bleeding • 20 mL/kg NS/LR bolus, repeat 2 or 3x as needed • Transfuse PRBCs as indicated

Distributive Shock

Septic	Anaphylactic	Neurogenic
Management Algorithm: • Septic Shock	• IM epinephrine (or autoinjector) • Fluid boluses (20mL/kg NS/LR) • Albuterol • Antihistamines, corticosteroids • Epinephrine infusion	• 20mL/kg NS/LR bolus, repeat PRN • Vasopressor

PALS: Recognition and Management of Shock

Management of Shock Flowchart

Cardiogenic Shock

Bradyarrhythmia/Tachyarrhythmia	Other (e.g. CHD, Myocarditis, Cardiomyopathy, Poisoning)
Management Algorithm: • Bradycardia • Tachycardia w/ poor perfusion	• 5 to 10 mL/kg NS/LR bolus, repeat PRN • Vasoactive infusion • Consider expert consultation

Obstructive Shock

Ductal-Dependent (LV Outflow Obstruction)	Tension Pneumothorax	Cardiac Tamponade	Pulmonary Embolism
• Prostaglandin E_1 • Expert consultation	• Needle decompression • Tube thoracostomy	• Pericardiocentesis • 20 mL/kg NS/LR bolus	• 20 mL/kg NS/LR bolus, repeat PRN • Consider thrombolytics, anticoagulants • Expert consultation

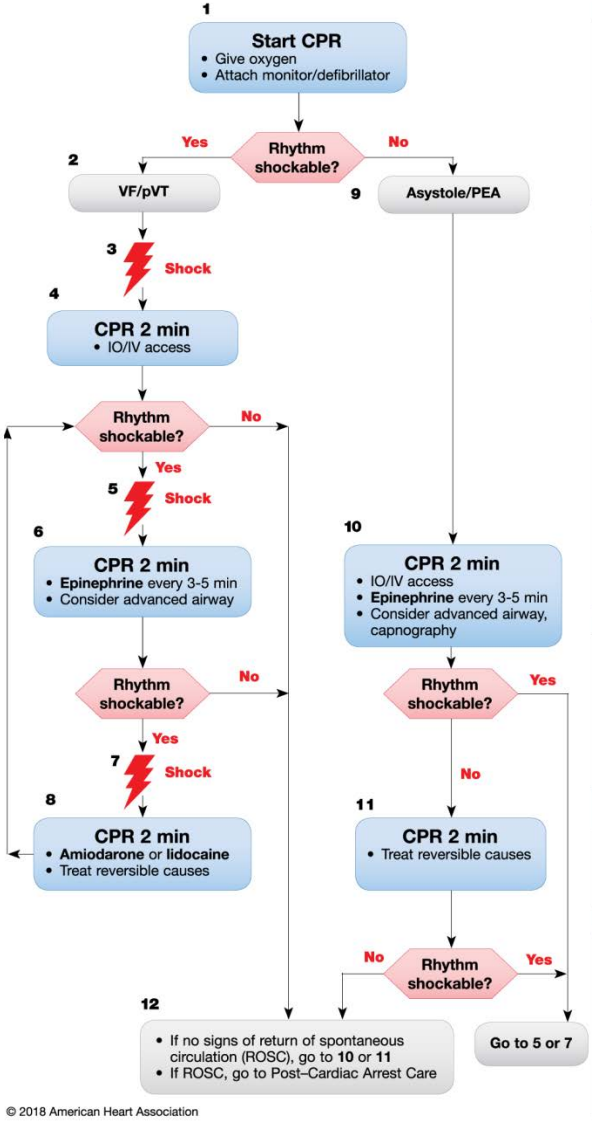
Shock

Hemodynamic Parameters in Shock

Type	Examples	Preload (CVP, PCWP)	Afterload (SVR)	CO (SV*HR)	Mixed venous O_2	Treatment
Distributive	• Sepsis • Anaphylaxis • Severe neurologic injury (loss of α-1 activity)	↓	↓	↑ *then* ↓	↑	• **Sepsis**: crystalloid (20 cc/kg NS, repeat PRN) + abx • **Anaphylaxis**: epi + crystalloid • **Neurogenic**: crystalloid + α-active pressors, (norepi @ 0.05-2 mcg/kg/min)
Hypovolemic	• Blood loss • GI or Renal losses • ↓ intake	↑	↑	↑	↓	• **Crystalloid replacement**: 20 cc/kg, repeat PRN • For blood loss: c/s PRBCs
Cardiogenic	• Myocarditis • MI • Dysrhythmia	↑	↑	↑	↓	Targeted at etiology - **inotropes**, revascularization, **anti-arrhythmics**, cardiovert
Obstructive	• Tamponade • PE	↑	↑	↑	↓	**Fix obstruction** (pericardiocentesis, thrombectomy/lysis for PE)

PALS: Cardiac Arrest

Pediatric Cardiac Arrest Algorithm—2018 Update



CPR Quality

- Push hard (≥⅓ of anteroposterior diameter of chest) and fast (100-120/min) and allow complete chest recoil.
- Minimize interruptions in compressions.
- Avoid excessive ventilation.
- Change compressor every 2 minutes, or sooner if fatigued.
- If no advanced airway, 15:2 compression-ventilation ratio.

Shock Energy for Defibrillation

First shock 2 J/kg, second shock 4 J/kg, subsequent shocks ≥4 J/kg, maximum 10 J/kg or adult dose

Drug Therapy

- **Epinephrine IO/IV dose:** 0.01 mg/kg (0.1 mL/kg of the 0.1 mg/mL concentration). Repeat every 3-5 minutes. If no IO/IV access, may give endotracheal dose: 0.1 mg/kg (0.1 mL/kg of the 1 mg/mL concentration).
- **Amiodarone IO/IV dose:** 5 mg/kg bolus during cardiac arrest. May repeat up to 2 times for refractory VF/pulseless VT.

-OR-

Lidocaine IO/IV dose: Initial: 1 mg/kg loading dose. Maintenance: 20-50 mcg/kg per minute infusion (repeat bolus dose if infusion initiated >15 minutes after initial bolus therapy).

Advanced Airway

- Endotracheal intubation or supraglottic advanced airway
- Waveform capnography or capnometry to confirm and monitor ET tube placement
- Once advanced airway in place, give 1 breath every 6 seconds (10 breaths/min) with continuous chest compressions

Return of Spontaneous Circulation (ROSC)

- Pulse and blood pressure
- Spontaneous arterial pressure waves with intra-arterial monitoring

Reversible Causes

- **H**ypovolemia
- **H**ypoxia
- **H**ydrogen ion (acidosis)
- **H**ypoglycemia
- **H**ypo-/hyperkalemia
- **H**ypothermia
- **T**ension pneumothorax
- **T**amponade, cardiac
- **T**oxins
- **T**hrombosis, pulmonary
- **T**hrombosis, coronary

PALS: Cardiac Arrest

Doses/Details for the Pediatric Cardiac Arrest Algorithm

CPR Quality

- Push hard (≥⅓ of anteroposterior diameter of chest) and fast (100-120/min) and allow complete chest recoil.
- Minimize interruptions in compressions.
- Avoid excessive ventilation.
- Rotate compressor every 2 minutes, or sooner if fatigued.
- If no advanced airway, 15:2 compression-ventilation ratio.

Shock Energy for Defibrillation

First shock 2 J/kg, second shock 4 J/kg, subsequent shocks ≥4 J/kg, maximum 10 J/kg or adult dose

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- **T**amponade, cardiac
- **T**oxins
- **T**hrombosis, pulmonary
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Estimating Endotracheal Tube Size

The formula for estimation of proper endotracheal tube size (internal diameter [i.d.]) for children 2 to 10 years of age, based on the child's age:

Uncuffed endotracheal tube size (mm i.d.) = (age in years/4) + 4

The formula for estimation of a cuffed endotracheal tube size is as follows:

Cuffed endotracheal tube size (mm i.d.) = (age in years/4) + 3.5

Typical cuffed inflation pressure should be <20 to 25 cm H_2O.

Drugs Used in PALS

Drug	Indications/Dosages
Adenosine	**SVT** • 0.1 mg/kg IV/IO *rapid* push (max 6 mg), second dose 0.2 mg/kg IV/IO *rapid* push (max 12 mg)
Albuterol	**Asthma, anaphylaxis (bronchospasm), hyperkalemia** • MDI: 4 to 8 puffs via inhalation q 20 minutes PRN with spacer (*or* ET if intubated) • Nebulizer: 2.5 mg/dose (wt <20 kg) *or* 5 mg/dose (wt >20 kg) via inhalation q 20 minutes PRN • Continuous nebulizer: 0.5 mg/kg per hour via inhalation (max 20 mg/h)
Amiodarone	**SVT, VT (with pulses)** • 5 mg/kg IV/IO *load* over 20 to 60 minutes (max 300 mg), repeat to daily max 15 mg/kg (2.2 g in adolescents) **Pulseless arrest (ie, VF/pulseless VT)** • 5 mg/kg IV/IO *bolus* (max 300 mg), repeat to daily max 15 mg/kg (2.2 g in adolescents)
Atropine sulfate	**Bradycardia (symptomatic)** • 0.02 mg/kg IV/IO (max single dose 0.5 mg), may repeat dose once in 3 to 5 minutes, max total dose child 1 mg, max total dose adolescent 3 mg • 0.04 to 0.06 mg/kg ET **Toxins/overdose (eg, organophosphate, carbamate)** • <12 years: 0.05 mg/kg IV/IO initially; then repeated and doubling the dose every 5 minutes until muscarinic symptoms reverse • ≥12 years: 1 mg IV/IO initially; then repeated and doubling the dose every 5 minutes until muscarinic symptoms reverse
Calcium chloride 10%	**Hypocalcemia, hyperkalemia, hypermagnesemia, calcium channel blocker overdose** • 20 mg/kg (0.2 mL/kg) IV/IO *slow* push during arrest, repeat PRN
Calcium gluconate	**Hypocalcemia, hyperkalemia, hypermagnesemia, calcium channel blocker overdose** • 60 mg/kg (0.6 mL/kg) IV/IO *slow* push during arrest; repeat PRN
Dexamethasone	**Croup** • 0.6 mg/kg PO/IM/IV (max 16 mg)
Dextrose (glucose)	**Hypoglycemia** • 0.5 to 1 g/kg IV/IO ($D_{25}W$ 2 to 4 mL/kg; $D_{10}W$ 5 to 10 mL/kg)
Dobutamine	**Heart failure, cardiogenic shock** • 2 to 20 mcg/kg per minute IV/IO infusion; titrate to desired effect
Dopamine	**Cardiogenic shock, distributive shock** • 2 to 20 mcg/kg per minute IV/IO infusion; titrate to desired effect
Epinephrine	**Pulseless arrest, bradycardia (symptomatic)** • 0.01 mg/kg (0.1 mL/kg of the 0.1 mg/mL concentration) IV/IO q 3 to 5 minutes (max single dose 1 mg) • 0.1 mg/kg (0.1 mL/kg of the 1 mg/mL concentration) ET q 3 to 5 minutes **Hypotensive shock** • 0.1 to 1 mcg/kg per minute IV/IO infusion (consider higher doses if needed) **Anaphylaxis** • IM autoinjector 0.3 mg (for patient weighing ≥30 kg) or IM junior autoinjector 0.15 mg (for patient weighing 10 to 30 kg) • 0.01 mg/kg (0.01 mL/kg of the 1 mg/mL concentration) IM q 15 minutes PRN (max single dose 0.3 mg) • 0.01 mg/kg (0.1 mL/kg of the 0.1 mg/mL concentration) IV/IO q 3 to 5 minutes (max single dose 1 mg) if hypotensive • 0.1 to 1 mcg/kg per minute IV/IO infusion if hypotension persists despite fluids and IM injection **Asthma** • 0.01 mg/kg (0.01 mL/kg of the 1 mg/mL concentration) subcutaneously q 15 minutes (max 0.3 mg or 0.3 mL) **Croup** • 0.25 to 0.5 mL *racemic* solution (2.25%) mixed in 3 mL NS via inhalation • 3 mg (3 mL of the 1 mg/mL concentration) epinephrine mixed with 3 mL NS (which yields 0.25 mL racemic epinephrine solution) via inhalation

Drugs Used in PALS

Drug	Indications/Dosages
Etomidate	**RSI** • 0.2 to 0.4 mg/kg IV/IO infused over 30 to 60 seconds (max 20 mg) will produce rapid sedation that lasts for 10 to 15 minutes
Hydrocortisone	**Adrenal insufficiency** • 2 mg/kg IV bolus (max 100 mg)
Ipratropium bromide	**Asthma** • 250 to 500 mcg via inhalation q 20 minutes PRN × 3 doses
Lidocaine	**VF/pulseless VT, wide-complex tachycardia (with pulses)** • 1 mg/kg IV/IO bolus • Maintenance: 20 to 50 mcg/kg per minute IV/IO infusion (repeat bolus dose if infusion initiated >15 minutes after initial bolus) • 2 to 3 mg/kg ET
Magnesium sulfate	**Asthma (refractory status asthmaticus), torsades de pointes, hypomagnesemia** • 25 to 50 mg/kg IV/IO *bolus* (max 2 g) (pulseless VT) *or* over 10 to 20 minutes (VT with pulses) *or slow* infusion over 15 to 30 minutes (status asthmaticus)
Methyl-prednisolone	**Asthma (status asthmaticus), anaphylactic shock** • Load: 2 mg/kg IV/IO/IM (max 60 mg); only use acetate salt IM • Maintenance: 0.5 mg/kg IV/IO q 6 hours (max 120 mg/d)
Milrinone	**Myocardial dysfunction and increased SVR/PVR** • Loading dose: 50 mcg/kg IV/IO over 10 to 60 minutes followed by 0.25 to 0.75 mcg/kg per minute IV/IO infusion
Naloxone	**Narcotic (opiate) reversal** • Total reversal required (for narcotic toxicity secondary to overdose): 0.1 mg/kg IV/IO/IM/subcutaneous bolus q 2 minutes PRN (max 2 mg) • Total reversal *not* required (eg, for respiratory depression associated with therapeutic narcotic use): 1 to 5 mcg/kg IV/IO/IM/subcutaneously; titrate to desired effect • Maintain reversal: 0.002 to 0.16 mg/kg per hour IV/IO infusion
Nitroglycerin	**Heart failure, cardiogenic shock** • Initiate at 0.25 to 0.5 mcg/kg per minute IV/IO infusion; titrate by 1 mcg/kg per minute q 15 to 20 minutes as tolerated. Typical dose range 1 to 5 mcg/kg per minute (max 10 mcg/kg per minute) • In adolescents, start with 5 to 10 mcg *per minute* (***not*** per kilogram per minute) and increase to max 200 mcg *per minute*
Nitroprusside	**Cardiogenic shock (ie, associated with high SVR), severe hypertension** • 0.3 to 1 mcg/kg per minute initial dose; then titrate up to 8 mcg/kg per minute PRN
Norepinephrine	**Hypotensive (usually distributive) shock (ie, low SVR and fluid refractory)** • 0.1 to 2 mcg/kg per minute IV/IO infusion; titrate to desired effect
Procainamide	**SVT, atrial flutter, VT (with pulses)** • 15 mg/kg IV/IO load over 30 to 60 minutes (do not use routinely with amiodarone)
Prostaglandin E_1 (PGE_1)	**Ductal-dependent congenital heart disease (all forms)** • 0.05 to 0.1 mcg/kg per minute IV/IO infusion initially; then 0.01 to 0.05 mcg/kg per minute IV/IO
Sodium bicarbonate	**Metabolic acidosis (severe), hyperkalemia** • 1 mEq/kg IV/IO *slow* bolus **Sodium channel blocker overdose (eg, tricyclic antidepressant)** • 1 to 2 mEq/kg IV/IO bolus until serum pH is >7.45 (7.50 to 7.55 for severe poisoning) followed by IV/IO infusion of 150 mEq $NaHCO_3$/L solution titrated to maintain alkalosis
Terbutaline	**Asthma (status asthmaticus), hyperkalemia** • 0.1 to 10 mcg/kg per minute IV/IO infusion; consider 10 mcg/kg IV/IO load over 5 minutes • 10 mcg/kg subcutaneously q 10 to 15 minutes until IV/IO infusion is initiated (max single dose 0.4 mg)
Vasopressin	**Catecholamine-resistant hypotension** • 0.0002 to 0.002 unit/kg per minute (0.2 to 2 milliunits/kg per minute) continuous infusion

Status Epilepticus

PowerPlans	Neuro seizure admit plan
Definition	Seizure lasting > 30 min or two sequential seizures w/o return to baseline. Neurologic emergency! Refractory SE is > 60 min
Presentation	Generalized SE, focal SE, hemi-convulsive status w/ hemiparesis
Differential	Sepsis, hypoglycemia, meningitis/encephalitis, skull fracture/trauma, HTN, mass, herniation
Treatment	

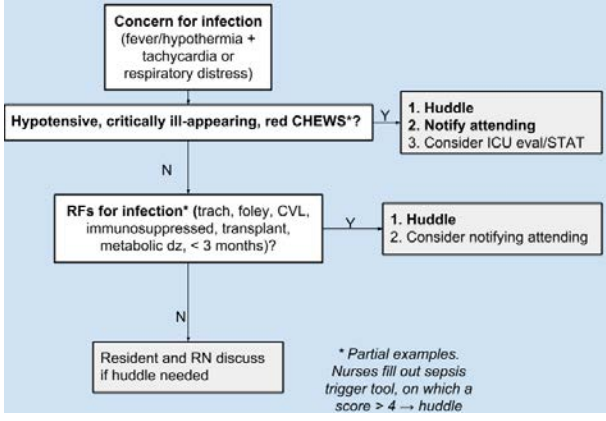
Step 1 (0 - 5mins)	• **Monitors** • **O2** • **IV access** • **STAT labs:** glucose, CBC, chem10, LFTs, UA/blood/urine cultures if febrile, urine tox screen, AED levels if relevant **Lorazepam IV** **(0.1 mg/kg/dose**. Max 4mg) If no access: **Diazepam PR** **(0.5 mg/kg if < 5 yo; 0.3 mg/kg if 6-11 yo; 0.2 mg/kg if > 11 yo)** * Note: Rapid redistribution → increased risk of seizure recurrence
Step 2 (10 - 15mins)	**REPEAT Lorazepam IV** (0.1 mg/kg/dose. Max 4mg) + **Fosphenytoin IV** (20mg/kg infused over 7 min. Will decrease BP) or **Keppra IV** 60 mg/kg IV (max dose 4500 mg)
Step 3 (20 - 30mins)	Consult neurology. Consider LP, EKG. **Phenobarbital IV** (20mg/kg infused over 15-20m. Will decrease RR; be prepared to intubate/bag)

Sepsis Huddle

Huddle Steps (Resident Responsibilities)
1. **Review vital sign trend**
2. **Examine patient** (especially respiratory, mental status, perfusion)
3. **Discuss IV access**
4. **Review antibiotic plan:** new agent(s) needed, delivery priority, need for ID consult
4. **Consider fluid bolus**
5. Discuss plan for repeat assessment

USE SEPSIS POWERPLAN TO ENSURE STAT IV ANTIBIOTICS AND FLUIDS

Sepsis Huddle



ABGs/VBGs

- Presented as **pH/PCO2/PO2/HCO3-**
- **Venous pH + 0.035 = Arterial pH**
- Look at past VBGs for baseline pCO2 (e.g., chronically elevated in ex-preemies w/CLD)
- VBGs sufficient to assess acid-base status & clinical response to treatments (in general). **ABG preferred over VBG:**
  a. to accurately determine **PaCO2 in severe shock**
  b. to accurately determine PaCO2 if hypercapnic (i.e. PaCO2 >45 mmHg)

Stepwise Approach:

1. **Compare pH to normal** range
2. Identify the **primary process** that led to the change in pH (using PCO2/HCO3)
3. Calculate the **serum anion gap (SAG)**
   a. **SAG = Na+ - (Cl- + HCO3-)**. If **>12**, there is a primary AG metabolic acidosis
4. Identify the **compensatory process** (if one is present)
5. Identify if any other disorders are present or there is a **mixed acid-base process using delta/delta = (AG - 12) / (24 - Bicarb)**
   a. < 0.4 → pure Non-AG Metabolic Acidosis (NAGMA)
   b. 0.4 - 0.8 → mixed NAGMA + High-AG Metabolic Acidosis (HAGMA)
   c. 0.8 - 2.0 → a pure HAGMA
   d. >2.0 → mixed HAGMA + metabolic alkalosis

Normal Blood Gas Values

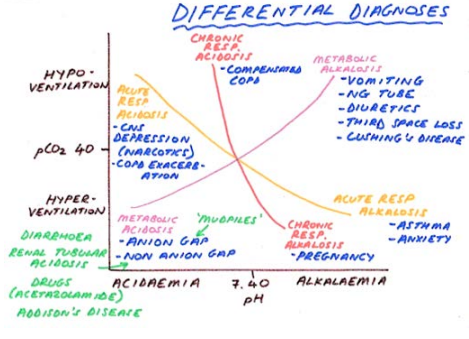
	Arterial	Venous
pH	7.35 - 7.45	7.31 - 7.41
pCO2 (mmHg)	35 - 45	40 - 50
pO2 (mmHg)	75 - 100	36 - 42
HCO3 (meQ/L)	22-26	Same
BE	-2 to + 2	Same
Oxygen Saturation	> 95%	60 - 80%

ABGs/VBGs

Compensation

Disorder	Defect	Compensatory Response*
Respiratory Acidosis	↑ pCO2	↑ **HCO3-** Acute = **+1** MeQ/L HCO3- for +10 mm Hg PaCO2 Chronic = **+4** MeQ/L HCO3- for +10 mm Hg PaCO2
Respiratory Alkalosis	↓ pCO2	↓ **HCO3-** Acute = **-2** MeQ/L HCO3- for -10 mm Hg PaCO2 Chronic = **-5** MeQ/L HCO3- for -10 mm Hg PaCO2
Metabolic Acidosis	↓ HCO3	↓ **pCO2** PCO2 = 1.5 x HCO3 + 8 +/- 2 (Winter's Formula)
Metabolic Alkalosis	↑ HCO3	↑ **pCO2** pCO2 + 0.6 for + 1.0 mEq/L HCO3

* HCO3 = kidneys (days); CO2 = lungs (minutes)
Limits of compensation: HCO3 = 15 - 38. CO2 = 10



Status Asthmaticus

A-B-C	**Epinephrine 0.01 mg/kg IM PRN extremis**
Initial Treatment	**PowerPlans: ED Asthma Status Plan** • **"Unineb" = Albuterol + ipratropium combination nebs** (*note: 1x Unineb = 3x Combineb)* • **Steroids (if no improvement after first neb or patient on home steroids)** *Dexamethasone = dosed q24-48h 0.6 mg/kg* *Prednisone/Prednisolone = dosed q12h 2mg/kg* *Methylprednisolone 2mg/kg*
If poor response, add	Magnesium sulfate 40mg/kg (2mg max) → monitor for hypotension, consider NS bolus **Continuous nebulized albuterol** → titrate to HR
If poor response continues, add	• **Terbutaline: Loading dose 5-10 mCg/kg IV/SC over 10m. Infusion 0.4 mCg/kg/min IV** → EKG, troponin, CK q12h • Consider Heliox 70:30 helium: oxygen mixture
If impending respiratory failure	• **Rapid sequence intubation** • Mechanical ventilation: Minimize PEEP, maximize E time. Permissive hypercapnia. Anticipate air leak, pneumothorax, bronchospasm, PEA.
As patient improves	• **"Last on, first off" to peel off therapy**

CSF Analysis

Age-Based Ranges for CSF Studies

Age	WBC/mm^3 Mean (Range)	Glucose (mg/dL) Mean (Range)	Protein (mg/dL) Mean (Range)
Premature	9	50 (24-63)	115 (65-150)
Term newborn	8.2 (0-22)	52 (34-119)	90 (20-170)
0-4 weeks	11 (0-35)	46 (36-61)	84 (35-189)
4-8 weeks	7.1 (0-25)	46 (29-62)	59 (19-121)
>8 weeks	2.3 (0-5)	61 (45-65)	28 (20-45)

General Heuristics for CSF Interpretation

Diagnosis	WBC	Glucose	Protein	Opening Pressure	Other
Bacterial Meningitis	↑ mostly PMNs	↓ (<60% serum glucose)	↑↑	↑	+CSF Cx / gram stain, often +BCx
Viral Meningitis	Slightly ↑, mostly lymphocytes	Normal	Normal to slightly ↑	Normal	HSV may have RBCs in CSF
TB Meningitis	↑ (PMNs → lymphocytes)	↓ (<60% serum glucose)	↑	Variable	+AFB

CSF Analysis

General Heuristics for CSF Interpretation

Diagnosis	WBC	Glucose	Protein	Opening Pressure	Other
Fungal Meningitis	↑ (lymphocytes)	↓ (<60% serum glucose)	↑	Variable	Fungal Cx
GBS	Normal	Normal	↑↑	Normal	So-called "albumino- cytologic dissociation"
SAH	Normal (accounting for peripheral ratio of RBC to WBC)	Normal	↑	Normal to ↑	Xanthochromia = yellow appearance of CSF, suggests long-term presence of RBCs (to dx from traumatic tap)

Trach Troubleshooting

Tracheostomy Basics

Major types	Shiley or Bivona (more flexible, better for active children)
Sizes	A "3.0" trach has an **inner diameter** of 3.0 mm, sizes vary by age
Cuffed vs. Uncuffed	**Cuffs improve air seal, prevent aspiration,** but uncuffed allows spontaneous breathing, improved vocalization, may be appropriate for infants and small children
Outer vs. Inner Cannula	Outer cannula holds stoma open, inner cannula can be removed for cleaning
Fenestration	Improves vocalization
Trach Ties	The part that wraps around the neck to keep trach in place

Trach Complications

Plan ahead!	• Differentiate new (< 7 days) vs. mature stoma (> 7 days) • Know if your patient can be ventilated "from above" in event of trach malfunction • Know your patient's trach brand, size, features and have replacement trach at bedside, including one size smaller
Decannulation	• Staff assist, call RT urgently • If new stoma, do NOT blindly replace trach, call ORL
Obstruction	• **Mucous plugging → suction, replace inner cannula**, etc. • **Back-walling** = Distal end of trach obstructs against posterior tracheal wall → call RT, reposition trach, may need longer trach • **Tracheal stenosis or granulation tissue** → call ORL, may need to be addressed surgically • Consider deflating cuff and ventilating "from above" if possible
Bleeding	• Although rare, have high index of suspicion for tracheo-arterial fistula, call ORL • Differentiate blood from trach vs. from stoma/trach site

Respiratory Support for Spontaneously Breathing Patients						
Type	**O2 Delivery**	**CO2 Exit**	**FiO2**	**Rate**	**Pros**	**Cons**
"Blow By" Oxygen	O2 tubing or simple mask held by a child's face	Mouth	**<30%** (limited evidence)	At least 10L/ min through a reservoir (such as mask)	Can be used in children who can't tolerate other methods	Limited and variable O2 delivery
Nasal Cannula						
Low flow	Through nasal prongs attached to tubing	Mouth	**25-40%** (100% O2 delivers variable FiO2 based on placement of nares, patient's inspiratory effort and minute ventilation)	**1-4L/min** (Rates >2L/min can create Positive airway pressure in newborns/ infants)	Mobile, infants can feed w/ low -flow in place, may be better tolerated than a mask	- Cannot reliably deliver high concentrations of FiO2 - Prongs can be difficult to keep in position
High flow				Up to **8L/min** in infants, up to **60L/min** in children/adults		
Masks						
Simple Mask	O2 enters mask through a tube	Holes in the side of the mask	**35-50%** (Room air can enter through exit holes, mixing w/ delivered O2)	**6-10L**/min	Can deliver higher concentrations of FiO2 than NC	Cannot reliably deliver precise concentrations of O2 because of mixing w/ room air
Partial Rebreathers	O2 enters the mask through a tube as well as from an **attached reservoir**	Holes in the sides of the mask. Room air can still enter, but not as much as w/ the simple mask.	**50-60% O2**	**10-12L/min**		
Non-Rebreather Masks	O2 enters the mask through a tube as well as from an **attached reservoir w/ a one-way valve**	Two exhalation ports; one is fitted w/ a one-way valve and one allows mixing (fail-safe so that if the O2 delivery port blocked, patient doesn't suffocate)	Up to **95% O2**	**10-15L/min**	Max FiO2 administered to a spontaneously breathing patient	*stored *in the code cart* at BCH

See ICU Non-Invasive Positive Pressure Ventilation for CPAP/BiPAP on page 233

Anxiety/Agitation/Delirium

Definition	Anxiety, agitation, and delirium can often present together and can be difficult to differentiate in the seriously ill child. Management is often similar.
Anxiety	Common among children with chronic or life-threatening illnesses. Difficult to separate from physical symptoms; may **exacerbate physical symptoms (pain, dyspnea, etc.)**
Agitation	Unpleasant state of arousal → loud speech, crying, ↑ motor activity/autonomic arousal
Delirium	An acute-onset **disturbance of consciousness that fluctuates throughout the day**
Trx: Non-pharmacologic	Treat underlying cause, meditation, diaphragmatic breathing, massage, biofeedback therapy, **regulate sleep/wake cyc**le, frequent **reorientation to time and place**, frequent reassurance, **minimize use of restraints**
Trx: Pharmacologic	• Ask psych team when to use PO vs. IV/IM • **Onset of Action:** ▪ **PO/enteral** -- usually 30-60 minutes for beginning of peak effects ▪ **IM** -- usually 15-30 minutes ▪ **IV** -- usually 5-15 minutes

Drug	Dose	Notes
Diphenhydramine	**1 mg/kg per dose PO/IM/IV** Limits per 24h: 7 and under: 50-75mg 8-12 y/o: 75-100mg; Adolescents: 100-150mg	Anticholinergic Avoid if dehydrated, CF, asthma, previous paradoxical rxn
Lorazepam	**0.02-0.05 mg/kg q6h prn** PO/SL/IV/SC → 8-12 y/o: ~0.5mg. 13+: 1mg Limits per 24h: 8-12 y/o: 2mg; Adol.: 3mg	Avoid in delirium. **Avoid in pts < 7 y/o**
Clonidine	7 and younger: 0.025-0.05mg first dose 8-12 years old: 0.05mg first dose 13+: 0.1mg first dose	Useful w/ hx of ADHD, PTSD, younger children
Clonazepam	**0.005-0.01 mg/kg PO q8-12h** Can increase every 3 days up to 0.05-0.1 mg/kg PO q8-12h (max 0.2 mg/kg/day)	Avoid in delirium
Haloperidol	**0.01-0.02 mg/kg PO q8h prn (max 0.5-1 mg)** Acute agitation: 0.025 mg/kg PO & can repeat 0.025 mg/kg in 1 hr as needed	IM form for acute agitation, **delirium**, psychosis/mania
Risperidone	**.25-0.5 mg PO qPM or divided (max 3 mg/day)**	Order only w/ psychiatry input
Quetiapine	**25 mg q12h PO** Increase daily by 25mg/dose **(max 100-200 mg q12h)**	
Olazapine	1.2-2.5 mg PO daily (max 5 mg/day)	

Overnight Behavioral Plan

- Ordersets: Agitation (mild), agitation (moderate), agitation (severe), behavioral health safety plan, behavioral restraints
- **Err on the side of more restrictive** - when in doubt, put on a 1:1, order suicide precautions including finger foods, "arms length" if any significant concern for active attempts to hurt self, security at door for elopement risk, security in room if needs hands-on (care companion cannot put arms on/only observe and alert RN and team of concerns)
- **Behavioral Rapid Response (BRR) Call 5-5555**: For active unsafe behaviors. Summons BRT psych RN, on-call psychiatrist (if in house), ER psych SW (if in house)
- Never allow patient to get between you and exit. Always ask for escort (including BRT clinician or PCS clinician). Put lanyards, long-hair, loose clothing away as able, etc.
- **PGY-2s and above are the only people allowed to order chemical restraints** (one-time IMs. Not possible to write PRN IM psychotropic meds.)

Adverse Drug Reactions

Type A vs. B ADRs

Type A	Predictable, dose/duration dependent (ex: overdose, SEs, drug interactions). 85-95%	
Type B	Unpredictable hypersensitivity reactions (intolerance, idiosyncrasy, immunologic). 10-15%	
	I - Immediate (mins-hrs) - IgE mediated	Anaphylaxis, angioedema, hives, hypotension, N/V/D
	II - Delayed (variable) - Cytotoxic	Hemolysis, thrombocytopenia, neutropenia
	III - Delayed (weeks)- Immune-complex	Serum sickness, arthus reaction, vasculitis
	IV - Delayed (days to weeks)- Cell-mediated	Contact dermatitis, SJS/TEN, DRESS

Organ-Specific ADRs

Exanthems	Diffuse fine macules/papules days after drug initiation	Allopurinol, aminopenicillins, cephalosporins, AEDs, sulfonamides
Urticaria/ Angioedema	W/i minutes of drug initiation	B-lactam antibiotics, ACEI
Fixed eruption	Hyperpigmented plaques that recur in same site	Tetracyclines, NSAIDs, carbamazepine
Pustules	Acneiform, Acute generalized eczematous pustulosis	Steroids, sirolimus, Antibiotics, CCBs
Bullous	Tense or flaccid blisters	Furosemide/Vanco, Captopril/penicillamine
SJS	Fever, erosive stomatitis, ocular involvement, purpuric macules (face, trunk) w/ <10% epidermal detachment	Sulfa antibiotics, AEDs, oxicam NSAIDs, and allopurinol.
TEN	Similar to SJS but w/ >30% epidermal detachment	Same as SJS, mortality as high as 50%
Lupus (skin)	Erythematous/scaly plaques in photodistribution	Hydrochlorothiazide, CCB, ACEIs
Hematologic	Hemolytic anemia, thrombocyto/granulocytopenia	Penicillin, quinine, sulfonamides
Hepatic	Hepatitis, cholestatic jaundice	acetaminophen, sulfonamides
Pulmonary	Pneumonitis, fibrosis	Bleomycin, Nitrofurantoin, MTX
Renal	Interstitial nephritis, MGN	Penicillin, sulfonamides, allopurinol

Multiorgan ADRs

Anaphylaxis	Urticaria/angioedema, bronchospasm, GI sx, hypoTN	B-lactam antibiotics, monoclonal Abs
DRESS	Cutan. eruption, fever, eosinophilia, hep. dysfxn, LAD	AEDs, sulfonamides, minocyc., allopurinol
Serum Sickness	Urticaria, morbiliform rash, arthralgias, fever	Heterologous abs, infliximab, bactrim,PCN
SLE	Arthralgias, myalgias, fever, malaise	Hydralazine, Procainamide, Isoniazid
Vasculitis	Cutaneous or visceral vasculitis	Hydralazine, penicillamine, propylthiouracil

Desensitization

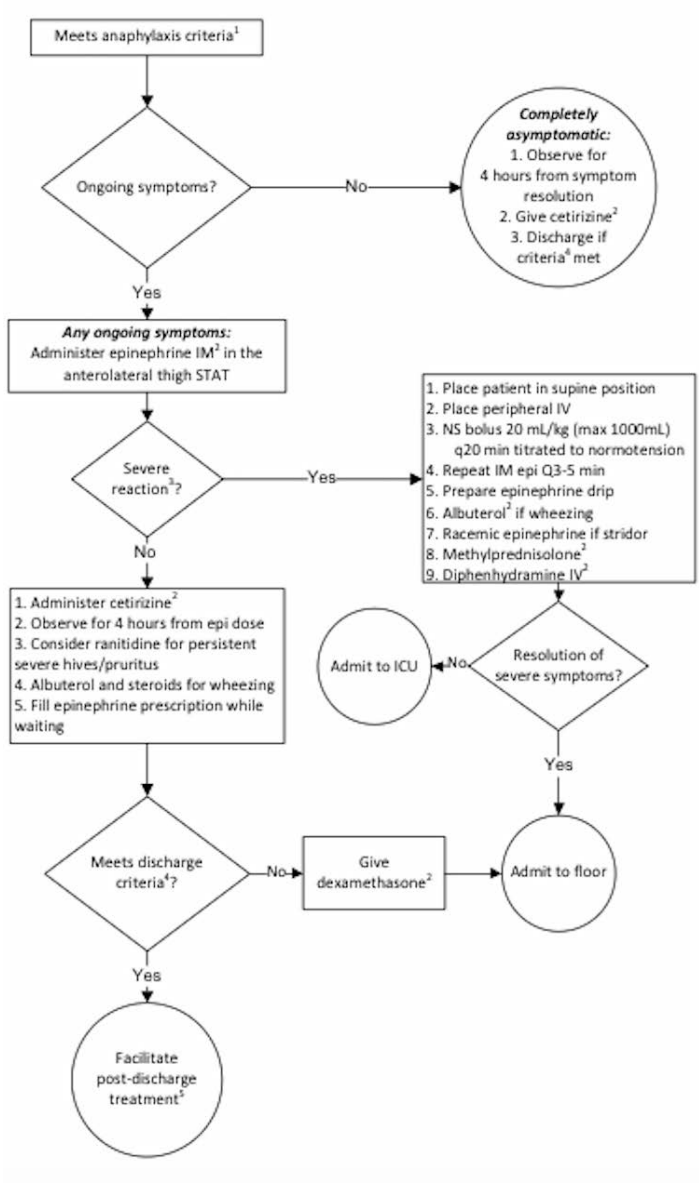
Definition: give increasing doses over hours → mast cells/basophils unreactive to Ag activation (Only for Type I HSRs)
Result: Temporary tolerance → patient can receive the drug at usual intervals. When drug is stopped, desensitization ends (d-wk)

Anaphylaxis*	
Definition	Acute, life threatening systemic HSR (min- hours) w/ ≥1/3 of the following criteria: • **Hives plus another system:** acute onset illness (mins- hours) involving skin, mucosa, or both, and ≥1 of the following: respiratory compromise, reduced BP or symptoms of end-organ dysfunction. • **Two systems involved:** ≥2 of the following must occur rapidly after exposure to a likely allergen (mins-hrs): skin-mucosal involvement, respiratory compromise, reduced BP or associated symptoms of end-organ dysfunction, persistent GI symptoms • **Hypotension:** reduced BP after exposure to known allergen (mins-hrs)
Allergens	Meds (B-lactams, ASA/NSAIDs), food, insects, cold/heat, exercise, latex
Clinical	• Skin involvement in 90%, respiratory in 70%, CV (hypotension) in 45%, GI in 45% • Monitor for biphasic reaction (4-23% occurrence)- sx recur w/i 10h (but up to 72h)
Severe Reaction	Hypotension w/ wide PP, AMS/confusion, syncope, cyanosis, dyspnea, hypoxia
Med Dosing	• Epinephrine IM (1 mg/mL) - 0.01 mg/kg (<10 kg), 0.15 mg/kg (10-25kg), 0.3 (>25 kg) • Cetirizine - 2.5 mg (6mo-2 yrs), 5 mg (2-5 yrs), 10 mg (≥6 yrs) • Diphenhydramine - 1 mg/kg IV/PO (max 50 mg) • Dexamethasone 0.6 mg/kg (max 16 mg) OR methylprednisolone 1 mg/kg (max 60) • Ranitidine - 2 mg/kg PO (max 150 mg) OR 1 mg/kg IV (max 60 mg)
ED Discharge Criteria	No hypotension, resolved wheezing, ≤ 2 doses of Epi
Post-discharge Treatment	3 days of Cetirizine daily, consider ranitidine, f/u with PCP/Allergy

Anaphylaxis*

Management

Emergent

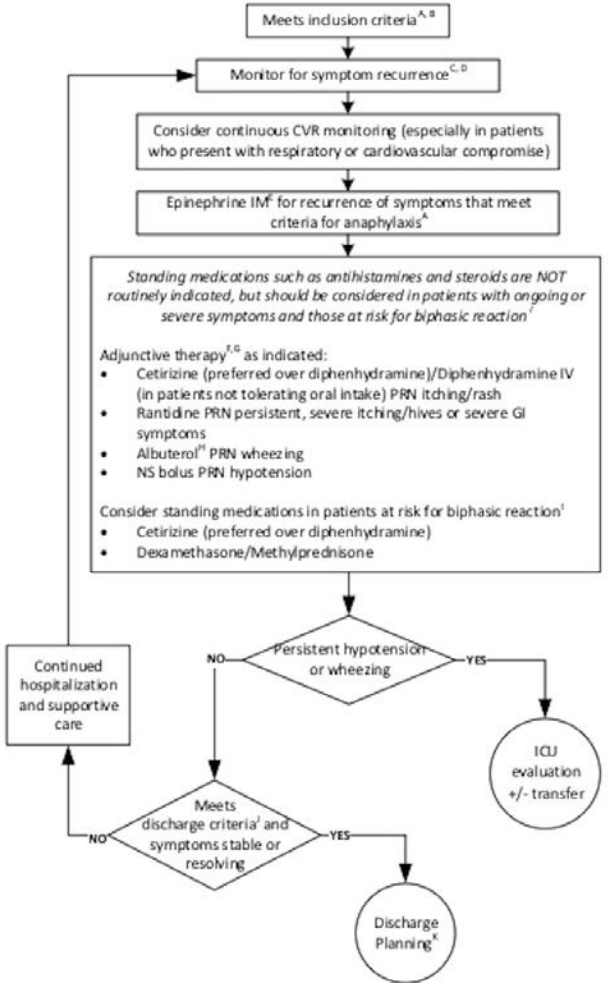


Management of Anaphylaxis continued on next page →

Anaphylaxis*

Management

Inpatient



Primary Immunodeficiencies	
Pathophysiology	• Genetic defects in the adaptive (B- or T-cell) or innate (phagocytes, complement) immune systems lead to recurrent infections • Over 200 distinct disorders: B cell defects (65%), combined B and T cell deficiencies (15%), phagocytic disorders (10%), T cell deficiencies (5%), and complement deficiencies/others (5%)
Epidemiology	The overall incidence is 1:10000, and overall prevalence is 1:2000.
Clinical	• Can be nonspecific and broad • **Constitutional**: Poor growth, failure to thrive • **GI**: chronic diarrhea. • **Derm**: Atopic and non-atopic dermatitis, severe diaper rash, neonatal rash, anhydrosis, as well as delayed separation of the umbilical cord (LAD) • **Immuno**: Recurrent infections, autoimmunity • Family history of consanguinity or family history of immunodeficiency or unexplained childhood deaths puts a child at higher risk of having or developing a primary immunodeficiency
Physical Exam	• **Vital signs**: Growth parameters • **General exam**: Note dysmorphisms, including teeth and hair (abnormal in NEMO). Look for infectious sources (sinusitis, otitis, pneumonia, thrush, diaper rash) • **HEENT exam**: Note tonsils (absent in XLA) and examine for thrush and other signs of infection such as sinusitis or recurrent otitis media • **CV exam**: Note any cardiac anomalies including heart sounds, pulses, perfusion, and overall volume status as cardiac anomalies can be a part of certain syndromes associated w/ immuno-deficiency syndromes (e.g.: DiGeorge Syndrome) • **Respiratory**: Note symmetry of lung exam, quality of air entry, and lung sounds as pulmonary anomalies may be a manifestation of immunodeficiency syndromes • **GI**: A thorough GI exam including abdominal exam for elements like hepatosplenomegaly and rectal exam for possible anal atresia is important • **GU**: Primary immunodeficiencies can also lead to GU anomalies; assess for absence/presence of appropriate male/female organs in the correct number • **Derm exam**: Skin exam for eczema/dermatitis (i.e. WAS, SCID, hyper IgE syndrome) as well as erythroderma (Omenn Syndrome). Note telangiectasia (AT), warts, granulomas, poor wound healing or ulcers • **Neuro**: A thorough neuro exam may also hint at the etiology of an immunodeficiency (ataxia-telangiectasia), an infection such as meningitis, or may help elucidate an alternate cause of symptoms
Diagnosis	• **Initial labs**: CBC w/ differential (note especially lymphopenia), chem7, albumin, urinalysis, ESR, CRP, quantitative immunoglobulins (IgG, IgA, IgM, IgE), specific vaccine antibody studies (tetanus, HiB, pneumococcal). • **Follow-up labs**: HIV testing. B- and T-cell subset, complement screening (C3, C4, AH50, CH50), vaccine challenge (administer pneumococcal or other vaccine and measure titers 4-6 weeks later), Dihydrorhodamine (DHR) assay (CGD). Leukocyte adhesion defect testing (LAD). • **Advanced lab analysis**: T cell proliferation studies (mitogen, antigen), T and B cell memory panels, NK cell function assays, Toll-like receptor assays. Immunodeficiency genetic panel. Whole exome or whole genome sequencing.
Treatment	Varies widely based upon the deficiency. Common therapies include prophylactic antibiotics, IVIG, bone marrow transplant.

Indications for a Primary Immunodeficiency Evaluation

- ≥8 ear infections w/i one year
- >2 serious sinus infections w/i one year
- >2 pneumonias w/i one year
- FTT, poor weight gain, or abnormal growth parameters
- Abnormal physical exam suggestive of syndrome
- Recurrent skin or organ abscesses
- Persistent thrush (mouth/skin), at >12 months of age
- Severe or overwhelming infection
- Infection w/ unusual organisms
- Need for intravenous antibiotics to clear infections
- Infections w/ opportunistic organisms (Aspergillus, Pneumocystis)
- Severe forms of viral infections (HSV, VZV, EBV)
- Complications from a live vaccine
- A family history of primary immunodeficiency
- Abn. TRECs on newborn screen x2
- Abn. screening CBC (profound leukopenia, lymphopenia, eosinophilia)

Classification of Primary Adaptive Immunodeficiencies

B-cell (Humoral)		
Diseases	• X-linked agammaglobulinemeia • Transient hypogammaglobuniema of infancy • IgA deficiency	• IgG deficiency • IgG subclass deficiency • Specific antibody deficiency
Clinical Manifestations	• Generally presents <12 mo old (3-6 mo, due to loss of maternal antibody) • Bacterial infxn (sinusitis, otitis, pneumonia) • Abscesses (recurrent) • Bronchiectasis	• Chronic diarrhea or gastroenteritis • Failure to thrive • Enteroviral meningoencephalitis (chronic)
Organisms	Encapsulated: • S pneumo • HiB • N meningitides • Salmonella typhii	Also: • S Aureus • Pseudomonas • Enteroviral meningoence-phalitis
Vaccine Issues	Do not give live vaccines for severe defects. Vaccination not necessary if on IgG replacement Effectiveness of other vaccines is uncertain	
T-cell Defects (Cellular)		
Diseases	• DiGeorge Syndrome • SCID (T-/B+)	
Clinical Manifestations	• Typically presents at birth/early infancy. • Mucocutaneous candidiasis • Severe viral infections • Opportunistic infections • Fungal infections	• Bacterial infections • Warts or severe eczema • Chronic diarrhea • Failure to thrive
Organisms	• Candida • PJP • Mycobacterium	• VZV, HSV, CMV infections • Salmonella typhii
Vaccine Issues	Do not give live virus vaccines if substantial T cell defect	

Classification of Primary Adaptive Immunodeficiencies

Combined B/T Cell Defect		
Diseases	• SCID (T-/B-) • CVID • Omenn syndrome • Wiskott-Aldrich syndrome • Ataxia-telangiectasia • Hyper IgM syndrome	• X-linked lymphoproliferative disease (XLP) • NEMO (NK-kappa B essential modifier) deficiency • Hyper IgE syndrome • DOCK8 deficiency • ZAP70 deficiency
Clinical Manifestations	• Typically presents in 1st year of life. XLP/CVID can present as teens/adults. • Infections (sinusitis, otitis, pneumonia) • Abscesses (recurrent) • Chronic diarrhea or gastroenteritis • Failure to thrive	• Mucocutaneous candidiasis • Viral/opportunistic infections • Fungal infections • Increased cancer risk • WAS: eczema, sinusitis • AT: telangiectasias, int. disability
Organisms	• Candida • PJP • Mycobacterium	• VZV, HSV, CMV infections • Encapsulated bacteria
Vaccine Issues	Do not give live vaccines (OPV, BCG, smallpox, YF, live influenza, MMR, MMRV, rotavirus). Effectiveness of other vaccines is uncertain.	
Phagocytic Defects		
Diseases	• Chronic granulomatous disease (CGD) • Chediak-Higashi syndrome (CHS) • Lymphocyte adhesion deficiency (LAD)	
Clinical Manifestations	• Typically presents in infancy • Poor wound healing • Delayed separations of the umbilical cord (LAD) • Lymphadenitis/abscesses	• Catalase (+) bacterial infections (CGD) • Candidiasis • Chronic gingivitis, oral disease • Hepatosplenomegaly
Organisms	Catalase-(+) bacteria: • S aureus • Pseudomonas • Burkholderia cepacia • Nocardia • Enterobacteria erratia and Klebsiella)	Fungal infections: • Aspergillus • Candida albicans
Vaccine Issues	• Live viral vaccines contradindicated in CH & LAD, but OK in CGD • Live bacterial vaccines are contraindicated. Other vaccines are safe/ effective	

Classification of Primary Adaptive Immunodeficiencies continued on next page →

Classification of Primary Adaptive Immunodeficiencies

Complement Defects		
Diseases	**Classical pathway**: C1q, Cqr, C1s, C2, C4 Hereditary angioedema (C1-est) C2: most common in Causasians	**Lectin pathway**: MBL, M-/L-/H-ficolin, CL-11, MASPs **Alternative pathway**: Factors D, B, and properdin
Clinical Manifestations	• Can present at any age • Angioedema of the face, lips, hands, feet, GI tract, throat (C1-inh) • Recurrent sinopulmonary infections • Bacteremia/pyogenic bacterial infections	• Meningitis • Autoimmune disease (lupus-like) • Often autosomal dominant inheritance • Associated w/ atypical HUS
Organisms	• Encapsulated bacteria • Neisseria	
Vaccine Issues	• No vaccine contraindications • Refer to CDC guidelines re: additional vaccinations for protection against encapsulated bacteria	

Characteristics of Selected Immunodeficiencies

Disorder	Category	Characteristics
Ataxia Telangiectasia (AT)	Combined B- and T- cell	Progressive cerebellar ataxia, oculocutaneous telangiectasia, diminished/ absent deep tendon reflexes. Intellectual disability. Defect in the ATM gene (11q22.3). Elevated serum AFP. Inc risk of malignancy (i.e. leukemia, lymphoma). Avoid radiation (CT, x-rays)
Chediak-Higashi Syndrome (CHS)	Phagocytic	Neutropenia, oculocutaneous albinism. Recurrent skin and sinopulmonary infections. Severe gingivitis and periodontal disease, adenopathy, progressive neurologic findings. Most patients enter “accelerated phase” resembling lymphohistiocytosis. Defect in CHS1 gene (1q42.1-q42.4). Blood smear shows characteristic giant cell granules.
Chronic Granulomatous Disease (CGD)	Phagocytic	Recurrent bacterial infections, often w/ encapsulated and catalase-positive organisms, due to inability of neutrophils to generate oxidative burst. Also prone to infections w/ fungi. Can see recurrent granulomas and abscesses, both superficial and deep-seated. Majority are X-linked, also autosomal recessive forms. Abnormal DHR.
Common Variable Immunodeficiency (CVID)	Combined B- and T- cell	Can present in childhood or adolescence/adulthood. Recurrent sinopulmonary infections, opportunistic infections, autoimmune diseases. Can see granulomas, hepatosplenomegaly, bronchiectasis. Impaired B cell differentiation w/ hypogammaglobulinemia and poor response to polysaccharide vaccines (ie tetanus, pneumococcal). Mutations in a number of geneshave been described in subsets of patients.
DiGeorge Syndrome	T-cell	Heterogeneous T-cell disorders, ranging from normal immune system to severe T-cell immunodeficiency w/ SCID-like features (in 0.5% or less). Abnormal development of the 3rd and 4th pharyngeal pouches, leading to thymic hypoplasia, hypoparathyroidism, congenital heart disease, characteristic facies. Most common genetic defects = del. 22q11.2 & 10p13-14.

Characteristics of Selected Immunodeficiencies		
Disorder	**Category**	**Characteristics**
DOCK8 Deficiency	Combined B- and T- cell	Autosomal recessive form of hyper IgE syndrome w/ a distinct genetic cause and unique features compared to autosomal dominant form. Autosomal recessive. Presents in childhood w/ atopic dermatitis, severe food allergies, asthma, recurrent sinopulmonary infections and otitis. Often extensive cutaneous viral infections (HSV, warts, molluscom). Frequent skin infections and abscesses (S Aureus). Candidiasis. Inc risk of malignancy, especially viral-associated (HPV, HSV, EBV). Low B and T cell counts, very high serum IgE and eosinophilia, however few cases reported w/ normal IgE levels. Defect is in the DOCK8 gene (9p24). Treatment is bone marrow transplant.
Hyper IgE Syndrome	Combined B- and T- cell	Recurrent bacterial infections of the skin and upper and lower respiratory tracts. Abnormal features (not often presents until adulthood): coarse/ thickened facial features, frontal bossing, wide alar base of nose, high arched palate. History of prolonged retention of primary teeth, increased fractures w/ minor trauma, eczema. Labs show elevated IgE, eosinophilia. Dominant negative mutations in STAT3.
Severe Combined Immunodeficiency (SCID)	Combined B- and T- cell, depending on the type	Presents in the first 3-12 months of life. Abnormal newborn screen (low TRECs). Recurrent infections (bacterial, virus, fungus), failure to thrive, recurrent fevers, chronic diarrhea, poor growth, infections caused by vaccines. Definitive diagnosis by absolute T cell count <300, abnormal T cell proliferation studies, OR presence of maternal T cells in circulation. Multiple genetic defects (RAG1, RAG2, ADA, Artemis, IL2RG). Immunologic emergency, needs positive pressure room, urgent work-up and evaluation for bone marrow transplant.
Selective IgA Deficiency	IgA	Most patients (85-90%) are asymptomatic. Occasional susceptibility to recurrent infections, malignancy, autoimmune disease. Theoretical increased risk of anaphylaxis to blood products; however, this is controversial and rarely seen.
Wiskott-Aldrich Syndrome	Combined B- and T- cell	Triad: thrombocytopenia, eczema, chronic otitis media/sinusitis. On exam: severe eczema, petechiae. Defect in the WAS gene (Xp11.23). Increased risk of autoimmune disease, malignancy (i.e. lymphoma).
X-linked Agammaglobulin-emia (XLA)	B-cell	Defect of B cell maturation resulting in complete absence of B cells/ hypogammaglobulinemia. Recurrent bacterial infections. Exam notable for absent tonsils and lymph nodes. Defect in BTK gene (Xp22). Autosomal recessive forms also. Treatment is IgG replacement
X-linked Lymphoprolifer-ative Disease (XLP)	Combined T- and B- cell	X-linked recessive. Presentation is typically in childhood. Most commonly presents w/ a fulminant EBV infection (often w/ hepatitis, hepatosplenomegaly, liver failure), often causing secondary hemophagocytic lymphohistiocytosis or aplastic anemia. About 1/3 of XLP patients have dysgammaglobulinemia. Inc risk of malignancy, esp. lymphoma. Death is from lymphoma or HLH.. Caused by mutation in XLP/SH2D1A (Xq25) gene encoding for signaling protein called. SAP- defects impair both cellular and humoral immunity, Treatment is bone marrow transplant.
ZAP-70-related SCID	T-, B+ cell	Autosomal recessive. Presents in the first 2 years of life., generally age 6-12 months Similar to SCID w/ recurrent infections, opportunistic infections, chronic diarrhea, failure to thrive. However, patients have normal lymphocyte count and detectable lymphoid tissue. Diagnosis by T cell subsets: CD8+ cells are low/absent, CD3+ and CD4+ are normal or high. Defect is a mutant ZAP-70 gene (2q11.2), involved in T cell receptor signaling and T cell function. Treatment is bone marrow transplant.

Specific Antibody Deficiencies

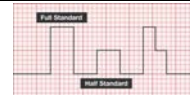
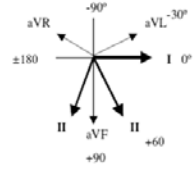
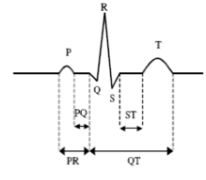
	Presentation	Labs					
		IgG	IgA	IgM	IgG subclass	Vaccine response	B cells
IgG Subclass Deficiency	Recurrent severe infections (controversial)	NL	NL	NL	At least 1 is low	LOW	NL
Selective IgA Deficiency	Asymptomatic or associated w/ autoimmune, GI, atopic disorders	NL	LOW	NL	NL	NL OR LOW	NL
Hyper IgM Syndrome	Severe infections, including PJP	LOW	LOW	NL OR HIGH	LOW	LOW	NL
Specific Antibody Deficiency	Often asymptomatic	NL	NL	NL	NL	LOW	NL
CVID	Recurrent infections	LOW	NL OR LOW	NL OR LOW	LOW	LOW	NL

Characteristics of Selected SCID disorders

Type	Gene defects		Treatment
T-, B+ SCID	• IL2RG (most common form, X-linked) • JAK3 • IL7RA • IL2RA	• CD3D/E/Z • PTPRC • CORO1A • ZAP70	Bone marrow transplant or gene therapy (IL2RG)
T-, B- SCID	• RAG1/RAG2 (common) • Artemis (common) • Adenosine deaminase (ADA, common) • PRKDC	• AK2 • LIG4 • Cernunnos (NHEJ1)	• Bone marrow transplant or gene therapy (ADA) • ADA can be treated w/ gene therapy or enzyme replacement

Diagnostic Approach to Primary Immunodeficiencies

Initial Labs (Most Cases)	**Next step** (Include w/ initial labs if suspicious of specific disorder)	**Advanced** (Depending on specific history)
• CBC w/ differential • Quantitative immunoglobulins (IgG, IgA, IgM, IgE) • Specific antibody studies (tetanus, HiB [PRP], pneumococcal)	• B- and T-cell subsets • T cell proliferation studies (mitogen, antigen) • Complement screening (CH50, AH50, C3, C4) • DHR (dihydrorhodamine assay for CGD)	• T and B cell memory panels • NK cell function assay • Toll-like receptor studies • Specific genetic testing

EKG Approach	
Standardization Marker	• 2 big boxes tall = "full standard" and 10 mm= 1 mV • 1 big box tall = "half standard" and 5 mm = 1 mV • Limb leads can be in full standard while the precordial are in half standard 
Paper Speed	Standard 25mm/s → Small box = 0.04s, Big box = 0.2s
Ventricular Rate	• 300-150-100-75-60-50 rules if the rhythm is regular • OR count the number of QRS complexes in the rhythm strip (10 seconds) and multiply by 6 (works even if the rhythm is irregular).
Rhythm	NSRM = (1) P before every QRS (2) QRS after every P (3) normal P axis (0-90°, upright P waves in I and aVF)
QRS Axis	Determine axis by looking at leads I and aVF • ↑ in I, ↑ in aVF = axis between 0 and +90° • ↑ in I, ↓ in aVF = axis between -90 and 0° • ↓ in I, ↓ in aVF = axis between -90 and 180° • ↓ in I, ↑ in aVF = axis between +90 and 180° Once you've identified axis quadrant, find the most isoelectric limb lead. • The QRS axis is 90° away from the most isolelectric lead • Normal axis varies w/ age (newborn = rightward b/c RV dominance in utero, childhood = leftward b/c LV becomes dominant) • Superior (negative) axis or >180° = AV canal defects, tricuspid atresia and large VSDs. • Leftward axis in a cyanotic newborn is highly suggestive of tricuspid atresia 
Intervals and Segments	**PR interval:** atrial depolarization (P wave) and delay at AV node. (PQ segment) • A normal PR interval increases w/ age • Prolonged PR intervals are seen in AV nodal block (heart block) • Short PR intervals are seen in pre-excitatory conditions such as WPW • Variable PR interval can be seen in wandering atrial pacemaker, multifocal atrial tachycardia and Wenkebach-type 2nd degree heart block • Depressed PR segment may be seen in pericarditis  **QRS interval:** ventricular depolarization. • The upper limit of normal increases w/ age (0.07 s in newborns to 0.10 s in adults) • A wide (prolonged) QRS is indicative of depolarization which proceeds independent of the His -Purkinje system or in which depolarization via the His-Purkinje system is aberrant • This is seen in ventricular arrhythmias, pre-excitation, IV conduction delays and BBB **QT interval:** ventricular depolarization (QRS) and repolarization. • QTc normalizes QT interval accounting for HR, calculated w/ Bazett formula: QT (sec) / √RR (sec) • A normal QTc in the newborn = 0.47 s, it shortens in older children to 0.45, and then elongates to the normal adult vales of approximately 0.44 s in men and 0.46 s in women • Prolonged QTc is seen in congenital long QT syndrome, electrolyte derangements (hypokalemia, hypomagnesemia and hypocalcemia) and is caused or worsened by many medications

EKG continued on next page →

EKG Approach

Intervals and Segments

Q waves: ventricular septal depolarization, which proceeds from left-to-right and inferior-to-superior

- Small q waves should be seen in the inferior and left-facing leads (I,II,V5,V6 and III and aVF).
- Duration should not exceed 0.04 sec and amplitude should not exceed 25% of QRS wave in height
- Abnormally tall or long Q-waves may represent ischemia
- Q waves in V1 and V2 are always abnormal

U Wave: small deflection often seen closely following the T wave, which may represent repolarization of the Purkinje fibers or after depolarizations w/i the ventricle

- A U wave is a normal finding if it is small (<25% the amplitude of the T wave), there is an isoelectric segment between the T wave and U wave, and if the U wave is upright.
- If any of these features are not met, the U wave may be pathologic
- Prominent U waves are seen most often seen in hypokalemia, but can also be seen in other electrolyte derangements, ventricular hypertrophy, LQTS and w/ antiarrhythmic therapy.
- Inverted U waves are concerning for ischemia, ventricular hypertrophy or cardiomyopathy.
- U waves are often more prominent at slow heart rates (<65 bpm).
- If U waves are large (>25% of the T wave amplitude) and there is no isoelectric segment between the T wave and U wave, they should be included in the QTc calculation (which becomes the QTUc)

ST segment: represents ventricular repolarization

- Elevation or depression >1mm in limb leads or >2mm in precordial leads is abnormal and is concerning for ischemia if seen in a territorial distribution (especially w/ reciprocal changes in other territories) or pericarditis if diffuse
- Concave "smiling" ST-elevation is often normal, as seen in benign early reoplarization, however convex "frowning" ST-elevation is ominous

R/S progression: R/S ratio represents the ratio of left to right ventricular forces

- R waves in the right precordial leads represent depolarization of the right ventricle and S waves in these leads represent depolarization of the left ventricle. Pattern reversed in left precordial leads
- In newborn period of a FT infant, the RV is dominant and as such the R wave in lead V1 should be greater than the S wave
- As a child ages, the LV becomes progressively more dominant until late adolescence when an adult-type R/S progression is seen w/ small R waves and large S waves in V1 w/ large R waves and small S waves in V6

T wave: normal T wave pattern varies w/ age

- At birth, all T waves should be upright
- Over the first days of life, leads V1-V3 invert (V1first, V3last) and after 7-10 days of life it is pathologic for there to be upright T waves in lead V1and represent RV strain if present
- It is normal for the T waves in leads V1-V3to be inverted in children and between the ages of ~8 and 20 y/o, these T waves start to become upright (V3 first, V1 last), although it is not abnormal for T wave inversion to persist into an individual's 20s and this is called a persistent juvenile T wave
- It is always abnormal to see an inverted T waves in leads V5+ V6. (ischemia or ventricular strain)

Peaked T-waves are seen in hyperkalemia and elevated ICP and abnormally flat in hypokalemia

Chamber Size

RAE: P wave height >2.5 mm (2.5 small boxes)

LAE: P-wave duration >2.5 small boxes (100 msec)

- Notched in leads I or II or biphasic in lead V1
- Terminal neg. portion > 1 small box deep/wide.

LVH: R-wave > 98th% in I, II, aVL, aVF, V5, V6.

- S-wave > 98th% in V1, V2
- Inverted T in V5 or V6
- Left axis deviation

RVH: R wave >98th% in aVR, III, V1, V2, V4R

- S wave >98th% in I, V5, V6
- qR pattern in V1
- Upright T in V1 (pre-adol.) suggests RV strain
- Right axis deviation

Strain: QRS-T angle > 90° (diff. btw QRS / T axes)

EKG Approach

Normal EKG Values By Age

AGE	0-7 days	1 wk–1 mo	1 mo-6 mo	6 mo-1 yr	1 yr-5 yr	5-10 yr	10-15 yr	>15 yr
Rate (beats/min)	90-160 (125)	100-175 (140)	110-180 (145)	100-180 (130)	70-160 (110)	65-140 (100)	60-130 (90)	60-100 (80)
QRS axis (degrees)	70-180 (120)	45-160 (100)	10-120 (80)	5-110 (60)	5-110 (60)	5-110 (60)	5-110 (60)	5-110 (60)
PR lead II (msec)	80-150 (100)	80-150 (100)	80-150 (100)	80-150 (100)	80-150 (120)	80-150 (120)	90-180 (140)	100-200 (160)
QRS duration (msec)	40-70 (50)	40-70 (50)	40-70 (50)	40-70 (50)	45-80 (65)	45-80 (65)	50-90 (70)	60-90 (80)
Maximum QTc† (msec)	450 max	450 max	450 max	450 max	440 max	440 max	440 max	430 max
QRS V_1 Q (mm)	0	0	0	0	0	0	0	0
R (mm)	5-25 (15)	3-22 (10)	3-20 (10)	2-20 (9)	2-18 (8)	1-15 (5)	1-12 (5)	1-6 (2)
S (mm)	0-22 (7)	0-16 (5)	0-15 (5)	1-20 (6)	1-20 (10)	3-21 (12)	3-22 (11)	3-13 (8)
QRS V_5 Q (mm)	0-1 (0.5)	0-3 (0.5)	0-3 (0.5)	0-3 (0.5)	0-5 (1)	0-5 (1)	0-3 (0.5)	0-2 (0.5)
R (mm)	2-20 (10)	3-25 (12)	5-30 (17)	10-30 (20)	10-35 (23)	13-38 (25)	10-35 (20)	7-21 (13)
S (mm)	2-19 (10)	2-16 (8)	1-16 (8)	1-14 (6)	1-13 (5)	1-11 (4)	1-10 (3)	0-5 (2)
QRS V_6 Q (mm)	0-2 (0.5)	0-2 (0.5)	0-2 (0.5)	0-3 (0.5)	0-4 (1)	0-4 (1)	0-3 (1)	0-2 (0.5)
R (mm)	1-12 (5)	1-17 (7)	3-20 (10)	5-22 (12)	6-22 (14)	8-25 (16)	8-24 (15)	5-18 (10)
S (mm)	0-9 (3)	0-9 (3)	0-9 (3)	0-7 (3)	0-6 (2)	0-4 (2)	0-4 (1)	0-2 (1)
T-wave V_1 (mm)	*0-4 days* = −3 to +4 (0) *4-7 days* = −4 to +2 (−1)	−6 to −1 (−3)	−6 to −1 (−3)	−6 to −1 (−3)	−6 to −1 (−3)	−6 to +2 (−2)	−4 to +3 (−1)	−2 to +2 (+1)

Values are 2nd – 98th percentile (mean) From Keane et al. *NADAS' Pediatric Cardiology*. 2006.

CXR	• **Heart Size**: >50-60% of thorax is abnormal on PA film (confounded by: poor inspiration, AP technique, thymic shadow) • **Lung Fields**: increased pulmonary blood flow (increased pulm. vasc. markings, engorged vessels) = sign of overcirc. • Decreased vascular markings indicate decreased pulmonary blood flow. • Pulmonary edema and effusions may indicate CHF. • **Thymic Shadow**: lack of a thymic shadow in neonates should raise suspicion for 22q11 del. and assoc. cardiac defects • **Aortic Arch**: sidedness (left-sided aortic arch is normal) • **Heart Border**: Left or right atrial enlargement • **Rib Notching**: suggests the presence of collateral vessels, as can be seen in coarctation.
What To Do Next	• 4-extremity BP: Upper > Lower (or less commonly R arm > Lt arm) suggests obstruction of the aorta (e.g. interrupted arch, coarctation). Exception to the rule: L arm > R suggests aortic obstruction w/ aberrant right subclavian. • Pre- and post-Ductal O2 sats (measure on right arm and either foot) • Hyperoxia Test: PaO2 < 100 mm Hg on 100% RA suggests cyanotic congenital heart disease. >200 suggests pulmonary etiology. Pulse oximetry can be used as approximation if unable to obtain ABG. • Consult cardiologist
When To Start Prostaglandins	• After workup, if high suspicion for cyanotic heart disease start PGE1 0.05 mcg/kg/min as soon as possible • Monitor for apnea and hypotension • Consider securing airway if patient requires transport

Arrhythmias and Pacemakers

Premature Ventricular Contractions (PVCs)

Presentation	Range: asymptomatic → **palpitations, lightheadedness**. Irregular pulse on exam
Pathophys	Re-entry, enhanced automaticity, triggered activity
Workup	**EKG, 24-48 Holter, chem10, thyroid panel**. May require echo or exercise testing. (dependent
Treatment	Usually none. **Trx underlying cause** (if one exists, e.g. a drug). Beta blockers or CCBs if symptomatic. If refractory, radiofrequency catheter ablation.

Arrhythmias and Pacemakers continued on next page →

Arrhythmias and Pacemakers

Premature Atrial Contractions (PACs)

Presentation	Range: asymptomatic → **palpitations, lightheadedness.** Irregular pulse on exam
Pathophys	Re-entry, enhanced automaticity, triggered activity from after depolarizations
Workup	Similar to work up for PVCs
Treatment	Rarely required. **Beta-blockade** can be considered for symptomatic PACs

Bradyarrythmia

Presentation	Usually asymptomatic; lightheadedness, SOB, exercise intolerance or syncope and cardiovascular collapse; poor feeding, irritability and/or respiratory abnormalities in infants • Newborn to 3 years: < 90-100 bpm • 3 to 9 years: < 60 bpm • 9-16 years: < 50 bpm • Well trained adult athletes: <40 bpm
Pathophys	Caused by increased ICP, **medications** (beta blockers, digoxin, acetylcholinesterase inhibitors, analgesics and sedatives as well as alpha 2 blockers), structural CHD, myocarditis, anorexia
Workup	Assess for **perfusion**, Hx for causes and medications; **EKG**
Treatment	• Observation if asymptomatic • Complete block or advanced 2nd degree block: **pacemaker** • **CPR if HR <60** w/ per perfusion, consider epinephrine, atropine, transcutaneous pacing

AV Block

Degree	PR Interval	Pathophys
1st Degree	**Prolonged PR interval** Birth- 4 wks: 0.08-0.12 1-3 mos: 0.08-0.13 3-12 mos: 0.08-0.14 1-3 yrs: 0.08-0.15 3-5 yrs: 0.1-0.15 5-8 yrs: 0.09-0.16 8-12 yrs: 0.1-0.17 12-16 yrs: 0.1-0.18	**Increased vagal tone, idiopathic, acute rheumatic fever (ARF), Lyme dz,** hypothermia, cardiomyopathy, electrolyte disturbances
2nd Degree Mobitz I (Wenkebach)	**Progressive lengthening of PR** → non-conducted P wave	• At the level of the AV node **(does not progress to complete heart block)** • Healthy individuals during sleep
2nd Degree Mobitz II	**Normal PR interval, intermittent nonconducted P waves** (ratio of P waves: QRS, e.g. 2:1 = 2 P waves per 1 QRS)	**BELOW level of AV node** (e.g., His bundle pathology, a/w CHD or cardiac surgery) → **may progress to complete heart block**
3rd Degree (Complete)	**Complete AV dissociation**	• Narrow QRS (junctional beats) vs. **wide QRS (ventricular beats) → may cause hemodynamic collapse** • Congen. heart block in infants of mothers w/**SLE** (anti-Ro/anti-La Ab), L-TGA • Acquired heart block: myocarditis, **Lyme dz**, ARF, MI

Supraventricular Tachycardia (SVT)

Presentation	• **Paroxysmal** palpitations, chest pain, shortness of breath, dizziness or syncope w/ sudden onset and sudden resolution • HR characteristically invariable and is generally > 220 bpm in infants and > 180 bpm in children
Workup	EKG w/ narrow QRS complex, delta waves, retrograde P waves or not visible P waves
Treatment	• **Vagal** maneuvers (ice to face for babies, Valsalva maneuvers, blowing through a straw) • Give **adenosine** 0.1 mg/kg (max dose 6-12 mg) as a rapid IV push through an IV as close to the heart as possible, followed by very rapid NS flush (this may be repeated at 0.2 mg/kg) • Immediate **synchronized cardioversion** is indicated if the patient is unstable

Arrhythmias and Pacemakers	
Pre-Excitation	
Presentation	Episodes of paroxysmal supraventricular tachycardia or asymptomatic/incidental finding on EKG
Pathophys	Early conduction of atrial impulses to the ventricle defined by **short PR interval, wide QRS, delta wave**
Workup	Echo to r/o structural heart disease (Ebstein's anomaly); exercise testing
Treatment	**Catheter ablation** is curative; beta-blocker or other antiarrhythmic medications
Ventricular Tachycardia and Ventricular Fibrillation	
Presentation	Range: asymptomatic → palpitations, chest pain, dizziness or syncope→ hemodynamic collapse and rapid death
Pathophys	Can be due to drugs, electrolyte abnormalities that prolong QT, underlying cardiac disease, syndromes including LQTS, Brugada syndrome, CPVT and ARVC can also predispose to these rhythms, as well as accessory pathways (as in WPW)
Workup	EKG, electrolytes, blood gas, and toxicologic screening
Treatment	**VTach w/ a pulse**: • **Amiodarone** (5 mg/kg over 20-60 mins), Lidocaine (1 mg/kg over 2-4 minutes) • **Synchronized cardioversion** 0.5-1 J/kg initially, repeat w/ up to 2 J/kg. May be used w/ or instead of medical therapy • Magnesium (25 mg/kg over 10-20 minutes) if torsade de pointes is suspected **VFib or pulselss VTach**: • **CPR** immediately • **Defibrillate** initially w/ 2 J/kg, repeat at 4 J/kg w/ a maximum of 10 J/kg every 2 mins • If not converted, use **Epinephrine** (0.01 mg/kg = 0.1 ml/kg of 1:10,000 IV), may repeat every 3-5 mins • Consider Lidocaine, Amiodarone and Magnesium Sulfate
Long QT Syndrome	
Presentation	• Range: incidental findings → syncope, palpitations, arrhythmia, seizures, or sudden death. • Often provoked by exercise, fright and rapid temperature changes (such as diving into cold water)
Pathophys	• **Congenital forms**: ion channelopathies (Romano-Ward, Jervell and Lange-Nielsen Syndrome, Andersen syndrome) • **Acquired causes of Long QT**: Electrolyte abnormalities (hypokalemia, hypomagnesemia and hypocalcemia) Macrolides, quinolones, metronidazole, multiple antifungals, most anti-emetics, SSRIs and TCAs, many antipsychotics, multiple antiarrhythmics, methadone and diphenhydramine
Workup	• **EKG** w/ prolonged QTc (upper limit of normal 400-460 ms), T-wave alternans, notched T-waves or low resting HR; electrolytes • Often want to test family members as well for genetic LQT syndromes as AD transmission most common.
Treatment	Adequate magnesium, potassium and calcium level; Avoid any medications that may prolong QTc (a full list can be found at **www.crediblemeds.org**) and activities known or suspected to provoke it; **Beta blockers**, ICD placement and left thoracic sympathectomy are options for high-risk patients

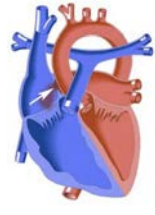
Arrhythmias and Pacemakers continued on next page →

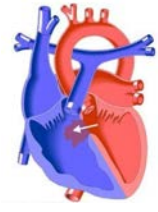
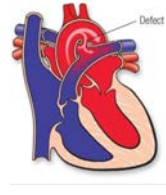
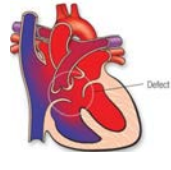
Arrhythmias and Pacemakers

Pacemakers

Positions	Describes how pacemaker functions and programmed • **Position 1**: The chamber being paced (A = atrium, V = ventricle, D = dual • **Position 2**: The chamber being sensed (A, V, D or O = no sensing). • **Position 3**: Response to a particular sensed event (I = a sensed event inhibits pacemaker output, T = a sensed event triggers pacemaker output, D = dual modes of response (i.e. a sensed event in the atrium inhibits pacemaker output in the atrium, but triggers ventricular pacemaker output w/ a programmed delay to mimic intrinsic AV delay), O = no response to sensed events).
Settings	Re-entry, enhanced automaticity, triggered activity • **AAI**: Atrial demand pacing and is an appropriate mode for patients w/ sinus node dysfunction, but should not be used for patients w/ AV node dysfunction • **VVI**: Ventricular demand pacing and is used quite commonly-- results in loss of AV synchrony and can result in a type of cardiomyopathy called pacemaker syndrome (signs and symptoms similar to heart failure) • **DDD**: Dual chamber pacing- provides more physiologic pacing w/ preserved AV synchrony and may be used in patients w/ both sinus node and AV node dysfunction. This mode of pacing can result in four different rhythms: ▪ Normal sinus rhythm (pacemaker does not fire) ▪ Atrial pacing w/ a native QRS (pacemaker provides atrial impulse only) ▪ AV sequential pacing (pacemaker provides atrial impulse w/ a programmed PR interval mimicking AV node function followed by ventricular impulse) ▪ Atrial sensing and ventricular pacing (pacemaker provides ventricular impulse only at intervals mimicking AV node function)

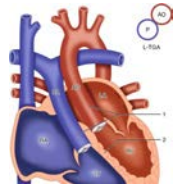
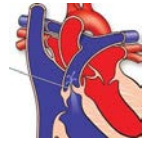
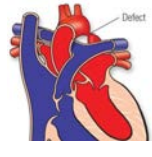
Acyanotic Heart Disease

Lesion	Basics	Hx/Exam	Studies	Treatment
Atrial Septal Defect	• Volume overload • 4 types based on location and embryologic origin. 1. Ostium primum: low in septum; can involve AV valve. 2. Ostium secundum: most common; near foramen ovale. 3. Sinus venosus: may involve connection w/ SVC, IVC, often associated PAPVC. 4. Coronary sinus (defect between CS and LA, not truly in atrial septum). • Amount of L→ R shunt depends on side of defect, SVR relative to PVR, relative LV and RV compliance • PAPVC has similar hemodynamic consequences as ASDs	**Hx**: often asymptomatic, may result in poor growth. When causing significant overcirculation, causes fatigue, dyspnea, CHF and can lead to pulmonary vascular disease (Eisenmenger syndrome). Paradoxical emboli **PE**: Fixed and widely split S2. SEM caused by increased flow across PV, not flow through septal defect. Diastolic rumble if significantly increased volume of flow across the tricuspid valve.	**EKG**: Enlargement of right-sided chambers, RBBB (complete or incomplete), RAD. Superior axis in primum ASD **CXR**: Overcirculation (increased pulmonary vascular markings). Cardiomegaly. 	• Secundum defects may close spontaneously • Surgery indicated if symptomatic or is Qp:Qs>2:1. Surgical or cath patch closure. • Surgical goal = close the defect and avoid development of irreversible pulmonary hypertension/ Eisenmenger's syndrome

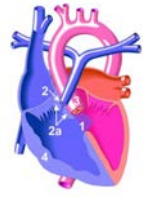
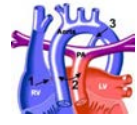
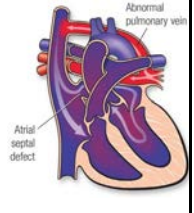
Acyanotic Heart Disease				
Lesion	**Basics**	**Hx/Exam**	**Studies**	**Treatment**
Ventricular Septal Defect	• Volume overload and possible pressure overload. • Opening in ventricular septum. - Occurs in one of four locations: inlet, outlet, membranous, muscular. • Degree of shunting determined by size of defect and relative SVR/PVR • If small in size (and restrictive) may not be hemodynamically significant. • If moderate in size, can cause pulmonary overcirculation and left-sided volume overload • If large can expose RV to systemic pressure in addition to volume overload	**Hx**: depends on size. Symptoms occur as PVR decreases during first weeks of life and flow across the defect increases. Sx of CHF include, tachypnea, poor growth, sweating, feed fatigue, dyspnea. **PE**: early or holosystolic regurgitant-type murmur. Smaller defects are louder because of higher pressure gradient across lesion. Large defects may cause very quiet murmurs. Volume overload can produce a left-sided heave.	**EKG**: normal or LAE, LVH, sometimes RVH if defect is large and RV is exposed to systemic pressure OR if pulmonary vascular disease has developed due to chronic overcirculation **CXR**: most often normal. +/- mild cardiomegaly or increased pulmonary blood flow.	• May spontaneously close on own, especially small muscular types. • Surgery if symptomatic or persistently elevated PVR. Otherwise, may observe. • Repair is surgical patch closure or cath device closure • Surgical/cath goal = close the defect. 
Patent Ductus Arteriosus	• Volume overload. • Common in premature newborns. • Can be asymptomatic. Can also cause pulmonary overcirculation, CHF and systemic hypoperfusion	**Hx**: Respiratory distress, feeding fatigue, poor growth, CHF. **PE**: continuous "machine-like" murmur at LUSB (though murmur can also be systolic only). Wide pulse pressure, bounding or palmar pulses.	**EKG** is often normal. Can have LVH or RVH. **CXR**: Nml +/- increased vascular markings. +/- cardiomegaly. 	• Indomethacin, ibuprofen or Tylenol in preemies. Less likely to be successful in non-preemies. • Surgical ligation or cath coiling in larger children • Surgical/cath goal = close the duct
AV canal Defects	Volume overload Components: 1. Primum ASD 2. Inlet VSD 3. AV valve defects Occurs on a spectrum: 1. Partial AV canal (ASD, single AV valve annulus w/ separate MV and TV orifices and cleft MV) 2. Transitional AV canal (Cleft MV, ASD and hemodynamically insignificant VSD) 3. Intermediate AV (Large ASD and VSD, single valve annulus, distinct TV and MV orifices) 4. Complete AV canal (ASD, VSD, common AV valve) Common in T21	**Hx**: presentation similar to that of VSD w/ CHF: poor growth, sweating, feed fatigue, dyspnea. Severity depends on type of defect. **PE**: Murmurs of ASD, VSD, MR +/- gallop.	**EKG**: Superior axis. +/- RVH, LVH. **CXR**: cardiomegaly +/- increased vasc markings. 	• Surgery often required before 1st birthday to prevent CHF. • Patch closure of septal defects, often involves valvuloplasty. • Surgical goal = closing defects and achieving AV valve competency • Complications: AV valve regurgitation and stenosis after repair

Acyanotic Heart Disease continued on next page →

Acyanotic Heart Disease

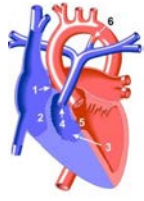
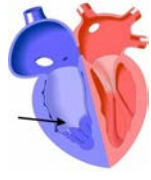
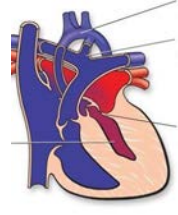
Lesion	Basics	Hx/Exam	Studies	Treatment
Congen. Corrected TGA	• Transposed great arteries (PA off LV, Ao off RV) • L-looped ventricles • Segmental anatomy is {S,L,L} or, less commonly, {I,D,D} • **Blood flow**: LA-->RV-->Aorta-->Body-->IVC/SVC-->RA-->LV-->PA-->Lungs-->Pulmonary veins-->LA • Often associated w/ other cardiac defects (often a VSD) • Often have coronary anomalies	**Hx**: No cyanosis unless other cyanotic defects present. Can present w/ right heart failure in early adulthood as RV cannot tolerate work load as systemic ventricle. **PE**: Dependent on associated defects. May have stigmata of right heart failure. May have loud S2 due to anterior position of AoV.	**EKG**: Q waves in right precordial leads, no Q waves in left-sided leads. Often have conduction system abnormalities including bradycardia and AV block. **CXR**: Dextrocardia or mesocardia are common. 	• Conventionally, only associated defects were repaired. • The newer anatomic approach involves the "double switch" operation, which involves an arterial and atrial level switch via baffling or a Senning-Rastelli procedure if significant PS is present. • Often "training" of the LV w/ PA banding before the LV is made the systemic ventricle is required, unless significant PS is present. • Timing of surgery is a major challenge
Pulmonary Valve Stenosis	• Pressure overload • Stenotic pulmonary valve, causing increased pressure on RV, TR, may be transmitted toRA • "Critical"if ductal patency required for pulmonary blood flow. These children require prostaglandins and early repair. ductus).	**Hx**: If mild/moderate, asymptomatic. If severe, w/ RV dysfunction and TR, hepatomegaly. If critical, can present w/ cyanosis. **PE**: SEM at LUSB, ejection click. +/-TR murmur. Often worsens in first few months of life, then stabilizes.	**EKG**: Normal to RAD, RVH. +/- RV strain pattern **CXR**: +/- ↓vasc markings 	• If critical start PGE • Repair is balloon valvuloplasty in cath lab. Surgical repair if severely thickened valve, or muscular subpulmonary stenosis. • Surgical/cath goal = relieve obstruction, will often have some degree of PR afterward
Aortic Stenosis	• Pressure overload. • Can be at level of valve, supravalvar or subvalvar. • LVOT obstructional LVH, systolic and diastolic dysfunction, CHF, MR. Severe LVOTO causes decreased CO • Critical if ductal patency required for systemic blood flow • Supravalvar stenosis common in William's Syndrome.	**Hx**: Infants often asymptomatic. Stenosis worsens w/ age, causing CHF or even cardiogenic shock. **PE**: Harsh SEM at base, radiating to neck. Ejection click w/ valvar stenosis. LV heave or tap.	**EKG**: LVH +/- strain pattern. **CXR**: normal to cardiomegaly. pulmonary edema possible 	• If critical PGE to maintain CO. • Repair is cath balloon valvuloplasty or surgical aortic valvuloplasty or valve replacement. • Surgical goal = relieve obstruction, avoid AR.
Coarctation of the Aorta	• Pressure overload. • Narrowing of the descending aorta in one of three locations: pre-ductal, juxtaductal (most common) or postductal (adult-type). Often worsens as PDA closes. • Common in Turner Syndrome.	**Hx**: In infants, often presents as PDA closes: poor growth, sweating, feed fatigue, dyspnea and can present as cardiogenic shock. Upper extremity hypertension, w/ drop in lower extremity BPs **PE**: SEM at LUSB radiating to back. BP gradient btwn right arm and legs. Brachiofemoral delay and/ or decreased/ absent femoral pulses.	**EKG**: RVH in infancy. LVH in children. **CXR**: Cardiomegaly. "3 sign", rib notching in older children (collateral vessels eroding bone). 	• **Infants**: PGE if signs of shock to maintain CO. • Repair is surgical coarct excision and anastomosis or cath balloon dilation and possibly stenting. • Surgical goal = relief of obstruction. • **Complication**: re-coarctation

Cyanotic Heart Disease

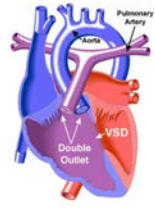
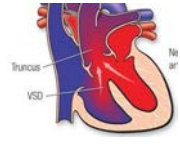
Lesion	Basics	Hx and Exam	Studies	Treatment
Tetralogy of Fallot	• Anterior malalignment of the conal septum, causing: 1.Large VSD. 2.RV outflow obstruction. 3.Overriding aorta. 4.RV hypertrophy. • Degree of cyanosis depends on amount of RVOT obstruction • "Pink Tets" have minimal RVOT obstruction (VSD-like physiology) and "Blue Tets" have significant RVOT obstruction. • Pulmonary Atresia and Major Aorto-Pulmonary Collateral Arteries (TOF/PA/MAPCAs) is the most severe variant • Hypercyanotic episode ("Tet Spell"): occurs 2/2 to • Dynamic worsening of RVOT obstruction • Increased PVR • Decreased SVR and results in cyanosis and, if persistent, acidosis 2/2 RàL shunting	**Hx**: May have "Tet Spells" Symptoms can range from severe cyanosis to predominantly pulmonary over circulation and volume overload resulting in heart failure depending on degree of RVOTO "Balanced" tets (moderate PS, Qp:Qs close to 1) may present only w/ a murmur **PE**: SEM at LUSB (2/2 RVOT obstruction, VSD does not cause murmur). Absent or soft P2.	**EKG**: RAD, RVH, RAE, RBBB **CXR**: "boot-shaped" heart. Decreased pulmonary markings. +/- right-sided aortic arch. Look for absent thymic shadow (seen in patients w/ 22q11 deletion). Coronary artery anomalies are common, may have absent ductus arteriosus 	• PGE if neonatal cyanosis to preserve ductal patency and pulmonary blood flow. • **Surgical repair**: patch closure of VSD and relieve RVOT obstruction (may require muscle bundle resection, patch augmentation of RVOT which may be valve-sparing or a transannular patch) • Unifocalization for TOF/PA/MAPCAs • Surgical goal = close VSD, relieve RVOT obstruction • Will often have PR after repair • Acute hypercyanotic episode: 1.Decrease PVR Supplemental O2 Morphine Bicarb 2.Increase SVR Knees to chest Alpha-1 agonists 3.Increase systemic venous return • Beta blockers may be used to prevent infundibular spasm
Transpos. of the Great Vessels	• Aorta arises from RV, pulmonary artery arises from LV w/ D-looped ventricles. • Results in two parallel circulations and severe cyanosis unless mixing occurs at the atrial or ventricular level (PDA alone is not sufficient)	**Hx**: Profound cyanosis and tachypnea at birth. If large VSD, can have comfortable dyspnea. **PE**: Often no murmur if no VSD. +/- single S2.	**EKG**: RAD, RVH **CXR**: "Egg on a string" heart. Increased pulmonary vascular markings. Right-sided aortic arch. 	• PGE in newborns. • Often emergent balloon atrial septostomy to ensure mixing of the two parallel circulations. • **Surgical repair**: arterial switch w/ transfer of the coronary buttons. Older surgeries involved atrial switch (i.e. Mustard, Senning) • Surgical goal = restore normal connections between ventricles and great vessels
Total Anomlous Pulmonary Venous Return	• Pulmonary veins do not return to LA • Four types: 1.Supracardiac 2.Intracardiac 3.Infracardiac 4.Mixed • Cyanosis due to mixing of oxygenated and deoxygenated blood or pulmonary edema is veins are obstructed (common in infracardiac type) • Must have mixing lesion to survive • Anomalous connection causes L--> R shunt and there is shunting of mixed blood R--> L at the atrial or ventricular level, causing cyanosis (net shunt is usually L--> R)	**Hx**: can mimic RDS if obstruction is present. Can present w/ signs of RV volume overload is obstruction is not significant (similar to other Là R shunt lesions). **PE**: If vein obstruction, single loud S2, If no obstruction, increased RV impulse, SEM at LUSB, diastolic TV rumble. +/- fixed split S2. No significant cyanosis if Qp:Qs is high and there is no obstruction	**EKG**: RAD, RVH, +/-RAE. **CXR**: if pulm vein obstruction, pulm edema (similar to RDS), "Snowman in a snowstorm" 	• Emergent surgery if severe vein obstruction: anastomose pulm venous confluence to LA and close ASD • Supportive care including O2, inotropes, mechanical ventilation, ECMO as needed • Consider PGE if cyanotic, though need to be judicious as this can increase pulmonary blood flow and worsen pulmonary edema if obstruction present • Surgical goal = connect pulm veins to LA and close mixing lesion.

Cyanotic Heart Disease continued on next page →

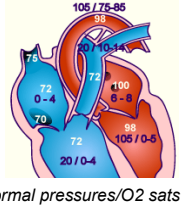
Cyanotic Heart Disease

Lesion	Basics	Hx and Exam	Studies	Treatment
Tricuspid atresia	• No outlet from RA-->RV. Supply to LA via PFO or ASD. • Classified based upon great arterial relationship (d-TGA in type II), presence of VSD and degree of PS • If no VSD, will have hypoplastic RV and pulmonary atresia • If + VSD, variable severity of RV and PA hypoplasia • Pulmonary blood flow may be PDA dependent	**Hx**: Variable timing (50% present on DOL 1), depending on size of VSD and degree of PS. Usually cyanotic by 2 months w/ cyanosis, tachypnea. **PE**: +/- VSD murmur. Single S2. 	**EKG**: RAE, LVH, LAD w/ superior axis (distinguishes TA from most other forms of cyanotic disease). **CXR**: Usually decreased pulmonary vascular markings. Can have increased if d-TGA	• PGE if cyanotic, to maintain pulm flow • Some neonates require atrial septostomy. • Manage CHF if present. • Surgical repair: staged palliation: BT shunt--> bidirectional Glenn--->Fontan. • Surgical goal = make two separate circulations w/ passive blood flow to the lungs and LV-driven systemic flow
Ebstein's Anomaly	• Tricuspid valve is inferiorly displaced into RV w/ leaflets adherent to RV wall, often associated w/ ASD/PFO and can have PS • Causes atrialization of the RV and RA enlargement • Impaired RV output 2/2 TR, RV dysfunction, possible RVOTO from redundant valve tissue. • Can cause a "circular shunt" in utero (Ao-->ductus-->retrograde PA -->RA--> PFO--> LA--> LV--> Ao) and hydrops • Frequently associated w/ WPW • Classically associated w/ maternal Li therapy	**Hx**: Variable presentation from cyanosis in delivery room and early right heart failure to adults w/ murmurs, arrhythmia or incidental EKG findings based upon degree of TV displacement **PE**: systolic murmur 2/2 TR. Often has gallop. 	**EKG**: RAE, RBBB. May have WPW and may present in AVRT. **CXR**: Cardiomegaly, which can be massive and box-like 2/2 RAE. Decreased pulmonary vascular markings can be normal.	• Consider PGE in neonates w/ severe cyanosis. • Improves as PVR falls • Surgical repair: Variable depending on severity, but may include TVplasty (Cone procedure) or replacement, reduction atrioplasty and ventricular plication. If severe, may require palliation down single ventricle pathway. • Surgical goal = improve RV function, reduce TR
Hypoplastic Left Heart Syndrome	• Group of left-sided obstructive anomalies characterized by underdevelopment of the left heart thought to be secondary to reduced in utero blood flow • Requires PDA and ASD for survival • Three types: • MS/AS • MS/AA • MA/AA • Further classified based upon presence or absence of unrestrictive atrial septal defect • If atrial septum is intact (IAS) or restrictive, outcome is poor	**Hx**: Presents w/ cyanosis secondary to left atrial hypertension and pulmonary edema if atrial septum intact or restrictive. Presents w/ cardiogenic shock and CHF if atrial septum unrestrictive as PDA closes. **PE**: Increased RV impulse, single S2, often no murmur, poor pulses, cool extremities	**EKG**: RVH, reduced left-sided forces. **CXR**: Cardiomegaly, ↑ pulm markings. 	• PGE to preserve ductal patency and systemic perfusion • Balloon atrial septostomy if IAS • Surgical repair: Three-stage univentricular palliation: • Atrial septectomy, creation of neoaorta, modified BT-shunt or Sano shunt v. Hybrid procedure • Bidirectional Glenn (superior cavopulmonary anastomosis) • Fontan (total cavopulmonary shunt) • May require heart transplant • Surgical goal = separation of pulmonary and systemic circulation w/ passive pulm return and RV-generated systemic flow

Cyanotic Heart Disease

Lesion	Basics	Hx and Exam	Studies	Treatment
Double Outlet Right Ventricle	• Family of lesions where both great vessels arise from RV • VSD always present • Three types : 1. TOF-type: oxygenated blood passing through VSD directed to aorta, PS present. 2. TGA-type: oxygenated blood directed through subpulmonic VSD to PA (Taussig-Bing heart). 3. VSD-type: normally-related vessels, no PS.	**Hx**: 1. TOF presents like TOF 2. TGA-type presents like TGA, but usually w/ better mixing 3. VSD type like VSD **PE**: variable, based on type of DORV	**EKG**: No hallmark EKG, because of variety of physiology types. **CXR**: Cardiomegaly and pulm flow depend on degree of PS present 	• Medical management determined by Qp:Qs. • Treat CHF if present • Surgical repair depends on physiology • Surgical goal = separation of pulmonary and systemic circulations versus single ventricle repair
Truncus arteriosus	• Failure of embryonic bulbar trunk to divide into PA and aorta. • Associated w/ a VSD, aortic arch and coronary anomalies • Several subtypes depending on how PAs come off the truncus. • Cyanosis is secondary to mixing • Both ventricles feed both arteries, pulmonary overcirculation worsens as PVR falls • Associated w/ 22q11 syndrome	**Hx**: CHF over first few weeks as PVR falls and dependent on degree of truncal valve regurgitation **PE**: loud single S2, ejection click. SEM at LUSB. Diastolic de-crescendo murmur from truncal regurgitation. Bounding pulses from diastolic runoff	**EKG**: LVH, RVH **CXR**: Cardiomegaly. Increased pulmonary vascular markings. +/- right-sided aortic arch. 	• Treat CHF if present • Surgical repair: Division of pulmonary arteries from truncus and placement of RV-PA conduit. Closure of VSD. • Surgical goal = establishing separated pulmonary and systemic circulations.
Pulmonary Atresia	• Fused pulm valve leaflets. Inability of flow from RVàPA. Malformed RV and TV w/ tricuspid regurg. • Pulm flow depends on PDA. • R-->L shunt via atrial or ventricular level. • PA w/ intact ventricular septum (PA-IVS) can result in a high pressure RV and RV-coronary fistulae à "RV-dependent coronary circulation"	**Hx**: Cyanosis at birth that worsens as PDA closes. **PE**: PDA murmur. 	**EKG**: Mild LAD from weak right side. RAE. **CXR**: ↓ pulm markings	• PGE in newborns • Surgical repair: surgical or cath valve repair. If RV cannot be grown by increase in flow. • Surgical goal = pulm valve integrity w/ normal circulation. If this not possible and RV remains non-functional, goal is Fontan physiology. • If coronary circulation is RV-dependent in PA-IVS, RV decompression may cause "steal" and massive ischemia

Catheterizations/Caring for the Post-Cath Child



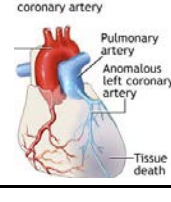
Normal pressures/O2 sats

1. Inspect **access site (usually femoral) for bleeding** or hematoma formation.
2. Assess **distal pulses** and ensure they are intact and equal bilaterally
3. Compare **lower extremity warmth, edema and skin color.** Signs of venous thrombus include edema, increased warmth and erythema. Signs of arterial thrombus include pain, pallor, paresthesia/numbness, poor pulses and cool extremities.
4. Listen t**o heart and lung sound**s and think about what you should be hearing given what procedures were performed
5. Most patients will require at least one **hemoglobin/hematocrit check to ensure they are not bleeding**
6. Some patients will require **a chest x-ray** to ensure they have not developed a pneumothorax and to ensure their device has not migrated

Cardiomyopathy	
Hypertrophic Cardiomyopathy (HCM)	
Presentation	Often discovered incidentally on EKG (LVH, T-wave abnormalities). If symptomatic: dyspnea, exertional chest pain, fatigue, presyncope, syncope, palpitations, ventricular arrhythmias and sudden death; Exam w/ left-sided heave and lateral displacement of the PMI; audible S4 and a harsh mid to late systolic murmur at the mid to lower left sternal border that is louder while standing as well as w/ the Valsalva maneuver as decreased LV volume worsens the obstruction
Pathophys	Usually AD. Myofibrillar disarray and hypertrophy of the LV, most commonly the interventricular septum→ LVOT obstruction and diastolic dysfunction
Workup	**EKG** may show left axis deviation, LVH w/ or w/o strain and pathologic septal Q waves in the inferior and lateral leads +/- LA enlargement; Echo w/ diagnostic LV and septal hypertrophy; +/- cardiac MRI (to assess tissue characteristics and risk stratify), catheterization, EP studies, genetic testing (AD)
Treatment	ICD if high-risk features of history of arrhythmia. Beta-blockers or calcium channel blockers reduce obstruction and have antiarrhythmic properties; septal or left ventricular myomectomy and septal alcohol ablation are sometimes utilized
Dilated Cardiomyopathy	
Presentation	Signs of right-sided heart failure (**peripheral edema, hepatomegaly, JVD**) and left-sided heart failure (**pulmonary crackles, cold extremities and weak pulses**), plus often tachycardic, tachypneic, DOE. On exam a systolic murmur representing AV valve regurgitation may be present w/ an audible S3 or S4
Pathophys	**Systolic dysfunction** w/ enlargement of ventricles, usually idiopathic but can be secondary to myocarditis, ischemia or scarring processes, valvular disease, thyroid disease, nutrient deficiencies (selenium, carnitine, thiamine), drugs (especially anthracyclines), toxins, radiation, infiltrative processes, muscular dystrophies, familial DCM syndromes
Workup	**CXR** w/ cardiomegaly, pulmonary vascular congestion/edema; **EKG** w/ sinus tachycardia and may show LVH and non-specific ST-T changes; may be low voltages and atrial enlargement; arrhythmias may be present; **Echo** w/ LV chamber dilation and poor contractility
Treatment	Diuretics, ACE inhibitors, digoxin
Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC)	
Presentation	Lightheadedness, palpitations, chest pain and syncope as well as signs of right-sided heart failure
Pathophys	Fibrofatty replacement of the right ventricular myocardium leading dangerous ventricular dysrhythmias (and less often SVT) and ventricular dysfunction
Workup	EKG, echocardiogram, EP studies, MRI and genetic testing
Treatment	Beta-blockers plus restriction from sports; if history of VT or VF or have certain high-risk features should have an ICD placed
Restrictive Cardiomyopathy	
Presentation	Signs and symptoms of heart failure (see CHF section)
Pathophys	Non-compliant ventricular tissue→ **diastolic** dysfunction and atrial enlargement w/ relatively normal ventricular dimensions
Workup	**Echo**
Treatment	Heart failure management (see CHF section)

Cardiomyopathy	
Left Ventricular Non-Compaction Cardiomyopathy (LVNC)	
Presentation	Signs and symptoms of heart failure (see CHF section)
Pathophys	During fetal cardiac development, the ventricular myocardium begins as a spongy, highly-trabeculated tissue that should become "compacted" ventricular cavity becomes relatively smooth, especially w/i the LV, which doesn't happen in patients w/ this In patients w/ LVNC
Workup	**Echo**
Treatment	Heart failure management (see CHF section)

Congestive Heart Failure	
Presentation	• **Infants**: Tachycardia, tachypnea, feeding difficulty, diaphoresis (particularly w/ feeding) and poor growth • **Children and Adolescents**: Shortness of breath, orthopnea, cough, peripheral edema. • **PE Finding**: Gallops, murmurs (MR/TR), hepatomegaly, edema of ankles or eyelids, tachypnea, tachycardia, crackles, cool extremities, delayed cap refill, weak pulses.
Pathophys	Multiple etiologies-- structural heart disease, arrhythmia, ischemia, cardiomyopathies, myo/ pericarditis, hypertension, and systemic issues including severe anemia, and severe thyroid disease
Workup	• **CXR**: Cardiomegaly and pulmonary edema, Kerley B lines • **EKG**: Atrial or ventricular enlargement, ischemia, arrhythmia • **Echo**: Depressed systolic function, +/- ventricular dilation and/or hypertrophy • **Labs**: If severely depressed cardiac output, may have acidosis, elevated lactate, elevated BNP, abnormal electrolytes and elevated CK and Troponin (if myocardial injury is present). If right sided may have abnormal liver studies.
Treatment	• **Diuresis**: Furosemide or other loop diuretic are first-line. Thiazide diuretics and spironolactone also may be used, usually in chronic CHF. • **Inotropes**: Digoxin increases contractility. Dopamine, isoproterenol and dobutamine may be used in sicker ICU patients. • **Afterload reduction**: ACE inhibitors decreased SVR and may positively impact cardiac remodeling. Milrinone infusion has a similar effect and may be used in sicker patients. • **Other Measures**: O2 and correction of anemia aid O2 delivery. Salt restriction aids diuresis. Treating underlying illness (e.g. infection, arrhythmia, acidosis) can improve contractility. Sedation and mechanical ventilation can decrease demand on the heart.

Coronary Artery Anomalies	
Anomalous Left Coronary Artery off the Pulmonary Artery (ALCAPA)	
Presentation	Recurrent episodes of irritability and emesis as well as **signs of congestive heart failure in infants**→ diaphoresis, tachycardia, tachypnea, respiratory distress, weak peripheral pulses and cool extremities , +/- gallop or MR murmur
Pathophys	The left coronary artery arises from the pulmonary artery rather than the left coronary cusp of the aortic valve→ can lead to ischemic cardiomyopathy 

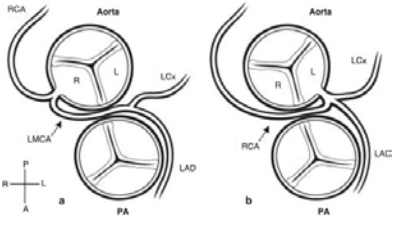
Coronary Artery Anomalies continued on next page →

Coronary Artery Anomalies

Anomalous Left Coronary Artery off the Pulmonary Artery (ALCAPA)

Workup	CXR w/ cardiomegaly, pulmonary edema**.** EKG w/ signs of anterolateral ischemia manifest as pathologic Q waves (often very deep, but fairly narrow), inverted T waves and ST-segment elevation in leads I, aVL and V4-V6. Prolonged QTc may also be seen. **Echo is definitive**, may confirm w/ MR/ CT/angiography
Treatment	Surgery to reimplant LA to aorta and patch pulmonary artery

Anomalous Aortic Origin of a Coronary Artery (AAOCA)

Presentation	Range from asymptomatic→ massive ischemia and **sudden death**
Pathophys	Variation in the number, shape or location of the ostia (origin) of the coronary arteries, usually non pathologic. LCA or LAD arising from the right coronary cusp leads the anomalous vessel to course anteriorly around the aortic valve, placing the vessel between the aorta and pulmonary artery and at risk for compression during times of peak cardiac output. Anomalous LCA from the right coronary cusp (picture on L) is always trx w/surgery, even if asymptomatic, due to high risk of sudden death Anomalous RCA from the left coronary cusp (picture on R) is also associated w/ increased frequency of sudden death, though to a lesser extent. Treatment is debated. 

Pulmonary Hypertension

Presentation	Acute→ Sx of right heart failure. CHronic→ dyspnea w/ exertion and fatigue. Can lead to hemoptysis and sudden death from arrhythmias. Exam w/ RV heave, +/- TR murmur, cyanosis, clubbing, RHF signs such as JVD, hepatomegaly, peripheral edema
Pathophys	**Mean pulmonary atrial pressure >25 mmHg at rest**. Causes are 1. Pulmonary arterial HTN 2. Left heart dysfunction/obstruction 3. Lung pathology or hypoxemia 4. Chronic thromboembolism 5. Multifactorial
Workup	• **EKG**: **RV hypertrophy** often w/ accompanying strain (excessive right-sided forces for age w/ QRS-T angle > 90 degrees) In children, upright T-waves in V1 after 7-10 days of life suggests this diagnosis as can a qR pattern in V1. • **CXR**: may show mildly enlarged cardiac chambers, underlying lung disease and **prominent proximal pulmonary arteries** w/ diminished distal pulmonary vasculature. • **Echo**: may show enlarged or **hypertrophied right-sided chambers**. Position of the interventricular septum (which should bow into the usually low pressure RV) may flatten or bow into the LV. If present, the TR jet can estimate RV pressure using the Bernoulli equation (upper limit of normal is ~25mmHg). Septal defects may also be used in this manner. • Definitive diagnosis of pulmonary hypertension is done via **cardiac catheterization**. Mean PA pressures greater than 25 mmHg are diagnostic. This often performed w/ pulmonary vasodilator testing to assess response to potential therapies.
Treatment	Correct underlying cause! Counseling to avoid strenuous activity esp. Isometric exertion, avoid alpha adrenergic meds. Pulmonary vasodilators can be used→ Remodulin (IV infusion of trepostinil), Bosentan (endothelin receptor antagonist), Sildenafil (phosphodiesterase inhibitor), nifedipine (calcium channel blocker), iNO

Cardiac Infections

Myocarditis

Presentation	**Range**: asymptomatic → chest pain, palpitations, syncope, CHF w/ DOE and fatigue. Exam w/ fever, tachycardia, ventricular arrhythmias, new murmur or cardiogenic shock (poor pulses, hypotension, cool extremities)
Pathophys	Usually due to viruses (coxsackie B, adenovirus and enterovirus, and more recently HHV6 virus and parvovirus B19, measles, mumps, rubella, CMV, HIV, arboviruses, parvovirus, and influenza) or inflammatory conditions (Kawasaki disease, ARF)
Workup	**Lab workup**: CBC, inflammatory markers, cardiac enzymes, viral serologies and may include rheumatologic screening if a systemic inflammatory process is suspected **CXR**: may show cardiomegaly and pulmonary vascular congestion/edema. **EKG**: non-specific and may show sinus tachycardia, arrhythmia, heart block, prolonged QT-interval, bundle branch blocks, abnormal QRS axis, diffusely low voltage QRS complexes (<5 mm in full standard across the limb leads), non-specific ST-T changes and diffuse ST elevations w/ PR depression if there is coincident pericarditis. **Echo**: is useful for evaluating cardiac function and ruling out other causes of cardiac dysfunction, but cannot definitively diagnosis myocarditis. Gadolinium-enhanced cardiac MRI which shows late gadolinium enhancement is suggestive of myocarditis, though is somewhat nonspecific. Endomyocardial biopsy via right heart cath may be diagnostic, but has low sensitivity.
Treatment	Largely supportive. Tx CHF w/ diuretics, ACE inhibitors +/- milrinone (can worsen hypotension), dobutamine, antiarrhythmic, anticoagulant. IVIG used but data is limited

Endocarditis

Presentation	Subacute → low-grade fevers, myalgias, fatigue, weight loss, exercise intolerance or acute→ Rapid, fulminant, high fevers, toxic appearance (usually Staph aureus). Exam w/ tachycardia, new murur, splenomegaly, **Roth spots** (retinal lesion), **Janeway lesions** (palms/soles), **Osler nodes** (painful fingers and toes), **splinter hemorrhages**
Pathophys	Bacteria (usually **S. Aureus, viridans strep, coag neg staph**) that damage endothelium and set off clotting cascade leading to fibrin deposition over valve
Workup	**Labs**: Draw blood culture x 3 initially, then daily if persistently febrile. CBC w/ elevated WBC, +/- anemia. Elevated ESR and CRP. Microscopic hematuria due to renal emboli. **CXR**: May show evidence of CHF or septic emboli. **ECG**: May show AV conduction defects if vegetation involves conduction system. **Echocardiogram**: TTE is adequate in most kids. TEE indicated only if TTE inadequate. Abscence of echocardiographic vegetations does not exclude a clinical dx of endocarditis.
Modified Duke Criteria	**Pathologic Criteria**: (1) Pathologic lesions on histology (vegetation/abscess w/ active IE) or (2) microorganism identified on histology or culture of vegetation/abscess. **Clinical Criteria** (Modified Duke Criteria): 2 major or 1 major + 3 minor or5 minor. **Major Criteria**: (1) ≥2 blood cultures w/ typical organisms (or persistently positive); (2) Endocardial involvement (vegetation, abscess, new valvular regurgitation). **Minor Criteria**: (1) predisposition, (2) fever, (3) vascular phenomena (septic emboli, mycotic aneurysm, ICH, Roth spots, Janeway lesion), (4) immunologic phenomena (GN, RF+, Osler nodes).
Treatment	Antibiotics→ empiric coverage should cover **Staph, Strep, and Enterococci** (e.g. vancomycin)--> tailor based on sensitivities. Generally 4-6 weeks. Surgery→ if persistent bacteremia despite therapy, heart failure, progressive valvular dysfunction, conduction tissue involvement or large lesion at high risk of embolizing.
Complications	Heart failure (most common indication for surgery), perivalvular abscess (suspect if new conduction abnormality or persistent bacteremia), pericarditis, septic emboli, metastatic abscess, embolic stroke, renal infarction

Cardiac Infections continued on next page →

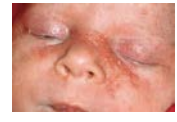
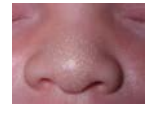
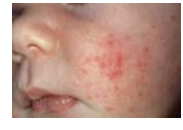
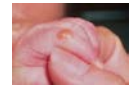
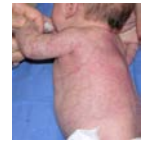
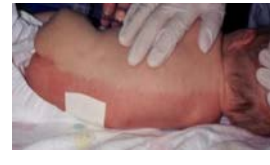
Cardiac Infections	
Pericarditis	
Presentation	**Chest pain, often relieved by leaning forward** +/- tachypnea and dyspnea. Exam can have friction rub, weak apical impulse, poor perfusion, hepatomegaly.
Pathophys	• **Infectious** (bacterial, viral (Coxsackie), fungal, parasitic and TB) • **Inflammatory** (ARF, SLE, uremia, radition, drugs), traumatic, oncologic, chronic (constrictive pericarditis)
Workup	**EKG**: Decreased precordial voltages indicate effusion; diffuse ST elevation w/ PR depression is seen in pericarditis. Electrical alternans may be manifest as QRS of alternating amplitude or axis and is seen in pericardial effusion There may be diffusely low voltage (< 5mm in full standard) QRS complexes in the limb leads.
Treatment	Managed **conservatively** w/ rest, observation for evidence of hemodynamic decline and NSAIDs

General Tips for Cardiology Rotation	
Team Structure	• **1 Fellow**: should be first stop for everything. **Trust them!** They are fantastic and want to teach. • **4 Residents**: one will be on outpatient, one post-call (but will round), two there all morning • **Attendings** (usually 4-5 of them) ▪ General cardiology - most patients are usually on this team ▪ Heart Failure/Transplant - You will always round w/ the attending on this team, sometimes there will be a fellow too ▪ BACH - adult congenital. You will round w/ the BACH attending and fellow ▪ Electrophysiology - You should see the fellow every day ▪ Pulmonary hypertension - you will occasionally have patients on this service and will round w/ the attending ▪ Primary attending - cardiology is a team sport, meaning there are multiple physicians on the care team. This is the patient's longitudinal cardiologist who will check in periodically • Of note, there is also an NP team. This team is separate from the MD team during the day, but you will cross-cover them overnight and on weekends/holidays (which means when you are overnight, you will need to signout to the NP team in the morning)
Admissions	You will have a few types of admission. The main ones will be from the CICU, from the ER, and post-Cath ▪ **CICU Admission**: You and your fellow go to 8S (bring a COW) and hear signout directly from the team caring for the patient. ▪ Write transfer note ▪ Transfer accept order ▪ Transfer med rec ▪ **ER Admission**: Just like any other admission, except the cardiology fellow sees them in the ED and there is a consult note ▪ **Post-Cath**: Usually you won't get signout on this patient. The fellow will get some signout from the patient's primary cardiologist. Ask them for more information and do some chart review for more information.
Resources	• **Medical Team Coordinator**: should be your first stop for questions on basically everything non-medical. This includes scheduling a procedure, getting prior authorization for medications, discharge planning, how to put in a specific order, where the food is - really, anything and everything. They are AMAZING ▪ Will also send you a welcome email before the rotation w/ excellent resources. Try to read them! • **Fellow**: Cardiology is a great time to learn and the fellows are excited about the heart and want to teach. Don't be afraid to ask them questions about the physiology and pathophysiology • **Attendings**: similarly excited to teach. Many of them will bring a whiteboard on rounds and draw out the physiology of the patient. Feel free to ask them to do so if you want to learn more!

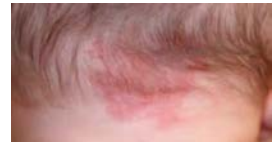
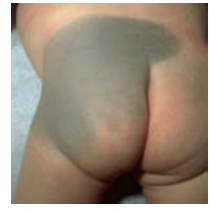
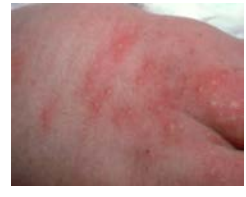
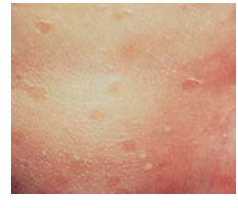
Disaster Planning	
Use Your Resources!	
Fellow	Should always be your first call. Run the list w/ them multiple times a day and at night. Before they go lie down, “disaster round” w/ them and ask all the questions you have about what to do if a X happens to Y patient.
Nurses	They have been doing this for longer than we have and know these patients incredibly well. Ask them for tips as well. On midnight rounds, always say hello and ask them what they are worried about for each patient.
Code Cards	Carry them w/ you. They have lots of great information on them
CICU	They are right next door and can get over to the general cardiology floor very quickly. Don’t be afraid to call them. Always better to over call than under call them.

Describing Dermatologic Lesions	
Primary Lesion	**Description**
Macule	Flat, not palpable; color change; <1cm
Patch	Flat, not palpable; color change; >1cm
Papule	Raised; <1 cm (implies epidermal process like a wart)
Plaque	Raised; >1 cm usual flat topped
Nodule	Raised; round-topped lesion w/ depth; >0.5cm up to 1 cm
Tumor	Very large, round-topped lesion w/ depth ; >1cm
Wheal	Edematous, raised, hive-like
Vesicle	Clear, fluid filled; <0.5 cm
Bulla	Clear, fluid filled; >0.5 cm
Pustule	Exudate filled; <1cm
Telangiectasia	Dilated superficial capillaries
Secondary Changes	**Description**
Scale	Flakes; thickening of outermost layer (stratum corneum)
Crust	Dried serous exudate
Desquamation	Loss of outermost layer of skin (stratum corneum)
Erosion	Loss of superficial layers of skin (epidermis only involved, does not scar)
Ulcer	Loss of deeper layers of skin (extends to dermis, scars)
Fissure	Deep linear cracks in skin
Atrophy	Thinning of skin
Excoriation	Erosions due to scratching
Lichenification	Thickened, leather-like skin due to habitual rubbing
Scar	Connective tissue alteration due to dermal damage
Color Descriptor	**Description**
Erythematous	Red
Purpuric	Violaceous color due to blood pigment
Petechial	Pinpoint, non-blanching; bleeding from capillaries
Hyperpigmentation	Darker than normal skin color
Hypopigmentation	Lighter than normal skin color

Describing Dermatologic Lesions	
Arrangement/Distribution	**Description**
Annular	Forming part or all of a circle
Linear	Forming a line
Cluster	Forming a group of lesions
Acral	Over distal portions of limbs: finger tips, knuckles, elbows, knees, buttocks, toes, heels
Generalized	Throughout body
Photodistributed	Sun-exposed areas

Neonatal Skin Findings		
Sebaceous Hyperplasia	Minute, profuse yellow-white papules frequently on forehead, nose, lip, and cheeks	
Milia	1-2 mm pearly, opalescent cysts	
Neonatal Acne	Inflammatory papules and pustules usually w/o comedonal lesions	
Sucking Blisters	Solitary or scattered superficial bullae on upper limbs of infants at birth (presumed in utero sucking)	 
Cutis Marmorata	Evanescent, lacy, reticulated red and/or blue cutaneous pattern when exposed to low environmental temperatures	
Harlequin Color Change	When infant (usually immediate newborn period and in low birth weight infants) is on side dependent area is deep red and upper half (longitudinally) is pale	

Neonatal Skin Findings continued on next page →

Neonatal Skin Findings		
Nevus Simplex (Salmon Patch)	Small, pink, ill-defined vascular macule usually on glabella, eyelids, upper lip and nuchal area	
Dermal Melanocytosis (Mongolian Spots)	Blue or slate-gray macular lesions	
Erythema Toxicum	Benign, self-limited evanescent eruption usually in term infants presenting w/ firm, yellow-white papules and pustules w/ a surrounding erythematous flare	
Transient Neonatal Pustular Melanosis	Superficial pustules, ruptured pustules w/ a fine scale, and hyperpigmented macules	
Seborrheic Dermatitis	Erythema and greasy scales usually on the scalp (cradle cap)	

Diaper Dermatitis		
Diagnosis	**Contact Dermatitis**	***Candida* dermatitis**
Epi	Most common cause	Second most common cause
Exam	Spares creases/skin folds 	"Beefy" red rash involving skin folds w/ satellite lesions 
Treatment	Topical barrier ointment/paste (petrolatum, zinc oxide)	Topical antifungal (nystatin)

Dermatologic Conditions	
Acne	
Presentation	**Pathophys**: obstruction of pilosebaceous unit by abn keratinization and sebum w/ bacterial proliferation (P. acnes) and inflammation
Treatment	**Comedonal**: (1) topical retinoids (2) benzoyl peroxide and topical abx **Papulopustular**: (1) maximize topical tx (2) oral antibiotics (3) hormonal therapy **Nodulocystic**: isotretinoin ***Abx**: Tetracycline, Doxycycline, Minocycline, Erythromycin **Tips**: • Use topical abx in conjunction w/ benzoyl peroxide (to avoid P. acnes resistance) • Benzoyl peroxide inactivates tretinoin à apply benzoyl peroxide in AM and tretinoin in PM • OCPs and spironolactone can be considered in female pts • May take 6-8 weeks to see improvement • Rx: 30-60 gm w/ refills
Atopic Dermatitis	
Presentation	• **Def**: chronic inflammatory condition leading to pruritic, erythematous, and scaly lesions • **Presentation**: usually before 2 y/o, infants (scalp, face, extensor surfaces), children (flexural surfaces); allergic triad (asthma + allergic rhinitis) • **Complications**: superinfection w/ staph and strep (weeping, crusting, pustules) or herpes simplex (vesicles) • Associated w/ keratosis pilaris (Hyperkeratotic follicular papules, usually on back of arms but also frequently on lateral cheeks of infants and younger children) and pityriasis alba (Hypopigmented, flat, indistinct border, usually face)

Dermatologic Conditions continued on next page →

Dermatologic Conditions

Atopic Dermatitis

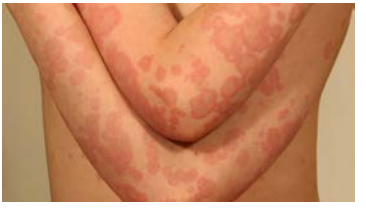
Treatment

- **Lifestyle**: eliminate allergens, short baths w/ warm water and mild soap
- **Bleach baths** (decrease bacteria):
  - For a full bathtub of water, add 1/2 cup of bleach
  - For a half-full tub of water, add 1/4 cup of bleach
  - For a baby tub, add 1 teaspoon of bleach per gallon of water
- **Emollients**: Hydrolated Petrolatum, Vaseline™, Eucerin™, Cetaphil™
- **Topical Steroids**: (see chart)
- **Topical immunomodulators**: Calcineurin inhibitors (Tacrolimus ointment (Protopic) 0.03%, 0.1%; Pimecrolimus (Elidel) 1%): used on facial lesions, less risk of tissue injury; approved for >2 years of age
- **Anti-Staph antibiotics** (if bacterial infection): Cephalexin, Trimethoprim-sulfamethoxazole, Mupirocin
- **Antipruritic medication**: Diphenhydramine or Hydroxyzine

Erythema Multiforme

Presentation

- Usually skin only (minimal mucosa)
- <10% BSA
- **Etiology**: infection (HSV, mycoplasma PNA), medications (Penicillins, sulfonamides, NSAIDs, barbiturates)
- **Presentation**: erythematous papules expanding to target-like plaques w/ dusky violaceous centers, found symmetrically on distal extremities and progress proximally



Treatment

- Treat/discontinue underlying cause
- Supportive care

Stevens Johnson Syndrome

Presentation

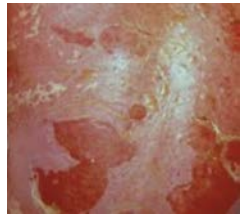
- Skin + 2 or more mucosa
- 10-30% BSA
- **Etiology**: infection & meds (above)
- **Presentation**: mucosal involvement, prodromal fever, sore throat, HA, malaise, erythematous target like lesions forming blisters that rupture

Treatment

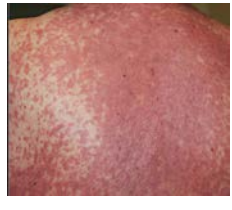
- **DERM EMERGENCY**
- Treat/discontinue underlying cause
- Magic mouthwash for stomatitis, artificial tears for ocular involvement
- Care to avoid scarring and adhesions
- Hospitalize, treat like burn patient (fluids, electrolytes, pain, prevent infection)

Dermatologic Conditions

Toxic Epidermal Necrolysis

Presentation	• Skin + 2 or more mucosa • >30% BSA • **Etiology**: as above • **Presentation**: extensive skin and mucosal involvement (conjunctival, oral, genital, pulmonary), large bullae that rupture and leave large erosions (Nikosky +) 
Treatment	• DERM EMERGENCY • (see SJS) • Consider IVIG

Drug Reaction w/ Eosinophilia and Systemic Symptoms (DRESS)

Presentation	• **Def**: potentially life-threatening adverse drug-induced reaction characterized by skin rash, hypereosinophila, liver involvement, fever, and lymphadenopathy • **Etiology**: carbamazepine, allopurinol, sulfasalazine, phenobarbital, lamotrigine, nevirapine, and more • Can also be assoc w/ HHV 6, eBV and CMV reactivation • **Presentation**: usually 2-6 weeks after initiation of drug tx, rash is often morbilliform or exfoliative and may be assoc w/ facial edema • Classify w/ RegiSCAR scoring 
Treatment	• Discontinue medication • Coticosteroids and IVIG may improve sx but evidence is not definitive • Recovery is prolonged (6 or more weeks) and may have intermittent flare-ups, 10% mortality rate

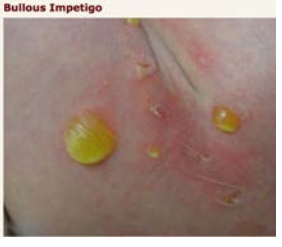
Dermatologic Conditions continued on next page →

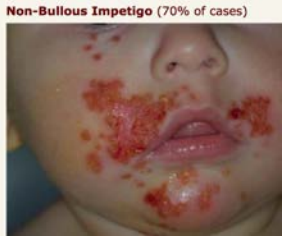
Dermatologic Conditions

Impetigo

Presentation

- **Def**: contagious superficial skin infection, can be primary (direct infection of previously normal skin) or secondary (infection of skin that has already been disrupted)
- Classified as bullous or non-bullous (70%)
  - **Non-Bullous**: usually occurs on traumatized skin, Staph aureus coag pos and strep pyogenes (GABHS), spread by contact, non-pruritic, no constitutional sx
  - **Bullous Impetigo**: more common in infants and young children, caused by staph aurus coag positive (same types as toxic shock and scalded skin), bulla develop on intact skin





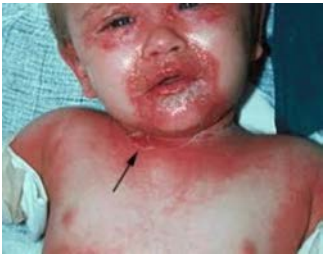
Treatment

- Mupirocin (Bactroban): applied tid for 7-10 days
- May need oral abx for widespread disease
- If MRSA consideration, Clindamycin should be used

Staph Scalded Skin

Presentation

- **Def**: exfoliative toxin-producing S. aureus
- **Presentation**: fever, irritability, skin tenderness → diffuse erythema and flaccid blisters → scaling and desquamation



Treatment

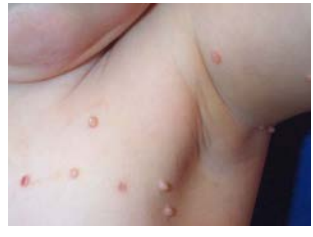
Case dependent: Oxacillin, Nafcillin, or Vancomycin

Dermatologic Conditions

Molluscum Contagiosum

Presentation

- **Def**: wart-like lesion caused by DNA poxvirus
- **Presentation**: small flesh-colored, dome shaped, umbilicated papules most common in school aged children, immunocompromised patient may have extensive disease; transmitted by fomites/close contact; if molluscum in genital area of child must consider possible sexual abuse



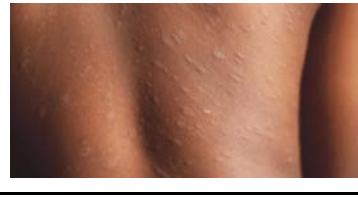
Treatment

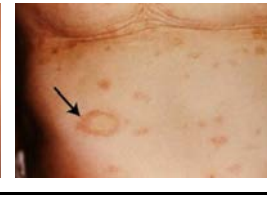
Self-limited

Pityriasis Rosea

Presentation

- **Def**: self-limited skin condition presenting w/ a single erythematous herald patch followed w/ collection of smaller patches usually lasting between 2-12 weeks
- **Presentation**: usually presents in pts ages 10-35





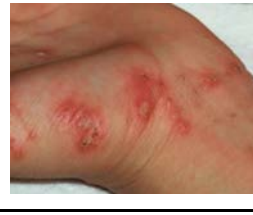
Treatment

- Self-limited
- Inform patient and family of long duration

Scabies

Presentation

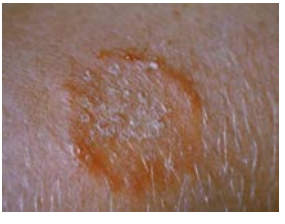
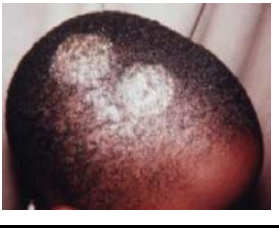
- **Def**: mite infection transmitted by contact
- **Presentation**: rash and severe itching (delayed type IV hypersensitivity) w/ papules, nodules, scaling, and sometimes linear distribution



Treatment

- Permethrin (single application has 90-95% cure rate, do not use <2 months old, can reapply in 7 days)

Dermatologic Conditions continued on next page →

Dermatologic Conditions	
Lice	
Presentation	Diagnosis usually made by nits (eggs) on hair shafts, adult lice may be difficult to see
Treatment	• 1% Permethrin rinse (Nix) and Pyrtherin (Rid) • Do not use shampoo/conditioner prior to tx • Requires retreatment 7-10 days later (not ovicidal) • Additional methods: wet combing; butter, olive oil, mayo, petroleum jelly to suffocate lice • Tx of family not usually indicated
Tinea Corporis	
Presentation	• **Def**: superficial dermatophytosis • **Presentation**: scaly erythematous pruritic patch w/ centrifugal spread and subsequent central clearing w/ raised annular border 
Treatment	• **1st line/localized**: topical antifungal (may take several weeks to clear) • **2nd line/extensive**: oral antifungals (terbinafine, griseofulvin)
Tinea Capitis	
Presentation	• **Def**: superficial dermatophytosis • **Presentation**: scaly erythematous patch that can progress to alopecia w/ inflammation 
Treatment	Oral griseofulvin or terbinafine

Cutaneous Signs of Systemic Disease	
SLE	Erythematous patches in photodistribution, “malar” face
Discoid Lupus	Annular, scaly plaques, atrophy, and dyspigmentation in photodistribution
Juvenile Dermatomyositis	Erythematous/violaceous scaly, macules, overlying knuckles, face and extensor surfaces
HSP	Purpuric papules and plaques on buttocks and lower extremities
Kawasaki Disease	Erythematous maculopapular to urticarial plaques, edema, desquamation
IBD	Aphthae; erythema nodosum; pyoderma gangrenosum, thrombophlebitis, perianal fissures
Graft vs. Host	Acute onset erythema, papules, vesicles, bulla
DRESS	Diffuse erythema, urticarial macules and plaques
SLE	Edematous, urticarial plaques
Discoid Lupus	Erythematous patches in photodistribution, “malar” face

Drug Eruptions	
Uticaria	Penicillins, cephalosporins, sulfonamides, aspirin/NSAIDS, radiocontrast, TNF inhibitors
Angioedema	Aspirin/NSAIDS, ACEi
Serum-Sickness Reaction	Cephalosporins, penicillins, minocycline, bupropion, sulfonamides
Exanthematous	Any drug
Drug rash w/ eosinophilia and	Phenytoin, phenobarbital, carbamazepine, lamotrigine, allopurinol, sulfonamides,
Pustular (acute generalized	Beta-lactams, macrolides, clindamycin, terbinafine, calcium channel blockers,
Acneiform	Corticosteroids, androgen, lithium, iodines, phenytoin, isoniazid, tetracycline, B
Vasculitis	Penicillins, NSAIDs, sulfonamides, cephalosporins
SJS/TEN	Sulfonamides anticonvulsants, NSAIDs, allopurinol, dapsone
Drug-induced Lupus	Minocycline, procainamide, hydralazine, isoniazid, penicillamine, carbamazepine, chlorpromazine, infliximab

Hemangioma Red Flags

- Beard distribution (evaluate airway)
- Periocular (ophtho)
- Paraspinal midline
- Hemangiomatosis (multiple small hemangiomas → evaluate for parenchymal hemangiomas, especially hepatic and CNS
- Very large hemangioma
- Associated thrill or bruit
- Head tilting

Classes of Topical Steroids (JAAD 2006; 54:723)	
Potency Class	**Common Examples**
Class 1: Superpotent	Betamethasone 0.05% G/O/L, Clobetasol 0.05% C/O/G/S/F, Diflorasone 0.05% O, Halobetasol 0.05%
Class 2: Potent	Betamethasone 0.05% C, Desoximetasone 0.25% C/ 0.05% G, Fluocinonide 0.05% C/O/G/S
Class 3: Upper Mid	Betamethasone valerate 0.1%/0.12%F, Diflorasone 0.05% C, Triamcinolone 0.1% O
Class 4: Mid-Strength	Fluocinolone 0.025% O, Hydrocortisone 0.2% O, Mometasone 0.1% C/L, Triamcinolone 0.1% C
Class 5: Lower Mid	Desonide 0.05% O, Fluocinolone 0.025%, Hydrocortisone 0.2% C, Triamcinolone 0.025% O/L
Class 6: Mid	Betamethasone 0.1% C, Desonide 0.05% C, Fluocinolone 0.01% C/S, Triamcinolone 0.025% C
Class 7: Least Potent	Hydrocortisone 1%-2.5%

Note: C= cream, G= gel, L= lotion, O= ointment, S= solution, F=foam
Potency: Ointment (thickest, most potent) > Gel > Cream > Lotion (liquidy, easier to spread)
Class 1 Uses: Severe dermatoses over non-facial/non-intertriginous areas, especially good for palms and soles)
Class 2-4 Uses: Mild-to-moderate non-facial/non-intertriginous dermatoses
Class 5-7 Uses: consider when treating large areas (given likelihood of systemic absorption), also eyelid/genital dermatoses

Adrenal Insufficiency	
PowerPlan/ Ordersets	MICU adrenal stim testing, Endo AMB adrenal disorders
Definition	Impaired secretion of the adrenal glucocorticoid and/or mineralocorticoid hormones either by adrenal destruction, dysgenesis, impaired steroidogenesis, or deficient stimulation. • **Primary**: failure to produce adrenal cortical hormones including cortisol and aldosterone. ▪ Cortisol deficiency leads to hypotension and hypoglycemia. ▪ Aldosterone deficiency leads to hypotension, hyponatremia, hyperkalemia. • **Secondary**: Pituitary dysfunction leads to impaired release of ACTH and subsequent cortisol deficiency, particularly in situations of physiologic stress • **Tertiary**: Hypothalamic dysfunction leads to impaired release of corticotropin releasing hormone (CRH) and subsequent decreased ACTH production
Presentation	N/V, abd pain, salt craving, fatigue, dizziness, syncope, orthostatic hypotension; in infants: poor feeding, lethargy
Diagnostic Studies	Chemistry: ↓ Na, ↑ K, ↓ Glu, metabolic alkalosis, ketonemia, or ketonuria, Antibodies against 21-hydroxylase for autoimmune AI, ↑ ACTH >100pg/mL w/ ↓ cortisol < 10 µg/dL Early morning (4-8am) cortisol: < 3 µg/dL suggestive. > 18 µg/dL rules out Cosyntropin stimulation test: (can be performed at any time)
Acute Treatment	• Hydrocortisone 50 mg/m2/dose (max 100 mg/m2) IV x1 then 25 mg/m2/dose IV Q6hr, Normal saline bolus then 1.5 to 2 x maintenance of dextrose containing isotonic fluids ▪ In addition to glucocorticoid effect, hydrocortisone also has some mineralocorticoid effect, so aldosterone replacement (fludrocortisone) is not required while a patient is on stress dose hydrocortisone (but this is not true of prednisolone, prednisone, or dexamethasone, which have no mineralocorticoid activity) • Stress dose steroids: Hydrocortisone 50 – 100 mg/m2/day divided q6 hours (IV, PO or IM) ▪ Give for fever > 101F, surgery or anesthesia, vomiting/dehydration, fracture ▪ Give in times of stress, until adrenal recovery has been confirmed
Maintenance Therapy	Cortisol 6-20 mg/m^2/day divided 2-3 times per day depending on etiology; For primary AI, fludrocortisone acetate 0.05-0.2 mg PO qday, Salt supplementation may be required in infants

Diabetic Ketoacidosis	
PowerPlan/ Ordersets	DKA ICP order set, MICU DKA order set, NODM CPG order set, Also see DKA card - note: 2-bag method card PENDING
Definition	Plasma glucose> 200 mg/dL AND acidemia (venous pH<7.3, arterial pH<7.35, or venous HCO3<15 mmol/L) AND moderate or large ketonuria or ketonemia (the presence of ketones in the blood)***
Pathophysiology	Hyperglycemia → ↑ plasma osmolality → osmotic diuresis ; ↓ Insulin → impaired K entry into cells ; Decr phosphate intake; ↓ Insulin + met acidosis → phosphate shift out of cells; ↓ Na, ↓ K, ↓ Phos
Presentation	Hyperglycemia, vomiting, abd pain, dehydration, AMS Hx: Wt loss, polyuria, polydipsia
Diagnostic Studies	D stick, VBG, CBC, Chem 10, serum osmolality and beta-hydroxybutyric acid, HgbA1C, UA, EKG. Consider pancreatic autoantibodies if new onset, if not clearly type 1 diabetes. ▪ Consider ABG in very ill patient ▪ Check D sticks q1 and VBG, Chem 10 and beta-hydroxybutyric acid q2h until anion gap closes ▪ Check UA q void

Diabetic Ketoacidosis continued on next page →

Diabetic Ketoacidosis

Treatment

IV fluids (+/- dextrose), Insulin

NS Bolus: Initially give **10-20 mL/kg NS bolus;** may repeat if persistent hypotension

- **Fluid Selection**: Fluids at **1.5-2x maintenance if corrected serum Na<135 mEq/L**; slow rate if signs of cerebral edema
- Use **2-Bag Method Calculator** (in reference text of DKA PowerPlans): Bag 1 NS plus electrolytes Bag 2: D12.5 0.45% NS plus electrolytes, hung together w/ insulin on a trifuse. Rates of each fluid are titrated to the **goal dextrose concentration**:

Goal Dextrose Concentration	
Blood Glucose (mg/dL)	**Goal Dextrose**
>300	0%
276-300	5%
251-275	7.5%
201-250	10%
≤ 200	12.5%

- Target Blood Glucose: 150 – 250 mg/dL
- Do not lower the insulin dose unless BG is still ≤ 200 mg/dL while on D12.5% at 2x maintenance. Discuss with endocrine.

Table 1	
Plasma K (mEq/L)	**IV fluid K [ ] (mEq/L)**
<3	40-60
3-4.5	30-40
4.6-5	20
>5	0

- Na (corrected Na should remain normal or move towards normal. If decreases by > 1mEq/hr, evaluate for evolving cerebral edema
- **Add K based on Table 1**: Use K acetate and K phosphate, NOT KCl because of risk of hyperchloremia and non-gap metabolic acidosis. Max K that can be given is 80 mEq/L.
- **Phosphate Content**: max phosphate is 20 mEq/L Kphos at 2x maintenance to avoid causing hypocalcemia
- DO NOT give HCO3 as increases the risk of cerebral edema

Insulin: DO NOT give bolus of insulin (see how to order insulin below)

- After initial fluid bolus and repeat glucose measurement, start infusion of regular insulin 0.05-0.1 units/kg/hr (50 units regular insulin in 50 ml NS)
- Continue insulin infusion until anion gap is closed and patient is ready to eat
- Transitioning from IV to subQ: Make sure patient has **meal in front of them before turning off drip**, give Humalog (see table below for amount), turn off insulin infusion and IV fluids 30 minutes later and have patient eat

Diabetic Ketoacidosis

Subcutaneous Insulin Regimen

Subcutaneous Insulin Regimen:

Total Daily Dose (TDD) (unit/kg/day):

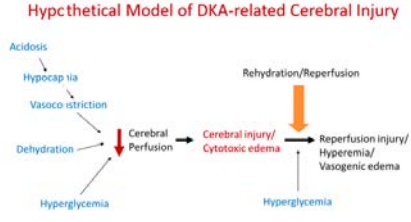
	No DKA	DKA
Age < 6y or A1c < 7%	0.15 - 0.25	0.5 - 0.75
Prepubertal	0.25 - 0.5	0.75 - 1
Pubertal	0.5 - 0.75	1 - 1.2
Postpubertal	0.25 - 0.5	0.75 - 1

A. Basal - bolus regimen (recommended initial regimen):
~50% of TDD as long acting insulin (Lantus) once daily
~50% of TDD as rapid acting insulin (Humalog) divided in meals

B. Split - mixed insulin regimen:
2/3 TDD QAM (1/3 Humalog + 2/3 NPH)
1/3 TDD QPM (1/3 Humalog Qdinner & 2/3 NPH bedtime)

Sliding Scale:

Humalog	BG 250 - 400	BG > 400
None – Small Ketones	5-10% TDD	10-15% TDD
Mod – Large Ketones	10-15% TDD	15-20% TDD



Cerebral Edema: Peak incidence is 8-12 hours after initiation of therapy, but can occur as late as 24 hours

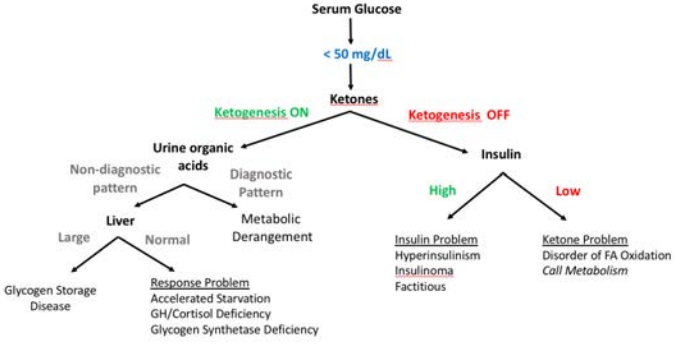
- Treat Empirically: reduce IV fluid infusion rate, raise HOB by 30 degrees, give mannitol 1 g/kg IV over 20 mins, repeat as necessary, consider 3% saline, 2-3 ml/kg IV, repeat as necessary, transfer to ICU, consider intubation, consider STAT head CT once airway is stabilized

Important Formulas

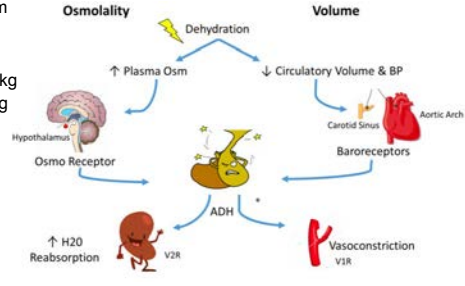
- Corrected Na: serum Na + (1.6*[plasma glucose – 100]/100)
- Anion Gap: serum Na – (Cl + HCO3) **Note: use serum Na, NOT corrected Na
- Effective Osmolarity: 2[measured Na + glucose/18]

How to order subcutaneous insulin at BCH

1. Either type insulin into search tab (or get to this via the NODM admit plan)
2. If not going through NODM, click "insulin .SC injection regimen orderset"
   a. You will first be required to select frequency of POCT checks, parameters for RN to notify MD about glucose levels. Now for the insulin…
3. You will most likely order scheduled glargine (Lantus). You will then most likely order lispro (Humalog) for the correction factors and carbohydrate ratios. **These are nested ordersets and can be confusing**
   a. Scroll down to correction factor and select box "insulin lispro 100 unit/mL correction factor Orderset". Then scroll down to insulin: carbohydrate ratio and select box "insulin lispro 100 unit/mL carbohydrate ratio orderset"
   b. ***make sure to click both before clicking "OK" in bottom right***
4. You will then be directed to the nested orderset where you can type in the times of day and doses that you want to give the correction factor and carb ratio
   a. For correction factor you will have to decide if same CF for all times of day versus different times (ex, different for daytime meals vs at night). Click OK and then you will be prompted to carb ratio orderset
   b. Again you will have to decide if same CR for all times of day versus different times

Hypoglycemia	
PowerPlan/ Ordersets	ED hypoglycemia critical labs plan, ICP hypoglycemia fasting plan, NICU hypoglycemia plan, Metabolism hypoglycemia admit plan
Definition	Plasma glucose ≤ 40-50 mg/dL; *Normal fasting blood sugar is 60-100 mg/dL*
Etiology	**Decreased Production of Glucose** • Decreased release of glucose from liver: glycogen storage diseases, liver failure • Impaired gluconeogenesis: fructose 1,6 diphosphatase deficiency, pyruvate carboxylase deficiency, maple syrup urine disease, ethanol • Galactosemia, hereditary fructose intolerance • Disorders of fatty acid oxidation (↓FAO → ↓ATP and glycerol production → ↓gluconeogenesis) **Increased Utilization/Impaired Conservation of Glucose** • Disorders of fatty acid oxidation • Ketotic hypoglycemia (accelerated starvation) • Starvation **Decreased Production and Increased Utilization of Glucose** • Hyperinsulinemia ▪ Endogenous: congenital (transient or permanent), insulinoma ▪ Exogenous insulin ▪ Sulfonylureas ▪ Dumping syndrome • Counter-regulatory hormone deficiency: growth hormone (only in infants), cortisol/ACTH • Beta Blockers
Presentation	• Early manifestations (blood sugar 40-70): sweating, tachycardia, tremor, hunger • Later manifestations (blood sugar <40): lethargy, irritability, confusion, seizure, coma • Ask about any medications in home (sulfonylureas, beta blockers, insulin) • Ask about temporal relationship to feeds
Diagnostic Approach	
Diagnostic Studies	Send critical labs at time of hypoglycemia. (Endocrine service can help w/ prioritization of labs) • Plasma blood glucose (< 50 mg/dL to be considered "critical sample"), electrolytes, beta-hydroxybutyrate, insulin level,VBG, Lactate, Pyruvate, Ammonia, Growth hormone, Cortisol, Free fatty acids, Total and free carnitine, Serum amino acids, acylcarnitines • UA for ketones, Urine organic acids, Acylglycines

Hypoglycemia	
Treatment	IV Dextrose: "Hawaii 5-0 Rule" • 10 cc/kg bolus of D5W, 5 cc/kg bolus of D10W, 2 cc/kg bolus of D25W • Glucagon (can use if no IV access and patient unable to take PO's): 0.03 mg/kg (max 1 mg) IM, IV, or subQ. Effective for hypoglycemia caused by hyperinsulinemia. Does not work if glycogen stores are depleted or w/ glycogen storage diseases

Diabetes Insipidus	
PowerPlan/ Ordersets	DMICU DI orderset, Endo AMB DI Plan
Definition	Failure to produce or respond to antidiuretic hormone, leading to excessive free water loss and subsequent hypernatremia.
Etiology	• **Central**: Failure of posterior pituitary to secrete ADH • **Nephrogenic**: Failure of kidney to respond to ADH
Presentation	Polyuria, nocturia, increased thirst, polydipsia
Diagnostic Studies	• Chem 10, UA, serum osm, urine osm • Lab criteria ▪ Serum Na >145 mEq/L ▪ Serum osmolarity > 300 mosm/kg ▪ Urine osmolarity < 300 mosm/kg • Urine output > 4 ml/kg/hr • Water deprivation test 
Treatment	**Central Diabetes Insipidus**: vasopressin IV vs PO/intranasal/SC ddAVP • Post-op patients/ICU: vasopressin infusion at 1 milliunit/kg/hr • Titrate drip q5-10 minutes to max rate 10 milliunits/kg/hr w/ goal urine output <2 ml/kg/hr • Replace fluid deficits w/ NS to avoid hyponatremia • Check serum sodium and osm every hour • Non-operative, non-ICU patients: ddAVP either PO 0.05 mg BID or intranasal 5-30 mcg/day (3 mo-12 yr) or 10-40 mcg/day (>12 yr) and titrate to goal of daily breakthrough diuresis. **Nephrogenic DI**: • Low salt diet, thiazide diuretics, access to water • Can try ddAVP if only partial nephrogenic

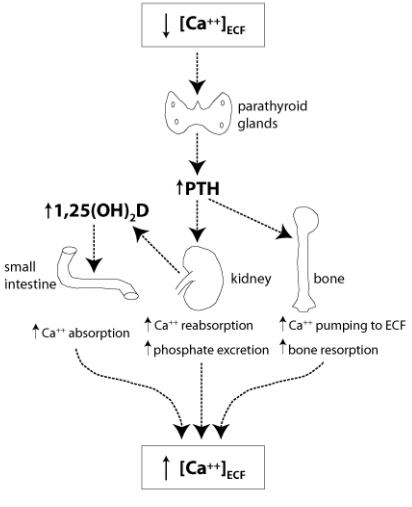
Syndrome of Inappropriate ADH (SIADH)	
Definition	Inappropriate antidiuretic hormone release → hyponatremia, hypoosmolality, and inappropriately concentrated urine
Etiology	**CNS disorders**: post-operative, infection, stroke, hemorrhage, trauma, Tumors (usually adults), particularly lung cancer (small cell), Drugs: carbamazepine, cyclophosphamide, others. **Pulmonary disease**: pneumonia, Surgery, HIV

SIADH continued on next page →

Syndrome of Inappropriate ADH (SIADH)

Pathophysiology	• ADH binds to V2R receptors in collecting tubules causing aquaporin-2 water channels to move from cytosol to luminal membrane. Leads to increased water reabsorption. • Excessive/unregulated release of ADH from posterior pituitary or ectopic release (such as in lung cancer) leads to inappropriate retention of free water leading to hyponatremia.
Presentation	• Decreased UOP, hyponatremia, low serum osm and high urine osm • Patients typically have euvolemic hyponatremia, so do not have peripheral edema/ascites
Diagnostic Studies	Chem 10, UA, Serum osmolality (low) and urine osmolality (usually high), urine sodium (usually above 40 mEq/L)
Treatment	• Fluid restriction is mainstay of therapy. Goal to increase serum sodium by 6-8 mEq/L/day. Risk of central pontine myelinolysis w/ rapid correction. ▪ Start w/ restriction to 2/3 maintenance fluids daily (1 L/m2/day) • Increased solute intake • Can use hypertonic saline in conjunction w/ loop diuretic for symptomatic hyponatremia (seizures, AMS) To calculate the necessary dose of 3% hypertonic saline: ▪ mEq sodium infused = [desired plasma sodium (mEq/L) – actual plasma sodium (mEq/L)] x 0.6 x weight (kg) ▪ Each mL of 3% hypertonic saline has just over 0.5 mEq of sodium ▪ Give slowly (over 3-4 hours), goal not to inc plasma Na by more than 3 mEq/L/hr ▪ Given until symptoms resolve of serum Na reaches 125 mEq/L

Calcium Homeostasis



Calcium Homeostasis

	Calcium	Serum PTH	25-OHD	Alk Phos
Hypoparathyroidism	Low	Low	Normal	Normal
PTH Resistance	Low	High	Normal	Normal
Vit D Deficiency	Low	High	Low	Normal/high
Vit D Resistance	Low	High	Normal	Normal
Renal Disease	Low	High	Normal/low	Normal/high
Hypomagnesemia	Low	Normal	Normal/low	Normal
Metastatic Disease	High	High	Normal	High

Hypocalcemia

Definition

- Normal values are age specific and vary between labs
- Hypoalbuminemia will lower the serum calcium concentration by 0.8 mg/dL for every 1.0 g/dL reduction in serum albumin (below 4 g/dL)

Etiology

Low PTH

Congenital

- Genetic syndromes (DiGeorge, mitochondrial d/o, HDR hypoparathyroidism, deafness, renal anomaly, etc)
- Mutations in production of PTH
- CaSR activating mutations
- Parathyroid aplasia/dysplasia

Acquired

- Hypomagnesemia or hypermagnesemia
- Autoimmune (APS1)
- Infiltrative disease (copper/iron deposition)
- Acquired post-surgery

High PTH

Renal Failure

- Vit D deficiency or increased Vit D metabolism (liver/renal disease, meds)
- Pseudohypoparathyroidism (end organ resistance to PTH)
- Excess phosphate intake
- 1a-hydroxylase deficiency, defects in vitamin D receptor

Hypocalcemia continued on next page →

Hypocalcemia

Etiology

Other Causes

Neonatal

- **Maternal Factors:** Mother w/ diabetes, Vit D deficiency, AED use, hyperparathyroidism, or eclampsia
- **Neonatal Factors:** low birth weight, prematurity, IUR, asphyxia
- Other Illness: sepsis, RDS, hyperbilirubinemia, renal failure

Miscellaneous

- **Hungry Bone Syndrome:** Avid bone mineralization after recovery from severe mineralization defect (e.g., vitamin D deficiency)
- **Osteopetrosis:** oss of osteoclast function
- Citrate or Lactate administration (e.g., from blood transfusion)
- **Pancreatitis:** complex formation w/ fatty acids
- **Drugs:** bisphosphonates, foscarnet, chemotherapy

Clinical Manifestations

Acute hypocalcemia
- Tremor, muscle spasms, paraesthesias, tetany (Chvostek, Trousseau signs)
- Seizures
- QT prolongation, impaired contractility
- Psychiatric symptoms (anxiety, agitation, hallucinations)

Vitamin D deficiency: rickets, muscle weakness, hypotonia, growth retardation
- Xrays show osteopenia, widening of the metaphysis, cupping/splaying of growth plate, formation of cortical spurs, fractures

Diagnostic Studies

- Albumin and/or ionized calcium to determine if true hypocalcemia
- If hypocalcemia confirmed send PTH, magnesium, phosphate, BUN, creatinine, 25OH-vitamin D

Treatment

- Calcium salts PO for chronic hypocalcemia
- Calcium salts IV for acute hypocalcemia
  - Ca gluconate 100 mg/kg (= 1mL/kg of 10% solution)
  - CaCl 20 mg/kg (= 0.2 mL/kg of 10% solution) for emergencies only (irritant, causes necrosis if extravasates)
- Replenish magnesium stores or give vitamin D as appropriate
  - If initiating treatment for vitamin D deficiency, always give calcium along vitamin D to prevent hypocalcemia from hungry bone syndrome
- In hypoparathyroidism, give 1,25 vitamin D (calcitriol) rather than ergocalciferol/cholecalciferol because of decreased 1a-hydroxylation in the kidney
- If hyperphosphatemic, avoid [Ca+] X [PO4] >55 because of risk of metastatic calcification

Hypercalcemia

Definition

Normal values are age specific and vary between labs

Etiology

Parathyroid Related

- Primary hyperparathyroidism (adenoma or hyperplasia)
- Tertiary hyperparathyroidism (only occurs in chronic renal failure)
- Familial hypocalciuric hypercalcemia (loss of function CaSR)

Hypercalcemia

Etiology

Increased Bone Reabsorption

- Malignancy (metastatic or PTHrP secretion)
- Hypervitaminosis D
- Hypervitaminosis A
- Immobilization

Increased 1,25 OHD Production

- Granulomatous disease (sarcoid, tuberculosis)
- Subcutaneous fat necrosis in neonates

Metabolic Disorders

- Hypophosphatasia (defective alk phos)
- Blue diaper syndrome (defect in tryptophan metabolism)
- Congenital lactase deficiency

Renal Causes

Thiazide diuretics

Other

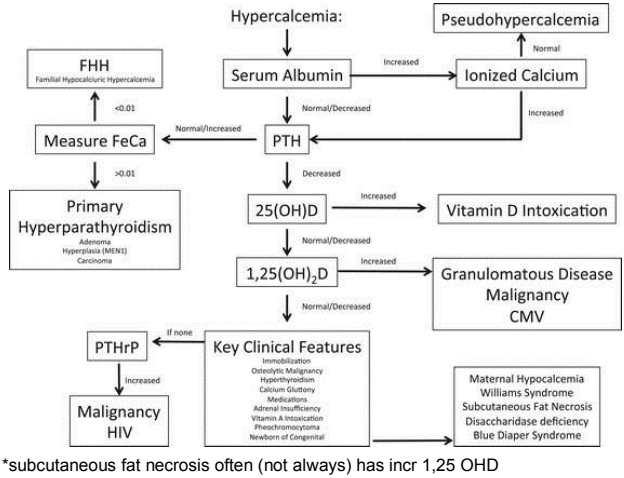
Adrenal insufficiency, Williams syndrome, thyrotoxicosis, milk alkali syndrome, excess calcium intake, ECMO (mechanism not well understood but thought to be secondary to incr PTH)

Clinical Manifestations

"Stones, bones, moans, psychiatric overtones"

- **Renal symptoms**: polyuria, renal stones, nephrocalcinosis
- **Musculoskeletal system**: Bone pain, joint aches
- **GI system**: paralytic ileus, abdominal cramping, constipation, anorexia, vomiting
- **Nervous system**: headache, personality change, proximal muscle weakness
- In infants, failure to thrive
- W/ severe hypercalcemia (>14 mg/dL) can have lethargy and coma

Diagnostic Algorithm



*subcutaneous fat necrosis often (not always) has incr 1,25 OHD

Hypercalcemia continued on next page →

Hypercalcemia	
Treatment	For severe hypercalcemia (>14 mg/dL) and/or symptomatic: • Increase calcium excretion: IV hydration w/ NS is first line; after hydration, may add, furosemide, • Decrease bone resorption: calcitonin: inhibits osteoclast bone resorption, promotes Ca and phos excretion. ▪ Calcitonin: inhibits osteoclast bone resorption, promotes Ca and phos excretion. • Initial dose IM/subq 2-4 units/kg every 12 hours, may increase to 8 units/kg every 12 hours to a max of every 6 hours. Most patients develop tachyphylaxis w/i 48 hours ▪ Bisphosphonates: inhibit osteoclast activity. Watch for hypocalcemia; also for hypophos and hypomag. • Pamidronate dose 0.5-1 mg/kg in children • Primary hyperparathyroidism - parathryoidectomy

Not in Handbook – See EBGs
1. Premature adrenarche 2. Vitamin D 3. Short stature

DKA Card

Boston Children's Hospital

Department of Pharmacy,
Divisions of Endocrinology,
& Medical Critical Care

DKA Definition

Glucose > 200 mg/dL **AND**
Moderate to Large Ketonuria *(or B-OHB > 3 mmol/L)* **AND**
Venous pH < 7.3, Arterial pH < 7.35 or serum tCO_2 or venous HCO_3 < 15 mEq/L

Therapy:

1. NS BOLUS *PRN upon arrival to ED*

NS 10 mL/kg IV x 1, may repeat with caution.
Goal is to ensure adequate perfusion, not euvolemia.

2. FLUID MANAGEMENT 2-BAG METHOD

*Defer initiating 2-bag method if serum K >4.5 mEq/L, consider NS or D5NS if glucose ≤ 300 mg/dL

Rate:
1.5 - 2x maintenance (MAX rate usually 2x)
Initial IVF for at least 4 - 6 hours.

Corrected Na^+ should remain normal or move towards normal. If decreases by > 1 mEq/L/hr or corrected serum sodium is <135 mEq/L, evaluate for evolving cerebral edema & follow neuro exam closely.

IV Fluid Therapy with the 2-bag method:

Bag #1: **NS** with Potassium Acetate 20 mEq/L and Potassium Phosphate 20 mEq/L
Bag #2: **D12.5W 1/2NS** with Potassium Acetate 20 mEq/L and Potassium Phosphate 20 mEq/L

DKA Card continued on next page →

Determining the Infusion Rate:

Infusion rates of both bags are determined using the [DKA 2-Bag Infusion Rate Calculator]
*may be found in the hyperlink in all DKA Powerplans, BCH formulary, on eLibrary or Powerchart link

Prescriber should order the fluids once, then modify infusion rates throughout the course; *do not cancel/reorder for each rate change.*

Goal Dextrose Content (used in the calculator)

Goal Dextrose Concentration	
Blood Glucose (mg/dL)	Goal Dextrose
>300	0%
276 – 300	5%
251 – 275	7.5%
201 – 250	10%
≤ 200	12.5%

Potassium Content: *(after voiding)*

Goal K^+ = 3.5 – 4.5 mEq/L

Serum K^+ (mEq/L)	K^+ in IVF (mEq/L)
≤4.5	40
>4.5	0
* May add K up to 80 mEq/L if needed for significant hypokalemia but patient cannot remain on the 2-bag method	

3. INSULIN

Do Not give insulin bolus

Insulin infusion: After 1 hr of NS administration, initiate regular insulin infusion (1 unit/mL in NS) at 0.1 unit/kg/hr*

* **For mild DKA** (venous pH 7.2 - 7.29; serum tCO_2 or venous HCO_3 10 - 15 mEq/L) may use 0.05 unit/kg/hr

Target Blood Glucose: 150 – 250 mg/dL
Most patients require increasing dextrose & potassium concentrations as the anion gap normalizes.
If BG remains < 200 mg/dL, K^+ remains < 3 mEq/L (despite goal dextrose concentration of 12.5% and infusion rate at 2x maintenance), and anion gap is near to normal, reduce insulin infusion to 0.075 unit/kg/hr, then to 0.05 unit/kg/hr. Discuss with endocrine prior to adjusting.

Subcutaneous Insulin: *start when:*

- Patient can eat & drink
- At mealtime
- vpH > 7.3, tCO_2/vHCO_3 > 15 mEq/L and/or anion gap 14
- Give first subcutaneous rapid and long-acting insulin 15 min pre-meal, stop IVF & insulin drip 30 min after subQ dose *(May need to continue IVF if patient refuses to eat)*

Subcutaneous Insulin Regimen:

Total Daily Dose (TDD) (unit/kg/day):

	No DKA	DKA
Age < 6y or A1c < 7%	0.15 - 0.25	0.5 - 0.75
Prepubertal	0.25 - 0.5	0.75 - 1
Pubertal	0.5 - 0.75	1 - 1.2
Postpubertal	0.25 - 0.5	0.75 - 1

A. Basal - bolus regimen (recommended initial regimen):
~50% of TDD as long acting insulin (Lantus) once daily
~50% of TDD as rapid acting insulin (Humalog) divided in meals

B. Split - mixed insulin regimen:
2/3 TDD QAM (1/3 Humalog + 2/3 NPH)
1/3 TDD QPM (1/3 Humalog Qdinner & 2/3 NPH bedtime)

Sliding Scale:

Humalog	BG 250 - 400	BG > 400
None – Small Ketones	5-10% TDD	10-15% TDD
Mod – Large Ketones	10-15% TDD	15-20% TDD

IV FLUID LIMITS

Fluid	PIV Max	CVL Max
Potassium	80 mEq/L	200 mEq/L
Dextrose	12.5%	50%

Maximum Phosphorous infusion rate: 0.12 mMol/kg/hr

Maximum Potassium infusion rate: (see administration of supplemental potassium policy)
All patients: ≤0.25 mEq/kg/hr (max 7.5 mEq/hr)
>0.25mEq/kg/hr (must have continuous ECG monitoring)
ICU/ICP/ED/HemeOnc/HSCT: >0.5 mEq/kg/hr (max 15mEq/hr)

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COMPLICATIONS

All patients are dehydrated & depleted of Na^+, K^+, Cl^-, PO_4^-, Mg^{2+}

1. Cerebral Edema:

Peak Incidence during first 8-12 hours after initiation of therapy, but can occur as late as 24 hours

Treat Empirically:
- Decrease IV rate, raise HOB @ 30°
- Mannitol 1 g/kg IV over 15 min, follow UOP and VS (BP, HR) for subsequent diuresis. *If no response within 20 – 30 min, repeat mannitol, or consider 3% Hypertonic Saline 5 mL/kg over 15 min*
- Consider ETT placement for airway control & hyperventilate to pCO_2 pt had prior to intubation – slowly normalize over 12-24 hrs
- *Consider* STAT head CT once airway is stabilized

Symptoms (in increasing order of importance & severity):
Headache, emesis, increased BP (dBP > 90mmHg), change in level of consciousness/responsiveness, delirium or confusion, unequal or dilated pupils, cranial nerve palsy, papilledema, age-inappropriate incontinence, bradycardia (sustained drop of 20bpm from baseline), respiratory irregularity or arrest, sudden onset of polyuria (from DI secondary to pituitary necrosis)

2. Hypophosphatemia:

Symptoms usually occur when Phos < 1 mg/dL

- ↓ ATP→ ↓ cardiac output (CHF) or possible cardiac arrest (< 0.5 mg/dL)
- Decreased Hgb affinity for O_2
- Metabolic encephalopathy (irritability, paresthesias, then confusion, seizure, coma)
- Ileus & dysphagia
- Proximal myopathy
- Hemolysis (if Phos < 0.5 mg/dL)

3. Hyponatremia:

Always use measured sodium. The brain is exposed to the measured sodium (not corrected sodium).

Na^+ 115 - 120 mEq/L: seizure, coma, respiratory arrest
Na^+ 120 - 125 mEq/L: HA, lethargy, obtundation
Na^+ 125 - 130 mEq/L: nausea & malaise
Symptomatic Hyponatremia: infuse 3% Hypertonic Saline 5 mL/kg IV over 15 min. Stop infusion when symptoms resolve.

4. Hypoglycemia

Most patients will eventually require $D_{12.5}W$ with sodium and potassium @ 2x maintenance. If BG's still < 200 and anion gap is near to normal, reduce insulin infusion to 0.075 unit/kg/hr, then to 0.05 unit/kg/hr. Discuss with endocrine prior to decreasing.

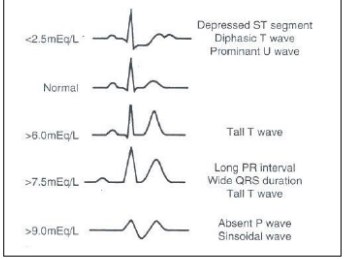
5. Hypokalemia:

Hypokalemia always occurs even with normal serum potassium due to extracellular shift.
Symptomatic Hypokalemia: 0.5 – 1 mEq/kg IV K+ intermittent dose over 2 hr

Goal K^+ = 3.5 - 4.5 mEq/L

ECG Changes: *usually when K^+ < 3 mEq/L*
U Waves (best seen in V4 - V6)
Flat T Waves (best seen in II & V2)
Long QTc (< 6mo: >0.44sec; Child: >0.43sec; Adult: >0.424sec)

K^+ ECG changes



6. Hypocalcemia:

May result with excess phosphate administration.
Clinical Presentation: ↓ BP, tetany, laryngospasm

Important Values

K^+:
K^+ < 2 mEq/L: significant weakness
K^+ < 3 mEq/L: *see "Hypokalemic ECG changes" above.*
K^+ 3.5 - 4.5 mEq/L: goal values
K^+ 5.5 - 6.5 mEq/L: peaked T waves
K^+ > 7 mEq/L: wide P waves
K^+ > 8 mEq/L: absent P waves
K^+ > 9 mEq/L: A-V Block, VT, V-Fib

Na^+:
Always use the measured Na^+ since the brain is exposed to the measured Na^+
Na^+ < 130 mEq/L: Nausea & malaise may begin
Na^+ < 120 mEq/L: Seizure, coma, resp arrest

Phos:
Phos < 1 mg/dL: symptoms possible
Phos < 0.5 mg/dL: risk of metabolic collapse

CALCULATIONS

Corrected $Na^+ = Na^+ + [(Glu - 100)/100] \times 2$

Anion Gap = $Na^+ - (Cl^- + HCO_3)$ [Normal 8-12]

Osmolality = $2(Na^+ + K^+) + (Glu/18) + (BUN/2.8)$

* Effective Osmolality = $2(Na^+ + K^+) + (Glu/18)$
(more relevant in DKA as BUN crosses BB barrier)

GOALS

1. Target blood glucose 150-250 mg/dL
2. Blood glucose should fall 70-100 mg/dL/hr after the first hour
3. Corrected Na^+ should remain normal or trend towards normal
4. Anion gap closes to 14, venous pH rises > 7.3, serum tCO_2 or venous HCO_3 rises > 15

LABS

Glucometer Q1h while on insulin infusion; then before meals, before bed, Q2am while on subcutaneous insulin

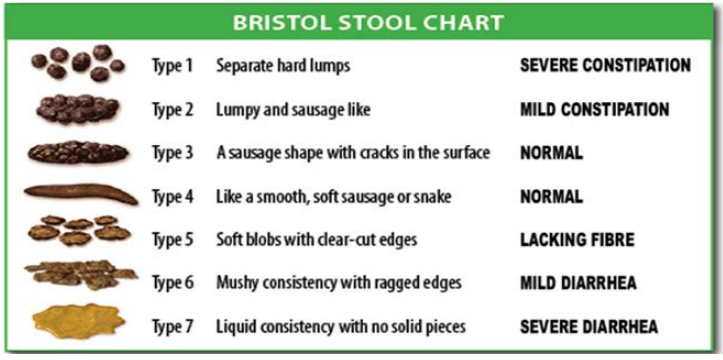
Chem 10, beta-hydroxybutyrate & VBG Q2h while on insulin infusion, then prn while on subcutaneous insulin

Consider continuous $etCO_2$ or transcutaneous CO_2 while on insulin infusion – it should start low and rise towards 35-45. If drops, check patency of insulin infusion.

Urine ketones initially, no need to follow repeatedly

Other: HgbA1c, consider pancreatic autoantibody panel (refer to CPG for recommendations), TFT's, c-peptide, insulin

ECG



Constipation*

PowerPlans	GI AMB Constipation, GI Constipation Cleanout
Presentation	Two of the following for two weeks: • ≤ 2 defecations/week • fecal/urinary incontinence after toilet trained • painful/hard bowel movements • rectal fecal mass • large diameter stools that obstruct toilet
Differential	• **95% functional** (diet/**excess dairy**, inadequate fluids, withholding), 5% organic (anatomic e.g. anal stenosis, hypothyroidism, CF, celiac, lead poisoning, neurologic e.g. Hirschsprung's or CP) • **Red flags**: Passing meconium >24 HOL, **constipation beginning < 1 month of age**, FH Hirschsprung, tight rectum gripping finger; **explosive stool** and air from rectum upon withdrawal examining finger, midline dimple, lower back hair tuft, lower limb weakness, motor delay, fever
Initial Workup	If red flags or signs of systemic illness: refer to ED/admit → chem10, KUB, contrast enema/rectal bx if suspect Hirschsprung's
Treatment	**Clean Out** **Inpatient**: • **Cleanout & Bowel Prep: Go-Lytely** infusion via NG tube + IV fluids OR orally with **MiraLax 34 g q30 mins x4 hrs** • Follow electrolytes and BUN/Cr if infusing for >12 hrs. f Go-Lytely is complete and effluent is not clear, start NS enemas • **Chocolate bomb:** 4oz chocolate ice cream + 15mL senna, + 30mL mineral oil + 30mL milk of magnesia • **SMOG enema:** 20 mL normal saline + 20 mL mineral oil + 20 mL glycerin **Outpatient**: • **Day 1-3:** Miralax BID (2 caps (34 g) BID x 2 days) + stimulant laxative • **Day 3 on:** Miralax daily as maintenance. Toilet-sitting 3x/day after meals, reward -based toilet training **Chronic** **<6m**: - Bicycle legs, **prune juice** (1-2 oz/day in 2-4oz water) - If no relief → glycerin suppository **>6m**: • **1st Line – Softeners:** lactulose (1-2g/kg/day) or MiraLax (8.5g/day if <20k, 17g.day if >20k) or colace • **2nd Line – Stimulants** (Rx for 2 weeks or less): senna, bisacodyl (Dulcolax), milk of magnesia or **Emollients** (mineral oil, glycerin supp.)

Diarrhea*	
PowerPlans	GI Chronic Diarrhea Labs Plan, SSYCE Plan, Stool Studies plan
Differential	• **Acute**: Gastroenteritis (viral or bacterial), food poisoning, antibiotic-associated, toxic ingestion, hyperthyroidism, disaccharidase deficiency (infants) • **Chronic**: Postinfectious lactase deficiency, IBS/IBD, Celiac, milk protein allergy (infants), lactose intolerance, laxative abuse, giardiasis, secretory tumor, lymphangiectasia, familial villous atrophy
Workup	• Consider FOBT, ESR/CRP, fecal calprotectin or lactoferrin, infectious stool studies (SSYCE esp. If febrile, bloody stools, immunocomp.), C. diff, stool for O&P, viral antigens including rotavirus), fecal elastase, fecal reducing substances • To differentiate osmotic vs. secretory diarrhea: • Stool Osmolar Gap = Stool Osm - (2 x [stool Na + stool K]) ▪ **Osmotic Diarrhea (osmolar gap > 100)**: Maldigested nutrients draw water into the intestinal lumen (e.g., celiac, pancreatic disease, lactose intolerance). Stool volume **decreased with fasting**. ▪ **Secretory Diarrhea (osmolar gap < 100 mOsm/kg)**: Secretion of water into intestine exceeds absorption (e.g., cholera, hyperthyroidism, nonosmotic laxative use). Large volumes, **does not decrease with fasting.**
Management	• Hydration • Generally avoid anti-diarrheals

GER/GERD*	
PowerPlans	GI AMB Gastroesophageal Reflux Plan
Presentation	• **GER**: Reflux of gastric constants through LES into esophagus. **Normal** in infants. LES tone improves by 6m • **GERD** = GER + "troublesome symptoms" (back arching/Sandifer syndrome, **excessive crying** (>3h/day), **feeding difficulties, slow weight gain, parental concern**
Treatment	**Approach to GERD in the older child (JPGN 2018;66: 516-554)** • H&P, diet and lifestyle changes and if no improvement, brief trial of acid suppression with H2RA or PPI (4-8 weeks only) • Consider GI referral if no improvement on PPI or if unable to wean → upper endoscopy +/- pH impedance testing

Approach to infant GERD (JPGN 2018;66: 516–554)	
1	**Reflux precautions:** Elevate the head of the bed, avoiding overfeeding, keep infants upright after feeds, thicken feeds (Similac SpitUp/Enfamil AR, or with rice/oatmeal cereal [1 teaspoon of cereal per ounce of formula))
2	2-4w trial of **hydrolyzed or amino acid formula** or eliminate cow's milk in maternal diet if BFing
3	Consider GI referral **4w** trial of **Ranitidine or PPI** (limited evidence of efficacy; ↑ risk of CAP PNA, GI infections, vitamin deficiencies and fractures)
Refractory	Referral to GI (will consider Nissen fundoplication)

Inflammatory Bowel Disease*	
PowerPlan	GI Inflammatory Bowel Disease Admit Orderset/Workup Plan/Medications Plan

Inflammatory Bowel Disease*

	Crohn's	Ulcerative Colitis
Epi	• More common in whites, Ashkenazi Jews • Onset in teens-20s and 50s-60s. Unusual in <5y	• Onset in teens and young adults
RFs	NOD2/CARD15 mutations. >200 risk loci associated with IBD; Turner's Syndrome	• **Familial inheritance with less strong genetics** • Wiskott Aldrich Syndrome
Presentation	• **Systemic**: poor weight gain, anorexia, delayed puberty, anemia, fatigue • **GI** ▪ **Early**: abd. pain, RLQ mass (ileal involvement), bloody stools, perianal skin tags, fistulas, and abscesses. Primary sclerosing cholangitis. ▪ **Late**: stricture formation, intraabdominal abscesses, colon cancer (8-10y after onset) • **Extraintestinal**: erythema nodosum, pyoderma gangrenosum, arthritis, uveitis/episcleritis, nephrolithiasis, osteoporosis, thrombosis	• Frequent, **bloody diarrhea**, tenesmus, abdominal pain similar to infectious colitis. • Similar sx as CD, but less likely to have systemic symptoms. • **Extraintestinal**: erythema nodosum, arthritis, thrombosis, PSC
	Toxic Megacolon: fever, tachycardia, dehydration, electrolyte disturbance, hypoTN/shock, abd distention, vomiting, severe pain. ↑ risk w/antimotility agents (loperamide or opiates) → **SAT Abd XR + Surgery c/s**	
Workup	• High **ESR/CRP**, low albumin, low Hct, low B12, +fecal leukocytes, high fecal calprotectin/lactoferrin. • p-ANCA -, **ANCA +** (80% of patients) • Upper GI/SBFT/MRI/low dose CTE/ WCE: **skip lesions**, "cobblestoning," narrowing or obstruction • **Endoscopy**: Inflammation can occur anywhere in the gut but most commonly is ileocecal, patchy involvement, colonic aphthous lesions, linear fissures, **rectal sparing, perianal findings (skin tags, fissures fistulae)** • **Biopsy**: chronic inflammation, noncaseating granulomatous, **transmural inflammation**	• High **ESR/CRP**, low albumin, low Hct, +fecal leukocytes, high fecal calprotectin/lactoferrin. • **p-ANCA + (60% of patients)** • **Endoscopy**: friable colonic mucosa with **continuous extension from rectum up to prox colon**, pseudopolyps, "backwash" ileitis, +/- gastritis • **Biopsy**: chronic mucosal inflammation in lamina propria, crypt abscesses
Treatment	• **Corticosteroids**: systemic or topical (enteric-coated or rectal) • **Aminosalicylates (5-ASA):** timed release, enteric-coated, pH-release, rectal suppository or enema (only in mild disease) • **Immunomodulators**: thiopurines (azathioprine, 6-MP – check TPMT activity before starting), methotrexate, tacrolimus take 2-3 mon to work so require a steroid bridge to manage acute inflammation • **Biologics**: infliximab(IV) , adalimumab (SC) (anti- TNF alpha antibody medications) [need anti-Hep B sAg, VZV titer or 2 vaccines, TB within 6m to initiate] • **Vedolizumab**: anti-integrin used mainly for maintenance of Crohns colitis • **Ustekinumab**: anti- IL12/23 used mainly for maintenance.Antibiotics - ciprofloxacin+metronidazole also useful in mild active CD. • **EEN**: A formula based diet that can be used in place of steroids which is as effective as steroids at inducing remission, particularly good in growth failure and SI disease • **Surgery**: for complications such as stricture, fistula, abscess formation and to remove isolated areas of bowel involvement • **Specific Carbohydrate or anti-inflammatory diets**: as adjuvant • Use PCDAI index to measure Trx response	• **Corticosteroids** and **oral and rectally administered 5-ASA formulations** as with CD • **Immunomodulators**: 6-MP (check TPMT activity before starting), tacrolimus, cyclosporine • **Biologic agents**: infliximab (anti- TNF alpha antibody) -IV medication used for induction and maintenance. • **Vedolizumab**: anti-integrin used mainly for maintenance (UC >Crohns). • **Tofacitinib (Xelganz)**: approved for adult UC • **Surgery**: colectomy can be curative, but require either ileostomy (undesirable) or ileal-rectal/ileal-anal anastamoses (complicated surgeries, prone to recurrence with any residual rectal mucosa) • **Specific Carbohydrate or anti-inflammatory diets**: as adjuvant • **Probiotics (VSL#3)**: may be complimentary • Use Pediatric Ulcerative Colitis Activity Index (PUCAI) to measure trx response (Gastroenterology 2007;133:423-432)

Celiac Disease

PowerPlans	Celiac Disease Orderset, Celiac Gene Assessment, GI AMB Celiac Disease (Future) Plan
Presentation	• **Classical**: Malabsorption (FTT, steatorrhea), abd pain, gas, **distension, constipation or diarrhea**, anemia, non-erosive arthritis, dental enamel defects, aphthous ulcers, dermatitis herpetiformis (pruritis papules/vesicles), neuropsych (ADHD, depression, HA). ↑ risk in T1DM, autoimmune thyroid dz, Turner and Down syndrome. • **Infants**: **present irritable, wasted extremities, buttocks, and distended abdomen**
Pathophys	**HLA-DQ2 or -DQ8** (predisposition, **necessary for dz)** + environmental trigger → **Antibodies to gliadin** (gluten byproduct), tissue transglutamidase (tTG; cross-links and deamidizes gliadin peptides) → **enterocyte destruction**
Workup	• **Serologies**: anti-tTG IgA, anti-endomysial IgA, anti-gliadin. Always check IgA levels (IgA deficiency can yield false-negatives);DGP IgA if < 2 yrs old • **Biopsy**: intraepithelial lymphocytes, villous atrophy, crypt hyperplasia
Treatment	• Gluten-free diet ($$, needs very strict adherence, hard to maintain). Wheat, rye, barley all contain gluten. Oats are controversial. Improvement in 2-4w. • **Follow with TTG until normalized (usually by 12 months). Follow Vitamin D and B 12 levels as well as Thyroid.** Check if immune against Hep B

Malabsorption

	Presentation/Pathophys	Workup
Carbs	• **Frequent, watery stools** • Pathyphys: carbs digested by amylase (saliva and pancreas), so **pancreatic disease** can lead to poor carb digestion • **Lactase deficiency** (lactose intolerance): usually adult-onset • **Bacterial overgrowth**/alteration of bowel flora → increased lactate production and temporary lactase deficiency leading to lactose intolerance	• Fecal pH < 5.5 (can also be seen transiently in viral enteritis) • Stool reducing substances >0.5%. *need fresh stool • Breath hydrogen test used to detect lactase and sucralase deficiency (rare)
Fat	• **Greasy, foul-smelling stools** (steatorrhea) • Cause by diseases affecting bile production/secretion or **poor enterohepatic circulation of bile salts** (e.g., ileal resection) or **pancreatic insufficiency** (eg. cystic fibrosis, Schwachman-Diamond) 2/2 inadequate lipase • Critically affects absorption of the fat-soluble vitamins **A, D, E, and K**. • **Giardia** infection often associated with fat malabsorption	• Spot fecal fat: non-specific • Split fats (fatty acids) more suggestive of malabsorptive process • Neutral fats more suggestive of pancreatic dysfunction • 72 hr fecal fat: > 5 g per 24 hours suggests malabsorption (diet during these 24 hrs should be >35% fat)
Protein	• **Edema, hypoalbuminemia** • Usually related to **deficiency of pancreatic proteases (e.g. cystic fibrosis)** • Different from protein-losing gastroenteropathy (PLE) (2/2 mucosal disruption or increased lymphatic pressure)	• Serum total protein, albumin • Stool alpha-1 antitrypsin (for PLE)

Autoimmune Hepatitis

Presentation	Acute vs. subacute. Transaminitis > bilirubin elevation. Hypergammaglobulinemia. Fatigue, amenorrhea.
Pathophys	• **Type 1 (classic):** any age/gender. +ANA, anti-SM. • **Type 2**: girls. anti-LKM. Recurrence more common in Type 2.
Workup	LFTs, Ig levels, auto-antibodies, maybe liver biopsy
Treatment	Prednisone (18-24m) + azathioprine/6-MP (steroid-sparing; check TPMT enzyme activity first. Low TMPT levels = risk of myelosuppression). Relapse more common if trx weaned in 1st 3 years of therapy or during puberty.

GI Imaging

Abdominal XR

Description	• Radiography • Positions: PA upright most common • **Left lateral decubitus** can be used for closer evaluation of peritoneal free air or to look for air trapping
Used to Evaluate	• Abdominal pain • Constipation • Abdominal distension • **Vomiting** • Concern for **mass** • Concern for **ingestion**
Potential Pathology Visualized (finding)	• Ileus, bowel obstruction (dilated loops of bowel) • Foreign body • Constipation (stool burden) • Necrotizing enterocolitis, bowel ischemia (pneumatosis, pneumoperitoneum, air in the biliary tree) • Bowel perforation (free air under diaphragm)
Patient Prep	None

Modified Barium Swallow

Description	• Videofluorography to evaluate the function of the **phases of swallowing** • Barium impregnated foods of **different consistency** are given to the patient and swallowing function assessed indications
Used to Evaluate	• **Dysphagia** • Coughing, choking, drooling with swallowing • **Aspiration PNA**, known or suspected • Neurologic or anatomic disease that may affect swallowing function
Potential Pathology Visualized (finding)	• Swallowing dysfunction, e.g. aspiration or laryngeal penetrationo • Anatomic anomalies (esophogram, UGI series or endoscopy may be better depending on the structural anomaly)
Patient Prep	• NPO for several hours (check BMC or BCH policies) • Patient needs to be able to cooperate with exam (needs to be able to attempt swallowing when fed)

Upper GI Series (with small bowel follow through)

Description	• Single (oral) contrast study with still or fluoroscopic images • Double contrast (oral + gas) can help evaluate mucosal integrity • Esophagus (esophogram) → doodenal-jejunal junction (upper GI series)
Used to Evaluate	• Abdominal pain, epigastric pain/discomfort • Congenital syndromes associated with intestinal **malrotation** • Weight loss or failure to thrive • Vomiting • Upper GI bleed • Bowel dilation in short bowel syndrome patients • Anastomotic stricture or abnormality in post-surgical short bowel syndrome patients
Potential Pathology Visualized (finding)	• Malrotation • Hiatal hernia • Gastritis, duodenitis, peptic ulcer disease • Duodenal laceration or intramural hematoma • Pyloric stenosis (though ultrasound is preferred) • Bowel dilatation post-surgery • Anastomotic abnormality
Patient Prep	• NPO for at least two hours • Must be able to swallow contrast • Contrast may be placed through an enteral tube if small bowel follow through is desired

GI Imaging continued on next page →

GI Imaging	
Abdominal Ultrasound (with doppler)	
Description	U/S evaluation of liver, gallbladder, spleen, pancreas, kidneys, and IVC/aorta
Used to Evaluate	• Abdominal trauma --> FAST exam evaluates for abdominal fluid/blood • Abdominal pain • Splenomegaly or reversal of portal flow in patients on chronic parenteral nutrition as a surrogate marker or portal hypertension
Potential Pathology Visualized (finding)	• **Intussuscep.** • **Pyloric stenosis** • **Appendicitis** • Suspicion for abdominal mass • Liver/gall bladder pathology • Pancreatitis • Nephrolithiasis • Ovarian cyst, torsion, ectopic pregnancy
Patient Prep	• None • NPO for 6 hours (if looking for gallstones)
Abdominal CT	
Description	• Cross sectional imaging of abdominal structures • Both IV and oral contrast can be used
Used to Evaluate	• Colicky pain • Abd trauma (once stable) • c/f cancer, liver dz • Features of SI Crohn's disease (fistula, stricture, abscess)
Potential Pathology Visualized (finding)	• Nephrolithiasis, **urinary tract calculi (non-con)** • Pelvic or abdominal masses (contrast) • Inflammatory bowel disease • SBO/LBO • Diffuse liver disease (steatosis, iron deposition disease, cirrhosis) • Appendicitis • Abdominal trauma
Patient Prep	Oral or IV contrast as indicated
Contrast Enema	
Description	• Contrast agent per rectum • **Water-soluble** (gastrograffin) if **bowel perforation** suspected • **Air** if **intussusception** suspected
Used to Evaluate	• Inflammatory bowel disease • c/f obstruction • Anastomotic stricture or abnormality in post-surgical short bowel syndrome patients
Potential Pathology Visualized (finding)	• Lower abdominal obstruction in the neonate (Hirshprung's disease, meconium ileus, ileal atresia) • Intussusception (diagnostic and therapeutic) • Anastomotic abnormality
Patient Prep	None

Upper Gastrointestinal Bleeding

Presentation

Hematemesis (vomiting of red blood or coffee ground-like material) and/or melena (black, tarry stools). **Fast UGI bleed can present with BRBPR**.

Pathophys

Proximal to ligament of Treitz (distal duodenum)

Treatment

Depends on cause. In general, NPO + high-dose PPI (or PPI drip), fluids + blood product resuscitation, correct coagulopathy, **sometimes octreotide drip**.

	Common	Uncommon
Infant		
	• Swallowed maternal blood (from delivery or mother's nipples) → w/u: Apt test • Esophagitis (from stress, hypoxia, indomethacin, dexamethasone)	• Gastric ulcer
Older Child		
Esophagus	• Esophagitis (reflux pill-induced e.g. tetracycline) • Mallory-Weiss tear	• Esophagitis (viral, allergic, candidal, caustic) • Foreign body • Duplication cyst • Varices
Stomach	• Gastritis (NSAIDs, H. pylori) • Stress ulcer	• Gastritis (Crohn's, portal hypertension) • Ulcer (e.g.,Zollinger-Ellison) • Cushing ulcer (↑ICP) • Leiomyoma • Varices • Vascular malformation (e.g., Dieulafoy Dz)
Duodenum	Duodenitis (e.g., Crohn's disease)	• Ulcer (e.g., H. pylori, Curling ulcer in burn victims) • Foreign body • Duplication cyst • Vascular malformation • Hemobilia (intrahepatic bleeding from biliary tree)
Other	• Swallowed blood from mouth/ nasopharynx • Facial trauma, tooth extraction, epistaxis	• Swallowed blood (e.g., Munchausen by proxy, pulmonary hemorrhage)

GI Bleeding continued on next page →

Lower Gastrointestinal Bleeding

Presentation

Hematochezia (bright red or maroon-colored blood or fresh clots per rectum), **painful vs non-painful is important distinction**.

Pathophys

Distal to ligament of Treitz (distal duodenum)

	Common	Uncommon
Infant	• **Anal fissure** (often w/constipation) • Milk protein allergy (mucus in stool, diarrhea) • Necrotizing enterocolitis • Swallowed maternal blood or epistaxis (can present as hematochezia 2/2 rapid transit)	• Vascular lesions • Hirschsprung enterocolitis • Intussusception • Intestinal duplication • Meckel diverticulum • Infectious enterocolitis
Older child	• Anal fissure (r/o sexual abuse) • Intussusception • **Infectious enterocolitis** (salmonella, shigella campylobacter, E. coli 0157, Yersinia, C. diff) • Inflammatory bowel disease (delayed puberty, wt. loss) • **Meckel diverticulum** (large painless bleeding) • Perianal streptococcal cellulites • Juvenile/inflammatory polyp- painless	• Nodular lymphoid hyperplasia • Vascular malformations • Intestinal duplication • Henoch-Schonlein purpura • Infectious diarrhea (e.g., CMV colitis. amebiasis) • Hemorrhoids • Colonic or rectal varices • Neutropenic enterocolitis/typhlitis (immunosuppressed)

Substances That Interfere with Stool Guaiac Tests

False Positive	False Negative
• Meat (rare or well done) • Ferrous sulfate (if stool pH <6) • Tomatoes • Cherries • NSAIDs	• Vitamin C • Storage of specimen > 4 days • Outdated reagent or card

Total Parenteral Nutrition (TPN)

Enteral feeding is preferred route of nutrition support: ↓ gut atrophy, ↓infections (boosts gut immune function).

Indications	Abnormal nutritional status or low birth weight (z-score < -2 weight for age or weight for height, < 2500g), dysfunctional GI tract or NPO > 4 days in consultation with Nutrition Service and Dietitian
Access	If Osm > 900, must run through central line. Calculate % of daily maintenance fluids, consider heart or renal limitations.
Monitoring	Weight daily, height (>24 months) periodically, length (<24 months) weekly, head circumference (<24 months) weekly, fluid balance daily, vital signs daily, Chem10 daily until stable; Chem10/hepatic function panel + TG weekly, nutritional labs if patient is on PN and minimal feeds for > 1 month checked periodically (Se, Cu, Zinc, Iron, Carnitine, CRP, vitamins A, D, E, INR, Manganese, Aluminum, Iron studies, Essential fatty acid profile)

Infant Formulas

- See "Formula Card" on BCRP website (Virtual White Coat) for more info.
- 1 oz = 30mL
- Standard infant formula = 20kcal/oz. Toddler/infant formula (1 year+) = 30kcal/oz

Type	Brands
Cow's Milk	• Enfamil (cheapest) • Similac Advance (claims to have better calcium absorption) • "Step 2" or "next step" versions (babies > 6 m) have more calcium, protein • Preemie versions: Enfacare, Neosure - 22 kcal/oz, extra calcium, phosphorus
Partially Hydrolyzed (Whey = Cow's Milk Based)	• Good Start (made by Nestle, covered by WIC)
Soy (Lactose-Free, for lactose intolerance or galactosemia)	• Prosobee (made by Enfamil), Isomil (made by Similac), Goodstart Soy • *Can cause constipation
Hydrolyzed, Semi-Elemental	• Nutramigen (cheapest, covered by WIC) • Alimentum (sweeter taste) • Pregestimil
Amino Acid-Based, Elemental ($$$)	• Neocate (covered by WIC) • Elecare (higher MCT oil content, less osms)
Caloric Supplements	• Formulas can be safely concentrated up to 28 kcal/oz. If increased renal solute load is undesirable, use carb/lipid caloric supplements instead: • Polycose powder (carbohydrate-based) • Corn oil, medium chain triglyceride (MCT) oil (lipid-based) • Duocal (contains both carb and fats, only for infants >1 year)

Clostridium Difficile

PowerPlan	C. diff Treatment Plan
Presentation	• Ranges from asymptomatic colonization to mild diarrhea to fulminant colitis with fever and severe illness. Complications: perforation, toxic megacolon • **Illness (but not colonization) is rare in children < 2 y/o** b/c they lack cellular machinery to bind C. diff toxin
Pathophys	Anaerobic, Gm+, toxin-producing bacillus. Spores extremely resistant. Toxins disrupt endothelial cytoskeleton → inflammation, necrosis. Usually associated with antibiotic use (esp. clindamycin, cephalosporins, penicillins), PPIs, immunosupp, state, IBD (esp. UC)
Workup	Stool enzyme immunoassay (EIA) = high sens/spec. Stool culture is not helpful. Sample should be **fresh** (on ice if outpatient), and usually only one sample is needed to confirm infection. Positives auto -reflex to PCR.
Treatment	• Metronidazole (IV or PO) 30 mg/kg/day 10-14 days. • Trx failure, underlying IBD, or severe disease: Vancomycin (must be PO!) 40 mg/kg/days (max 125 mg/dose) 10-14 days. • Fecal microbial transplantation for chronic-recurrent C diff (>3x). • Fidaxomycin being used more often as well

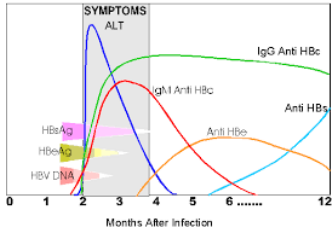
Acute Gastroenteritis*	
Presentation	Diarrhea (3+ loose/watery stools per day), vomiting, fever, anorexia, cramping. Common, 2 episodes/ year on avg in children < 5.
Pathophys	• **Viruses** (**rotavirus, norovirus**, enteric adenovirus, calicivirus, astrovirus, enterovirus) are major cause → low-grade fever, vomiting, watery diarrhea WITHOUT blood. • Bacteria (SSYCE +C.Diff) cause infiltration of mucosal lining → fever, abdominal pain, **bloody stools, positive stool leukocytes** • Parasitic (*Giardia, Cryptosoporidia, Cyclospora, E. histolytica*)
Treatment	• Dehydration score determines management. If severe, obtain POC BG + lytes and start IVF. • Otherwise, oral rehydration solution, e.g. Pedialyte or ½ strength apple juice (theoretical risk that high osmolality fluids will worsen diarrhea and hypoNa fluids will lead to hypoNa, but one RCT demonstrated improved outcomes w/ ½ strength apple juice b/c Pedialyte = not tasty.) No evidence for bowel rest or bland diet.

Infectious Hepatitis	
Hepatitis A	
Transmission	Fecal-oral, blood
Epi	High in Mexico, S. America, Africa, Asia
Incubat	2-8 wks
Prophylaxis	HepA Vaccine. pre- / post-exposure with polyclonal IgG
Treatment	• Supportive • Vit K for coagulopathy
Prognosis	Usually self-limiting
Hepatitis B	
Transmission	Blood, sex, maternal-fetal (90% vertical transmission rate, but **infants almost always become chronic carriers**; OK to breastfeed)
Epi	• 1-2% in US • Higher in Asia and South America • 10-20% in China, sub-Saharan Africa
Incubat	1-4 mo
Prophylaxis	**Post-exposure with HBIg and HBV vaccine within 12 hours** (newborns born to HBV+, needlesticks)
Treatment	• **Entecavir** • **Tenofovir** • **Peginterferon alfa-2a** • **IFNa**: 20-50% will seroconvert, but lots of systemic side effects • **Lamivudine**: high rate of resistance
Prognosis	• Self-limited or progression to chronic HBV/carrier status (esp. neonates) • Cirrhosis in 3% • Increased risk of hepatocellular CA (yearly RUQ ultrasound, AFP level)
Serologies	• **HBsAg** (surface antigen): indicative of **acute** infection, disappears in 3-6 months • **HBsAg** for **>6 months: carrier state** • **HBeAg** (secretory protein) and **HBV DNA** by PCR suggest **active viral replication** • **IgM anti-HBc** (antibody to core protein): secondary indicator of **acute** infection • **HBsAb** (antibody to surface protein): neutralizing antibody, suggests **recovery or response to HBV vaccine**

Infectious Hepatitis

Hepatitis B

Serologies



Interpretation of Tests for Acute Hepatitis B

Anti-HBc IgM	Anti-HBc IgG	HBsAg	Anti-HBs	Interpretation
Positive	Negative	Positive	Negative	Acute HBV infection
Negative	Negative	Positive	Negative	Early acute HBV infection
Negative	Positive	Negative	Positive	Resolved acute HBV infection
Negative	Negative	Negative	Positive	Not infected Prior vaccination for HBV
Negative	Negative	Negative	Negative	Not infected
Negative	Positive	Positive	Negative	Chronic HBV infection

Hepatitis C

Transmission	Blood, sex, maternal-fetal (<5% vertical transmission rate; OK to breastfeed)
Epi	Seroprevalence 0-1% worldwide
Incubat	1-3 mo
Prophylaxis	None
Treatment	Direct-acting antiretrovirals (DAA), specific treatment depends on genotype. (ledipasvir/sofosbuvir, sofosbuvir/ribavirin)
Prognosis	• 20% spontaneous clearance • Remainder will have slow progression to cirrhosis/hepatocellular CA if untreated

Hepatitis D (only if co-infected w/HepB)

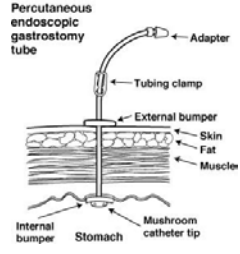
Transmission	Blood, sex (less common)
Epi	<3% of HBV+ patients
Incubat	3-7 wks
Prophylaxis	None
Treatment	• I FN-based • Lamivudine is not helpful
Prognosis	Worse prognosis and faster progression than HBV alone

Pancreatitis	
PowerPlan	Acute Pancreatitis Plan, Acute Pancreatitis Critical Care Plan, ED Pancreatitis Plan, GI Pancreatitis Labs Plan
Presentation	**Epigastric abd pain** w/band-like pain to back, fever, **N/V**, ileus, jaundice/clay-colored stools
Diagnostic Criteria	At least 2 out of 3: Abdominal pain (see above) + Amylase or lipase > 3 ULN, imaging compatible w/ pancreatitis (U/S, EUS, MRI/MRCP)
Workup	Chem10, **amylase/lipase** (lipase rises earlier, elevated for longer, more specific), **lipids**, albumin, glucose, LFTs. ALT > 3x ULN has >95% PPV for gallstone pancreatitis
Pathophys	Congenital anomalies (e.g. **choledochal cys**t, pancreatic divisum), infectious (**mumps, mycoplasma**, coxsackie, influenza, salmonella, GNRs), drugs (**valproic acid,** L-asparaginase, steroids), systemic dz (**CF w/pancreatic sufficiency**, lupus, RA, HUS, Kawasaki, IBD), metabolic (**hyperlipoproteinemia**, hyperCa, DM), EtOH and gallstones (less common), BAT (e.g. handlebar injury), genetic (SPINK1) 10% will have recurrence.
Treatment	NPO (PO once no n/v), NS bolus(es), 1.5x mIVF (consider LR if Ca wnl), nausea control (Zofran), acid blockade (IV pantoprazole), pain control (morphine, ketorolac, acetaminophen) Admit to ICP if obese, hypertriglycidemia, diabetic, severe abd pain, or difficulty performing reliable serial exams. ICU if HD unstable.
Complications	SIRS, ARDS, Pseudocytst (RUQ US Abd), abscess, pleural effusion (CXR)

Liver Enzymes		
Pattern	**Lab Findings**	**Ddx**
Hepatocellular	↑ AST & ALT >> ↑ GGTP, alk phos, bilirubin	• Viral infxn (HepA, CMV, EBV, VSV, HSV) • Meds/toxins • Shock (LDH also high) • Autoimmune hepatitis • Steatosis • Celiac Dx • Hemochromatosis (↑ ferritin) • A1AT • Wilson's Dz (↓ ceruloplasmin) • EtOH (2:1 AST: ALT)
Cholestatic	↑ Alk-Phos, GGTP & Direct Bili >> AST, ALT	• Bile duct obstruction/ abnormalities • Infectious Hepatitis • Cirrhosis • Meds/toxins (anabolic steroids, amox/clauv, erythromycin, bactrim, TPN) • PBC/PSC • A1AT • Alagille syndrome • Inborn errors of metabolism
Infiltrative	↑ Alk-Pho with nml bili (send GGT to determine if from liver or bone)	• Granulomatous Dz (sarcoid, Tb) • Amyloidosis • HCC, mets to liver

Functional Gastrointestinal Disorders (FGID)

Pathophys	• Hypersensitivity (visceral nervous system, CNS), motility disturbance, microbiome disturbance, psychological factors including caregiver stress, and abnormal responses to both normal and abnormal physiologic stimuli • **Alarm Sx** (CANNOT be FGID): **blood in stool**, multiple episodes of diarrhea > daily, persistent fevers, **weight loss**, nighttime awakenings for pain or to have BM	
General Treatment	1. Pt/family **education about FGIDs** (explain the positive aspects of FGID diagnosis vs. something more concerning. The word "functional" may be offputting, so try sensitive stomach or irritable bowel if family seems upset by term.) **Reassurance** = most important. **Juicious ordering of labs/imaging only with alarm symptoms** and after discussing possibility of FGID. 2. **CBT**: Relaxation training, cognitive restructuring, **modifying family response** 3. **Antispasmodics** (hyocyamine, dicyclomine; TCAs or SSRIs if comorbid anxiety/depression) 4. **Identify and avoid food triggers** (e.g., avoid tomatoes/citrus, caffeine, carbonation, greasy, spicy foods) **In hospital, consider "Magic Mouthwash"** if "something" necessary, e.g. over a weekend (AlOH/ diphenhydramine/lidocaine/MgOH/simethicone/hyoscyamine) for abdominal pain	
Disorder	**Symptoms (Rome IV Criteria)**	**Specific Treatment**
IBS	• Recurrent **abd pain**, at least 1d/week x3 months, a/w: **Defecation, change in frequency/form of stool** • May be Diarrhea-/Constipation-Dominant/ Mixed • (look for association with excitement or stress)	• **Probiotics** (lactobacillus or bifidobacteria) • Bio-psycho-social approach • Medications target symptoms, but educate that **goal is to improve rather than cure**
Functional Dyspepsia	>1x/week of: Bothersome **postprandial fullness** (uncomfortably full after regular-sized meal) w/early satiation, **epigastric pain/burning**	• Small, frequent meals • Time limited empiric trials of **acid suppression** or **prokinetics** • **Peppermint oil (IBguard)** • Limit fructose, sorbitol • Consider **cyproheptadine if weight loss** • **Sulcralfate helpful for burning**, best to use single dose at night
Abdominal Migraine	• Paradoxical **episodes of acute periumbilical abd pain lasting 1h+**, often i/s/lo family hx of migraine • Must be **completely asymptomatic between attacks** • Note: is a controversial diagnosis	• **Avoid caffeine** • Ppx: cyprohepatdine, propranolol • Abortive trx: **triptan (IV, intranasal), dark/ quiet room**
Functional Abdominal Pain	• Functional abdominal pain with no alarm signs (10-15% of school-age children. Often **vague, diffuse pain**, occurs often at times of separation (bedtime) or school. Better over summer, weekends or vacation. • **Almost never focal**	• See general trx • Consider referral to **Functional Abd Pain Clinic if severe**
Cyclic Vomiting Syndrome	• Stereotypical **episodes of intense vomiting** separated by weeks to months (usually presents in 3 - 7 y/o - uncommon onset after puberty), completely fine between attacks, often i/s/o maternal hx of migraine • Often, parents can tell it is coming (e.g. child is pale) before bed. Typically happens at night. • (r/o malrotation, inborn error of metabolism, increased intracranial pressure, UPJ obstruction, pancreatitis, and **cannabanoid hyperemesis syndrome** - responsive to hot showers, capsaicin cream)	See abdominal migraine trx above + IV hydration + ondansetron

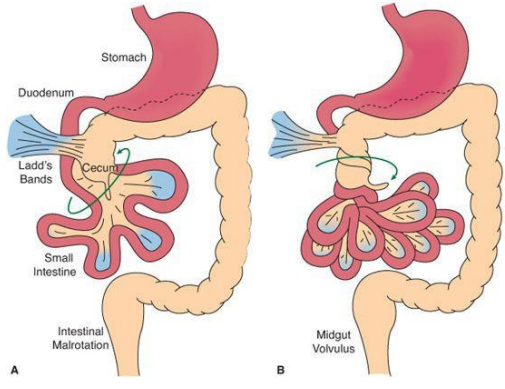
G Tubes/J Tubes	
Indications	• Inadequate intake (lower threshhold in already malnourished, premature, oncologic kids). NG/NJ = first line, short term; GT/GJ/JT = if feedings indicated > 2 months. • Before calling for help, know: what kind of tube (type, size), who placed it (surgery, GI, IR), how old is the original tract.
Troubleshooting	• **Falls out**: ▪ **For NEW T-type PEG tubes placed by GI less than 6 months ago**, do not attempt replacement. Call GI fellow as tube will likely need replacement by interventional radiology ▪ **Surgically-placed G-tube**: Page Gen Surg. Replace immediately with same-sized tube. If new tube is not immediately available, use Foley catheter in same French size (or 1 size larger to help dilate the tract). Do not force the tube in, as this can lead to false-tracking. • **Clogged Tubes**: **Crush 1 tab of sodium bicarb (324 mg) and 1 tab of Viokase 8 in 5 mL water**. Instill slurry into feeding tube; wait 30-60 min, withdraw, and flush. (Orderset: Sodium Bicarbonate for Tube Obstruction) • **Granulation Tissue**: Stabilize tube. Consider silver nitrate vs. triamcinolone cream VS salt in small amount of water. • **Contact Dermatitis**: Absorbent topical powder, dressing. Consider Aveeno, Dombro, topical antifungal. • **Cellulitis**: Outline erythema. Will require antibiotic course.
Device	**How They Work**
Percutaneous Endoscopic Gastrostomy (PEG) Tube	• Usually T-type tube with cross-bar to hold internal balloon tight to abdominal wall. • Needs 6 months before conversion to skin-level device. This is done with sedation. 
Surgically Placed G-Tube	• **MIC-G**: non-skin level device with 3 ports (feeds, meds, and balloon); has round disk flange to hold it to abdominal wall • **MIC-KEY**: skin level button device with 2 ports; tubing swivels, allowing patient to move comfortably. **Now using AMT tubes instead of Mic-Key** • **Bard button**: skin level device, slightly smaller than MIC-KEY • **MIC-GJ**: non-skin level device placed by IR through existing gastrostomy site; has separate ports for gastric and jejunal • **MIC-KEY-GJ**: skin level button device with separate ports for gastric and jejunal; multiple jejunal exit holes allow for decreased clogging
Jejunal Tube	• No bolus feeds; continuous only, requires slow advances • Needs **large water flushes (15-30 mL) after medications and feeds to prevent clogging** • Crushed medications can precipitate and should not be given through the J tube (eg. ciprofloxacin) • If vomiting look for intussusception around tube with tube study.

Newborn GI

Pyloric Stenosis

Pathophys	Hypertrophy of pylorus. RFs = bottle feeding, maternal smoking
Presentation	**Immediate post-prandial projectile vomiting,** "hungry vomiter," palpable olive-like mass**. Classically presents in 3-6w infants, but can worsen by 2-3 month**s (rare by 12w), 4:1 male:female
Workup	BMP **(hyperchloremic metabolic alkalosis**), CBC (should be nml), bili (unconjugated hyperbili), hemoccult stool (should be neg), **abdominal ultrasound**
Treatment	1. Address dehydration and correct alkalosis 2. Surgical consult for pyloromyotomy (definitive treatment) 3. Post-op refeeding can start within hours

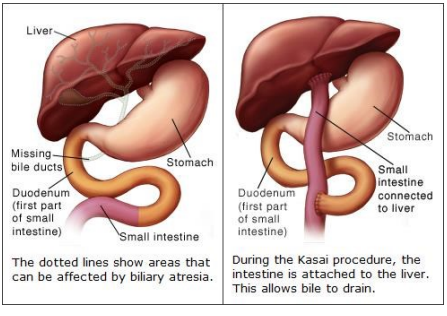
Malrotation/Volvulus

Pathophys	• **Malro**: **arrest in normal rotation** in embryonic gut. Misplaced cecum is attached by peritoneal bands (Ladd bands) which cross the duodenum, leading to risk of volvulus. **Mostly asymptomatic**. • **Volvulus**: Small bowel twisting around SMA → vascular compromise, ischemia, necrosis. 
Presentation	Bilious vomiting, third spacing, HD instability
Workup	• Bilious vomiting + signs of sepsis/hemodynamic compromise + suspicion of volvulus □ rapid resuscitation and surgical exploration • If HD stable → KUB, upper GI series (corkscrew appearance), U/S (whirlpool sign), CT in adults. Laproscopy if indeterminate.
Treatment	• **Ladd procedure**: division of Ladd bands, widening mesenteric base, explore duodenum with tube for patency, **appendectomy** (to avoid future confusion w/abd pain), **bowel resection as needed, placement of bowels in nonrotation**. • Post-op, address **short gut syndrome** if relevant

Biliary Atresia

Pathophys	• Grouped into 3 categories • The most common type (70-85%) is perinatal and involves a progressive **fibro-proliferative obliteration of the bile ducts** → destruction of the extrahepatic biliary tract → direct hyperbili, cirrhosis, liver failure. Etiology unknown. • 2nd type of BA ("Biliary Atresia Splenic Malformation) is associated with laterality malformations - situs inversus, asplenia/ polysplenia, malrotation, interrupted IVC, cardiac anomalies. • 3rd type is associated with other congenital anomalies- intestinal atresia, imperforate anus, kidney and cardiac anomalies.

Biliary Atresia continued on next page →

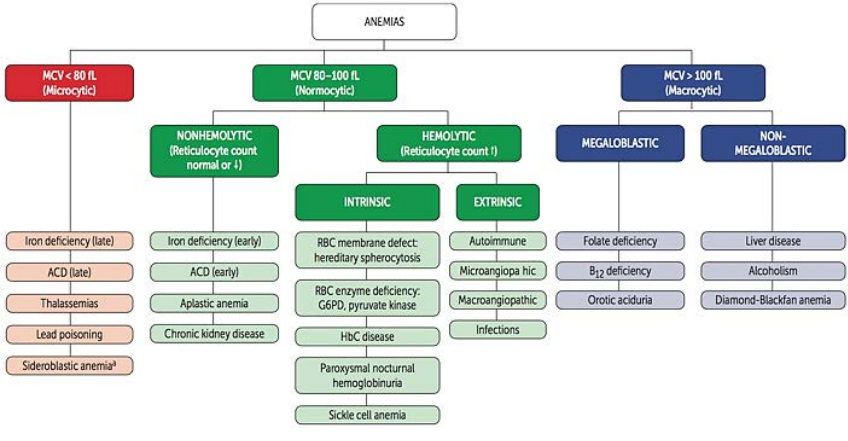
Newborn GI	
Biliary Atresia	
Presentation	**Jaundice, acholic stools,** hepatomegaly
Workup	Bilirubin (**conjugated hyperbi**li), liver enzymes(tr**ansaminitis, elevated GGTP),** abd u/s **(inability to visualize gallbladder or small gallbladder**), HIDA scan (looks for excretion of bile from liver), liver biopsy, intraoperative cholangiogram
Treatment	• 100% mortality by age 2 if untreated. • **Kasai procedure (hepatoportoenterostomy)** - (best if done before 2 months. Removal of portal tract remnant followed by Roux-en-Y anastomosis of jejunal loop directly to liver capsule to allow bile drainage. • 60-70% of patients undergoing Kasai will **eventually need liver transplant** 

Anemia

Characterization by MCV and RC

Reticulocyte count	Microcytic anemia (MCV <80)	Normocytic anemia (MCV 80-100)	Macrocytic anemia (MCV >100)
LOW	Iron deficiency (***EBG***) Lead poisoning (***EBG***) Chronic disease Aluminum toxicity Copper deficiency Protein malnutrition	Chronic disease RBC aplasia (TEC, infection, drug induced) Malignancy JRA Endocrinopathies Renal failure	Folate deficiency Vitamin B12 deficiency Aplastic anemia Congenital bone marrow dysfunction (Diamond-Blackfan or Fanconi syndromes) Drug induced Myelodysplasia Trisomy 21 Hypothyroidism
NORMAL	Thalassemia trait Sideroblastic anemia	Very Acute bleeding Phlebotomy Hypersplenism Dyserythropoietic anemia II	
HIGH	Thalassemia syndromes Hemoglobinopathies	Antibody-mediated hemolysis Hypersplenism Microangiopathy (HUS, TTP, DIC, Kasabach-Merritt) Membranopathies (spherocytosis) Enzyme disorders (G6PD, PK) Hemoglobinopathies Acute/chronic bleeding	Dyserythropoietic anemia I, III Active hemolysis

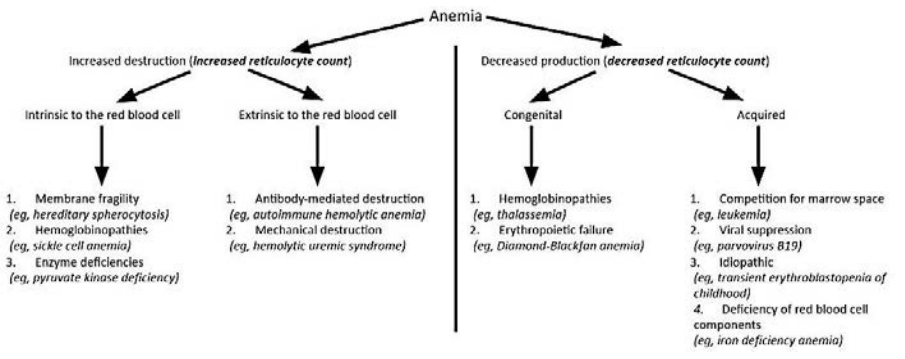
Approach to Anemia (by Retic vs. MCV)



Anemia continued on next page →

Anemia

Approach to Anemia (by Retic vs. MCV)



Microcytic Anemias

	Serum Iron	TIBC	%Transferrin sat (Fe/TIBC)	Ferritin	Smear
Iron def anemia	↓	↑	↓<12%	↓	Hypochromic, microcytic
Anemia of chronic disease (inflam)	↓	↓	Normal >18%	Normal/↑	Hypochromic, normocytic, or microcytic
Lead poisoning	↑/normal	↓/normal	Normal	↑/normal	Stippled, microcytic
Sideroblastic	↑	↓	↑/normal	↑	Ringed siderbloasts (BM)
Hemochromatosis	↑	↓	↑	↑	
α/β Thalassemia	Normal	↑	Normal	Normal	Microcytci RBCs, Target cells (α) basophilic stippling (B)

Thalassemia	Variant	Defect	Clinical
α	**α thalassemia minima**	1 α-globin allele	**Asymptomatic** (no anemia)
	α thalassemia minor	2 α-globin alleles	**Minimal anemia** ("α-thalassemia trait"), +target cells
	Hemoglobin H disease	3 α-globin alleles	**Hgb H** (4 β-globins) Microcytic anemia, **Chronic hemolytic anemia**, pallor, splenomegaly, decreased lifespan
	Hydrops fetalis	4 α-globin alleles	**Hgb Bart's** (4 γ-globins) **Fetal edema** → intrauterine death
β	**β thalassemia minor**	1 β-globin allele	**↓β-globin, ↑HgB A2** ($\alpha 2\delta 2$) **Minimal anemia** ("β thalassemia trait")
	β thalassemia major	2 β-globin alleles	**Absent β-globin, Hgb** F ($\alpha 2\gamma 2$) + **HgB A2** **Severe anemia**

Sickle Cell Anemia

Patho	Autosomal recessive missense mutation (Val → Glu) at position 6 of B-globin gene (Ch. 11)
Clinical	**Vaso-occlusive (pain) crisis**: ischemia → pain • Triggers: cold weather (vasospasm); hypoxia; Infection; dehydration; acidosis; alcohol intoxication; emotional stress; pregnancy; exertional stress. • **Bones**: femur, tibia, humerus, and lumbar vertebrae (femoral head --> avascular necrosis). • **Joints and soft tissue:** dactylitis or hand and foot syndrome-painful and swollen hands/feet • **Abdomen**: can mimic an acute abdomen. • **Renal:** papillary necrosis --> isosthenuria (ie, inability to concentrate urine). • **Lungs**: acute chest syndrome. • **CNS**: Cerebral infarction (children → exchange transfusion), hemorrhage (adults), seizures, transient ischemic attacks, cranial nerve palsies, meningitis, sensory deficits, and acute coma. • **Skin:** Ulceration, especially over bony prominences (malleoli) • **Eye**: Retinal hemorrhages, proliferative retinopathy (more common in HbSC) • **Penis**: Prevents drainage of blood from the corpus cavernosum leading to priapism.

Anemia

Sickle Cell Anemia

Clinical cont.

Acute chest syndrome (ACS): pulmonary infarction → fever, cough, chest pain, chills, SOB
Hyposplenia: splenic autoinfarction → susceptible to infections w/ encapsulated bacteria
Osteomyelitis: Salmonella > Staph in children, treat w/ CTX/Vanc
Fever: Viral; Bacterial including encapsulated organisms: H. flu, S. pneumoniae.
- Children w/ sickle cell anemia also have lower serum IgM levels, impaired opsonization, and sluggish alternative complement pathway activation, so are susceptible to Mycoplasma pneumoniae, Salmonella typhimurium, Staphylococcus aureus, and Escherichia coli.

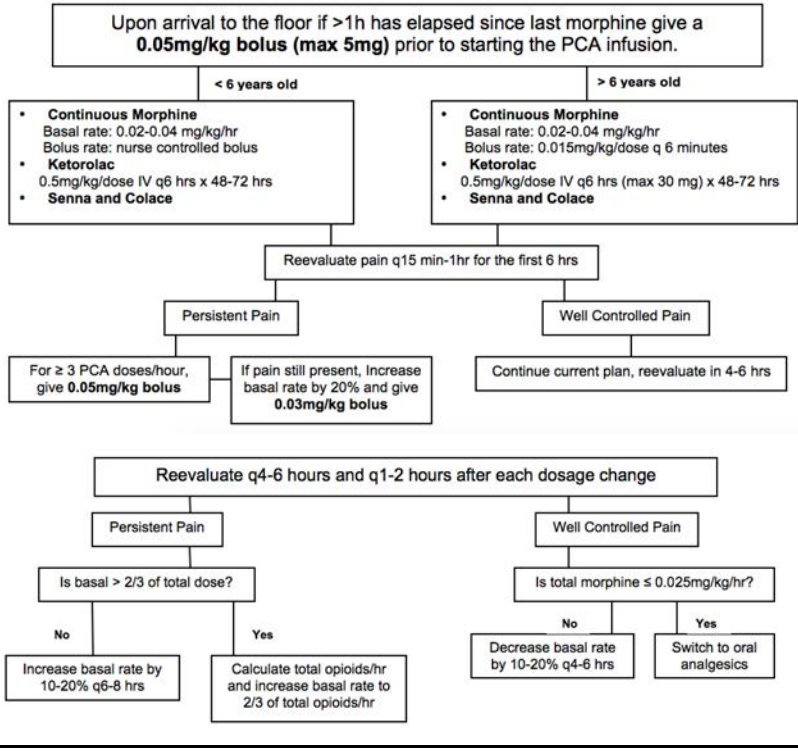
Sepsis: Strep pneumo is most common cause
Aplastic crisis: decreased retic/RBCs/plts/WBCs, parvo B19 infection, pallor, weakness, fatigue
Splenic sequestration crisis: splenic vascooclusion → rapid splenomegaly, prior to autosplenectomy

Diagnosis

- **Labs (VOC):** CBC w/ manual diff: compare to baseline Hct, Reticulocyte count, Electrolytes including BUN and creatinine, Clot (hold for Blood Bank) ,Blood culture for first temperature >101 and qday w/ temperature spikes, ABG (if hypoxic)
- **Studies (VOC):** CXR: PA and Lateral (fever, chest wall pain, hypoxia, or respiratory symptoms)
- **Labs (fever):** CBC w/ manual diff: compare to baseline Hct, Reticulocyte count, Electrolytes including BUN and creatinine, Clot (hold for Blood Bank), Blood culture for first temperature >101 and qday w/ temperature spikes, Room air ABG, Throat culture (if suggestive on exam), Stool specimens (if having diarrhea), Viral panel, LP (if neurologic signs/symptoms)
- **Studies (fever):** CXR: PA and Lateral (fever, chest wall pain, hypoxia, respiratory symptoms, or < 36 months of age), UA/culture (cath all males < 6 mo, females <2 yo, or any child w/ urinary symptoms)

Treatment

Inpatient Management of Vasoocclusive Crisis (see Sickle Cell Cards on next page for more details)
*** NOTE: Card applies only to BMC. BCH practices may vary.**



Anemia continued on next page →

Anemia

Treatment cont.	**Inpatient Management of Sickle Cell Fever** • IV bolus of 10 - 20 ml/kg if dehydrated→ IV fluids @ 1.25 Maint (+/- for fluid intolerance v. dehydration) • Ceftriaxone: 50mg/kg IV q24h (max 1g/day) after cultures. If suspecting meningitis: 50mg/kg IV q12h (max 2g/day). Give <1 hour after arrival. • Vancomycin: 40-60 mg/kg/day IV divided q6h for CNS involvement, septic shock, or central line/ port. • If allergic to cephalosporins or PCN, then give Vancomycin as above and Gentamicin: 7.5mg/kg IV q24h if <10 yo; 6mg/kg/day IV q24h if >10 yo. **Outpatient Management and Follow Up:** • Observe in ED for 2 hrs after giving ceftriaxone. Return if: Temp >40; poor PO intake; lethargy; respiratory symptoms; pain • Follow up in Hematology clinic, PMD's office, or ED in 24 hours for reevaluation & 2nd dose of CTX • Follow up blood culture at 24, 48, and 72 hours→ Call PMD regarding ED visit & to assure follow up

BMC Inpatient Management Guidelines for Patients w/ Sickle Cell Disease (SCD)

*Should not replace clinical judgment or pedi heme consult
Pediatric Hematology Consults: On Call Pager 5731

- Consult Pediatric Hematology on admission for all patients w/ SCD (place consult order in EPIC and page on-call pager 5731 to discuss)
- Please page daily after rounds to discuss management and as needed
- Please read daily consult note for detailed recommendations

Management of Vaso-occlusive Episodes (VOE)

Opioids	• All patients being admitted for VOE should receive scheduled or continuous IV opoids. PRN dosing is inappropriate. Start w/ morphine unless noted otherwise in chart or by patient/parent. (dosing calculator available on the pediatric emergency medicine intranet site) • For patients 7 years and older: PCA (basal + demand dose) • For patients under age 7 or not developmentally ready for PCA demand dosing: PCA basal rate only + IV PRN, OR scheduled IV opioid q2-4 hours
Other analgesics	• Standing NSAID: ketorolac on admission; after 72 hours switch to standing ibuprofen every 6 hours. • Additional modalities: hot packs, lidocaine patches, distraction, child life, relaxation, acupuncture on Wednesdays
Fluids, monitoring & labs	• Hydration: D5 1/2NS at 1.25x maintenance is crucial to lessen sickling. • Continuous pulse oximetry • Routine labs are not needed for uncomplicated VOE • DVT prophylaxis should be addressed for all patients per inpatient protocol
Mgmt & prevention of opioid side effects	• Constipation: Standing stimulant laxative (senna) and daily Miralax on admission. Titrate to achieve one soft, formed stool every 1-2 days. Escalate as needed, may add Mg citrate, milk of mag, lactulose, and (rarely) methylnaltrexone. • Pruritus and nausea: Start w/ camphor-menthol lotion for mild itching. Next step is a naloxone drip at 0.5 mcg/kg/h, titrate up to 2 mcg/kg/h every 3-4 hours for significant itching/nausea. Can then add Zofran. Avoid Benadryl given sedating effect. • Hypoventilation: Maintaining ventilation is crucially important in preventing atelectasis and ACS. ▪ Incentive spirometer 10x per hour while awake and q4 overnight. For younger patients use bubbles or pinwheel. ▪ Keep head of bed elevated to 30 degrees at all times ▪ Have patient sitting up in bed, out of bed to chair, and ambulating as tolerated ▪ Standing albuterol q4-6 hours for patients w/ asthma, history of wheezing w/ prior VOE, pain in the chest or back, or any current wheezing or cough ▪ Oxygen overnight: Goal O2 sat > 96% or patients known baseline. Can provide NC O2 at 0.5-1L for mild desats while asleep. This does not replace the need for incentive spirometry. ▪ Continue any home respiratory therapies (home O2, CPAP, etc)

Anemia

Titration of PCA/ opioids

- Use patient reported pain score (compare to baseline/chronic pain level) AND change in pain AND patient functional status to assess pain control
- Assess for VOE versus opioid side effects to help w/ dose adjustment
- Re-assess pain control frequently, especially during first 24 hours, and adjust PCA as needed w/ a goal of providing 2/3 of total opioid dose as basal and 1/3 as demand
- Consider increasing basal rate by 20% overnight early in the admission to avoid falling behind in pain control while asleep
- As pain is captured, wean PCA rate and then switch to orals

Weaning to orals

Please discuss patient specific plan w/ pedi heme; details will depend on length of admission, pain tolerance, and patient preference. In general, when pain is well controlled replace the basal PCA w/ SCHEDULED long or short acting oral medication (MS Contin, oxycodone, or hydromorphone) leaving PCA demand button. If pain remains well controlled after 12-24 hours, then replace PCA demand w/ a standing short acting medication (often oxycodone, tramadol, or hydromorphone). This step should be considered a both a conversion and a wean.

Quick conversion from IV to oral opiates (meant as a guide not a mandate)

Total Basal IV morphine use over 24 hours	Total Basal IV dilaudid use over 24 hours	MSContin dose	If using ONLY oxycodone
10mg	2.5mg	15mg PO q12	5mg PO q6
15mg	4mg	15mg PO q8	5mg PO q4
20mg	5mg	30mg PO q12	10mg PO q6
30mg	8mg	30mg PO q8	10mg PO q4

Discharge planning

- Ready for discharge when pain is controlled on oral meds (pain may not be gone at this time)
- Continue standing pain meds x 48 hours at home before tapering to prn
- Anticipate home opioid needs; ask if opioids are available at home, and prescribe meds in hand early on day of discharge; if patient prefers to fill meds at home pharmacy provide written prescriptions early in hospital course-controlled substance prescriptions cannot be faxed or sent electronically. Be aware of specific MA prescribing requirements for opioids.
- Schedule follow-up in Pediatric Hematology clinic w/i a week (clinic phone # 617-414-4841), appointments are available every day Mon-Fri

Management of Acute Chest Syndrome (ACS)

ACS in SCD is multifactorial. Causes include infection, bronchospasm, inflammation, and fat embolization. It can be very serious and needs to be managed very closely.

Optimize Ventilation

Optimize ventilation to prevent serious sequelae from ACS

- Incentive spirometry 10x per hour while awake and q4 hours overnight
- Have patient sitting up in bed, out of bed to chair, and ambulating as tolerated
- Examine patient for any drop in O2 saturation—do NOT simply put on oxygen w/o evaluating.
- Standing albuterol nebulizer q4-6 hrs for ALL patients w/ ACS; add inhaled corticosteroid only if on one at home
- Consult pediatric pulmonology for any patient w/ wheezing, severe ACS, or as needed to help optimize respiratory status; please notify pedi pulmonology when of their patients are admitted w/ ACS
- Consider high flow NC or bipap as appropriate (requires PICU transfer)

Fluids, Monitoring & Labs

- Fluid balance needs to be monitored carefully; patients w/ SCD require increased IVF in cases of VOE or fever/dehydration, however over-hydration can worsen ACS. In general use IV + PO at 1x maintenance for patients w/ ACS. Must have strict Is/Os ordered and reviewed regularly to adjust fluids as needed.
- Continuous pulse oximetry
- All patients w/ ACS should have an active type and screen
- DVT prophylaxis should be addressed for all patients per inpatient protocol

Anemia continued on next page →

Anemia

Management of Acute Chest Syndrome (ACS)

Antibiotic Treatment	• Include coverage for pneumococcus and atypicals (typically ceftriaxone and oral azithromycin). • See Fever guidelines for details.
When to Transfuse	• Only transfuse when approved by pediatric hematology • Need to balance need for immediate treatment w/ long term risks of alloimmunization. If the patient does not have an oxygen requirement we typically attempt medical management w/ antibiotics and aggressive pulmonary toilet for 24 hours before transfusing. Potential indications for transfusion in ACS include a drop in Hb > 2g/dL below baseline w/o appropriate reticulocytosis, a significant oxygen requirement, or worsening work of breathing. • See Blood Transfusions section for details.
Discharge Planning	• Stable for discharge when blood cultures are negative x 48 hours and respiratory status is stable/ improved • Should complete a full course of antibiotics to cover both pneumococcus and atypicals • Schedule follow-up in Pediatric Hematology clinic w/i a week (clinic phone # 617-414-4841), appointments are available every day Mon-Fri • Please refer to Pediatric Pulmonary for outpatient follow-up (referral for "SCD w/ ACS")

Management of Fever (temp > 101.3 if over 2 months of age)

- Detailed history and physical exam to identify potential source
- Lab studies
  - CBC w/diff, retic count, blood cultures
  - UA and cx as appropriate
  - Consider throat culture, viral respiratory panel, other studies as indicated
  - CXR (PA and lateral) in patients with respiratory symptoms or hypoxia (including O2 sats > 3% below baseline)
- Antibiotics (goal within 30 minutes): Do not delay treatment while awaiting lab results and CXR; needs empiric antibiotics even if a source of infection is identified
  - Ceftriaxone 50 mg/kg IV or IM (max dose 2g)
  - Add Vancomycin for hemodynamic instability or meningitis; consider in patients with port or history of infection with resistant organism.
  - If allergic to ceftriaxone use Clindamycin, or Levofloxacin if over age 18
  - Add Azithromycin PO for pts with positive CXR or respiratory symptoms

Blood Transfusions in SCD

Blood Transfusions in SCD are used to increase RBC mass and oxygen carrying capacity and to decrease proportion of sickle cells. Acute benefits of transfusion must be weighed against the long term risks, including alloimmunization. Phenotypically matched (ABO, Rh-D, Kell, C, E), sickle negative, leuko-depleted irradiated packed red blood cells are the blood product of choice. More extensive phenotyping needed for patients on chronic transfusion. It may take hours for the blood bank to find matched blood, and even longer in cases of alloimmunization so maintain an active type and screen if you anticipate needing to transfuse a patient.

Potential Indications for Transfusion	• Aplastic crisis/acute anemia (drop in Hb > 2g/dL below baseline) w/o an appropriate reticulocytosis • Acute chest syndrome (ACS) not responsive to medical management or severe disease/ hypoxemia • Symptomatic anemia • Pre-procedure prophylaxis (goal Hb of 10 g/dL) • Splenic sequestration (should see drop in platelet count as well; monitor spleen size and labs frequently).
Amount of Blood to Transfuse	Based on goal Hb • mL of PRBC = (desired Hb - current Hb) x (wt (kg) x Blood Vol(ml/kg)) /(Hb of PRBC) • Blood volume = 80mL/kg for children • Hb of PRBCs = 18.5g/dL at BMC • 1 unit PRBC = 250-350 ml; consider rounding down to a whole unit to avoid extra donor exposure. Premedicate only if history of transfusion reaction. Need for post-transfusions labs to be dictated by individual case, but typically 4 hours after transfusion has ended to allow time for fluid shifts.

Anemia

Hemolytic Anemias

	Path	Smear	Coombs	Clinical/Dx	Treatment
Drug-Induced	Drug induces IgG → cross-react w RBCs	Burr Cells Schistocytes	Direct (+)	Cephalosporins, PCNs, Quinidine, NSAIDs, Methyldopa	Stop drug
Autoimmune Hemolytic Anemia	Warm - IgG: Primary or Secondary (HIV/ EBV, SLE,, Drugs (PCN), ALPs/ immunodeficiencies, Evans, Transplant,non-Hodgkin Lymphoma)	Spherocytes	Direct (+) IgG +/- C3	Asymp/life-threatening hemolytic anemia (mainly extravascular), splenomegaly,, indirect hyperbilirubinemia, elevated LDH, venous thromboemboli	First line: RBC Transfusion, Prednisone (long taper over ~3-6 months), 2nd line: Rituximab, 3rd line immunosuppressantsS plenectomy
	Cold - IgM: EBV (mono), Mycoplasma	Agglutination	C3+	Hemolytic Anemia (intravascular),indirect hyperbilirubinemia, elevated LDH, hemoglobinuria, low haptoglobin l	RBC transfusion, once Hb is high enough IVF support to protect kidneys, Avoid cold (warmed IVF/blood); second line: Rituximab, plasmapheresis
	Paroxysmal Cold Hemoglobinuria (PCH): IgG (Donath-Landsteiner Ab): EBV, mycoplasma	Spherocytes or bland smear	Must ask blood bank to look for Donath-Landsteiner Ab	Hemolytic Anemia (extra/ intravascular), indirect hyperbilirubinemia, elevated LDH	RBC transfusion, warmed IVF/blood, keep warm
Mechanical	Microangiopathici: DIC, TTP,HUS, Macroangiopathic: Kasabach-Merritt Syndrome,AS, Pros. valves	Schistocytes	Neg	Hemolysis + Thrombocytopenia DIC: fever, hypotension, prolonged PT/PTT and low fibrinogeni TTP: Hemolytic anemia, thrombocytopenia +/- fever, renal insult, and neurologic changes, normal PT/PTT/fibrinogen, low ADAMTS13 activity HUS: hemolytic anemia, thrombocytopenia, fever, bloody diarrhea (E Coli) Atypical HUS: hemolytic anemia, thrombocytopenia, fever (stress trigger)	TTP: plasmapheresis, Sepsis: Treat underlying cause
Hereditary Spherocytosis	Defect in RBC membrane (vertical interactions, ex band 3, ankyrin)	Spherocytes +Osm. frag	Neg	Increase MCHC, Jaundice/gallstone, aplastic crisis	Folic acid, transfusions prn, +/-Splenectomy
Hereditary Elliptocytosis	Defect in RBC membrane (horizontal interactions, ex spectrin)	Elliptocytes	Neg	>50% elliptocytes on blood smear, ranges from clinically silent (no evidence of hemolysis) to chronic hemolytic anemia	None to folic acid +/- splenectomy
G6PD Def	Oxidants (fava, sulfa, dapsone, INH, quinine)→ hemolysis	Bite cells Heinz bodies	Neg	Jaundice, dark urine, back pain Epi: Asian, African Am, Middle E. Genetics: X-linked	Avoid oxidants Transfuse
Pyruvate Kinase Def	PK is required for RBC glycolysis	Dec. PK activity	Neg	Mild to severe chronic anemia, gallstones, iron overload	Folic acid, Transfusion, +/- Splenectomy
Paroxysmal Nocturnal Hemoglobinuria	Complement-med. intravascular RBC lysis	Absent CD55/59 Inc. LDH	Neg	Pancytopenia, Venous thrombosis (abd/cerebral), hemoglobinuria	Eculizumab Iron/Folate

Anemia continued on next page →

Anemia

Other Normocytic Anemias

	Path	Smear	Coombs	Clinical/Dx	Treatment
CKD-related	ESRD→ EPO def.	Normochr. normocytic		SE's of EPO: HTN, HA, Flu-like sx	EPO/Fe
Aplastic	BM failure	Pancytopenia		Pallor/fatigue, infections, bruising	Underlying

Macrocytic Anemias

	Path	Smear	Coombs	Clinical/Dx	Treatment
Folate def	Alcoholism, AEDs, severe anorexia/dietary limitations	Megaloblastic macrocyt.		Pallor/fatigue, atrophic glossitis	PO folate
B12 Def	Pernicious, chronic gastritis, malabsorp, parasite (*D. latum*), severe anorexia/dietary limitations	Megaloblastic macrocyt. Inc. methylmalonic acid and homocystine		Pallor/fatigue, subacute combine degeneration, atrophic glossitis, dementia	IM/IN B12 HD PO B12 Anti-IF Abs

Pediatric-Specific Anemias

	Path	Smear	Coombs	Clinical/Dx	Treatment
Prematurity	Preterm (dec EPO, dec. RBC life, inc. phlebotomy			Asymp or tachycardia, apnea	Fe/dec phleb
Erythroblastosis	ABO set-up/Rh disease, minor blood group Ags			Jaundice/hyperbili in 1st 24 HOL	Transf/Photo
Fanconi	AR/XL mut→aplastic	Pancytopenia, aplastic		Short, microceph, bent thumb, freckles, cafe-au-lait, ear abn.	Transfusion, +/- SCT
Diamond-Blackfan	Pure red cell aplasia	Macrocytic, normal WBC		Short, web neck, shield chest, cleft lip, triphalangeal thumbs	Steroids Transfusion

Transfusion Medicine

Consenting a Patient for Blood Products

Risks	• Fever, chills, hives/itching, and shortness of breath (can be managed w/ medicines) • Hemolytic transfusion reaction or transfusion-related lung injury (rare) • Bacterial or viral infection (hepatitis C, hepatitis B, HIV, malaria). Blood is extensively screened to prevent this.
Benefits	Improve blood clotting or oxygen delivery
Alternatives (may not work as well/quickly)	• Colony stimulating factor • Vitamin K • No treatment (note: parents may not refuse blood products in life-threatening situations)

Acute Transfusion Reactions

	Time	Path	Clinical	Treatment
Anaphylactic	Sec-Mins	IgA def → anti-IgA/IgG Abs	Shock, urticaria, angioedema, HoTN	EPI, IVF, O2 Washed RBCs
Urticarial	Anytime	Type I HSR (IgE mediated)	Hives, erythema	Benadryl, Wash
Anaphylactic	W/in mins	IgE-mediated, bradykinin-med if ACEi	HoTN, wheeze, N/V/D	ABCs, Epi, Beny
Acute Hemolytic	First 15 mins	ABO/Kidd incomp.→ hemolysis/comp activ. Rh/Kell/Duffy incom → hemolysis +Coombs, Pink plasma	Fevere, chills, back or flank pain, bleeding/DIC	NS/lasix M/f HoTN, AKI/DIC

Transfusion Medicine

Acute Transfusion Reactions

	Time	Path	Clinical	Treatment
Febrile Non-Hemolytic	1-6 hrs	Donor WBCs → TNF-alpha, IL □ RBC: anti-HLA, Plt: donor WBC cytokines	Low grade fever, chills, HA, flushing	APAP, meperidine Leukoreduction
Delayed Hemolytic	>3 days	Anamnestic IgG against exposed Ag (Kidd/ Duffy/Kell) → extravasc. hemolysis	Fever, anemia, jaundice, flu-like illness	R/O AIHA (+DAT)
Trans-related Lung Injury (TRALI)	1-6 hrs	Pre-Tx stress activates lung endotheial cells and primes PNMs Post-Tx donor anti-HLA Ab→primed PMNs	Fever, SpO2 <90%, PaO2/FiO2 <300 B/l pulm edema.	ABCs, O2, mech vent. Dec. in male donor
Trans-Assoc. Circ Overload (TACO)	1-6 hrs	High risk in elderly, CHF, CKD, chronic anemias	Cardiogenic edemas → dyspnea, hypoxemia	Stop, sit up , O2, diuretics, slower rate (1 cc/kg/hr)
Bacterial Sepsis	15-60 mins	Bacteria >> Viruses in donor blood. RBC: Yersinia, PsA, Plt: Staph epi (GPCs)	Fever (>39), rigors, Abd sxs, HoTN, shock	Antibiotics Screen
Specialized RBC's	**Irradiated**	BMT recipients, acquired.congenital cellular immunodef., blood from 1st/2nd deg. relatives		
	Leuko-reduced	Chronic transfusion, CMV seronegative at-risk pt's (AIDs, transplant), potential transplant candidates, previous febrile nonhemolytic transfusion reaction		
	Saline Washed	IgA def, Complement-dependent AIHA, allergic reactions w/ RBC transfusion		

Transfusion Products

Component	Contents	Vol	Indications	Contraindications	Considerations
Red Blood Cells (RBC)	Concentrated RBCs	200-300 mL	Symptomatic anemia (Hgb <7 g/dL); Acute hypovolemia due to hemorrhage	Pharmacologically treatable anemia (eg. iron, folate, B12 deficiencies)	Must be ABO compatible, cross-match compatible; Infuse w/i 4 hr or as patient tolerates*
Platelets (PLT)	>5.5×10^{10} PLT per 50 ml	60 mL	Bleeding related to thrombocytopenia or PLT dysfunction; Low PLT count	Patients w/ TTP, HUS or HIT; Not as effective in ITP, DIC, sepsis, uremia, hypersplenism	ABO and Rh compatible w/ patient's RBC if possible; Infuse 5-10 mL/min or as tolerated, usually w/i 1 hour.
Leukocyte Reduced RBC or PLT	RBC or PLT w/ WBC: <5×10^{6}	Similar to original	RBC/PLT indications plus history of febrile transfusion reactions; At risk of CMV and alloimmunization.	See RBC or PLT.	See RBC or PLT.
Cryo-precipitate (Cryo)	80-120 units Factor VIII; 150-250 mg Fibrinogen;	25 mL 40-70% orig.l plasma VWF	Fibrinogen Deficiency or dysfunction;	Safer and more concentrated therapy available (ie, for specific clotting factors).	Consider alternative Therapies; Should be ABO compatible if possible;
Fresh Frozen Plasma (FFP)	400 mg fibrinogen and 200 units of other clotting factors	200-250 mL	Clotting factor def. (if specific factor conc. not avail.), Ig. Volume required Severe liver disease; Rapid warfarin reversal; Vit K def. w. active bleed TTP; DIC; massive crystalloid + RBC transf. w/ ongoing bleeding; C1 esterase inhib def.	Safer and more concentrated therapy available (ie, for specific clotting factors).	Should be ABO compatible; Infuse 5-10 mL/min or as patient tolerates. Give 10-15 cc/kg.

Pancytopenia	
Marrow	Decreased cellularity (aplastic, myelofibrosis, chemo), normal cellularity (MDS, PNH), increased cellularity (leukemia, lymphoma, MM, mets)
Systemic	Spleen (cirrhosis, myelofibrosis), toxin (EtOH, cocaine), nutrition (B12/folate def), rheum (SLE, RA), sepsis
Meds	NSAIDs, PPIs, sulfas, antihistamine, chemo, anticonvulsants, antiprotozoals, heavy metals
Infectious	Virus (HIV, HB/CV, CMV/EBV, Parvo), bacteria (Brucella, TB), fungi (Histo), parasites (Leishmania, Malaria, Schisto)

Thrombocytopenia				
Definition	Platelets <150,000 → increased risk of hemorrhage, mucosal bleeding, petechiae, purpura, ecchymoses			
Pathogenesis	• **Decreased platelet production**: virus (EBV, Hep C, HIV, parvo), meds (chemo, thiazode, linezolid, chloramphenicol), leukemia, myelodysplasia, EtOH, BMF syndromes/aplastic anemia, Vit B12/Folate deficiency,congenital thrombocytopenias (WAS, TAR, MYH9) • **Increased platelet destruction**: virus (HIV, HSV/VZV, EBV), meds (heparin), ITP, DIC, TTP, HUS, HIT, HELLP, anti-phospholipid syndrome, vasculitis, vascular malformation(Kasabach-Merritt). • **Hypersplenism**: splenomegaly (cirrhosis, portal HTN) • **Dilutional/pooling**: massive transfusion, hypothermia/neonatal cooling			
Labs	Plts <150,000, normal PT/PTT Blood smear: poor production (typically normal/small plts), increased destruction (large/giant platelets)			
Causes		**Path**	**Clinical/Diagnosis**	**Treatment**
	ITP	Autoimmune: primary or secondary (Evans, immunodeficiency (ALPs, others), infectious (HIV, Hep), Rheum (, SLE), Transplant, medications/ vaccines)	Plt <100,000 Antecedent viral infection Diagnosis of exclusion ***ITP EBG***	Self-limited, Close Observation, Steroids, IVIG TPO-RA, immunosuppressants
	HIT	Heparin (>days of treatment) → complet w/ Plt F4 → complex formation→ Plt activation/aggreg → thrombosis/thrombocytopenia	Decision to screen based on 4T Score: Thrombocytopenia (>50% fall but >20), timing of plt fall, thrombosis or skin necrosis, other causes If >4 points: send ELISA/SRA	Stop heparin Lifelong avoidance Use argatroban, fondaparinux
	TTP	Dec. ADAMTS 13 (uncleaved vWF multimers) → plt agg. → thrombosis → plt consumption + microang. Hemolysis (schistocytes) Primary or Secondary (pregnancy, HIV, rheumatologic dx, transplant); congenital TTP can present late	Hemolytic Anemia and Thrombocytopenia, +/- Renal failure, and Neuro	Plasmapheresis, +/- Glucocorticoids, +/- Rituximab
	Classic HUS	E. coli O157:H7 → plt agg. → thrombosis → plt consumption + microang. Hemolysis (schistocytes)	Hemolysis, uremia, dec. plts, inc, fever, bloody diarrhea	Supportive, IVF, dialysis
	Bernard-Soulier	Dec. GpIb → dec. plt adhesion	Large/dec plt count	Supportive, perisurgical planning
	Glanzmann	Dec. GpIIb/IIIa → dec. plt agg	Normal plt countT	Supportive, perisurgical planning
	Anti-phospho-lipid syndrome	Persistent Antiphospholipid Abs w/ thrombosis or pregnancy complications → arterial/venous thrombosis	+Antiphos. Abs (anticardiolipin ab, B2glycoprotein ab, lupus Anticoag), thrombocytopenia; primary or secondary (underlying rheumatologic dx)	Anticoag: Hep/Warf Hydroxychloroquine
	HELLP syn	Preeclampsia + Hemolysis, Elevated Liver enzymes, Low Plts, HTN	Schistocytes on smear	Induce labor Deliver

Coagulation Disorders

Coagulopathy and Hypercoagulability

	Path	Clinical/Diagnosis	Treatment
VWD	AD/AR def. of VWF → abnormal mucocutaneous bleeding	Bruising, mucosal bleeding, menorrhagia. Typically VWF Ag and Activity low, may have decreased FVIII activity and prolonged PTT	Bleed: DDAVP (if responder) Severe bleed: VWF conc. Menorrhagia: OCPs Avoid aspirin use
Hemophilia	X-linked inheritance Hemophilia A: FVIII Def Hemophilia B: FIX Def	Hemarthrosis, ICH, mucosal bleeding, epistaxis, occ. hematuria, GI bleed. Prolonged PTT, decreased FVIII or FIX activity; PT and plt wnl	Hemophilia A: FVIII concentrates (DDAVP for some mild pts) Hemophilia B: FIX
Vit K Def (Warfarin Use)	Dec. synthesis of FX, IX,VII, II, Protein C, S Epi: neonates, antibiotics, malabsorp. (panc, celiac, IBD)	Easy bruising, mucosal bleeding, melena, hematuria, ICH (newborns) Inc. PT and PTT	Vit K (PO or IM) Acute bleed: FFP or PCC
DIC	Widespread pathologic intravascular coagulation → plt/factor consump., hemolysis Causes: **STOP M**aking **T**hrombi (**S**epsis, **T**rauma, **O**B comp, **P**ancreatitis, **M**alig, **T**ransfusion	Bleeding from wound/surgical site Hemoptysis, venous/art. Thrombosis → organ ischemia. HypoTN, jaundice, ext. cyanosis. Dec. Plts, fibrinogen, haptoglobin Inc. PT/PTT, D-Dimer, LDH	Treat underlying cause Aggressive support Acute bleed: Plt transfusion + FFP +/- RBC transfusion.
Inherited Hyper-Coagulable States	Factor V Leiden	FV cannot be inactivated by Prot C	Life-long anticoagulation in the setting of homozygous inheritance and prior venous thromboembolism (VTE)
	Prothrombin 20210 mutation	Increased Prothrombin levels	
	Antithrombin deficiency	Reduced inactivation of F2 (thrombin)	
	Protein C or S Deficiency	Reduced F5/8 inactivation, purpura fulminans w/ homozygous protein C def.	

Lab Changes by Disorder

	Platelet count	**BT** (NO LONGER PERFORMED)	PT	PTT
ITP	↓	↑	-	-
TTP-HUS	↓	↑	-	-
Hemophilia A/B	-	↑	-	↑
VWF Deficiency	-	↑	-	-/↑
DIC	↓	-	↑	↑
Vit K def/Warfarin	-	↑	↑	↑/-
End-stage Liver Disease	↓/-	↑/-	↑	↑

Hematologic Disorders of the Newborn/Child

	Pathogenesis	Clinical	Diagnosis	Treatment
Anemia of Prematurity	(1) Impaired EPO prod (2) Shortened RBC life (3) Iatrogenic blood loss	Asymptomatic Apnea, poor wt gain, tachycardia	Hemoglobin/Hct Reticulocyte count, Smear	Dec. phlebotomy Iron supplementation Transfusions
Transient Erythroblastopenia of Childhood	Acquired red cell aplasia (6 mo - 5 yo)	Gradual pallor, fatigue, etc.	Normocytic/chromic anemia, Hb (3-8), Reticulocyte count	Self-resolving

Hematologic Disorders continued on next page →

Hematologic Disorders of the Newborn/Child				
	Pathogenesis	**Clinical**	**Diagnosis**	**Treatment**
Neonatal polycythemia	Erythropoiesis from intrauterine hypoxia Risks: IGUR, maternal DM/HTN, smoking, delayed cord clamping, twin-twin transfusion	Ruddy skin, hypoglycemia, resp distress, cyanosis, apnea	Hct >65% in FT	If asymp → hydration/feeding If symp → partial exchange trans.

Anti-platelet, Anticoagulant Medications			
	MOA	**Monitor/Reversal**	**Side Effects**
Aspirin	Irrev. Inhibits COX → blocks production of Thromboxane A2 → blocks plt aggr.	GI bleed, Hyperventilation (resp alkalosis), Tinnitus, Reye Syndrome	
Clopidogrel	Inhib. Platelet ADP receptors → blocks GPIIb/IIIa expression → blocks plt aggr.	GI bleed	
Abciximab, Eptifatide (GP IIb/IIa inhibitors)	Binds platelet GP IIb/IIIa → blocks platelet aggr.	GI bleed, N/V, back pain	
Aggrenox	Inhib. Adenosine deaminase _ phosphodiesterase → inc adenosine/cAMP → vasodilation +dec. Plt aggr.	Dizziness, headache, nausea	
Heparin (continuous infusion)	Binds/activates antithrombin → inactivates thrombin/FXa → inhibits coagulation	PTT, anti-Xa (goal 0.3-0.7) Protamine sulfate (100%)	HIT, hypersensitivity, narrow therapeutic window
Enoxaparin, Dalteparin (LMWH) (SQ injection)	Binds antithrombin → inactivates FXa→ inhib. coagulation	Not routine/anti-Xa (0.5-1) Protamine sulfate (60%)	HIT (rare)
Fondaparinux (direct Factor Xa inhib) (SQ injection)	Binds antithrombin → inactivates FXa → inhibits. coagulation	Not routine, antiXa Not antidote	No risk of HIT (b/c does not bind PF4)
Rivaroxaban, Apixaban, and Edoxaban (direct Factor Xa inhib) (Oral)	Binds FXa → inhib. activation of FII (prothrombin→ thrombin)	Not routine /Andexanet alfa (severe/life-threatening bleeding)	Bleeding
Dabigatran (direct thrombin inhib) (Oral)	Direct thrombin (factor II) inhibitor	Not routine/Idarucizumab (severe/life-threatening bleeding)	Bleeding
Argatroban, Bivalirudin (Direct thrombin inhib) (continuous infusion)	Binds thrombin → inhibits coagulation	PTT (q2), PTT (1.5-3x baseline), check LFTs prior	Hemorrhage, hypotension
Warfarin (Oral)	Inhib. Epoxide reductase → inhib Vit. K dep. clotting factors: 2,7,9,10, protein C/S	INR Start IV Vit K, FFP q4, Kcentra (if severe)	Bleeding, Tetratogen, drug-induced interactions (cyt p450), skin necrosis

Note: Antibiograms are changed annually and digital Antibiogram+ is the most up to date resource. The following are based on BCH Antibiogram. **Sensitivities at BMC are different** (e.g., higher rates of clindamycin resistant MRSA)

Gram Negative Susceptibilities

Gram Negative	Amikacin	Ampicillin	Amp-Sulb	Aztreonam	Cefazolin (1st)	Cefepime (4th)	Ceftriaxone (3rd)	Ceftazidime (3rd)	Ciprofloxacin	Gentamicin	Levofloxacin	Meropenem	Minocycline	Nitrofurantoin	Pip-Tazo	Tobramycin	TMP-SMX
Citrobacter	●	-	-	-	-	●	-	-	●	▲	-	●	-	-	-	-	+
E. Coli	●	-	-	-	-	▲	▲	▲	+	▲	-	●	-	-	●	-	-
Enterobacter cloacae	●	-	-	-	-	●	-	-	●	●	-	●	-	-	-	-	▲
Haemophilus influenzae	-	-	▲	▲	-	●	▲	▲	▲	-	-	▲	▲	-	▲	-	-
Klebsiella pneumoniae	●	-	-	-	-	●	▲	▲	●	●	-	●	-	-	▲	-	▲
Moraxella catarrhalis	-	-	▲	-	-	●	▲	▲	▲	-	-	▲	▲	-	▲	-	▲
Neisseria gonorrhoeae	▲	-	-	▲	-	▲	▲	▲	-	▲	-	▲	-	-	-	▲	-
Neisseria meningitidis	-	▲	▲	▲	-	▲	▲	▲	▲	-	-	▲	-	-	▲	-	-
Proteus mirabilis	●	+	▲	-	-	●	●	●	●	●	-	●	-	-	●	-	▲
Pseudomonas aeruginosa	●	-	-	-	-	▲	-	●	▲	▲	-	●	-	-	●	●	-
Pseudomonas aeruginosa, CF	-	-	-	-	-	+	-	▲	-	-	-	-	-	-	▲	▲	-
Stenotro-phomonas	-	-	-	-	-	-	-	-	-	-	+	-	●	-	-	-	●

Key: ● = 90-100%, ▲ = 80-89%, + = 70-79%
Sources exclude outpatient urine

Gram Positive Susceptibilities													
Gram Positive	Ampicillin	Amp-Sulb	Azithromycin	Cefazolin (1st)	Cefepime (4th)	Ceftriaxone (3rd)	Clindamycin	Moxifloxacin	Oxacillin	Penicillin	Tetracycline	TMP-SMX	Vancomycin
Enterococcus faecalis	●	●	-	+	-	-	-	-	-	●	-	-	●
Staph aureus	-	+	-	-	+	+	+	-	+	-	●	●	●
MRSA	-	-	-	-	-	-		-	-	-	▲	●	●
Strep pneumoniae	●	●	-	-	●	●	+	●	●	●	-	-	●
Listeria monocytogenes	▲	▲	-	-	-	-	-	-	-	-	-	▲	-
GBS	▲	▲	-	▲	▲	▲	-	▲	▲	▲	-	-	▲
GAS	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	-	-	▲

Key: ● = 90-100%, ▲ = 80-89%, + = 70-79%

Anaerobe Susceptibilities										
Anaerobes	Ampicillin	Amp-Sulb	Ceftriaxone	Clindamycin	Meropenem	Metronidazole	Moxifloxacin	Penicillin	Pip-Tazo	Vancomycin
Bacteroides fragilis	-	▲	-	-	▲	▲	-	-	▲	-
Clostridium difficile	-	-	-	-	-	▲	-	-	-	▲
Clostridium perfringens	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Oral anaerobes	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲

Key: ● = 90-100%, ▲ = 80-89%, + = 70-79%

Dosing Recommendations for Common Infections	
Infection	**Common First Line Antibiotic Choice, Dose (Max/Dose) and Duration***
Bone and Joint	
Osteomyelitis	Cefazolin 50 mg/kg/dose IV q8 (2g) 4 weeks
Septic Arthritis	Cefazolin 50 mg/kg/dose IV q8 (2g) 3 weeks
Head and Neck	
Acute Otitis Media	Amoxicillin 45 mg/kg/dose BID (875 mg) 5-10 days
Acute Sinusitis	Amoxicillin-clauv 45 mg amox/kg/dose PO BID (1g) 10 days
Strep Pharyngitis	Amoxicillin 50 mg/kg daily (1g) 10 days
Suppurative Cervical Lymphadenitis	Ampicillin-Sulbactam 50 mg amp/kg/dose IV q6 (2g)
Gastrointestinal	
C. difficile	Metronidazole 10 mg/kg/dose PO TID (500 mg) 10 days
Rupture appendicitis	Piperacillin-tazobactam 100 mg pip/kg/dose IV q8 (6g) 7 days
Genitourinary	
PID, outpatient	Ceftriaxone 50 mg/kg/dose IM x1 (250mg) + Doxycycline 2.5 mg/kg/dose PO BID (100 mg) 14 days + Metronidazole 10 mg/kg/dose PO BID (500 mg) 14 days
PID, inpatient	Cefoxitin 40 mg/kg/dose IV q6 (2g) + Doxycycline IV/PO 2.5 mg/kg/dose PO BID (100 mg)
Pyelonephritis	Ceftriaxone 50 mg/kg/dose IV q24 (2g) 10 days
UTI 3-23 months, febrile, healthy, outpatient	Cephalexin 25 mg/kg/dose TID (500 mg) 10 days
UTI >24 months, healthy, outpatient	Cephalexin 25 mg/kg/dose PO TID (500 mg) 3-5 days
Respiratory	
Community-acquired pneumonia, outpatient	Amoxicillin 30 mg/kg/dose PO TID (500 mg-1g) 7 days
Community-acquired pneumonia, inpatient	Ampicillin 50 mg/kg/dose IV q6 (2g) 7 days
Community-acquired pneumonia, complicated	Ceftriaxone 50 mg/kg/dose IV q24 (2g) + Vancomycin 15-20 mg/kg/dose IV q6-8 h (1g)
Aspiration pneumonia	Ampicillin-sulbactam 50 mg amp/kg/dose IV q6 (2g) 7 days
Skin and Soft Tissue	
Cellulitis, non-purulent	Cefazolin 25 mg/kg/dose IV q8 (1g) OR cephalexin 25 mg/kg/dose PO TID (1g) 5-7 days
Cellulitis, purulent or abscess	TMP-SMX 6 mg TMP/kg/dose IV/PO q12 (160 mg) 5-7 days

*Make sure to review patient's allergic history prior to prescribing. While these are often first line antibiotic choices, clinical decision-making on antibiotic prescribing should be based on the patient's entire clinical picture.

Cellulitis & Abscess*	
Etiology	Beta-hemolytic strep, S. Aureus
Differential	Erysipelas, necrotizing fasciitis (pain out of proportion to exam, crepitus, toxic appearing), tenosynovitis (tenderness over flexor sheath, reduced motion), compartment syndrome (early → late: paresthesia, pain out of proportion/with stretch, pallor, pulseless)
Workup	• Diagnosis clinical based on tenderness to palpation, warmth, erythema, induration, fluctuance, fever • Obtain ultrasound if c/f abscess • Circle lesion w/indelible ink; TigerText to care team and/or place in chart (Cerner Camera Capture) • No need for labs (e.g., CBC) or MRSA swab if hemodynamically stable
Treatment	• Typically 5-7 days • **Non-purulent**: Cephalexin/cefazolin, clindamycin, ceftriaxone • **Purulent**: clindamycin, TMP-SMX, doxycycline • Consider MRSA coverage (TMP-SMX, vanc, linezolid) if: **no response to initial therap**y, systemic illness, recurrent infection, **prior history of MRSA**, **high prevalence of MRSA in community**

Osteomyelitis*	
Etiology	• Hematogenous seeding > direct inoculation vs. contiguous spread • S. aureus, GAS, S. pneumo, H. flu type b, Salmonella (sickle cell), E. coli (neonates), Group B Strep (<3 mo), Kingella, Bartonella (vertebral)
Presentation	Fever, localized pain, swelling, warmth, reduced ROM/weight bearing
Differential	Cellulitis, septic joint, fracture, sickle cell crisis, rheumatic disease, bleed/joint effusion, malignancy
Workup	CBC, CRP, ESR, BCx, plain film (only + after 10-14 days), **MRI** (sens 80-100%, spec 70-100%), technetium 99 bone scan
Treatment	• IV antibiotics +/- surgical debridement, full antibiotic course 4-6 weeks, ortho consult • 1st line: **Cefazolin or clindamycin, vancomycin if unstable/toxic-appearing** • Transition to PO antibiotics when no fever >24 hours, improved pain/ROM, CRP decreasing, BCx negative x48 hours

Septic Arthritis*	
Etiology	MSSA, Strep pneumo, GAS, > MRSA, Kingella, gonorrhea, Lyme
Presentation	Fever, localized pain, reduced ROM/weight bearing
Differential	Crystal-induced arthritis, inflammatory arthritis (SLE, reactive, sarcoid), OA, malignancy, hemarthrosis
Workup	• CBC, BCx, CRP, ESR, synovial fluid analysis, X-ray, US, consider Lyme Ab, ASLO, DNase-B ab • Kocher Criteria: (1) ESR >40, (2) WBC >12, (3) Fever >38.5, (4) Non-weight bearing • Risk of septic arthritis with 0/4 (0.2%), 1/4 (3%), 2/4 (40%), 4/4 (99.8%)
Treatment	• 1st line: **Cefazolin** x3 weeks, 2nd line: Clindamycin x3 weeks • Use ceftriaxone if concern for Lyme, gonorrhea, or GNR • Add vancomycin if clinically ill-appearing

Infectious Mononucleosis	
Etiology	**EBV** (90%) > CMV, HIV, HHV6/7, Hep B, Toxoplasma
Presentation	Fatigue, malaise, fever, dysphagia, LAD, splenomegaly (up to 65%)
Differential	Viral syndrome, strep pharyngitis
Workup	**Monospot** (poor sensitivity in first week - 75%), **EBV IgG/IgM titers, EBNA** (to determine whether the patient has longer-standing infection since IgM can be falsely positive in many situations), lymphocytosis >50%, atypical lymphocytes >10%, +/- transaminitis
Treatment	Supportive, **no contact sports 3 weeks** due to risk of splenic rupture. Avoid amoxicillin/other PCNs for treatment of concomitant strep pharyngitis given risk of associated rash

Acute Otitis Media*	
Etiology	**Strep pneumo, Moraxella catarrhalis, H. flu**
Differential	Otitis media externa, mastoiditis, serous effusion
Workup	**Acute symptoms + bulging TM + reduced TM mobility** with pneumatic otoscopy
Treatment	• Amoxicillin (1st line), augmentin (2nd line) • If no severe symptoms (>39 C temp, ear pain 48+ hrs, severe ear pain), no bilateral symptoms in <24 mo pt can defer antibiotic treatment.

Influenza*	
Etiology	Influenza A (including H1N1)/B
Presentation	Fever, cough, sore throat, rhinorrhea, myalgias, headaches, fatigue
Workup	Clinical + **rapid influenza diagnostic test** which detects the viral antigen **At BCH we use PCR test since other rapid flu tests have low sensitivity
Treatment	• If diagnosis identified **within 48 hours of symptom onset, antiviral therapy** (Tamiflu) should be given for 5 days. • Children at high risk should still be considered for antiviral therapy even after 48 hours. High risk is defined by: <5 years old, chronic pulmonary disease (asthma), cardiac disease, renal disease, hematologic disease (sickle cell), neurodevelopmental disorders (CP, seizure disorder), moderate to severe developmental delay, pregnancy, chronic immunosuppression, hospitalized with high risk of influenza complication
Prophylaxis	• Annual flu vaccination is recommended for every child and adolescent 6 months and older annually • Any child with an egg allergy of any severity can receive the influenza vaccine
Complications	Sinus or ear infections, pneumonia, myocarditis, sepsis

Fever of Unknown Origin*	
Definition	Fever without a source for >7-10 days
Differential	• Bacterial: endocarditis, mastoiditis, sub-diaphragmatic abscess, liver abscess, perinephric abscess, pyelonephritis, pelvic abscess, osteomyelitis, TB, salmonellosis (including typhoid), lymphogranuloma venereum, brucellosis, cat-scratch disease, leptospirosis, tularemia, psittacosis, tick-borne disease (e.g. Anaplasma, Babesia), Q fever, RMSF • Viral: adenovirus, arboviruses (e.g. West Nile, dengue), primary HIV, CMV, EBV, HBV, HCV • Fungal: blastomycosis, histoplasmosis • Parasitic: malaria, toxoplasmosis, visceral larva migrans • Granulomatous: sarcoidosis, granulomatous colitis • Collagen Vascular Disease: systemic juvenile idiopathic arthritis, polyarteritis nodosa, SLE • Malignancy: leukemia, lymphoma, neuroblastoma, Langerhans cell histiocytosis • Miscellaneous: diabetes insipidus, drug fever, Kawasaki disease, familial dysautonomia (Riley-Day Syndrome), familial Mediterranean fever or other periodic fever syndromes, HLH, infantile cortical hyperostosis (Caffey Syndrome), pancreatitis, serum sickness, ulcerative colitis, thyrotoxicosis
Workup	• History with ROS, travel history, animal exposures, outdoor activities, insect bites, food exposures, sexual history, IV drug use • Exam: skin exam, LN palpation, joint exam • Labs: CBC with differential, UA/UCx, BCx, HIV, LFTs, LDH, CPK, ESR/CRP, ANA, TST/IGRA, LDH/Uric acid • Imaging: CXR to start; may require abdominal axial imaging (MRI vs. CT) • Additional work-up as indicated by history and physical and decided upon with guidance from consulting teams and radiology
Treatment	• Unless patient is very ill, empiric **antimicrobial therapy should be avoided as it often delays diagnosis** • Can observe fever pattern for diagnostic purposes before treating fever • Glucocorticoids or other immunosuppressive therapy should be withheld until infectious etiology is adequately ruled out

Resources

1. **Information for patients and families:** newenglandconsortium.org, https://www.newbornscreening.info/
2. **Acute Illness Protocols:** https://newenglandconsortium.org/for-professionals/acute-illness-protocols/
3. **Newborn Screen Resources:** https://www.acmg.net/ACMG/Medical-Genetics-Practice-Resources/ACT_Sheets_and_Algorithms.aspx, http://genes-r-us.uthscsa.edu/resources.htm

What to do for a patient with a "metabolic crisis"?

- Page metabolism!
- No known dx: see overviews for specific crises (hyperammonemia, metabolic acidosis, etc.)
- Known dx: see above acute illness protocols.

Classification + Overview

Major classification of IEMs and examples are adapted in part from Rice GM et al, *Pediatrics in Review* 2016;37.

Glossary

3OHB	3 Hydroxybutyrate
3PGD	3 Phosphoglycerate dehydrogenase deficiency
CAH	Congenital adrenal hyperplasia
CPS	Carbamoyl phosphate synthetase
CPT-I&II	Carnitine palmitoyl transferase deficiency Type I and II
DH	Dehydrogenase
FAOD	Fatty acid oxidation defects/disorders
FDP	Fructose diphosphate
GALT	Galactose-1-phosphate uridylyltransferase
GIR	Glucose infusion rate
GLUT1	Glucose transporter protein type 1
GSD	Glycogen storage disease
HHH	Hyperammonemia, hyperornithinemia, homocitrullinuria
HMGCoA	3-Hydroxy-3-methlyglutaryl-CoA
IEM	Inborn error of metabolism
IVA	Isovaleric acidemia/Isovaleryl-CoA DH deficiency
LCAD	Long-chain acyl-CoA DH deficiency
LCHAD	Long-chain hydroxyacyl-CoA DH deficiency / 3-Hydroxyacyl CoA DH deficiency
L/P	Lactate/pyruvate ratio
MCADD	Medium-chain acyl-CoA DH deficiency
MCD	Multiple Carboxylase deficiency

Glossary continued on next page →

Glossary	
MMA	Methlymalonic acidemia
MSUD	Maple syrup urine disease
OA	Organic acidemia
OTC	Ornithine transcarbamylase
PA	Propionic acidemia/Propionyl-CoA carboxylase deficiency
PC	Pyruvate carboxylase
PDH	Pyruvate DH
PKU	Phenylketonuria
TEE	Total energy expenditure
THAN	Transient hyperammonemia of the Newborn
UCD	Urea Cycle Defect
VLCAD	Very long-chain acyl-CoA DH deficiency

Aminoacidopathies	
PowerPlans	Metabolism MSUD Admit Orderset
Biochemical Defect	Defect in AA metabolism → toxic AA metabolites accumulate
Presentation	• May present early (neonatal period) as catastrophic 'intoxication'-like disease → feeding difficulty, lethargy, tachypnea, and poor perfusion → encephalopathy (e.g., MSUD) • May present later w/ chronic encephalopathy (e.g., PKU) • Often NO acidosis or hyperammonemia (vs organic acidemias and UCDs)
Diagnosis	Definitive = quant plasma AAs + sequencing; may be suggested by NBS, labs w/ hypoglycemia, ketosis, liver dysfxn
Management	Restrict culprit AA in diet, monitor plasma AAs carefully, avoid catabolism

Disorder	Enzyme Blockade	Accumulated Substrate(s)	Presentation	Treatment
Phenylketonuria	Phenylalanine hydroxylase (Phe → Tyr)	Phenylalanine	Neurotoxicity, intellectual deficits, microcephaly, GDD, eczema	Avoid Phe, give special Phe -free diet, consider cofactor tx (sapropterin), enzyme substitution (adults)
Maple Syrup Urine Disease	Branched-chain alpha-keto acid dehydrogenase	BCAAs: Leu, Ile, Val, **Leu is neurotoxic, causes hypoNa**	Catabolic stress, high Leu intake → HA, confusion, halluc, lethargy, N/V → coma/ death	Stop all Leu, give Leu-free feeds, dex-containing IVF, AVOID hypotonic fluids (cerebral edema)
Homocystinuria	Cystathionine β -synthase (Hcy → cystathionone)	Homocysteine, Methionine	Intellectual disability, tall stature, thrombosis (Hcy is thrombophilic), downward lens dislocation, osteoporosis	B6 (cofactor for cystathionine β-synthase) in responsive patients,,, betaine (Hcy → Met)

Aminoacidopathies

Disorder	Enzyme Blockade	Accumulated Substrate(s)	Presentation	Treatment
Tyrosinemia	Fumaryl-acetoacetase (fumaroaceto-acetate, → fumarate + acetoacetate)	Tyrosine (blood), Succinylacetone (urine)	Liver failure, RTA - due to accumulation of **succinylacetone**	Nitisinone (blocks early step in Tyr metab - can't make succinylacetone), Tyr restriction

Carbohydrate Metabolism

PowerPlans	Galactosemia Admit Orderset
Biochemical Defect	Issues with glucose/fructose/galactose metabolism
Presentation	Timing depends on intro to culprit carb (**galactosemia** early d/t breastmilk, **fructose** introduced later) and from timing of spacing feeds (longer fasting = need to mobilize glycogen stores → GSD becomes manifest); often p/w metabolic crises (lethargy, encephalopathy, HD instability); may have stigmata of toxic deposition (see chart)
Diagnosis	Galactosemia is on the NBS (hereditary fructosuria and GSD are not); definitive with enzyme assays from blood (also done on cultured fibroblasts & liver); suggestive labs = hypoglycemia, ketosis, metabolic acidosis, liver dysfunction; reducing substances in urine present in galactosemia + hereditary fructose tolerance

Disorder	Enzyme Blockade	Accumulated Substrate(s)	Presentation	Treatment
Classic Galactosemia	Galactose-1-phosphate uridyl transferase (allows for transfer of Gal-1-P to Glu-1-P)	Gal-1-P, total galactose + urine **reducing substances**	Hepatomegaly, jaundice, vomiting, cataracts, FTT, lethargy, proximal RTA (Fanconi syndrome), *E Coli* sepsis after starting galactose-containing feeds (e.g., breastmilk).	No **galactose** - includes no **lactose** (milk / dairy)
Hereditary Fructose Intolerance	Aldolase B (splits F-1-P into DHAP + glyceraldehyde)	F-1-P - urine **reducing substances**	Similar to classic galactosemia, but **no cataracts**; occurs w/ fructose-containing foods	No **fructose** from diet - includes no **sucrose** or **sorbitol**
Glycogen Storage Disease (GSD) Type Ia (von Gierke)	Glucose 6 phosphatase (G6P → glucose + Pi)	G6P → lactate, triglycerides, and uric acid	~3-6 months: hypoglycemia 3-4 hrs after meal,, lactic acidosis, hepatomegaly, hypertriglyceridemia, hyperuricemia, "doll face," small size	Frequent meals, Uncooked cornstarch 1.5-2.5 g/kg PO q4-6h, avoid sucrose/fructose/ galactose, $NaHCO_3$ for acidosis, allopurinol for hyperuricemia

Carbohydrate Metabolism continued on next page →

Carbohydrate Metabolism

Disorder	Enzyme Blockade	Accumulated Substrate(s)	Presentation	Treatment
GSD Type IIa (Pompe)	Lysosomal acid α-glucosidase	Glycogen - accumulates in skeletal and cardiac muscles	Progressive hypotonia, macroglossia, loss of motor, respiratory, and cardiac functions (**cardiomyopathy**). Pilot optional test on NBS	ERT (alglucosidase alfa) Heart tx for CMP
GSD Type IIIa & IIIb(Cori)	Debranching enzyme	Glycogen - accumulates in liver and muscle	Similar to Ia but may be milder; IIIb causes neutropenia	Uncooked cornstarch + continuous feeds to maintain normoglycemia, high-protein diet
GSD Type V (McArdle)	Muscle phosphorylase	Glycogen - accumulates in muscle	Exercise intolerance / cramping, "second wind" phenomenon, myoglobinuria/ rhabdomyolysis	Carbohydrate administration before exercise, high-protein diet

Fatty Acid Oxidation Disorders

PowerPlans	Metabolism Fatty Acid Ox Disorder NOS Admit Orderset, LCFAOD Admit Orderset
Biochemical Defect	Mitochondrial FA oxidation (AKA β-oxidation) = main energy ($FADH_2$ / NADH for **gluconeogenesis** and **ketogenesis**) for **heart**, **skeletal muscle**, **neurons** when Glc is limited (starvation, exercise). Disorders occur d/t decreased carnitine uptake by cells (required for FA transport into the mitochondria), inhibiting entry of FAs into mitochondria, or by blocking β-oxidation. End result = energy-deficient state **without appropriate ketosis**.
Presentation	Fasting-induced vomiting, lethargy, coma, and hypoglycemic seizures, occasional hepatomegaly (may be Reye-like)
Diagnosis	**Hypoketotic hypoglycemia** +/- **liver failure**, **acidosis** & **hyperammonemia**. Acylcarnitine profile with specific findings. Confirmation w/ DNA mutation analysis (less frequently enzyme testing in cultured skin fibroblasts)

Disorder	Enzyme Blockade	Accumulated Substrate(s)	Presentation	Treatment
Medium-chain acyl-CoA DH deficiency	MCAD -- cannot degrade MC FAs to short-chain FAs and Acetyl CoA	C6, C8, and C10 acylcarnitines	Illness + poor PO → glycogen depletion → HKHG → brain injury, seizures, & death if untreated; excellent prognosis if treated On NBS in most states, but may present on DOL 2-3	Avoid fasting during illnesses, give dex-containing IVF if unable to tolerate PO, carnitine supplementation if low carnitine, **AVOID MCT**

Fatty Acid Oxidation Disorders

Disorder	Enzyme Blockade	Accumulated Substrate(s)	Presentation	Treatment
Long-chain / Very long-chain acyl-CoA DH deficiency	LCHAD/VLCAD	**LCHAD/TFP**: 3-hydroxy-acyl-carnitines (C16-OH) **VLCAD**: unsat. long-chain acylcarnitines (C14:1)	More severe than MCAD -- rhabdo, CMP, liver failure, and HKHG even w/ rx LCHAD may have peripheral neuropathy + retinopathy On NBS in all states	Dietary fat restriction MCT oil supplementation Avoid fasting; give dex-containing IVF Serial cardiac evaluations, check CK with illnesses
Primary Carnitine Deficiency	Defective carnitine transporter (OCTN2) -- dec GI absorption / renal reabs.	Elevated urine carnitine, low blood carnitine	CMP + recurrent HKHG, may progress to Reye-like picture **Blood**: low free carnitine **Urine**: elevated carnitine excretion	High-dose oral carnitine, avoidance of fasting, dex-containing IVF if unable to tolerate PO

Organic Acidemias

PowerPlans	Metabolism IVA, MMA, PA, Glutaric Acidemia Type I Admit Orderset (one for each)
Biochemical Defect	Defect in AA breakdown → accumulation of organic acid byproducts
Presentation	Neonatal lethargy, poor perfusion, vomiting, coma, CVAs, death
Diagnosis	Definitive: quant plasma AAs. Often on NBS (elevated C3 / C5 acylcarnitines). Usu p/w severe high AG metabolic acidosis, +/- hyperammonemia, hypoglycemia, liver dysfunction, ketosis, and secondary carnitine deficiency
Treatment	Stop all protein intake, high-dose carnitine, promote anabolism with D10NS + IL +/- insulin, +/- $NaHCO_3$ for severe acidosis, dialysis for life-threatening acidosis or hyperammonemia

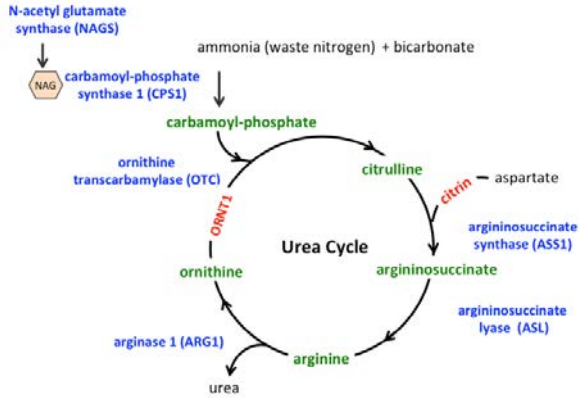
Disorder	Enzyme Blockade	Accumulated Substrate(s)	Presentation	Treatment
Methylmalonic acidemia	methylmalonyl-CoA mutase deficiency (MM-CoA → succinyl CoA)	Products of BCAAs (Ile, Val, Met) - MMA, methylcitrate, C3 acylcarnitine	Stressor (illness, excess protein intake) → metabolic crisis (high-AG metabolic acidosis, basal ganglia stroke, pancreatitis). Complications: renal dz, intellectual disability. Variable age of onset.	As above, plus Vitamin B12, liver or liver/kidney transplantation, avoid Ile, Val, Met, Thr in diet

Organic Acidemias continued on next page →

Organic Acidemias

Disorder	Enzyme Blockade	Accumulated Substrate(s)	Presentation	Treatment
Propionic acidemia	propionyl-CoA carboxylase deficiency (propionyl CoA → MM-CoA)	Products of BCAAs (Ile, Val, Met) - 3-OH propionic acid, methylcitrate, C3 acylcarnitine	Newborn period - profound metabolic acidosis w/ high AG and **prominent ketosis** → multiorgan dysfunction (cardiac, respiratory, pancytopenia, basal ganglia stroke, pancreatitis), hyperammonemia Later - cardiomyopathy and dysrhythmias	As above, plus liver transplant, avoid Ile, Val, Met, Thr in diet
Isovaleric acidemia	isovaleryl-CoA dehydrogenase (isovaleryl-CoA → → acetoacetate and Ac-CoA)	Products of Leu metabolism (Isovaleric acid and metabolites), C5 acylcarnitine	Neonatal: severe lethargy and obtundation, +AG metabolic acidosis, hypoglycemia, ketonuria, hyperammonemia, odor of IVA in urine, pancreatitis Infantile/late-onset: FTT, DD, seizures	As above, avoid Leu
Glutaric acidemia type I (GA1)	Glutaryl CoA DH deficiency	Products of Trp and Lys metab (plasma C5 dicarboxylic (C5DC) acylcarnitine)	Macrocephaly (risk of tearing of bridging veins → subdural hemorrhage), isolated **cerebral** acidosis -- may **not** have metabolic acidosis/ ketosis/hyperammonemia Catabolic stress → devastating neurologic injury (dystonia, movement disorders)	As above, restrict Trp and Lys in diet Aggressive sick day management

Urea Cycle Defects

PowerPlans	Several, including for known defects and unknown; search "metabolism urea" in PC for full list
Biochemical Defect	Deficiency in any of the 6 UC enzymes, which converting toxic nitrogenous metabolites from protein turnover to non-toxic urea for urinary excretion → NH_3 accumulation. 
Presentation	Interim healthy period → **catabolic stressor** (stress, infection, surgery, or starvation) → vomiting, feeding intolerance, tachypnea (due to central hyperventilation) → encephalopathy and coma, with potentially irreversible brain damage if untreated.
Diagnosis	Labs w/ **hyperammonemia** and **respiratory alkalosis** → metabolic acidosis. Send plasma/urine levels of UCD metabolites and confirm with enzyme testing
Treatment	**Acutely**: immediate treatment of hyperammonemia (see full details in section below): Stop all protein intake (but no longer than 36-48h), give dex-containing IVF (10-25% @ 1.5xM) and IL (1-3 g/kg/d) through central line, NH3 scavengers (Ammonul = Na benzoate and Na phenylacetate) usually with IV arginine, avoid hypoNa (would exacerbate cerebral edema), prepare for HD (absolute if NH3 > 300 µmol/L) **Long term**: Low-protein diet, avoid catabolism, include missing UC intermediates, liver tplt

Disorder	Enzyme Blockade	Accumulated Substrate(s)	Presentation	Treatment
Ornithine Transcarbamylase Deficiency	OTC (carbamoyl phosphate + ornithine → citrulline) - **most common**, XLR	NH_3 → cerebral edema Glutamine elevation Low arginine and citrulline as cycle is blocked proximally Elevated **orotic acid** in urine	**Hyperammonemic crisis**, typically early on, p/w poor feeding, lethargy, tachypnea, hypothermia, irritability, vomiting, ataxia, seizures, hepatomegaly, coma **NOT** always evident on NBS, may flag for low citrulline	As above, alongside: citrulline/ arginine, ± carnitine, ammonia scavengers such as glycerol phenylbutyrate. **Consider ammonul for acute hyperammonemia**

Urea Cycle Defects continued on next page →

Urea Cycle Defects

Disorder	Enzyme Blockade	Accumulated Substrate(s)	Presentation	Treatment
Citrullinemia	Arginosuccinate synthetase (citrulline + aspartate → argininosuccinate)	Same as OTC def but with elevated **citrulline**	Similar to OTC def, but can be in boys or girls as is AR inheritance All states include on	As above, alongside: arginine, glycerol phenylbutyrate, NO citrulline
Arginosuccinic aciduria	Arginosuccinate lyase (arginosucc → fumarate + arginine)	Same as OTC def but with elevated **citrulline** and **arginosuccinate**	Similar to citrullinemia All states include on NBS	Same as for citrullinemia
Carbamoyl phosphate synthetase (CPS) I deficiency & NAGS deficiency	CPS I (NH_3 + bicarb + Phos → CPS) NAGS is cofactor for CPSI	Same as OTC def but **without** elevated orotic acid in the urine	Similar to OTC deficiency **NOT** always evident on NBS, may flag for low citrulline	Same as for OTC deficiency

Mitochondrial Disorders / Primary Lactic Acidemias

Biochemical Defect	Disorders of **Krebs cycle** and **oxidative phosphorylation**; transmission via mitochondrial genes → defects vary / not all organs are affected equally
Presentation	Indolent, **progressive neurologic deterioration**, +/- poor feeding, vomiting, CMP, myopathy, liver failure, seizures, strokes, blindness, deafness, and nephropathy
Diagnosis	Definitive dx from enzyme assay or DNA testing; labs often show **+AG metabolic acidosis** and **primary lactic acidosis** +/- hypoglycemia w/ ketosis, liver dysfxn

Disorder	Enzyme Blockade	Accumulated Substrate(s)	Presentation	Treatment
Pyruvate Dehydrogenase Complex Deficiency	Pyruvate dehydrogenase (Pyruvate → Acetyl CoA + CO_2)	Pyruvate → **lactate**	Lactic acidosis, intellectual disability, hypotonia, seizures, exacerbated by ingestion of carbohydrates	Supplement with carnitine, thiamine, and lipoic acid (cofactors for pyruvate DH complex), high fat / low carb diet or ketogenic diet
Pyruvate Carboxylase Deficiency	Pyruvate carboxylase (pyruvate + CO_2 → oxaloacetate)	Pyruvate → **lactate** NH_3 (as Asp cannot be formed from OAA)	Severe lactic acidosis, hypothermia, hypotonia, hypoglycemia, hyperammonemia, lethargy, vomiting, often death as neonate or w/in 1 year for Type B; Types A & C are milder	High carb and protein diet; Treat metabolic crisis with 10% dex-containing IVF, avoid fasting, $NaHCO_3$ for acidosis, possible liver transplant

Lysosomal Diseases

Biochemical Defect	Deficiency in lysosomal enzyme → excess intracellular substrate (e.g., GAGs, MPS)
Presentation	• Substrate build-up → HSM, coarse facies, short stature, skeletal abnormalities • If nervous system involvement → intellectual disability, cataracts, neuropathy
Diagnosis	**Enzyme assay** on samples of WBCs, serum, or skin fibroblasts

Disorder	Enzyme Blockade	Accumulated Substrate(s)	Presentation (AR inheritance unless specified)	Treatment
Gaucher Disease	β-glucosidase (glucocerebrosidase)	Glucocerebroside	Type 1:HSM, bone disease, anemia & thrombocytopenia, absence of CNS disease Type 2&3: Primarily neurologic with DD, regression, early death	ERT, substrate reduction therapy
Tay-Sachs Disease	Hexosaminidase A	GM_2 gangliosides	By age 1 - DD, **exaggerated startle**, sz, macular cherry-red spot	Supportive
Niemann-Pick Disease	Sphingomyelinase	Sphingomyelin	Massive HSM, cherry red spot, interstitial lung disease; neuronopathic or non-neuronopathic	HSCT for non-neuronopathic
Krabbe Disease	Galactocerebrosidase	Galactocerebroside	Infantile-onset:By age 1 - irritability, rapid neurologic deterioration,early childhood death Later-onset: variable	Early HSCT
Metachromatic Leukodystrophy	Cerebroside sulfatase (arylsulfatase A)	Sulfatides	First years of life (late infantile form): DD/ regression; Juvenile form with regression, of dev and beh, then gait; Peripheral neuropathy in adult form	HSCT for juvenile and adult MLD
Fabry Disease	α-galactosidase	Globotriaosyl-ceramide (GL-3)	*XLR. Acroparesthesias, pain crises, corneal opacities, fatigue, angiokeratomas	ERT
Hurler Syndrome (MPS I)	α-L-iduronidase	Glycosamino-glycans (GAGs): dermatan + heparan sulfate	Coarse facies, DD, ID, corneal clouding, hearing loss, hernias, dysostosis multiplex	ERT, HSCT
Hunter Syndrome (MPS II)	Iduronate-2-sulfatase	GAGs as above	*XLR.Similar to MPSI r w/o corneal clouding.	ERT, HSCT

ERT = enzyme-replacement therapy. HSCT = hematopoietic stem-cell transplant.

Perioxisomal Disorders

Biochemical Defect	Peroxisomes = site for β-ox of VLCFAs, H_2O_2 degradation, and pipecolic, phytanic, and pristanic acid metabolism, also of bile acid synthesis, plasmalogen formation (for membranes and myelin).
Presentation	**Dysmorphic facies** (as below)) alongside shortened proximal limbs, epiphyseal stippling, hypotonia, seizures, encephalopathy, cataracts, retinopathy, hepatomegaly, and cholestasis.
Diagnosis	Elevated levels of substrate in question (see below), enzyme assays

Disorder	Enzyme Blockade	Accumulated Substrate(s)	Presentation (AR inheritance unless specified)	Treatment
Zellweger Syndrome	Several peroxisomal genes; often *PEX1*	VLCFAs and branched- chain FAs	Early neuromotor arrest, seizures, ID, craniofacial anomalies (large fontanel, midface hypoplasia, short pf, incr. neck fat),chondrodysplasia punctata (calcification of cartilage), renal cysts, liver failure - **cerebrohepatorenal** syndrome, death w/in 1 yr	Supportive care only; no disease-modifying rx
Refsum Disease	Defective phytanoyl-CoA -hydroxylase	Phytanic acid	Later onset (adolescence / adulthood) of ataxia, retinitis pigmentosa, ichthyosis, cataracts/ night blindness, anosmia, and hearing loss	Restrict phytanic acid intake (found in dairy, beef, lamb, seafood) Cardiac & ophtho surveillance
Adrenoleuko-dystrophy	*ABCD1* gene - issues shuttling VLCFAs in to peroxisomes	VLCFAs	*XLR. Seizures, intellectual disability, neuromotor arrest, adrenal insufficiency, hypogonadism, beginning with behavioral changes around **age 4-10.**	Lorenzo's oil (special preparation of FAs)- NOT PROVEN Treat adrenal disease HSCT

Differential Diagnosis by Clinical Manifestations

Presenting in **Neonatal period** or **early infancy**

History	Consanguinity (increased inc of AR disorders), ethnicity (e.g., tyrosinemia in French-Canadians of Quebec), SIDS or intellectual disability in family (all from possible undiagnosed IEMs), relation of symptom to introduction of new food, NBS results
Presentation	**Acute** and **severe**, simulating sepsis (lethargy, vomiting, tachypnea, seizures, poor perfusion) • classically ex FT, prev healthy, deterioration despite support, usu neg sepsis workup • d/t **deficiency of a product** or **excess of toxic substrate**, so called "intoxications" - organic acidemias, aminoacidopathies, and UCDs **Indolent** w/ **early** and **persistent neurological deterioration** • nl pregnancy, no interim healthy pd, d/t energy def: mitochondrial + peroxisomal disorders

Encephalopathy	Seizures	Hepatic	Cardiac	Hypoglycemia
MSUD MMA PA IVA MCD UCD	B6 responsive seizures MCD (biotin) Folinic acid responsive GLUT1 3PGD	Galactosemia Fructosemia Tyrosinemia Bile acid synthesis defects Glycosylation defects Ib LCHAD	FAOD Pompes	GSD FAOD Primary hyperinsulinemia

Differential Diagnosis by Clinical Manifestations

Physical Exam

Usually non-spec - **hepatomeg + HD instability** in metabolic crises; **dysmorphisms** are usu absent (though not always); **auditory** + **ophthalmologic** evaluations are an important part of workup

Dysmorphisms	
Peroxisomal disorders (Zellweger)	Trisomy 21 like facies
Pyruvate dehydrogenase deficiency	FAS like facies
Lysosomal disorders (I cell disease)	Hurler-like coarse facies
Glycosylation defects	Inverted nipples, fat pads/ lipodystrophy
Hydrops	
Storage disorders	Mucopolysaccharidosis, Niemann-Pick
Disorders affecting erythropoiesis	G6PD deficiency, pyruvate kinase deficiency
Disorders affecting liver	Neonatal hemochromatosis, galactosemia
Skin and hair manifestations	
Acrodermatitis enteropathica (Zn def)	Vesiculobullous/eczematoid lesions on perioral/ perineal areas
Hartnup	Pellagra like features
PKU	Blonde, fair, blue eyes
Hepatoerythropoetic & Congenital Erythropoetic Porphyrias	Photosensitivity with vesiculobullous Lesions and resulting scarring
Biotinidase deficiency	Rash and alopecia
Cataracts: Lowe, galactosemia, Zellweger and variants	
Hepatomegaly: Galactosemia, hereditary fructose intolerance, GSD type Ia & III, LCHAD, Tyrosinemia, hemochromatosis, Zellweger	

Initial Lab Workup and suggested diagnosis

Lab test	Common associations
VBG + chem 10	Acidosis and increased anion gap in organic acidemias
Blood glucose	Hypoglycemia in FAOD, glycogenolysis and glycosylation defects
LFTs and coags	Jaundice/hepatitis in tyrosinemia, galactosemia, hemochromatosis
Plasma ammonia	Increased in urea cycle defects and organic acidemias
Plasma lactate (L), pyruvate (P), and ketoacids (3OHB, AcAc)	Some IEMs have pathognomonic L/P / 3OHB/AcAc ratios
CBC w/diff	Neutropenia and thrombocytopenia with IVA, MMA, PA; neutropenia in GSD Ib
Blood Culture	Galactosemia a/w increased incidence of *E. coli* sepsis.
Urine pH	>5 in setting of acidosis suggests distal RTA.
Urine (non-glucose)reducing substances	Suggestive of galactosuria or fructosuria
Urine ketones (if acidosis or hypoglycemia)	See below

Secondary Workup (after talking w/

- **Urine**: Organic acids, acylglycines, mucopolysaccharides, oligosaccharides
- **Plasma**: AAs (quantitative), carnitine + acylcarnitine, Peroxisomal tests (VLCFA), bile acid analysis
- **CSF**: for amino acids (glycine), lactate, pyruvate, and neurotransmitters
- **Imaging**: Brain MRI/MRS, HIDA scan for biliary atresia
- *In general pre-prandial samples should be sent for most tests (at least 2-4 hours after last feed)

Differential Diagnosis continued on next page →

Differential Diagnosis by Clinical Manifestations

Later Onset
About 50% of patients with IEMs present beyond the immediate neonatal period (even as adults!)

History	*Episodic illness* precipitated by mild intercurrent illness, fasting, or change of diet, specific dietary preferences (e.g., autovegetarianism seen in conditions predisposing to hyperammonemia), behavioral issues such as ADHD (partially treated PKU)
Presentation	Can be classified into 2 patterns which may overlap: • **Acute**, presenting in a **metabolic crisis** w/ emesis, lethargy, seizures, tachypnea

Encephalopathy	**Without focal findings** look for predominant acidosis, hyperammonemia or hypoglycemia & work up as outlined below **With focal findings**: homocystinuria with thromboembolic event, mitochondrial disorders with CVA, biotin-responsive basal ganglia disease, some OA (striatal necrosis inorganic acidemias); cerebral edema in UCDs
Recurrent ataxia	MSUD, OTC, pyruvate dehydrogenase (associated peripheral neuropathy)
Psychiatric symptoms	UCD's, porphyrias, homocystinuria, cobalamin C disease, late-onset Tay Sachs
Dehydration	**Polyuria**: RTA, nephrogenic Diabetes Insipidus **Diarrhea**: glucose or galactose malabsorption, acrodermatitis enteropathica (Zn deficiency), sucrase isomaltase deficiency, congenital chloride diarrhea **Ketoacidosis**: MMA, IVA, PA, DM **Salt losing**: CAH, hypoaldosteronism
Reye syndrome-	UCD's and OA's, disorders of mitochondrial fatty acid oxidation and

• **Indolent**: **FTT, myopathies, neurological sequelae** (DD, ID, micro/microcephaly), dysmorphisms

Management of Metabolic Crises

General Principles

0. Consult metabolism!
1. ABCs: ? need for airway protection, intubation, mechanical ventilation, rehydration, inotropic support
2. Consider alternate dx: electrolyte imbalance, sepsis
3. Established dx: acute illness protocols above, family should have home / ED illness protocol

Acute Metabolic Encephalopathy

Definition	Acute **global cerebral dysfunction** → altered mentation w/ or w/o seizures NOT due to primary structural brain disease (e.g., tumor or hemorrhage) or infection (though some IEMs may cause strokes)
Etiologies	Hyperammonemia, metabolic acidosis-hyperlactatemia or ketosis, hypoglycemia, recurrent seizures ('excitotoxic' damage), specific toxins, e.g., copper deposition in Wilson's, electrolyte imbalances
Presentation	• Precipitated by high protein intake, catabolic state (fever/illness/GIB/fast), present w/ lethargy, AMS, seizures, tachypnea 2/2 metabolic acidosis or central stimulation by inc NH3 • FND, presentation @ older age, sudden onset, no PMHx, do NOT rule out IEMs

Management of Metabolic Crises

Acute Metabolic Encephalopathy

Management

- Reverse catabolism ASAP and prevent sequelae, do frequent neuro checks
- **Hydration**: 10 mL/kg NS bolus if dehydrated, then D10 NS + 20 mEq/L of KCl (add after ruling out hyperkalemia or after voiding) @ 1-1.5x M, avoid hyponatremia (predisposes to cerebral edema; minimum of 4-5 meq/kg/day of sodium in fluids)
- **Nutrition**: give calories via carbs + IL alone (unless FA ox d/o is on ddx, then no IL) to provide 1 -1.5x TEE (120-150 kcal/kg/day), preferably enteral nutrition (enteral carbs → portal vein → maximize insulin release); can give TPN if enteral feeds are not tolerated, start protein w/in 48h
- **Promote anabolism**: nutrition, ↓ counter-regulatory hormones → ensure adequate volume, ondansetron for vomiting, treat infxn/fever/pain, correct hypoglycemia (bolus of 2 or 5 mL of 25 or 10% Dextrose → rule of 50 (i.e., vol*%dex = 50), then infusion to maintain a GIR of 8-12 mg/kg/min [GIR in mg/kg/min = dextrose% x Vol (ml/kg/day) / 144]), maintain normoglycemia if needed with insulin @ 0.1mcg/kg/hr, titrating to maintain glucose between 100-120mg/dL (goal of high GIR = get glucose (i.e., calories), into the cells rather than add to Sosm by causing hyperglycemia)
- **Cofactor therapy**: try the vitamins below even empirically, but esp if these disorders are on ddx

Suspected Enzyme Deficiency	Cofactor
Propionyl-CoA carboxylase Beta-methylcrotonyl-CoA carboxylase Holocarboxylase synthase Pyruvate carboxylase Biotinidase deficiency	Biotin (dose depends on disorder)
Methylmalonyl-CoA mutase	Hydroxycobalamin 1 mg/day IM
BCAA DH (MSUD) Pyruvate DH Alpha-ketoglutarate DH	Thiamine (B1) 100 mg/day
Glutaryl-CoA dehydrogenase Medium acyl-CoA DH	Riboflavin (B2) 200 mg/day

- **L-carnitine**: inc urinary excretion of carnitine-bound organic acids → secondary deficiency; carnitine is neuroprotective and non-toxic, give 100mg/kg/day, max 6 g/d, 1st via IV bolus of daily dose, then divide q4-6h, IV or enteral; carnitine controversial in FAOD
- **Toxin removal**: CVVH ideal; can consider PLEX or peritoneal dialysis in neonates (less effective); extracorporeal toxin removal if severe
- **Specific rx**: Address underlying acidosis, hyperammonemia, metabolic pathway block

Risks of rx

Overhydration, cerebral edema / herniation (may need ventilation + other modes to control ICP while maintaining cerebral perfusion w/ mannitol, hypothermia), protein malnutrition (if no protein >48h)

Hyperammonemia

PowerPlan	Metabolism Hyperammonemia Admit Orderset
Definition	Normal ammonia levels vary w/ prematurity, age, and catabolic state; usu 15-35 µmol/L (up to 100 µmol/L in neonates), nl <50 µmol/L. Most IEMs >500, while ↑ NH_3 in liver failure, sepsis usually <500
Etiology / DDx	UCDs (OTC most common), hyperammonemia-hyperornithine-hypercitrulline (HHH) syndrome, organic acidemias (PA, IVA, MMA), FAODs (MCAD, LCAD, LCHAD), systemic carnitine deficiency, PC deficiency, THAN (esp in preemies), liver failure from any cause, VPA toxicity, infection with urease-positive organism (e.g., *Proteus*, *H pylori*), post-transplant idiopathic HA

Management of Metabolic Crises continued on next page →

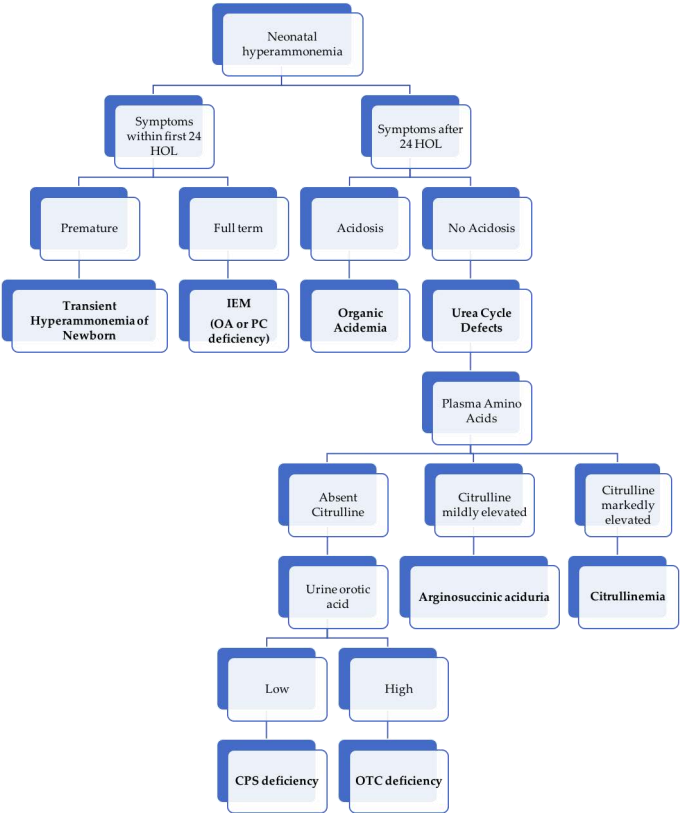
Management of Metabolic Crises

Hyperammonemia

Pathophys

Inc NH_3 in brain → astrocytes turn NH_3 into Gln → inc intracellular osmolality → cerebral edema. NH_3 inhibits α-KG DH → TCA cycle blocked → pyruvate ⇒ lactate, α-KG ⇒ Glu → excitotox/sz → cerebral edema, possible herniation. Even **brief** periods of hyperammonemia in infants may have chronic sequelae

Approach to DDx[3]



Presentation

Lethargy/delirium + vomiting → coma, sz, opisthotonic posturing; central hyperventilation/resp alkalosis; cerebral edema → inc ICP → HTN + bradycardia, CN VI palsy, encephalopathy

Workup

free-flowing sample in Na heparin tube w/o tourniquet, send to lab **on ice STAT** w/ chem 10, VBG, CBC/diff, plasma AAs, urine OAs, repeat NH_3 at least q6-8h alongside daily chem and others PRN

Treatment

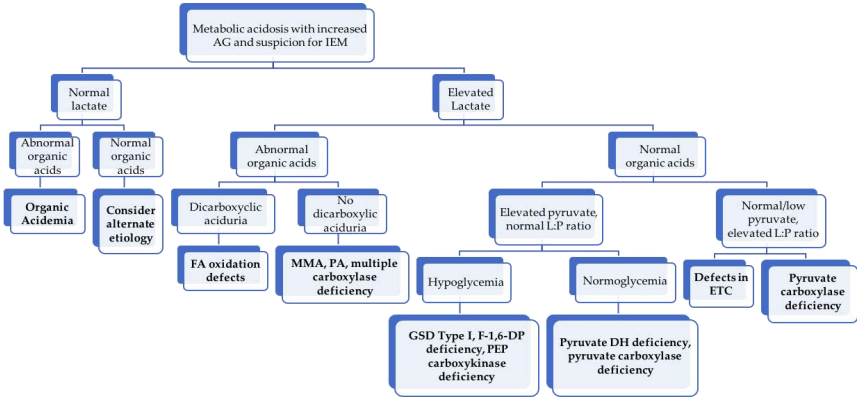
General measures/ABCs as above.
- **Stop protein intake**: start hydration and nutrition as described above for goal GIR of 10-12 mg/kg/min, aiming to provide 120-150 kcal/kg/day
- **Give ammonia scavengers**: sodium benzoate 250 mg/kg + sodium phenylacetate 250 mg/kg + 10% Arginine HCl (600 mg/kg) - avoid in Arginase deficiency
  - Mix the above in 35 ml/kg of 10% dextrose (no additional sodium) and give over 90 min
  - Repeat the same solution over 24 hours
- Consider **dialysis** for NH3 >175 mcmol/L (preferably ECMO-based, requiring NICU transfer)

Reintroduce protein w/in 48h to prevent endogenous protein from breaking down

Management of Metabolic Crises

Metabolic Acidosis (when due to IEM)

PowerPlan	Metabolism Lactic or Metabolic Acidosis NOS Admit Plan
Definition	Arterial blood gas with pH < 7.35, pCO2 < 35, bicarbonate < 22
Etiopathogenesis	Inherited: organic acidurias, primary lactic acidemias, renal tubular acidosis; **ANY** metabolic crisis, if left untreated long enough, will progress to metabolic acidosis
Presentation	Acute vomiting, dehydration, lethargy, and rapid, shallow breathing, often h/o protein load
Physical Exam	**Organic acidurias**: limb hypertonia/axial hypotonia, large amplitude tremor, myoclonic jerks, pedaling, sustained paraspinal contraction (opisthotonic posturing) **RTA**: Failure to thrive, polyuria, and rachitic changes **PDH deficiency**: blindness, hypotonia, DD, narrow forehead, frontal bossing, wide nasal bridge, long philtrum, and anteverted nostrils
Treatment	Hydration, caloric intake of 120-140kcal/kg/day, stop proteins initially (esp stop all BCAAs if MSUD is suspected), maintain glucose 100-150 (using high GIR +/- insulin), avoid hypoNa, cerebral edema If serum bicarb < 14 meq/L and pH < 7.2, give IV bolus NaHCO3 as 2.5 meq/kg over 30 minutes, then 2.5 meq/kg/day until serum bicarbonate is 24-28 meq/L HD = last resort but may be lifesaving in severe refractory cases (especially neonates)



Seizures (when due to IEM)

Etiology	Alteration of intracellular **osmolality**, depletion of substrates needed for **cellular metabolism** or **membrane function**, and/or intracellular accumulation of **toxic substances**
DDx	DDx of 'seizures in a newborn' is large, including many IEMs with poor prognosis. **Rare but potentially treatable etiologies**: **pyridoxine responsive** seizures, **folinic acid responsive** seizures, **serine responsive** 3-phosphoglycerate DH deficiency, sz from **hypoglycemia, biotin responsive** holocarboxylase synthetase deficiency, biotinidase deficiency.
Treatment	**See neurology section for treatment of status epilepticus**; avoid AEDs that block mitochondrial fxn (VPA, chloral hydrate) - c/s fosphenytoin, BZDs, and/or levetiracetam. Correct fever, electrolyte issues, acidosis, hypoglycemia. If refractory, c/s empiric pyridoxine (100-200 mg IV x1), folinic acid (2.5-5 mg PO once daily), L-serine (200-600 mg/kg/d div 6x/day), or biotin (5-20 mg PO once daily).

Convenient Formulas

Formula Name	Formula	Clinical Use
Modified Bedside Schwartz	eGFR = 0.413 x (height/Scr); ht in cm	Used ages 1-18 to estimate GFR
Insensible Fluid Loss	IFL = 300 mL/m^2/day BSA (m^2) = sqrt[(ht [in cm] x wt [in kg])/3600]	Use for oliguric patients when replacing insensible fluid plus urine/stool losses
Free Water Deficit	[(Current Na^+/Desired Na^+) - 1] x total body water (weight in kg x 0.6 for males, 0.5 for females) = water deficit in **liters**	Calculating **water** to be replaced in **hypernatremic** dehydration
Sodium Deficit	(140-actual Na^+) x TBW (wt in kg x 0.6 for males, 0.5 for females) = Na^+ deficit in **mEq**	Calc **Na** to be replaced in **hyponatremic** dehydration
Fractional Excretion of Sodium	**FENa** = (Urine Na x Plasma Cr) / (Plasma Na x Urine Cr)	Use in oliguric **AKI** to determine **pre-renal** (<1%, sodium-avid) vs **intrinsic renal** (>2%, tubular dysfunction) etiology
Fractional Excretion of Urea	**FEUN** = (Urine urea nitrogen x Plasma Cr)/ (Plasma urea nitrogen x Urine Cr)	Use in **AKI** if patient has recently been given **diuretics** (would alter Na excretion and therefore FENa), acute GN, or CKD; **pre-renal** <35%, **intrinsic renal** >50%
Urine Protein:Cr	Urine Protein:Cr on spot urine sample	Normal <0.2. > 3.5 indicates nephrotic-range proteinuria.
Transtubular Potassium Gradient	(urine K / plasma K) / (urine osm / plasma osm)	Normal = 8-9. TTKG <7 + **hyperkalemia** → aldo def / resistance TTKG >3 + **hypokalemia** → aldo ↑ vs renal K loss
Tubular Reabsorption of Phosphate	[1 - (urine phosphate x plasma creatinine) / (plasma phosphate x urine creatinine)] x 100%	Normal 80-98%. ↓ TRP can be seen in conditions with prox tubular dysfx, such as Fanconi syndrome / Type 2 RTA
Urine Calcium:Cr	Urine Ca:Cr on spot urine sample	Normal < 0.2. Use to assess for hypercalciuria in patients with hematuria, stones, and/or hypercalcemia.
Calcium levels w/ low albumin	Corrected Ca^{2+} = (4 - patient's albumin) x 0.8 + measured Ca^{2+}	Albumin = negatively charged, and therefore carries calcium.
Serum Osmolality	[2 x (Na^+ + K^+)] + (glucose/18) + (BUN/2.8) = Sosm in mOsm/kg Osmolar gap = measured serum osm - calculated serum osm	Osmolar gap >10 can be caused by toxic alcohols (ethanol, methanol, ethylene glycol, isopropyl alcohol), mannitol, and lorazepam infusions (which contain propylene glycol).

Fluid Management

Dehydration

Severity	% Volume Loss	Vital Signs	Physical Exam
Mild	3-5%	Normal	Oliguria
Moderate	6-9%	Inc HR, Orthostatic BP	Decreased skin turgor, delayed cap refill, dry mucosa, sunken fontanelle, oliguria
Severe	≥10%	Inc HR, Dec BP	Markedly decreased peripheral perfusion (cool, mottled extremities), lethargy/AMS, deep respirations, anuria

Is this child dehydrated? Steiner MJ; DeWalt DA; Byerley JS. JAMA 2004 Jun 9;291(22):2746-54.

Fluid Management

Dehydration

- **PowerPlans:** Gastroenteritis CPG Admit Plan, ED Gastroenteritis Pathway Plan
- **Clinical Pathways**: Gastroenteritis Clinical Pathway
- **Clinical Pearls**: Estimate degree of dehydration by s/sx above to calc amt of fluid necessary to replace
  - Fluid deficit = dry weight - current weight
  - If dry weight unknown, estimate: dry weight = (current wt) / (1 - p*[%dehyd/100]), where p = 0.6 for boys, 0.5 for girls (as % of total weight is water is 60% in boys and 50% in girls)
  - Oral rehydration is preferred to IV rehydration when possible
  - If giving IV rehydration: 20cc/kg bolus of normal saline - consider D5NS if hypoglycemic or acidotic, rpt PRN until HDS, if ongoing IV rehydration necessary, start IVF @ maintenance (D5NS unless child is <1 mo, has renal disease, etc); for hypernatremic dehydration, give hypotonic fluids (e.g., D5 ½ NS) **after** volume resuscitation

Maintenance Fluid Therapy

Fluid	Dex	Na^+	Cl^-	K^+	Ca^{++}	Buffer	Osm
Unit	g/dL	mEq/L					mOsm/L
Plasma	0.07-0.11	135-145	95-105	3.5-5	4.4-5.2	23-30 bicarb	308
NS (0.9%)	0	154	154	0	0	0	308
D5 NS	5	154	154	0	0	0	308
D5 ½ NS	5	77	77	0	0	0	154
D5 ¼ NS	5	34	34	0	0	0	78
3% saline	0	513	513	0	0	0	1026
D5 LR	5	130	109	4	3	28 lactate	284

Holliday-Segar Method (use for children > 14 days old)

Body Weight	cc/kg/day	cc/kg/hr
First 10 kg	100	4
Second 10 kg	50	2
Each additional kg	20	1

- Insensible Fluid Losses: 300 cc/m^2/day, with body surface area in m^2= square root of [(ht cm x wt kg)/3600]
- Maintenance Electrolyte Requirements: **Na**: 2-4 mEq/kg/day / **K**: 1-2 mEq/kg/day
- Choice of fluid depends on age, serum sodium, and degree of dehydration.
- **2018 AAP Clinical Practice Guideline** by Feld LG, Neuspiel DR, Foster BA, et al. *Pediatrics*. 2018;142(6):
  - **Bottom line**: when in doubt, use isotonic fluids + KCl and dextrose (e.g., D5NS + 20 mEq/L KCl)
  - **Exceptions**: neonates <28d or in NICU, CHF, renal disease, massive burns, hepatic disease, neurosurgical disorders, voluminous diarrhea, DI
  - **Why**: avoids iatrogenic hyponatremia (hypotonic fluids + non-osmotic stimuli to ADH release) without a notable increase in iatrogenic hypernatremia or hypertension.
  - **Note**: large amounts of NS → hyperchloremic non-gap metabolic acidosis. **Keep this in mind** when you see a persistent acidosis despite a normal anion gap when correcting patients in DKA!

Acid/Base

Simple Acid Base Disorders

Disorder	pH	pCO_2	HCO_3
Metabolic Acidosis	**< 7.35**	> 45	**< 22**
Metabolic Alkalosis	**> 7.45**	< 35	**> 26**
Respiratory Acidosis	**< 7.35**	**> 45**	< 22
Respiratory Alkalosis	> 7.45	**< 35**	> 26

Bold indicates primary disturbance -- non-bold indicates secondary response.
Lower serum bicarbonate levels (as low as 18 mmol/L) can be physiologically normal in neonates

- **Acidemia** → pH < 7.35. **Acidosis** → process that makes pH ↓
- **Alkalemia** → pH > 7.45. **Alkalosis** → process that makes pH ↑
- In **respiratory** disorders, the **pH** moves in the **same** direction as the **pCO_2**
- Always look at the pH! A high bicarb on a chem often represents a metabolic alkalosis, but could also be a compensation for chronic respiratory acidosis (e.g., in patients with chronic lung disease).

Metabolic Acidosis

PowerPlans	Metabolism Lactic or Metabolic Acidosis NOS Admit Plan
Approach	Is there a concomitant resp acidosis / resp alkalosis? Use Winter's Formula -- Expected pCO2 = ([1.5 x HCO3-]+ 8 ± 2), then calculate AG → [Na+ – (Cl- + HCO3)]. Normal = 3*albumin +/- 2 (12 in healthy pts).
Normal AG MAc	GI loss (diarrhea, laxative, ureteroenteric fistula) vs renal loss (RTA (see chart), acetazolamide use, renal failure (may also have elevated AG), aggressive rehydration with NS • Can calc urine AG, (UNa + UK) – (UCl); if positive → impaired renal acidification, if negative → GI loss of bicarb, works b/c urine Cl- = proxy for NH4+ secretion

Renal Tubular Acidosis: Hyperchloremic Metabolic Acidosis w/ +Urine AG

	Proximal (Type 2)	Distal (Type 1)	Hyperkalemic (Type 4)
Defect	Bicarb Reabsorption	H+ secretion	Inadequate aldosterone
Potassium	Normal/Decreased	Normal/Decreased	**Increased**
Urine pH	< 5.5	> 5.5	< 5.5
Renal stones	No	**Yes** (high urine pH → CaPhos stones, low urine citrate)	No
Clinical correlates	**Fanconi syndrome** (generalized prox tubular dysfunction → lose glucose, phos, AAs)	Hereditary channelopathies (may be a/w SNHL)	DM, primary adrenal insufficiency, use of ACEIs/ aldo antagonists

Increased AG MAc	**MUDPILES** **M**ethanol **U**remia **D**iabetic ketoacidosis/starvation ketoacidosis **P**araldehyde **I**nfection/Isoniazid/Iron/IEM **L**actic Acidosis **E**thylene Glycol **S**alicylates (cause primary metabolic acidosis and respiratory alkalosis)

Acid/Base

Renal Tubular Acidosis: Hyperchloremic Metabolic Acidosis w/ +Urine AG

Not fitting?	Use the "delta gap" → [AG - 12] / [24 - bicarb] - compares diff btw measured and normal AG vs diff btw normal bicarb and measured bicarb to answer the question: is each decrease in the bicarb accounted for by an increase in the AG? ▪ If **yes**, then DGap = 0.8 to 2 → high AG metabolic acidosis (MAc) **alone** ▪ If **no** and DGap <0.4 → low/normal AG MAc **alone** ▪ If **no** and DGap 0.4-0.8 → low/normal AG MAc **and** high AG MAc ▪ If **no** and DGap >2 → high AG MAc superimposed on chronic **metabolic alkalosis** or **respiratory acidosis** with metabolic compensation
Treatment	Directed at underlying etiology; see Metabolism section for acute management

Metabolic Alkalosis

Chloride Responsive (urine Cl- <20 mEq/L)	Loss of gastric secretions (HCl): vomiting, NG tube drainage, thiazide and loop diuretics (urine chloride varies based on when drug was given), CF
Chloride Resistant (urine Cl-> 20 mEq/L)	• **w/ HTN**: primary hyperaldosteronism, CAH, renovascular HTN, Liddle's syndrome • **w/o HTN**: Bartter / Gitelman syndrome, severe K or Mg loss

Respiratory Acidosis

DDx	• CNS depression • Nervous/Muscular disorders (Guillain-Barre, myasthenia gravis, botulism, muscular dystrophy) • Acute and chronic lung disease
Workup/Management	ABG/VBG, CXR, SaO_2, escalate respiratory support as needed

Respiratory Alkalosis

DDx	• Anxiety • Hypoxia • Pain • Salicylates • Urea cycle disorders (during metabolic crisis, hyperammonemia increases respiratory drive)

Hyponatremia

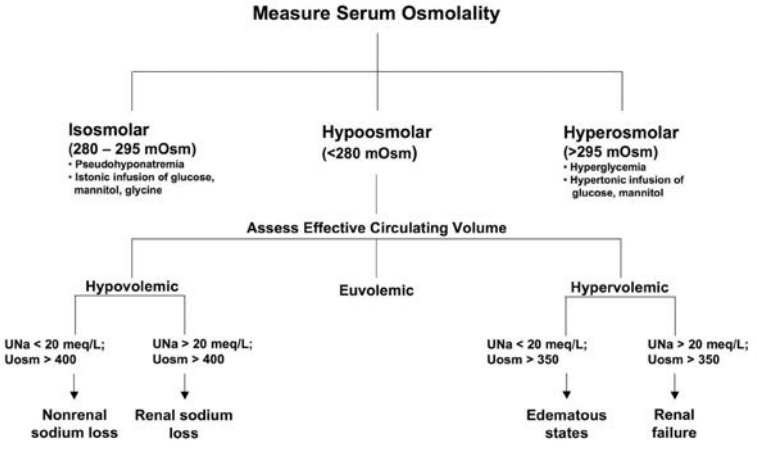
Definition

Mild: Na < 135
Moderate: Na < 130
Severe: Na < 120

Hypovolemic	Euvolemic	Hypervolemic
Nonrenal sodium losses GI Skin Sequestration Renal sodium losses Diuretics Cerebral salt wasting Mineralocorticoid/ Glucocorticoid deficiency	SIADH Psychogenic polydipsia Reset osmostat Drug-induced Hypothyroidism	Edematous states Nephrotic syndrome CHF Cirrhosis Renal failure (acute or chronic)

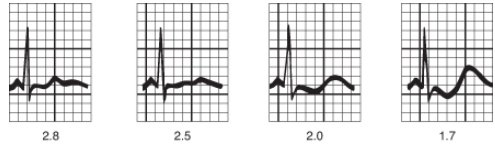
Hyponatremia continued on next page →

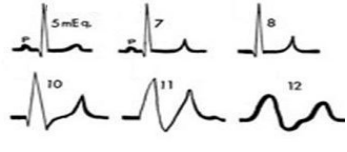
Hyponatremia

Definition	
Presentation	• Usu d/t underlying cause rather than symptoms from hyponatremia itself • Sx occur when hyponatremia evolves acutely (< 24h) & include N/V/HA → seizures, coma, and respiratory arrest
Workup	Chem 10, UA (proteinuria, hematuria, glucosuria), serum Osm (↓ in true hyponatremia. If ↑, look for hyperglycemia or other osms), urine Osm [if euvolemic, nl response to hyponatremia = suppress ADH → urine is maximally dilute (osmolality < 100 mosmol/kg, SG ≤1.003); abnormally conc urine + euvolemic hypoNa = SIADH; whereas ↑ ADH i/s/o hypovolemia = appropriate ↑ in ADH], urine Na (<20 = EABV depletion, >40 = SIADH, cerebral salt wasting, diuretic use, renal failure)
Treatment	Address underlying cause (volume if hypovolemic, fluid restriction if eu/hypervolemic), time course to match timing of onset (fast rx for onset <12h, slow rx for slow onset to prevent CPM) • **Acute, symptomatic**: ICU admit, 3% HTS to raise [Na] by 3-5 mEq/L (give ~TBW x 5 mEq/L x 2) • **Asymptomatic**: calc Na deficit [(140-actual Na) x weight in kg x 0.6 for males, 0.5 for females], then give IVF with missing Na content; should not exceed 0.6 mEq/L/hr rise in [Na] • **SIADH**: restrict free water intake to match insensible losses + UOP; use vaptans if severe

Hypernatremia

Definition	Serum sodium >145 mEq/L
Etiology	**Excessive water loss** (GI losses / Diuretics / Central or nephrogenic DI (see endocrine section) / Osmotic diuresis / Increased insensible losses / Impaired thirst mechanism) vs **excessive salt intake**
Clinical Manifestations	Lethargy, irritability, MS changes; typically presents w/ sx of underlying cause
Exam	Check volume status, neurologic exam, mental status
Workup	UA, chem 10, urine osm (appropriate response to hyperNa □ ↑ ADH □ concentrated urine. Inappropriately dilute urine i/s/o hyperNa □ think DI), serum osm (Uosm < Sosm □ think DI)
Management	• For **hypernatremic dehydration**, calc free water deficit: (Current Na/Desired Na -1) x TBW (weight in kg * 0.6 for males, 0.5 for females) = water deficit in liters; replace ½ of FWD w/in 24h, then remainder over next 1-2 days, and replace maintenance + ongoing losses. **Avoid** ↓ Na+ by >15 mEq/L over 24h (0.5 mEq/L/hr) d/t risk of cerebral edema. • **If due to DI**, see endo section for management

Hypokalemia	
PowerPlan	MSICU Intermittent IV Electrolyte Replacement Orderset
Definition	K+ < 3.5 mEq/L
Etiology	Decreased K+ intake (malnutrition), increased K+ entry into cells (alkalosis → H+ for K+ / insulin / beta adrenergic activity - albuterol, pheo), increased GI losses (diarrhea, vomiting, laxative abuse, copious GT losses), renal losses (diuretics -- loop/thiazide but NOT aldo antagonists, mineralocorticoid excess -- primary hyperaldo, hyperreninemic states [p/w HTN, hyperNa, metabolic alkalosis], Type I/II RTA, Gitelman/Bartter)
Pathophysiology	Low K+ → hyperpolarization of myocytes → lack of inhibition of voltage-gated Na+ channels → ↑ Na+ entry into myocytes and ↑ excitability → cardiac arrhythmias
Clinical Manifestations	(Generally only K+ < 3) -- muscle weakness, fatigue, constipation → ileus, tetany, rhabdo, respiratory muscle failure, EKG changes (ST depression → dec T wave amplitude → U waves) 
Workup	Chem 10, EKG (see below), TTKG: **(urine K+ x plasma osm) / (plasma K+ x urine osm)** - can only use when urine osm > 300. TTKG > 3 i/s/o hypoK suggests aldo excess.
Management	• Mild to moderate (K+ = 3.0-3.5 mEq/L) -- rx underlying d/o, give KCl 1 mEq/kg (max 20 mEq) PO q8-24h OR add KCl to IVF (max conc is 80 mEq/L via PIV). • If severe (K+<2.5 to 3 mEq/L or symptomatic, EKG changes), add KCl to IVF, give KCl 0.5-1 mEq/kg (max 30 mEq) IV x1 -- only in ICU, and should have EKG monitoring during infusion • Also correct Mg2+ if low (25-50 mg/kg IV, max 2g/dose) as hypoMg prevents resolution of hypoK

Hyperkalemia	
PowerPlan	MICU/MSICU/NICU hyperkalemia orderset
Definition	K+ > 5.5 mEq/L (up to 6.5 may be normal in neonates)
Etiology	↑ K+ intake (TPN, IVF, formula), ↑ K+ release from cells (acidosis [K+ efflux allows H+ influx to buffer acidosis], cell lysis [hemolysis, rhabdo, tumor lysis]), ↓ renal excretion (acute or chronic renal failure, hypoaldosteronism [adrenal insufficiency, hyporeninemic hypoAldo, ACE inhibitors -- look for hypoNa and metabolic acidosis], K-sparing diuretics [spironolactone, epelrenone, amiloride, triamterene]), pseudohyperkalemia (hemolyzed blood sample)
Pathogenesis	↑ K+ partially depolarizes cell membrane → inhibits voltage-gated Na+ channels → ↓ Na+ entry → impaired membrane excitability → weakness
Clinical Manifestations	• Muscle weakness (LE > UE) □ flaccid paralysis, arrhythmias (if K+ > 7) • **EKG changes** (in order of appearance): Tall peaked T wave, shortened QT □ PR/QRS lengthening □ "sine wave" QRS □ VFib 

Hyperkalemia continued on next page →

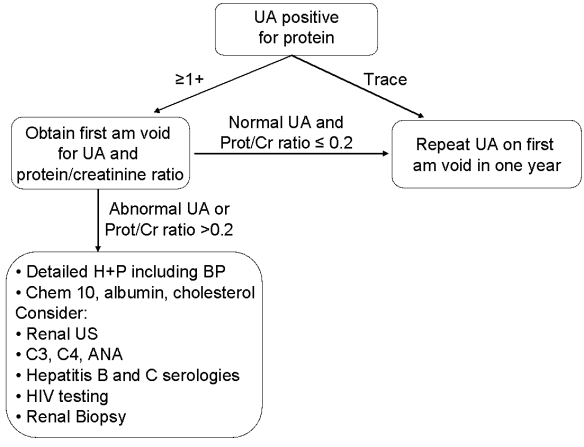
Hyperkalemia	
Workup	Chem 10 (ensure not hemolyzed -- free-flowing sample, order STAT), blood gas to assess acid/base status, EKG, TTKG (see above) -- low TTKG (<7) in setting of hyperkalemia may indicate aldo deficiency or resistance, plasma renin and aldosterone.
Management	If real and w/ EKG changes STOP K+ supplementation, K+-containing IVF, and K+-sparing medications **Stabilize cardiac membrane: calcium gluconate** 10% @ 0.5 mL/kg (=100 mg/kg) IV over 5 **calcium chloride** 20 mg/kg IV over 5-10 min if impending cardiac arrest **Drive K+ into cells** **insulin** 0.1 U/kg, max 10U IV with glucose: <5 yo: D10 (100 mg/mL) @ 5 mL/kg // ≥5 yo: D25 (250 mg/mL) @ 2-4 mL/kg IV (max 25g), infuse over 30 min **albuterol nebs**: neonates 0.4 mg in 2 mL NS // < 25 kg, 2.5 mg in 2 mL NS // 25-50 kg: 5 mg in 2 mL NS // >50 kg: 10 mg in 2-4 mL NS or 4-8 MDI puffs **bicarb**: 1 mEq/kg IV (max 50 mEq) over 10-15 min (< 6 mo: 2 mL/kg of 4.2% NaHCO3 // ≥ 6 mo: 1 mL/kg of 8.4% NaHCO3) **intubate + hyperventilate** (induce alkalosis) **Excrete total body K+** **Kayexalate** (1 g/kg, max 50g PO/PR q4h PRN) **Furosemide** 1-2 mg/kg IV (max 40 mg or 80 mg if renal insufficiency) q6h PRN **Dialysis** if emergent or if ongoing source of K+ release (tumor lysis, rhabdo)

Hematuria	
Definition	Red blood cells in the urine
Etiology	• **Extra-glomerular**: UTI, ureteral trauma, nephrolithiasis, cystitis (any UTI, adenovirus, cyclophosphamide), sickle cell disease or trait, malignancy (bladder CA, Wilms tumor) • **Intra-glomerular**: glomerulonephritis (see GN section), benign familial hematuria / thin basement membrane disease
Workup	• UA (+blood on dip AND +RBCs on micro?) • If only +blood, think myoglobin vs hemoglobin • If red but neg blood/neg RBC, think beets, rifampin, nitrofurantoin, doxorubicin, chloroquine • If cola- or tea-colored urine, RBC casts, marked proteinuria, or dysmorphic RBCs, think GN • If blood clots, uniform RBCs, urethral bleeding, think extra-gl.) • If h/o trauma, do CTAP • If s/sx UTI, do Ucx • If s/sx nephrolithiasis, do renal US +/- CTAP • If c/f GN, send chem 10, CBC/d/retic, C3/C4, albumin, ASLO, anti-DNase B, ANA, urine protein:Cr ratio; consider renal bx if concomitant proteinuria/HTN and/or rising serum creatinine

Proteinuria	
Definition	• Excessive excretion of urinary protein • **Dipstick**: estimates as follows: trace = 15-30 mg/dL / 1+ = 30-100 mg/dL / 2+ = 100-300 mg/dL / 3+ = 300-1000 mg/dL / 4+ = >1000 mg/dL • Primarily detects albumin • **Quantitative** (perform if dip pos): spot urine prot/Cr (nl <0.2 mg if age 2+, <0.5 if <2 yo; 3-3.5 mg/mg = nephrotic) / 24h: >100 mg/m2 per day is abnormal, >1000 mg/m2 per day is nephrotic

Proteinuria

Definition



Etiology

- **Glomerular** (inc filtration of macromolecules, esp albumin -- may be **transient** [fever, exercise, stress, seizures, resolves on rpt testing after stressor gone] vs **orthostatic** [present when standing and not when supine - first morning void] vs **persistent** [elevated on both supine/upright voids])
- **Tubular** (inc excretion of **low molecular weight proteins**, esp beta-2-microglobulin, that are normally filtered in the glomerulus and reabsorbed in the proximal tubule -- may be d/t congenital disorders of proximal tubule [Fanconi syndrome, cystinosis, galactosemia, Lowe syndrome] or with acute tubular injury [ATN, AIN, pyelo])
- **Overflow** (inc excretion of low molecular weight proteins d/t protein overproduction [multiple myeloma, myoglobin in rhabdomyolysis] .

Presentation

- If significant quantity, protein will be frothy; otherwise varies with cause
- If nephrotic, may have edema/HTN, may have stigmata of primary dx (oral ulcers, rash, and joint swelling in SLE; abdominal pain and palpable purpura in HSP; h/o recurrent UTIs with VUR, hepatitis and movement d/o in Wilson dz)

Nephritic Syndrome

Definition

Any of several conditions leading to glomerular hematuria, proteinuria, and potential AKI with azotemia/oliguria, edema, and hypertension.

Etiology

- Post infectious:
  - **Group A beta hemolytic strep**, either after pharyngitis or impetigo
  - Other infections: staph aureus/epi, pneumococcus, mycoplasma, viral
- IgA Nephropathy (most common glomerulopathy worldwide)
- SLE Nephritis
- **Membranoproliferative GN**: can be idiopathic or secondary to HBV/HCV or rheumatologic disease
- **Alport Syndrome**: XLR collagen IV mutations, a/w hearing loss, vision changes
- **Goodpasture Syndrome**: autoAb to Type IV collagen in glomerular and alveolar basement membranes → hemoptysis,
- **Vasculitis**: HSP, granulomatosis with polyangiitis (lung/sinus/kidney), eosinophilic granulomatosis with polyangiitis (asthma/neuropathy/lung/kidney/skin), microscopic polyangiitis (lung/kidney)

Nephritic Syndrome continued on next page →

Nephritic Syndrome	

Clinical Manifestations	• Hypertension
	• Hematuria
	• Fluid retention/edema
	• Sequelae of underlying disease
	  ▪ **SLE**: rash, arthritis, oral ulcers
	  ▪ **Vasculitides**: hemoptysis, skin ulcers
	  ▪ **Alport**: sensorineural hearing loss, vision changes
	• Ask about preceding sore throat (usually 2-3 weeks before onset of post strep GN) or current URI symptoms (which can be seen with IgAN)
	• Some patients may have rapid progression with development of acute renal failure over course of several days. Any of above etiologies can have a rapidly progressive course.

Exam	• Monitor BP • Assess volume status • Look for signs of lupus or other vasculitides such as rash, abdominal tenderness (HSP), joint swelling/tenderness
Diagnostic Studies	• **UA**: RBCs + proteinuria. Glomerular bleeding → dysmorphic RBCs and red cell casts • Chem 10 / CBC/diff/retic / serum albumin / ASLO + anti-DNase B / ANA + anti-dsDNA • **C3, C4**: low C3 seen with post-infectious GN and C3 glomerulopathy low C3/C4 in SLE; normal C3/C4 in IgAN, pauci-immune GNs (ANCA-associated vasculitis) and anti-GBM disease • **Urine protein to creatinine ratio**: typically will see proteinuria, sometimes in nephrotic range (nephrotic range protein is urine protein/Cr ratio >2) • If rapidly progressive course or significant renal insufficiency on admission, send anti-GBM Ab and ANCA (for Goodpasture disease and GPA/MPA). Patients with rapidly progressive course should have renal biopsy.

Treatment	• **Reasons for admission**: hypertension, acute renal failure, volume overload, or electrolyte abnormalities
	• Hypertension typically responsive to diuretics
	• Fluid and sodium restriction during acute phase
	• Patients with RPGN may be treated with pulse dose steroids
	  ▪ Patients with RPGN due to Goodpasture disease, SLE, or GPA/MPA may be treated with steroids, cyclophosphamide, and plasmapheresis
	• Post-infectious GN is typically self-resolving
	  ▪ Patients suspected to have post-infectious GN should have repeat complement studies sent in 8-12 weeks, at which time complement should return to normal. If still hypocomplementemic, consider other diagnosis such as C3 glomerulopathy or SLE

Nephrotic Syndrome	
Definition	Syndrome characterized by presence of heavy proteinuria (albuminuria >3 g/24 hours), hypoalbuminemia (<3.0 g/dL), edema, hyperlipidemia, and thrombotic disease
Etiology	• Minimal change disease (most common in children) • Focal segmental glomerulosclerosis • Membranous Nephropathy • Membranoproliferative GN (may be nephrotic + nephritic) • SLE (may be nephrotic + nephritic)
Pathophysiology	• Abnormalities in glomerular podocytes → increased filtration of proteins, esp **albumin**. Others include clotting inhibitors (Protein C, S, anti-thrombin III) → prothombotic state and immunoglobulins → susceptibility to serious infections. • Increased Na retention and hypoalbuminemia → edema • Decreased oncotic pressure → inc hepatic lipoprotein synthesis → hypercholesterolemia
Clinical Manifestations	• Edema, typically first appears in periorbital tissue/scrotum, then in dependent areas • HTN, HLD, increased risk of VTE • Can present with AKI

Nephrotic Syndrome

Exam	Edema, hypertension, assess for extra-renal findings that may suggest a secondary cause for nephrotic syndrome (e.g. infection)
Diagnostic Studies	• Chem 10; C3; see also section on proteinuria • UA + 24 hour urine collection >3 grams/day OR spot Ur prot:Cr ratio > 2 (normal <0.2) • Consider renal biopsy for diagnosis (see below)
Treatment	• Empiric steroids for presumed minimal change disease (if persistent past 1-2 wk) ▪ Prednisone 60 mg/m2/day (max 60 mg/day) for 4 weeks ▪ Then prednisone 40 mg/m2/day QOD for 4 weeks w/ gradual taper, generally for minimum total 2 -3 months • Consider biopsy if steroid resistant, steroid-dependent, or evidence of steroid toxicity ▪ In minimal change, see normal light microscopy but on EM there is diffuse foot process effacement • ACE inhibitors or ARBs are preferred for BP control (decrease glomerular pressure, → decreased protein filtration) ▪ e.g., **enalapril** 0.08 mg/kg per day (maximum of 5 mg/day), titrate to maximum dose of 0.6 mg/kg per day (maximum of 40 mg/day) re: BP response ▪ Use with caution for GFR <60 mL/min/1.73 m2 ▪ Re-check serum Cr, K 3-5 days after starting ACEI/ARB • Edema - **salt restriction** (< 2 mEq/kg/day) and **diuretics**: ▪ if intravascular volume normal (FeNa >2%) - furosemide 1-2 mg/kg/dose x2 doses ▪ If intravascular volume low (FeNa <2%) and edema is **severe** (anasarca, pleural effusions, ascites): • Albumin 25% 1 gram/kg IV over 4 hours • Give 1 mg/kg IV lasix at the 2 hour point • Give 1 mg/kg IV lasix after albumin infusion • Consider prophylactic anticoagulation if high-risk (age >12, albumin <2, fibrinogen >6) • Treat VTE if present with LMWH • Consider statin for HLD, especially if other ASCVD risk factors are present

Acute Kidney Injury

Definition	Acute decrease in GFR per KDIGO criteria: **Table 2 | Staging of AKI** Stage 1: Serum creatinine: 1.5–1.9 times baseline OR ⩾0.3 mg/dl (⩾26.5 μmol/l) increase; Urine output: <0.5 ml/kg/h for 6–12 hours Stage 2: Serum creatinine: 2.0–2.9 times baseline; Urine output: <0.5 ml/kg/h for ⩾12 hours Stage 3: Serum creatinine: 3.0 times baseline OR Increase in serum creatinine to ⩾4.0 mg/dl (⩾353.6 μmol/l) OR Initiation of renal replacement therapy OR, In patients <18 years, decrease in eGFR to <35 ml/min per 1.73 m^2; Urine output: <0.3 ml/kg/h for ⩾24 hours OR Anuria for ⩾12 hours
Etiology	**Pre-Renal**: decreased renal perfusion • Decreased intravascular volume: dehydration, blood loss • Decreased effective circulating volume: shock, heart failure, cirrhosis **Renal**: intrinsic renal parenchymal disease • Glomerular disease: glomerulonephritis, nephrotic disorders • Vascular: vasculitis • Tubulointerstitial: ATN (ischemia/progression of pre-renal AKI, aminoglycosides, myoglobin, uric acid in tumor lysis syndrome), interstitial nephritis (NSAIDs, penicillins) **Post-Renal**: obstructive uropathy (posterior urethral valves, tumor, large stones, etc). Needs to be bilateral compression to develop renal failure in a patient with otherwise normal kidneys.
Clinical Manifestations	• Fluid retention: edema, decreased urine output • Hematuria with intrinsic kidney injury (glomerulonephritis, ATN) • Uremia: nausea/vomiting, GI bleeding, pericarditis, pruritus, mental status change

Acute Kidney Injury continued on next page →

Acute Kidney Injury	
Exam	Look for hypertension and edema (periorbital and peripheral)
Diagnostic Studies	• UA: ▪ Hematuria, proteinuria, red cell casts suggests glomerulonephritis ▪ Muddy brown casts suggests ATN ▪ Urine eosinophils suggests acute interstitial nephritis (not a great test, may be positive even if only 1 eosinophil) • Urine electrolytes to calculate fractional excretion sodium (FENa) ▪ FENa = (UNa x PCr)/(PNa x UCr) ▪ FENa <1% suggests prerenal; FENa >2% suggests intrarenal • Chem 10 • CBC/diff • Consider CK if history suggestive of rhabdomyolysis • Renal US to look for hydronephrosis, obstructive uropathy, renal scarring
Treatment	• Correct associated electrolyte issues (hyperkalemia, hyponatremia, hypocalcemia, acidosis) • Manage hypertension (see section below) • Fluid management ▪ Small NS bolus (5-10 cc/kg) if hypovolemic or in pre-renal failure ▪ Reassess volume status and continue to give small boluses until patient is euvolemic ▪ Replace insensible losses plus 1:1 urine/stool output ▪ Insensible losses = 300 cc/m2/day ▪ *BSA = square root of [(ht cm x wt kg)/3600]* • Indications for dialysis: AEIOU ▪ **A**cidosis ▪ **E**lectrolyte anomalies refractory to medical management (hyperK/Phos) ▪ **I**ngestions (Li, ASA) ▪ **O**verload ▪ **U**remia (pericarditis, encephalopathy)

Chronic Kidney Disease	
Definition	• Irreversible kidney damage and reduction in kidney function; may be progressive • Requires 1 of 2 of the following (2012 KDIGO Clinical Practice Guideline); **ages 2+:** ▪ GFR < 60 mL/1.73 m2 for > 3 mo ▪ GFR > 60 mL/1.73 m2 alongside evidence of structural kidney damage or other marker of abnormal renal function (proteinuria, albuminuria, renal tubular d/o) ▪ For kids <2 → GFR <1 std dev below mean = mod dysfunction, <2 std dev = severe • Severity stratified by GFR from G1 (normal, ≥90) → G2 (60-89) → G3a (45-59) → G3b (30-44) → G4 (15-29) → G5 (<15) = ESRD / dialysis-dependence
Etiology	• Congenital causes (renal aplasia, reflux, PKD, obstructive uropathy) in ~60% • Glomerular disease (FSGS, membranous nephropathy, MPGN, SLE nephritis, etc.) • Other: HUS, Alport syndrome, cystinosis, interstitial nephritis, tumors
Pathophysiology	Multiple possible insults leading to intraglomerular HTN and glomerular hypertrophy → nephron loss → hyperfiltration in remaining nephrons → further glomerular damage → glomerulosclerosis, proteinuria, fibrosis
Clinical Manifestations	• Edema + HTN • Proteinuria / hypoalbuminemia • Anemia (due to EPO deficiency) • Dyslipidemia / accelerated ASCVD • Vitamin D deficiency with secondary hyperparathyroidism • Electrolyte derangements: hyperkalemia, hyperphosphatemia, hypocalcemia, metabolic acidosis • Growth failure, delayed puberty, and intellectual disability • Complications of uremia: pericarditis, platelet dysfunction, encephalopathy

Chronic Kidney Disease	
Diagnostic Studies	• Chem 10 • UA w/ urine protein:Cr ratio • CBC/diff/retic + iron studies • 25-OH Vitamin D, PTH • Fasting lipid panel • If etiology uncertain: see sections on proteinuria/hematuria, consider renal U/S and bx
Management	Stage G1/G2 → • Monitor kidney function closely • Educate about nephrotoxin avoidance (NSAIDs, contrast, smoking, obesity, dehydration) • BP control w/ ACEI/ARB ▪ ESCAPE trial - N Engl J Med. 2009;361(17):1639. Using ramipril (starting at 6 mg/m2/d and inc dose / adding other agents as needed), targeting 50th %ile BP for age, sex, and weight vs 90th %ile slowed rate of progression to ESRD Stages G3 and above, add the following → • Prepare for possibility of transplant, ideally prior to dialysis (HD vs peritoneal) • Na-restricted diet (2-3g/d) +/- diuretics (furosemide 0.5-2 mg/kg/d, HCTZ 1-3 mg/kg/d) • Management of hyperkalemia (low K diet, diuretics), acidosis (Na bicarb), hypocalcemia/ hyperphosphatemia (Vitamin D, calcimimetics, phos binders) • Rx anemia to goal Hgb 10-12 g/dL w/ EPO-stimulating agents (erythropoietin alfa, darbepoetin alfa) • In pts with significant uremia, consider preoperative DDAVP to prevent bleeding

Hemolytic-Uremic Syndrome	
Definition	• **Hemolytic Uremic Syndrome**: microangiopathic hemolytic anemia + AKI + thrombocytopenia • **Thrombotic Thrombocytopenic Purpura**: triad of HUS + fever + neurologic changes
Etiology	• Principally affects children under the age of five years. • 90% due to shiga toxin; of those 70% due to *enterohemorrhagic* E. Coli • Occurs in 6-9% of EHEC infections; usually begins 5-10 days after diarrhea onset • Non-diarrheal (atypical) HUS associated can be due to *S. pneumo* infection or due to defects in the complement system (e.g., mutations in complement regulatory proteins)
Pathophysiology	• **HUS**: Shiga toxin binds to receptors in glomerular, colonic, and cerebral cells → promotes adhesion and aggregation of platelets onto endothelial cells → thrombocytopenia and RBC shearing (microangiopathic anemia); in kidney, glomerular damage • **TTP**: due to deficiency or immune-mediated inhibition of ADAMTS13, a metalloproteinase responsible for breakdown of vWF. No vWF cleavage → coagulation occurs at a higher rate, particularly in microvasculature → platelet consumption → thrombocytopenia and microthrombi → microangiopathic hemolytic anemia.
Clinical Manifestations	• **Microangiopathic hemolytic anemia**: jaundice, pallor, dark urine • **Thrombocytopenia**: petechiae, bleeding • **Acute renal failure**: HTN, edema • **Central nervous system**: seizures, coma, stroke • **Cardiac**: dysfunction due to ischemia, uremia, fluid overload. • **Pancreas**: transient DM • **Liver**: Hepatomegaly, increased serum transaminases • **Heme**: In addition to anemia and thrombocytopenia, leukocytosis is common in diarrhea-induced HUS; the prognosis is worse with increased white blood cell counts

Hemolytic-Uremic Syndrome continued on next page →

Hemolytic-Uremic Syndrome

Diagnostic Studies	• **CBC/diff/retic**: anemia, thrombocytopenia w/ appropriate reticulocytosis • **Smear**: schistocytes • ↑ LDH, ↓ haptoglobin, Coombs negative (evidence of intravascular hemolysis) • **Chem 10**: evidence of acute kidney injury, elevated BUN/Cr • **LFTs**: elevation in transaminases, unconjugated hyperbilirubinemia • **UA**: may demonstrate proteinuria, hematuria • Stool culture • Head CT if any change in MS or abnormal neurologic exam
Treatment	• Treatment mainly supportive; judicious fluid management (see section on AKI), correct electrolyte abnormalities, transfuse RBCs if needed (avoid platelets unless actively bleeding, as this may worsen the TMA process), manage hypertension • If significant CNS involvement or if TTP suspected, consider plasmapheresis. • For non-STx mediated HUS, consider eculizumab (anti-C5 antibody; prevents activation of terminal complement pathway) • 5-10% mortality; 5-10% progress to ESRD; inc WBC, seizure, or CVA = poor prognostic factors

Hypertension

Definition

	Children 1-13 years old	Children >13 years old
Normal	<90th percentile	<120/<80 mmHg
Elevated BP	≥90th percentile to <95th percentile or 120/80 mmHg to <95th percentile (whichever is lower)	120/<80 to 129/<80 mmHg
Stage 1 HTN	≥95th percentile to <95th percentile +12 mmHg or 130/80 to 139/89 mmHg (whichever is lower)	130/80 to 139/89 mmHg
Stage 2 HTN	≥95th percentile + 12 mmHg or ≥140/90 mmHg (whichever is lower)	≥140/90 mmHg

Percentiles determined by gender, age, and height -- see Harriet Lane or *Formula & References*.
Source: Flynn et. al, Pediatrics. 2017;140(3):e20171904
Full percentile tables located on pages 140-143

Etiology

Essential Hypertension:
- Most common etiology in older children; increasing incidence with rise in obesity
- More likely in children who are overweight, postpubertal, and/or have a family history of hypertension

Secondary Hypertension
- **Renal Parenchymal Disease**
  - Glomerulonephritis, both acute and chronic
  - Renal scarring from pyelonephritis, VUR → CKD
- **Renovascular**
  - Renal artery stenosis: fibromuscular dysplasia, Neurofibromatosis I, Williams Syndrome
  - Thromboembolism (e.g., h/o UAC)
  - Aortic coarctation
  - Vasculitis: Takayasu's arteritis, polyarteritis nodosa
- **Endocrine**
  - Hyperthyroidism
  - Catecholamine excess: pheochromocytoma, neuroblastoma, exogenous catecholamines (cold medications, cocaine, amphetamines)
  - Corticosteroid excess: exogenous or endogenous (Cushing's)
  - Mineralocorticoid excess: congenital adrenal hyperplasia, primary hyperaldosteronism
- **Neurologic**: intracranial hypertension, familial dysautonomia

Hypertension	
Clinical Manifestations	• Depends on etiology; essential hypertension often asymptomatic and discovered on routine blood pressure screening • Renal parenchymal disease: may present with hematuria, edema • Catecholamine excess: headache, flushing, sweating, tachycardia • Hyperthyroidism: sweating, diarrhea, tachycardia • Hypertensive emergency can present with headache, altered mental status, chest pain, dyspnea (see section on hypertensive emergency on page 238)
Evaluation	**Phase 1:Confirmation** • Manual auscultatory measurement with appropriate-sized cuff on 3 separate occasions ▪ Bladder width: > 40% of upper arm circumference ▪ Bladder length: > 80% of upper arm circumference • Consider BP measurements at school, home, or ambulatory BP monitoring **Phase 2: Screening studies** • Urinalysis (microscopic if positive) • Chem 10 + uric acid (if concern for oncologic etiology, can also be elevated in essential HTN) • Renal ultrasound with doppler interrogation **Phase 3: Directed testing** • Determine etiology (tests to consider based on history, PE, screening results) ▪ TFTs ▪ Plasma/urine catecholamines and metanephrines ▪ Renin/aldosterone ▪ DMSA scan to identify renal scarring in the setting of severe VUR ▪ Renal arteriography • Assess for end-organ damage ▪ Echocardiogram (?LVH) ▪ Dilated eye exam (?retinal changes)
Treatment	• For essential hypertension, can consider dietary/lifestyle modifications as first-line approach for patients with Stage 1 hypertension and no evidence of end-organ damage • Pharmacologic therapy typically indicated for patients with Stage 2 hypertension, symptomatic hypertension, evidence of end-organ damage, or Stage 1 hypertension that does not improve after 4-6 months of lifestyle modifications • Choice of pharmacologic agent depends on underlying etiology ▪ For renin-mediated hypertension (renal artery stenosis, renal scarring), ACE-inhibitor usually best choice (e.g., ramipril 6 mg/kg once daily) ▪ For volume-related hypertension (e.g., glomerulonephritis) use diuretics (e.g., HCTZ 1-3 mg/kg once daily) • General principle is to choose one medication and increase dose until reach maximum recommended dose, then add an additional agent until hypertension controlled • **For treatment of hypertensive emergency, refer to hypertensive emergency section in critical care chapter on page 238**

Hypertension continued on next page →

Hypertension

Blood Pressure Levels for Boys by Age and Height Percentile

Age (Year)	BP Percentile ↓	Systolic BP (mmHg) ← Percentile of Height →							Diastolic BP (mmHg) ← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	50th	80	81	83	85	87	88	89	34	35	36	37	38	39	39
	90th	94	95	97	99	100	102	103	49	50	51	52	53	53	54
	95th	98	99	101	103	104	106	106	54	54	55	56	57	58	58
	99th	105	106	108	110	112	113	114	61	62	63	64	65	66	66
2	50th	84	85	87	88	90	92	92	39	40	41	42	43	44	44
	90th	97	99	100	102	104	105	106	54	55	56	57	58	58	59
	95th	101	102	104	106	108	109	110	59	59	60	61	62	63	63
	99th	109	110	111	113	115	117	117	66	67	68	69	70	71	71
3	50th	86	87	89	91	93	94	95	44	44	45	46	47	48	48
	90th	100	101	103	105	107	108	109	59	59	60	61	62	63	63
	95th	104	105	107	109	110	112	113	63	63	64	65	66	67	67
	99th	111	112	114	116	118	119	120	71	71	72	73	74	75	75
4	50th	88	89	91	93	95	96	97	47	48	49	50	51	51	52
	90th	102	103	105	107	109	110	111	62	63	64	65	66	66	67
	95th	106	107	109	111	112	114	115	66	67	68	69	70	71	71
	99th	113	114	116	118	120	121	122	74	75	76	77	78	78	79
5	50th	90	91	93	95	96	98	98	50	51	52	53	54	55	55
	90th	104	105	106	108	110	111	112	65	66	67	68	69	69	70
	95th	108	109	110	112	114	115	116	69	70	71	72	73	74	74
	99th	115	116	118	120	121	123	123	77	78	79	80	81	81	82
6	50th	91	92	94	96	98	99	100	53	53	54	55	56	57	57
	90th	105	106	108	110	111	113	113	68	68	69	70	71	72	72
	95th	109	110	112	114	115	117	117	72	72	73	74	75	76	76
	99th	116	117	119	121	123	124	125	80	80	81	82	83	84	84
7	50th	92	94	95	97	99	100	101	55	55	56	57	58	59	59
	90th	106	107	109	111	113	114	115	70	70	71	72	73	74	74
	95th	110	111	113	115	117	118	119	74	74	75	76	77	78	78
	99th	117	118	120	122	124	125	126	82	82	83	84	85	86	86
8	50th	94	95	97	99	100	102	102	56	57	58	59	60	60	61
	90th	107	109	110	112	114	115	116	71	72	72	73	74	75	76
	95th	111	112	114	116	118	119	120	75	76	77	78	79	79	80
	99th	119	120	122	123	125	127	127	83	84	85	86	87	87	88
9	50th	95	96	98	100	102	103	104	57	58	59	60	61	61	62
	90th	109	110	112	114	115	117	118	72	73	74	75	76	76	77
	95th	113	114	116	118	119	121	121	76	77	78	79	80	81	81
	99th	120	121	123	125	127	128	129	84	85	86	87	88	88	89
10	50th	97	98	100	102	103	105	106	58	59	60	61	61	62	63
	90th	111	112	114	115	117	119	119	73	73	74	75	76	77	78
	95th	115	116	117	119	121	122	123	77	78	79	80	81	81	82
	99th	122	123	125	127	128	130	130	85	86	86	88	88	89	90

Hypertension

Blood Pressure Levels for Boys by Age and Height Percentile

Age (Year)	BP Percentile ↓	Systolic BP (mmHg) ← Percentile of Height →							Diastolic BP (mmHg) ← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
11	50th	100	101	102	103	105	106	107	60	60	60	61	62	63	63
	90th	114	114	116	117	118	119	120	74	74	74	75	76	77	77
	95th	118	118	119	121	122	123	124	78	78	78	79	80	81	81
	99th	125	125	126	128	129	130	131	85	85	86	87	87	88	89
12	50th	102	103	104	105	107	108	109	61	61	61	62	63	64	64
	90th	116	116	117	119	120	121	122	75	75	75	76	77	78	78
	95th	119	120	121	123	124	125	126	79	79	79	80	81	82	82
	99th	127	127	128	130	131	132	133	86	86	87	88	88	89	90
13	50th	104	105	106	107	109	110	110	62	62	62	63	64	65	65
	90th	117	118	119	121	122	123	124	76	76	76	77	78	79	79
	95th	121	122	123	124	126	127	128	80	80	80	81	82	83	83
	99th	128	129	130	132	133	134	135	87	87	88	89	89	90	91
14	50th	106	106	107	109	110	111	112	63	63	63	64	65	66	66
	90th	119	120	121	122	124	125	125	77	77	77	78	79	80	80
	95th	123	123	125	126	127	129	129	81	81	81	82	83	84	84
	99th	130	131	132	133	135	136	136	88	88	89	90	90	91	92
15	50th	107	108	109	110	111	113	113	64	64	64	65	66	67	67
	90th	120	121	122	123	125	126	127	78	78	78	79	80	81	81
	95th	124	125	126	127	129	130	131	82	82	82	83	84	85	85
	99th	131	132	133	134	136	137	138	89	89	90	91	91	92	93
16	50th	108	108	110	111	112	114	114	64	64	65	66	66	67	68
	90th	121	122	123	124	126	127	128	78	78	79	80	81	81	82
	95th	125	126	127	128	130	131	132	82	82	83	84	85	85	86
	99th	132	133	134	135	137	138	139	90	90	90	91	92	93	93
17	50th	108	109	110	111	113	114	115	64	65	65	66	67	67	68
	90th	122	122	123	125	126	127	128	78	79	79	80	81	81	82
	95th	125	126	127	129	130	131	132	82	83	83	84	85	85	86
	99th	133	133	134	136	137	138	139	90	90	91	91	92	93	93

Hypertension continued on next page →

Hypertension

Blood Pressure Levels for Girls by Age and Height Percentile

Age (Year)	BP Percentile ↓	Systolic BP (mmHg) ← Percentile of Height →							Diastolic BP (mmHg) ← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	50th	83	84	85	86	88	89	90	38	39	39	40	41	41	42
	90th	97	97	98	100	101	102	103	52	53	53	54	55	55	56
	95th	100	101	102	104	105	106	107	56	57	57	58	59	59	60
	99th	108	108	109	111	112	113	114	64	64	65	65	66	67	67
2	50th	85	85	87	88	89	91	91	43	44	44	45	46	46	47
	90th	98	99	100	101	103	104	105	57	58	58	59	60	61	61
	95th	102	103	104	105	107	108	109	61	62	62	63	64	65	65
	99th	109	110	111	112	114	115	116	69	69	70	70	71	72	72
3	50th	86	87	88	89	91	92	93	47	48	48	49	50	50	51
	90th	100	100	102	103	104	106	106	61	62	62	63	64	64	65
	95th	104	104	105	107	108	109	110	65	66	66	67	68	68	69
	99th	111	111	113	114	115	116	117	73	73	74	74	75	76	76
4	50th	88	88	90	91	92	94	94	50	50	51	52	52	53	54
	90th	101	102	103	104	106	107	108	64	64	65	66	67	67	68
	95th	105	106	107	108	110	111	112	68	68	69	70	71	71	72
	99th	112	113	114	115	117	118	119	76	76	76	77	78	79	79
5	50th	89	90	91	93	94	95	96	52	53	53	54	55	55	56
	90th	103	103	105	106	107	109	109	66	67	67	68	69	69	70
	95th	107	107	108	110	111	112	113	70	71	71	72	73	73	74
	99th	114	114	116	117	118	120	120	78	78	79	79	80	81	81
6	50th	91	92	93	94	96	97	98	54	54	55	56	56	57	58
	90th	104	105	106	108	109	110	111	68	68	69	70	70	71	72
	95th	108	109	110	111	113	114	115	72	72	73	74	74	75	76
	99th	115	116	117	119	120	121	122	80	80	80	81	82	83	83
7	50th	93	93	95	96	97	99	99	55	56	56	57	58	58	59
	90th	106	107	108	109	111	112	113	69	70	70	71	72	72	73
	95th	110	111	112	113	115	116	116	73	74	74	75	76	76	77
	99th	117	118	119	120	122	123	124	81	81	82	82	83	84	84
8	50th	95	95	96	98	99	100	101	57	57	57	58	59	60	60
	90th	108	109	110	111	113	114	114	71	71	71	72	73	74	74
	95th	112	112	114	115	116	118	118	75	75	75	76	77	78	78
	99th	119	120	121	122	123	125	125	82	82	83	83	84	85	86
9	50th	96	97	98	100	101	102	103	58	58	58	59	60	61	61
	90th	110	110	112	113	114	116	116	72	72	72	73	74	75	75
	95th	114	114	115	117	118	119	120	76	76	76	77	78	79	79
	99th	121	121	123	124	125	127	127	83	83	84	84	85	86	87
10	50th	98	99	100	102	103	104	105	59	59	59	60	61	62	62
	90th	112	112	114	115	116	118	118	73	73	73	74	75	76	76
	95th	116	116	117	119	120	121	122	77	77	77	78	79	80	80
	99th	123	123	125	126	127	129	129	84	84	85	86	86	87	88

Hypertension

Blood Pressure Levels for Girls by Age and Height Percentile

Age (Year)	BP Percentile ↓	Systolic BP (mmHg) ← Percentile of Height →							Diastolic BP (mmHg) ← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
11	50th	99	100	102	104	105	107	107	59	59	60	61	62	63	63
	90th	113	114	115	117	119	120	121	74	74	75	76	77	78	78
	95th	117	118	119	121	123	124	125	78	78	79	80	81	82	82
	99th	124	125	127	129	130	132	132	86	86	87	88	89	90	90
12	50th	101	102	104	106	108	109	110	59	60	61	62	63	63	64
	90th	115	116	118	120	121	123	123	74	75	75	76	77	78	79
	95th	119	120	122	123	125	127	127	78	79	80	81	82	82	83
	99th	126	127	129	131	133	134	135	86	87	88	89	90	90	91
13	50th	104	105	106	108	110	111	112	60	60	61	62	63	64	64
	90th	117	118	120	122	124	125	126	75	75	76	77	78	79	79
	95th	121	122	124	126	128	129	130	79	79	80	81	82	83	83
	99th	128	130	131	133	135	136	137	87	87	88	89	90	91	91
14	50th	106	107	109	111	113	114	115	60	61	62	63	64	65	65
	90th	120	121	123	125	126	128	128	75	76	77	78	79	79	80
	95th	124	125	127	128	130	132	132	80	80	81	82	83	84	84
	99th	131	132	134	136	138	139	140	87	88	89	90	91	92	92
15	50th	109	110	112	113	115	117	117	61	62	63	64	65	66	66
	90th	122	124	125	127	129	130	131	76	77	78	79	80	80	81
	95th	126	127	129	131	133	134	135	81	81	82	83	84	85	85
	99th	134	135	136	138	140	142	142	88	89	90	91	92	93	93
16	50th	111	112	114	116	118	119	120	63	63	64	65	66	67	67
	90th	125	126	128	130	131	133	134	78	78	79	80	81	82	82
	95th	129	130	132	134	135	137	137	82	83	83	84	85	86	87
	99th	136	137	139	141	143	144	145	90	90	91	92	93	94	94
17	50th	114	115	116	118	120	121	122	65	66	66	67	68	69	70
	90th	127	128	130	132	134	135	136	80	80	81	82	83	84	84
	95th	131	132	134	136	138	139	140	84	85	86	87	87	88	89
	99th	139	140	141	143	145	146	147	92	93	93	94	95	96	97

Urinary Tract Infections

Definition	• **Age < 2 mo**: ≥ 50,000 CFU/mL of a uropathogen OR 10,000-50,000 CFU/mL with pyuria on UA • **Age ≥ 2 mo**: significant bacteriuria (≥100,000 CFU/mL of **single** uropathogen from clean catch or ≥50,000 CFU/mL of uropathogen from cath sample) with associated inflammatory response (+LE/nitrite/WBC -- except if due to Enterococcus, Klebsiella, or PsA) and lower urinary tract symptoms (if appropriate age) • **Cystitis**: infection of urinary bladder • **Pyelonephritis**: infection of upper urinary tract (kidneys and ureters)

Etiology	• ~90% due to *E coli*; others include *Enterococcus*, *Proteus*, *Pseudomonas*, and *Enterobacter*
	• Adenovirus may cause acute infectious cystitis
	• Risk factors
	  • **Ages 2-23 months**: age <12 mo, max T ≥ 39 °C, nonblack race, female sex, uncircumcised male, no additional source of fever identified
	  • **Ages ≥ 2 years**:
	  ▪ Female sex (shorter urethra, wetter periurethral environment)
	  ▪ Lack of circumcision (in male infants)
	  ▪ Sexual activity (receptive vaginal intercourse -- S saprophyticus; unprotected insertive anal intercourse)
	  ▪ Urinary tract anomalies (bladder stones, constipation, urinary retention, posterior urethral valves, VUR)
	  ▪ Bladder catheterization or instrumentation (predisposes to PsA, coag-neg Staph)
	  ▪ Sickle cell disease
	  ▪ DM or other immunosuppressive conditions

Pathophysiology	• **Newborns**: rare in first 6d life. May be due to hematogenous spread or ascending infection. Hematogenous spread more likely among preterm infants. Congenital anomalies of the kidney and urinary tract may predispose to UTI • **Beyond newborn period**: colonization of periuerthral area by uropathogens → attachment of pathogens to uroepithelium → inflammatory response. Inflammation of upper urinary tract (pyelonephritis) → renal scarring → HTN, ESRD

Clinical Presentation	**Age < 2 years**: fever may be sole manifestation, esp when ≥ 39 °C (102.2 °F)
	  • Concomitant upper respiratory infection or AOM does not r/o UTI
	  • May have concomitant poor feeding, irritability, or FTT
	  • May cause **conjugated** hyperbilirubinemia
	Age ≥ 2 years:
	  • Cystitis: dysuria, urinary frequency, hematuria, suprapubic pain and TTP
	  • Pyelonephritis: fever, flank/back pain, nausea/vomiting, headache

Diagnostic Studies	**Don't Forget the UTI Clinical Pathway**
	
	Age < 2 mo: catheterized UA + urine culture.
	  • Obtain blood culture given risk of urosepsis
	  • Strongly consider LP (1-3% of infants with UTI have bacterial meningitis)
	  • Obtain renal/bladder U/S and consider VCUG if abnormal, if UTI is recurrent, or if pathogen other than *E. Coli* is identified
	  • If ultrasound suggests renal damage - consider DMSA scan after resolution of acute illness
	Age 2 mo-2 years:
	  • Low pre-test probability of UTI → consider starting with POCT UA on bagged urine sample. If normal, stop. If abnormal, obtain catheterized UA and send for culture. Do NOT send a bagged sample for culture.
	  • High pre-test probability of UTI → obtain catheterized UA and send for culture
	Age ≥ 2 years: clean catch UA → if +LE, nitrite, or WBC, send for culture
	  • Consider empiric antibiotics for ≥1+ LE **and** nitrite, ≥1+ LE **+/-** nitrite, **or** ≥10 WBC/hpf
	
	• Consider baseline creatinine if initiating nephrotoxic antibiotics
	• Consider CRP and procalcitonin: CRP <2 mg/dL helps exclude pyelo, while procalcitonin >0.5 ng/mL can help confirm pyelo

Urinary Tract Infections	
Treatment	**See BCH Clinical Pathway for Fever 0-1 month for additional recommendations** **Neonate 0-1 month (consult reference for preterm neonates):** **≥35 wk GA and ≤7 days old:** ▪ Ampicillin 50 mg/kg IV q8h ▪ Cefotaxime 50 mg/kg/dose q8h **OR** Gentamicin 4 mg/kg IV q24h **≥35 wk GA and >7 days old:** ▪ Ampicillin 50 mg/kg IV q6h ▪ Cefotaxime 50 mg/kg/dose q12h **OR** Gentamicin 5 mg/kg IV q24h **Infant/Child/Adolescent:** **Duration**: 5-7 days if afebrile, 7-10 days if febrile **1st line**: cephalexin 25 mg/kg/dose PO TID (max 500 mg/dose) vs ceftriaxone 50 mg/kg/dose IV q24h (max 2 g/dose) **2nd line**: TMP/SMX, amoxicillin-clavulanate, cefdinir, cefuroxime, ciprofloxacin (for adolsecents with pyelo), nitrofurantoin (for adolescents with cystitis) If Grade III-V VUR is identified on VCUG, can consider prophylactic antibiotics, though the decrease in UTIs is exactly matched by an increase in MDROs as the etiology for UTI, when present (Selekman RE et al., Uropathogen Resistance and Antibiotic Prophylaxis: A Meta-Analysis. Pediatrics 2018, e20180119)

Neurologic Emergencies

Status Epilepticus

PowerPlans	See new BCH Guidelines
Definition	Seizure lasting > 30 min or two sequential seizures w/o return to baseline in between. Neurologic emergency. If lasts greater than 60 min, considered refractory SE.
Presentation	May be generalized SE, focal SE, or non-convulsive (altered mental status)
Differential	Epilepsy, electrolyte derangement, febrile status, meningitis/encephalitis, space occupying lesion, stroke, hypertensive emergency/PRES, PNES
Red Flags	Refractory to treatment, focal neurologic deficits on examination
Workup	Initial labs include glucose, chem, UA/blood/urine cultures if febrile, urine tox screen, AED levels in patients taking AEDs, LP if concerns for CNS infections, imaging if examination is focal. Work up is considered following treatment.
Management	ABC's, correct electrolyte disturbances, call relevant neurology consult service

Timing	Meds	Dose
First Line (0-5 min)	IV Lorazepam If no access: Diazepam PR	(0.05 -0.1 mg/kg/dose) max 4 mg (0.5 mg/kg if < 5 y; 0.3 mg/kg if 6-11 y; 0.2 mg/kg if > 11 y
Second Line: (5 -15 min)	Repeat Benzos x 1 if no response in five minutes	Same dose
	Fosphenytoin IV	20 phenytoin equivalents/kg/ dose (max 1500 mg)
	Levetiracetam IV	60 mg/kg (max 4500 mg) over 5-15 minutes
Third Line (15-20 min)	Phenobarbital: monitor for resp. depression Give Levetiracetam OR Fosphenytoin (whichever was not previously given)	20/mg/kg IV push 60mg/kg IV 20 mg PE/kg/dose
	Consider repeat Fosphenytoin OR Valproic Acid	10 mg PE/kg/dose IV 20 mg/kg IV
Consider activating Code Blue or anesthesia stat x5-5555		

Complications	Cardiac arrhythmia, cerebral edema, hypotension, rhabdomyolysis, dehydration, pneumonia

Increased ICP

PowerPlans/EBG	Severe brain injury guidelines EBG
Pathophysiology	Elevated pressure due to cerebral edema or space occupying lesion, or abnormal CSF dynamics (obstruction, decreased absorption, increased production).
Presentation	**Infants**: bulging fontanelle, FTT, impaired upward gaze ("sunsetting"), macrocephaly, splitting sutures **Children**: diplopia, headache, AMS, papilledema, morning vomiting

Neurologic Emergencies

Increased ICP

Differential	Mass lesions (tumor, abscess, hematoma, AVM), impaired cerebral blood flow (hypercarbia, VST), impaired CSF absorption, cerebral edema (hypoxia, ischemia, abrupt sodium shifts, hemorrhage, trauma, fluid shifts, infection, tumor)
Red Flags	Signs and symptoms suggestive of herniation syndromes: declining consciousness, elevated BP and slow pulse, irregular breathing, dilated and fixed pupils, impaired upward gaze
Workup	Measure HC in infants (normal head growth in term newborn 2 cm/month for first 3 months à 1 cm/month second 3 months à 0.5 cm/month for next 6 months; assess fontanelle in infants; do not perform an LP prior to obtaining imaging.
Management	**ICU STAT.** Elevate head of bed 30-45 degrees to improve venous drainage. Maintain normal glucose. Aim for SpO2 > 95% and CO2 b/w 35-45 mmHg. Avoid hypotension. Maintain euthermia. Avoid hyponatremia. See table below for modalities. Consider neurosurgical consultation .
Complications	Herniation syndromes: Falcine, uncal, trans-tentorial, cerebellar

Treatment	Dose/Route/Timing
Hyperventilation	Lower arterial pressure of carbon dioxide to 25-30 mmHg (only a temporizing measure)
Osmotic Diuretics	20% mannitol, 0.25 – 1g/kg IV infused over 15 minutes Hypertonic Saline 5-10mL of 3% given over 5 min
Corticosteroids	Dexamethasone IV 0.1-0.2mg/kg q6hr (most useful for reducing edema around mass lesions)
Hypothermia	Body temp b/w 27 deg C and 31 deg C
Barbiturate Coma	Pentobarbital

Chief Complaint: Ataxia

Acute Cerebellar Ataxia

PowerPlans	N/A
Pathophysiology	Post-viral (or vaccine) inflammation limited to the cerebellum **Presentation:** New ataxia (unsteady, wide-based gait and dysmetria) in a previously healthy child varying from mild unsteadiness to inability to stand; sensorium remains intact. Mild nystagmus may be present. Symptoms remit after a few days, but abnormal gait may drag on for months
Differential	Ingestions, cerebellitis, posterior fossa mass, opsoclonus-myoclonus-ataxia
Red Flags	Lethargy, fever, progressive course indicates cerebellitis, which is life-threatening. Opsoclonus suggests opsoclonus-myoclonus ataxia, which can indicate an underlying neuroblastoma. Headache and vomiting can indicate mass.
Workup	Perform a drug screen to r/o ingestion. MRI brain w/o contrast (contrast will be added by radiology if needed), to rule out posterior fossa mass as needed.
Treatment	Disease is self-limited and treatment is not required. Typically managed outpatient by PCP.

Desai et al. Acute Cerebellar Ataxia, Acute Cerebellitis, and Opsoclonus-Myoclonus Syndrome. Journal of Child Neurology. 27 (11) 1482-1488. 2012.

Chief Complaint: Weakness	
Guillain Barre[1]	
PowerPlans	N/A
Pathophysiology	Monophasic demyelinating neuropathy. Immune system attacks peripheral nerves. At least half of cases are preceded by viral infection (respiratory > GI illnesses). C jejuni enteritis is an infamous example
Presentation	Progressive motor weakness (ascending) & areflexia +/- autonomic dysfunction
Differential	Spinal cord lesion (transverse myelitis), acute flaccid myelitis, tick paralysis, toxic neuropathy
Red Flags	Weakness of muscles of respiration can indicate need for intubation.
Workup	CSF profile classically w/ albuminocytologic dissociation (elevated protein w/o leukocytosis). EMG is not helpful early in the disease course.
Treatment	IVIG or plasmapheresis; consult PT
Miller-Fisher variant of Guillain Barre[2]	
PowerPlans	N/A
Pathophysiology	Antibody-mediated (anti-Gq1b) demyelination of the cranial nerves w/ or w/o peripheral nerve involvement.
Presentation	Defined by the presence of areflexia, ophthalmoplegia and ataxia; viral illness usually precedes symptoms. Sensorium remains intact.
Differential	Guillain-Barre Syndrome, myasthenia gravis, spinal cord lesion, MS
Red Flags	Weakness of muscles of respiration can indicate need for intubation
Workup	MRI of the brain and spine; LP if no space-occupying lesion. CSF profile similar to that of GBS w/ albuminocytologic dissociation (elevated protein w/o leukocytosis)
Treatment	IVIG 2g/kg over 2-5 days
Multiple Sclerosis[3]	
PowerPlans	N/A
Pathophysiology	T lymphocytes attack oligodendrocytes à damaged axons (autoimmune-mediated demyelination); known genetic (HLA subtypes) and environmental (smoking, latitude, vit D) risk factors
Presentation	• Repeated episodes focal deficits (optic neuritis, weakness, numbness) separated in time. • Imaging often shows lesions separated by space w/i the CNS
Differential	ADEM (often a first presentation of MS- multiple lesions causing altered sensorium), NMO spectrum disorder (neuromyelitis optica), MOG-antibody associated demyelinating disease, malignancy, nutritional deficiency, leukodystrophy, mitochondrial disorder, CNS vasculitis
Red Flags	• Presentation is broad and variable • Seizure (indicating gray matter involvement), fever should lead you to rethink the diagnosis • Weakness of muscles of respiration and/or mental status changes can indicate need for intubation

Chief Complaint: Weakness	
Multiple Sclerosis[3]	
Workup	• Definitive diagnosis requires repeated episodes over time. • LP reveals CSF w/ elevated protein count +/- presence of oligoclonal bands (must be compared w/ serum); MRI is imaging modality of choice. • The presence of 3 or more white matter lesions on T2 imaging especially if perpendicular to the ventricles sensitive for diagnosis (Dawson's fingers)
Treatment	Acute exacerbations require short-course of steroids. Load w/ methylprednisolone (30 mg/kg; maximum 1 g) treat for 3-5 days. Neuroimmunology consultation for disease-modifying drugs.
Infantile Botulism[4]	
PowerPlans	N/A
Pathophysiology	• C. botulinum produces toxin that interferes w/ release of acetylcholine at NMJ (disrupts vesicle binding to the pre-synaptic membrane). • In infancy, C. botulinum colonizes intestinal tract in situ. • Contamination of honey or corn syrup, dusty environments near construction/agricultural soil disruption are culprits. • In adults, paralysis results from ingestion of the toxin.
Presentation	Descending paralysis: often starting w/ ophthalmoplegia (may involve pupillary response), followed by weak cry, dysphagia and progresses to weakness of respiratory muscles
Differential	GBS Miller Fisher variant, hypermagnesemia, SMA, Myasthenia Gravis
Red Flags	Weakness of muscles of respiration can indicate need for intubation
Workup	Isolation of organism in stool; EMG: short-duration, low-amplitude motor unit potentials
Management	• ICU care for severe presentation, may require ventilator support • Immune globulin • Avoid aminoglycosides (produce pre-synaptic neuromuscular blockage) • Treat w/ BIG prior to confirmation of stool/EMG if clinical suspicion is high
Complications	Apnea, respiratory failure, sudden infant death
Myasthenia Gravis[5]	
PowerPlans	None
Pathophysiology	Antibody blockade of the post-synaptic ACh receptor at the neuromuscular junction
Presentation	• Fatigable weakness (symptoms worse at the end of the day) • Diplopia and ptosis can be provoked by sustained upgaze, arm weakness can be provoked w/ repetitive arm pumps. • Weakness tends to present in the muscles of the face, causing dysphagia, dysphonia, drooling, dysarthria (bulbar symptoms) • **Myasthenic Crisis**: Presents w/ inability to clear secretions or maintain oxygenation (precipitated by infection, surgery, stress, meds, etc)
Differential	Botulism, Miller Fisher variant of GBS, brainstem lesion, thyroid ophthalmopathy
Red Flags	Check how high the patient can count in a single breath, NIFs, check sustained up-gaze; evaluate neck flexion/extension (sensitive test for diaphragmatic strength) to assess need for intubation

Weakness continued on next page →

Chief Complaint: Weakness

Myasthenia Gravis[5]

Workup	Ice pack for eval of ptosis (should improve as cold slows acetylcholinesterase activity; check for antibodies (anti-AChR, anti-MuSK), EMG: decrement in muscle potentials on repetitive nerve stim
Management	Avoidance of drugs which may exacerbate MG (see uptodate table). Monitor FVC/NIF and intubate for FVC < 15 mL/kg and NIF < -20. Suctioning, NG tube.
Treatment	See below: IVIG (0.4 g/kg/d x 5d), plasmapheresis if severe
Complications	Respiratory failure, death

Bell's Palsy

PowerPlans	Facial Palsy EBG
Pathophysiology	Acute paralysis of the peripheral facial nerve. Pathogenesis viral (most commonly HSV) but also may be post-viral or immune-mediated (VZV, Hepatitis, HIV, Lyme, EBV)
Presentation	Weakness in the upper and lower face, pain, tingling in ipsilateral ear canal, taste changes, impaired lacrimation and hypersensitivity to sound
Differential	Otitis media, trauma, tumor, TB, Ramsay Hunt Syndrome, Malignant Hypertension, Mastoiditis
Red Flags	HTN, other cranial neuropathies
Workup	Exclude other cause (i.e. HTN, trauma, active herpetic lesions c/w RHS), Lyme serologies
Management	• **Watchful waiting**: eye ointments/artificial tears to maintain hydration, eye patch or taping eyelid closed while sleeping, use of corticosteroids controversial (most kids have complete spontaneous recovery); valacyclovir/acyclovir if HSV suspected, doxycycline if Lyme is suspected May-November; consider MRI if other symptoms present . • **Empiric corticosteroids**: = Prednisone 2 mg/kg once daily x 5 days w/ 5-day taper (max 60 mg/dose). Start w/i three days of symptom onset.
Complications	Corneal ulcers if absent blink reflex/incomplete closure of palpebral fissure

CNS Manifestations of Lyme Disease

PowerPlans	N/A
Pathophysiology	B. burgdorferi from animals via tick vector
Presentation	fatigue, malaise, headache, facial palsy, peripheral neuritis, meningitis
Differential	Aseptic meningitis
Workup	Clinical diagnosis; lumbar puncture (elevated opening pressure, lymphocytic pleocytosis), screening test serum antibodies; confirmatory testing w/ western blot

Stage	Treatment
Early localized	**Ages 8 and older**: Doxycycline 4mg/kg/day divided BID x14 d **All ages**: Amoxicillin 50 mg/kg/d divided TID x14 d
Early disseminated and late disease	Same as early but for 21-28 d Ceftriaxone 75-100mg/kg IV or IM daily for 14-28d OR Penicillin 300K units/kg IV given in divided doses q4hr 14-28d

Chief Complaint: Weakness	
CNS Manifestations of Lyme Disease	
Management	See previous
Complications	Complications of meningitis, facial palsy, peripheral neuritis
Stroke[6]	
PowerPlans	Please call a code stroke if symptom onset < 5 hours prior (x52170); Neuroscience ICP admit plan or Neuro stroke plan, See Neurology Card
Pathophysiology	Acute onset neurologic dysfunction due to impaired blood supply to the brain; ischemic or hemorrhagic
Presentation	Acute onset unilateral weakness or numbness, acute onset altered mental status, new-onset focal seizures
Differential	Todd's paralysis following focal seizure, hemiplegic migraine, venous sinus thrombosis
Red Flags	Risk factors include infection, pro-thrombotic state, leukocytosis and anemia Risk factors for arterial ischemic stroke include Sickle Cell Disease and Cardiac Disease Risk factors for venous stroke are IBD, auto-immune disorders, infections and dehydration
Workup	Brain MRI/MRA w/ stroke protocol (includes DWI/ADC, FLAIR, T2, T1, susceptibility sequences) +/- MRV. TTE look for cardiac causes, serum labs to look for coagulopathy, if newborn add metabolic studies
Management	ABC's! Head of bed flat; IVF at maintenance, target SBP 50-90th percentile for age. Maintain euglycemia and normothermia, treat seizures, consider PICU admission and neurosurgical consult
Complications	Malignant edema which may lead to herniation, hemorrhagic conversion **(consider STAT CT for change in exam)**

1. Jones, H. Guillain-Barre Syndrome: Perspectives w/ Infants and Children. Seminars in Pediatric Neurology June 2000.
2. Shahrizaila, N, and Yuki, N. Bickerstaff brainstem encephalitis and Fisher Syndrome: anti-GQ1B antibody syndrome. Journal of Neurology, Neurosurgery and Psychiatry 84(5). 2013.
3. Krupp et al. International Pediatric Multiple Sclerosis Study Group criteria for pediatric multiple sclerosis and immune-mediated central nervous system demyelinating disorders: revisions to the 2007 definitions. Multiple Sclerosis Journal. April 2013.
4. Thompson et al., Infant Botulism in the age of botulism immune globulin. Neurology. June 2005.
5. Peragallo, J. Pediatric Myasthenia Gravis. Seminars in Pediatric Neurology. May 2017.
6. Lehman, et al., Transient focal neurologic symptoms correspond to regional cerebral hypoperfusion by MRI: A stroke mimic in children. American Journal of Neuroradiology. July 2017.

Chief Complaint: Altered Mental Status	
Meningitis: Inflammation of the leptomeninges secondary to infection **Encephalitis**: Infection of brain parenchyma secondary to infection (altered mental status, focal neurologic deficits)	
Bacterial Meningitis	
PowerPlans	**Fever in infant < 30 days**
Pathophysiology	Bacterial infection of the meninges. Caused by hematogenous spread or direct spread from sinuses or mastoids
Presentation	• Fever, headache, vomiting, meningismus, seizures • **Kernig Sign**: Stretching of hamstring w/ knee extension + back pain • **Brudzinski Sign**: passive neck flexion, involuntary hip/knee flexion
Differential	Viral meningitis/encephalitis, brain abscess, increased ICP, neoplasm, ADEM

Altered Mental Status continued on next page →

Chief Complaint: Altered Mental Status

Bacterial Meningitis

Red Flags	Focal neurological deficits, seizures, papilledema. Risk factors for TB (poor clinical outcomes), petechiae on exam (Neisseria)
Workup	It's all about the LP. CSF: WBC count often > 1,000, glucose often < 40 or < half of serum value, protein > 250, cell count w/ > 50% PMNs. Obtain imaging on comatose patients or those w/ focal neurologic deficits PRIOR to LP.
Management	In addition to ABX, dexamethasone used to reduce hearing loss in children 0.15mg/kg q6hr for 2-4 days. See table for ABX.
Complications	Seizure, stroke, elevated intracranial pressure

Age	Pathogen	Treatment
0-1 month	GBS, E. Coli, L. monocytogenes, S. pneumo	Ampicillin 75-100mg/kg q6-q8hr AND Cefotaxime 50 mg/kg q8hr OR Gentamicin 4mg/kg/dose q24hr
1-3 months	S. pneumo, E. coli, Neisseria, GBS, L. monocytogenes, H. flu	Ampicillin 50-100mg/kg q6-q8hr AND Cefotaxime 100mg/kg q8hr or Ceftriaxone 100mg/kg q6-8hr
3- 18 months	N. meningitides, S. pneumo, H. Influenzae	Cefotaxime 100mg/kg q8hr or Ceftriaxone 100mg/kg q6-8hr AND Vancomycin

Viral Meningitis and Encephalitis

PowerPlans	None
Pathophysiology	Viral infection and inflammation of the meninges
Presentation	Fever, headache,malaise, photophobia, altered mental status
Differential	HSV (HSV-1 most common in children, HSV-2 most common in neonatal period acquired through maternal transmission), EBV, VZV, CMV (consider if immunocompromised), Eastern Equine Virus, Subacute sclerosis panencephalitis (if remote hx of measles infection), Lyme
Red Flags	History of immunosuppression, transplant: consider less common organisms
Workup	• Consider MRI if focal neurologic deficits are present • LP should be performed; CSF profile w/ elevated protein and cells, lymphocytic pleocytosis.
Management	Largely supportive, w/ empiric treatment w/ antibiotics and acyclovir until cultures result HSV = Acyclovir 14 to 21-day course (<35 wk conceptual age 40 mg/kg/d divided q12; > 35 wk conceptual age 60 mg/kg/d divided q8hr); CMV = Ganciclovir
Complications	Rarely associated w/ long-term issues; HSV may cause hemorrhage w/i temporal lobes, causing seizures

Acute Disseminated Encephalomyelitis (ADEM)[1]

PowerPlans	N/A
Pathophysiology	Central demyelinating disorder, presumed immune-mediated mechanism
Presentation	Lethargy, headache, vomiting, focal neurological symptoms
Differential	Multiple Sclerosis, infectious/toxic/metabolic encephalitis leukodystrophy

Chief Complaint: Altered Mental Status	
Acute Disseminated Encephalomyelitis (ADEM)[1]	
Red Flags	Decreased level of arousal can indicate need for intubation for airway protection
Workup	MRI brain and spine w/ and w/o contrast, LP. T2 weighted MRI reveals confluent increased signal intensity throughout white matter, specifically corpus callosum and periventricular region; CSF can be normal or have elevated protein or WBC.
Management	High dose IV methylprednisolone; IVIG and plasma exchange may help refractory cases
Complications	• Typically a self-limiting, monophasic course • Multiple episodes raise concern for MS/MOG-associated demyelination
Autoimmune Encephalitis (NMDA Receptor Antibody Encephalopathy)[2]	
PowerPlans	N/A
Pathophysiology	• Antibodies bind to NR1 subunit of NMDAR and cause receptor endocytosis and subsequent neurologic dysfunction • Ovarian teratomas are an important cause in girls < 18 (31 %); Tumors rare in males • Overall, a rare disease
Presentation	Acute (<3 months) behavior and personality changes (including depression/anxiety/psychosis), seizures, stereotyped movements and autonomic instability
Differential	Viral encephalitis,neuroleptic malignant syndrome, psychosis, catatonia
Red Flags	Autonomic instability
Workup	• MRI Brain typically w/ lesions • EEG can show slowing and delta brush • ELISA test of Ab against NR1 subunit of NMDA receptor (autoimmune encephalitis panel) is diagnostic
Management	• If applicable, tumor resection • Methylprednisolone 30mg/kg (max 1g) IV daily x5d, IVIG 2g/kg over 2 to 5 days and plasma exchange are all first line treatments
Complications	Autonomic instability, seizures

1. Krupp et al. International Pediatric Multiple Sclerosis Study Group criteria for pediatric multiple sclerosis and immune-mediated central nervous system demyelinating disorders: revisions to the 2007 definitions. Multiple Sclerosis Journal. April 2013.
2. Dalmau, J. Clinical experience and laboratory investigations in patients w/ anti NMDAR encephalitis. Lancet Neurology. January 2011.

Chief Complaint: Headache	
Migraine	
PowerPlans	Migraine EBG
Pathophysiology	Cortical spreading depression: neurons fire in a sequential manner across the surface of the brain (causing an aura); associated w/ irritation and dysregulation of blood vessel tone of the overlying meninges, causing pain.
Presentation	Unilateral throbbing headache (frontal in young children), visual aura, photophobia, phonophobia, nausea, vomiting, relieved by rest
Differential	Venous sinus thrombosis, concussion, tension type headache, intracranial mass lesion

Headache continued on next page →

Chief Complaint: Headache	
Migraine	
Red Flags	Any symptoms suggestive of increased ICP (i.e. papilledema, nerve palsy, positional headache, emesis, encephalopathy, wake from sleep w/ headache), focal neurological deficits, change in character from typical headache, progressive worsening of headaches
Workup	Clinical diagnosis; consider MRI for red-flag symptoms
Management	See migraine headache treatment algorithm in EBG
Complications	Paralysis (hemiplegic migraine) visual disturbance/loss (if aura); emesis, disability (missed school, work), vertigo and clumsiness (basilar migraine)
Concussion	
See Sports Med	
Idiopathic Intracranial Hypertension (Pseudotumor Cerebri)	
PowerPlans	N/A
Pathophysiology	Syndrome of increased ICP due to impaired absorption at the arachnoid granulations. Risk factors: obesity, drugs (tetracyclines, retinoids, OCPs)
Presentation	• Patients have frontal, positional HA worse upon awakening • Visual disturbances, visual loss, +/- dizziness
Differential	Venous sinus thrombosis, intracranial mass lesion, migraine headache, tension headache
Workup	MRI/MRV required in children w/ HA and papilledema to rule out mass/hydrocephalus, venous sinus thrombosis. LP w/ elevated opening pressure is diagnostic.
Management	Acetazolamide 15-25 mg/kg/day (decreases rate of CSF production)
Complications	Vision loss, optic neuropathy
Febrile Seizure	
PowerPlans	Febrile Seizure EBG
Pathophysiology	Decreased threshold for seizure due to fever and immaturity of the CNS, often familial
Presentation	Simple: < 15 minutes, generalized, occurred once in 24 h; Complex: lasts > 15 minutes, focal, or occurred 2 or more times in a 24 hr period. Most commonly seen between 6 mo and 6 yrs of age
Differential	Meningitis, encephalitis
Red Flags	AMS, neck stiffness, lethargy, focal deficits lead to consideration of meningitis/encephalitis
Workup	If examination is normal, no further workup is required
Management	Reassurance and anticipatory guidance. For complex febrile seizures > 15 minutes, prescribe rectal Diastat. Antipyretics not shown to decrease risk.
Complications	30-50% recurrence rate. Minimally increased risk of epilepsy compared w/ the average population, slightly greater for those w/ complex febrile seizures

Chief Complaint: Headache	
First-time Unprovoked Seizure	
PowerPlans	N/A
Pathophysiology	Typically idiopathic (likely genetic), but sometimes symptomatic from underlying brain lesions
Presentation	• **Focal**: unilateral symptoms +/- AMS (dyscognitive vs. cognitive) • **Generalized**: bilateral tonic clonic movements (GTC), tonic, myoclonus, absence
Differential	Meningitis, encephalitis, intracranial hematoma, focal lesion (i.e. abscess, AVM, focal cortical dysplasia).
Red Flags	AMS, neck stiffness, lethargy, focal deficits lead to consideration of meningitis/encephalitis
Workup	If examination is normal, no further workup is required emergently. EEG is next step, as is neurology referral. If the seizure had focal onset or if the EEG shows focality (spikes arising from one portion of the brain), most neurologist opt to do an MRI of the brain w/o contrast.
Management	Indication for AED therapy is 2 or more unprovoked seizures, or one unprovoked seizure w/ an abnormal EEG. Keppra is often our first line because of both focal and generalized coverage w/ favorable side-effect profile, but we avoid it in cases of children w/ behavioral issues. Neurology admission for patients not returning to baseline following seizure or for multiple seizures upon presentation requiring immediate treatment.
Complications	Epilepsy for those who go on to have further unprovoked seizures. Rare complication of generalized epilepsy is SUDEP (sudden unexplained death in epilepsy patients)
Breakthrough Seizure (in a patient w/ epilepsy)	
PowerPlans	N/A
Pathophysiology	Decreased threshold for seizure due to fever, lack of sleep, missed medication dose, alcohol use vs. natural fluctuation of epilepsy (as is the natural history) that seizures may become more frequent w/o provocation
Differential	Evaluated potential underlying causes of increased seizure frequency
Red Flags	AMS, prolonged seizures
Workup	Neurology consultation for medication adjustment; kindly prepare the following: baseline seizure frequency and semiology (what the seizure looks like) vs. current frequency and semiology; doses of all AEDs, and most recent levels if available.
Management	Typically small adjustments to AEDs including addition of AEDs when needed
Complications	Continued seizures, status epilepticus, aspiration pneumonia, cerebral edema

Chief Complaint: Hypotonia/Developmental Delay	
Approach to Hypotonia	
PowerPlans	N/A
Pathophysiology	Central (UMN) vs. peripheral (LMN) injury or dysfunction leading to decreased tone, which is resistance to passive stretch of the muscle, often but not always associated w/ weakness.
Presentation	Failure to meet developmental milestones. Typically associated w/ head lag, can include dysphagia, FTT

Hypotonia/Developmental Delay continued on next page →

Chief Complaint: Hypotonia/Developmental Delay	
Approach to Hypotonia	
Differential	Perinatal injury (including HIE, in-utero stroke, TORCH infections), SMA, Myasthenia Gravis, mitochondrial disease
Red Flags	Regression: loss of milestones which had previously been attained can indicate metabolic disease, epileptic encephalopathy (ex. infantile spasms), or other progressive disorders including
Workup	Reflexes are the most important examination maneuver (you can tap a finger to assess a baby's reflexes): areflexia indicates a peripheral process and need for non-urgent EMG, present reflexes indicate a central process. Next is the presence of appendicular hypertonia, which is an increased resistance to passive stretch (and hyperreflexia) of the limbs despite the axial hypotonia (muscles of the neck and trunk), which can indicate perinatal injury and can be non-urgently assessed w/ MRI.
Management	Typically supportive (unless an underlying pathology w/ treatment is identified), using EI for children under age 3 or the school for older children w/ emphasis on PT and OT, ST as needed for dysphagia
Complications	Dependent on the underlying cause but sometimes associated w/ cognitive dysfunction in addition to developmental delay

Chief Complaint: Macrocephaly	
Approach to Macrocephaly	
PowerPlans	N/A
Pathophysiology	Increased head circumference as measured over the greatest antero-posterior diameter (w/ tape measure over the forehead just above the eyebrows and over the occipital protuberance. Can be caused by increased size of the brain, extra-axial spaces, or bone
Presentation	Crossing percentiles of head circumference or consistently large head circumference since infancy (please measure parents' heads if this is the case)
Differential	For consistent macrocephaly, benign familial macrocephaly is the most common cause, and the patient will have a parent w/ a large head as well. Imaging will reveal increased extra-axial space. This increase in extraxial space can also be caused by mechanical ventilation during infancy. It is not of great concern. Craniosynostosis (premature fusion of sutures) can cause an unusual shaped head. Paget's disease is a consideration if bones are noted to be thick
Red Flags	AMS, vomiting, lethargy, bulging fontanelle in infants, focal deficits lead to consideration of intracranial mass, meningitis
Workup	Examination and measurement of parents' heads. HUS for infants w/ open fontanelles, consider MRI if fontanelle is closed
Management	Dependent on cause. For intracranial lesions, treatment as appropriate, for large extra-axial space, no further treatment is required
Complications	In the case of crossing percentiles for head circumference, undiagnosed intracranial lesions may lead to permanent neurological deficit

NEUROLOGY REFERENCE CARD

WHO TO CALL FOR CONSULTS:

Patient service	Consultant
7S, 7N, 8S, 8E, 11S, BI NICU, BWH NICU, BWH Nursery	Neurology ICU resident
ED	Neurology ED resident
Floor (except 8E), ICP*	Neurology consult

*For daytime floor consults: if patient is followed by Epilepsy (see clinic notes), page Epilepsy Consult Fellow

Information to prepare for consults:

1. Acuity: Stroke STAT (call 52170)? Currently seizing? Impending herniation?
2. Consult question
3. Relevant Neurologic history
4. Seizure type/frequency (describe)
5. Current neuro meds (AEDs, tone meds, rescue meds). Calculate doses in mg/kg/d, times given.
6. Pertinent findings on YOUR neurologic exam (for headache, please do a fundoscopic exam)

MANDATORY CONSULTS:

1. Status epilepticus
2. Therapeutic hypothermia (in NICUs)
3. All ECMO patients
4. Cardiac arrest (most)

If a patient does not need a consult, but would benefit from urgent follow-up (<1-2 weeks), please have your Attending page the NOW Attending (Neurologist of the week).

IF PATIENT IS DUE FOR AN AED DOSE, PLEASE ADMINISTER ON TIME REGARDLESS OF WHETHER OR NOT OUR CONSULT IS DONE UNLESS OTHERWISE SPECIFIED. Consider trough levels.

Neurology Reference Card continued on next page →

THE NEUROLOGIC EXAM

Please try to do as much as possible. The more you practice, the better you'll get!

MENTAL STATUS (describe interactions):
1. Awake, comfortable, fussy, distracted, somnolent, obtunded
2. Oriented to person, place, day, month, year.
3. Follows directions
4. Maintains attention (months of the year or days of the week backwards)
5. Fund of knowledge appropriate for age
6. Memory (3 word recall at 1, 5 minutes)
7. Language: Speaking fluently, coherent, paraphasic errors, neologisms, naming, repetition.

CRANIAL NERVES:
CN II: visual acuity, visual fields, PERRLA, fundoscopic examination (disc margins at least)
CN III, IV, VI: Fixing and following, smooth eye movements or nystagmus.
CN V: Facial sensation to light touch
CN VII: Facial movements (smile, grimace, cheek puff)
CN VIII: Do they hear finger rub bilaterally?
CN IX- XII: Swallow function, any changes in articulation or voice quality, palate elevation, tongue midline or deviated. Test strength of shoulder shrug, neck rotation.

MOTOR: Describe tone (axial and appendicular), especially in newborns. Strength testing can be tricky with kids <3, but try to push and pull extremities and see how much they reciprocate. Describe abnormal movements (speed, quality, stereotyped?, suppressible?)

REFLEXES: Check especially for clonus and any asymmetry in reflexes. DTRs should be checked at brachioradialis, biceps, triceps, patellae and achilles tendons. Toes up or down with plantar reflex?

SENSATION: Check light touch at least. If there is question of a sensory deficit, please also do temp/pinprick and vibration/proprioception.

CEREBELLAR/COORDINATION: Finger-nose-finger (or describe if little kids reach for toys smoothly). Finger tapping, rapid alternating movements. Any sway on Romberg?

GAIT: Test normal gait. Do heel, tip toe and tandem if possible.

HEADACHES

Type	Characteristics
Migraine	Throbbing, pulsating pain. Unilateral in 60-70%, but often bilateral in younger patients. Worse with exertion, better with hydration, rest, darkness.
Tension	Bilateral pressure that waxes and wanes.
High pressure headache (e.g.: idiopathic intracranial hypertension)	Variable HA. Gradual. Some constant, some throbbing, variable location, though often retrobulbar. Worse when supine, Valsalva.
Trigeminal autonomic cephalgia (e.g.: cluster HA)	Unilateral, around the eye or temple. Rapid onset (minutes), pain is continuous, excruciating.
Medication overuse headache	Characteristics vary, but usually preceded by another HA disorder.

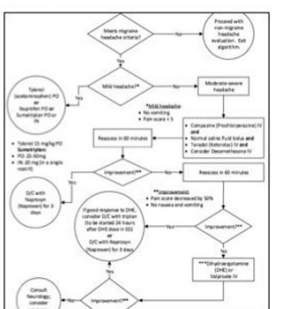
Associated symptoms	Risk factors
Associated with N/V, photo/phonophobia. Auras: usually visual, but can involve speech, sensory or motor deficits as well.	family history, female, R-L shunt
Associated with stress.	female, weight, drugs
Often associated vomiting. Transient visual obscurations in over half. Some with photopsia (flashes of light). Some with diplopia. Can have CN VI palsy.	obesity, prior history
Associated with lacrimation (ipsilateral), injection, congestion, sweating. +sensitivity to alcohol.	
Associated with use of opioids, NSAIDs, Tylenol, Fioricet for >=2 days/week x 3 mo.	

In the ED, see **Migraine EBG** (right):

Inclusion: Age 7+, low suspicion for other etiologies, HCG testing if of child-bearing age

HEADACHE RED FLAGS:

- acute onset
- atypical headache for patient
- neck stiffness
- worse when supine or with Valsalva
- waking from sleep
- vomiting w/o nausea or diarrhea
- focal neurologic symptoms
- altered mental status
- blurry/double vision



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SEIZURES

Seizures: Clinical manifestation of abnormal, excessive synchronous neuronal (cortical) discharges.

Epilepsy: At least 2 unprovoked seizures occurring >24h apart

Seizures are COMMON:

- 3-5% of children <5yo have a febrile seizure
- 1% of children <14yo have an afebrile seizure
- 0.5-0.8% of children have epilepsy

Classification (ILAE 2017):

Focal Onset (formerly "partial"): Originate in one hemisphere.

- Can be **Aware** vs. **Impaired Awareness**
- Can be **Motor** onset (automatisms, atonic, clonic, tonic, spasms, hyperkinetic, myoclonic) vs. **Non-Motor** onset (autonomic, behavior arrest, cognitive, emotional, sensory)
- Can have focal to bilateral tonic-clonic (formerly "secondary generalization")

Generalized Onset: Bilaterally distributed origin.

- **Motor** (tonic-clonic, clonic, tonic, myoclonic, atonic, spasms) vs. **Non-Motor** (absence)

Management (in general):

- Febrile seizures: no treatment, unless very recurrent, then consider benzo ppx with fever
- 1st unprovoked seizure: no treatment, obtain outpatient routine EEG
- 2nd unprovoked seizure: consider treatment, esp. if EEG abnormal

Diastat Dosing (consider script if prolonged seizure)

2-5 yr (0.5mg/kg)		6-11 yr (0.3 mg/kg)		12+ yr (0.2mg/kg)	
Weight (kg)	Dose (mg)	Weight (kg)	Dose (mg)	Weight (kg)	Dose (mg)
6 - 10	5	10 - 16	5	14 - 25	5
11 - 15	7.5	17 - 25	7.5	26 - 37	7.5
16 - 20	10	26 - 33	10	38 - 50	10
21 - 25	12.5	34 - 41	12.5	51 - 62	12.5
26 - 30	15	42 - 50	15	63 - 75	15
31 - 35	17.5	51 - 58	17.5	76 - 87	17.5
36 - 44	20	59 - 74	20	88-111	20

STATUS EPILEPTICUS

Definition: failure of mechanisms responsive for seizure termination, leading to prolonged seizures with high risk of chronic consequences (neuronal death)

Practical definition (for treatment): A seizure lasting longer than 5 minutes, or any ongoing seizures w/o return to baseline for 30 minutes.*

*for convulsive seizures. Guidelines are not well-defined for non-convulsive seizures.

Keep in mind, some of our Epilepsy patients have frequent and prolonged seizures every day that sometimes go beyond these criteria. It is often useful to ask the parents or consult clinic notes to get an idea of the severity of their Epilepsy.

Time	Agent
0-5 min	**Lorazepam** 0.1 mg/kg IV/IO/IM (max 4 mg)
5-15 min	Repeat **lorazepam** 0.1 mg/kg AND **Fosphenytoin** 20 mg/kg x1 IV/IO/IM (max 1,000 mg)
15-20 min	**Phenobarbital** 20 mg/kg x 1 IV/IO OR **Levetiracetam** 30 mg/kg x1 IV/IO *if allergic, consider **valproic acid** 20 mg/kg IV/IO over 5 minutes
20-30 min	Repeat **fosphenytoin** 10 mg/kg OR **Phenobarbital** if LEV was used third, OR **Levetiracetam** if PHB was used third

CHECKLISTS FOR CONSULTS:

Headache:

[ ] Are you concerned for intracranial hemorrhage or impending herniation?
[ ] where is the pain (i.e. front, back, right, left)?
[ ] character (e.g. pounding, squeezing, sharp, etc.)
[ ] severity (1-10)
[ ] duration
[ ] frequency, change in frequency
[ ] time from onset to peak severity
[ ] are there associated symptoms (sensitivity to lights/noises, nausea/vomiting)
[ ] associated autonomic symptoms (e.g. eye tearing, eye redness, rhinorrhea, ptosis, change in facial color or temperature)
[ ] associated deficits (e.g. numbness, tingling, weakness, difficulty speaking or understanding others)
[ ] visual changes (double, blurry, flashes)
[ ] is the pain preceded by anything (scotoma, strange smell, feelings)
[ ] exacerbating factors (position, Valsalva, day/night, activity)
[ ] alleviating factors
[ ] do the headaches wake the patient from sleep and if so at what time?
[ ] family history
[ ] what is their neurologic examination?
[ ] what medications does the patient take to prevent headaches?
[ ] what medications has the patient taken to abort the headache?
[ ] what has he/she been given so far?

Seizures:

[ ] actively seizing? Concern for herniation?
[ ] seizure history
[ ] baseline frequency, duration
[ ] semiology (not "GTC" – describe what happens)
[ ] history of status epilepticus?
[ ] clinic provider – Epilepsy or Neurology?
[ ] recent medication changes
[ ] current AEDs, dosing in mg/kg/d, dose timing
[ ] Missed/late AED doses?
[ ] **When is next dose due?** Get trough levels?
[ ] How is this seizure presentation different from their baseline/typical?
[ ] Current contributing factors (e.g. illness)?
[ ] Baseline developmental level (how much do they move/interact/see at baseline?) Are they now at their baseline?
[ ] Exam including VS (any O2 requirement), mental status (describe what they do spontaneously, and in response to a stimuli)

Stroke:

[ ] Stroke STAT (call 52170)? Acute/current neurologic deficits?
[ ] Last seen well time (if <5h, consider Stroke STAT; if >5h, call neuro consult)
[ ] acuity of onset?
[ ] deficits: speech (nonsensical, slurring, output), comprehension, vision (loss/double), vertigo, weakness, numbness, coordination, gait
[ ] Symptoms now (better, worse, same)
[ ] Risk factors: sickle cell, cardiac disease/shunt, personal or family history of stroke or clots (DVT/PE, miscarriage, stroke), hypercoagulable state

Common Pediatric Cancers	
Hematologic Cancers	
B-ALL	
Presentation	Non-specific/constitutional, bone pain, fever, malaise, lymphadenopathy, HSM, cytopenias, unilateral testicular enlargement
Epidemiology	• Peak incidence 2-5 yrs, M>F, 70-80% ALL. • Increased risk in Down syndrome, NF 1, Bloom syndrome, and ataxia telangiectasia
Notes about Grouping, Staging or Potential Prognostic Features	• **Low risk**: WBC <50K/uL AND age 1-9.9 yrs AND favorable cytogenetic (hyperdiploidy, trisomies 4/10/17 or ETV6-RUNX1) AND favorable response to treatment. • **Standard risk**: low risk features EXCEPT favorable cytogenetic changes • **High risk**: 10+ yrs, unfavorable cytogenetic, residual disease in BM after induction (MRD - measured @ BCH by next gen sequencing, > 1x10^-4 post-therapy measured at two time points) • **Very high risk**: high-risk AND failure to achieve remission at the end of induction therapy, OR certain cytogenetic markers (extreme hypodiploidy, t(9;22) BCR/ABL translocation, t(4;11) MLL rearrangement, iAMP21 amplification)
T-ALL	
Presentation	Anterior mediastinal mass (airway compression, SVC syndrome), hyperleukocytosis, constitutional symptoms
Epidemiology	Peak incidence 15-19 yrs, M>F, ~15% ALL. T-ALL and T-cell lymphoblastic lymphoma (NHL) distinguished by BM involvement (Leukemia if >25% blasts in CSF)
Notes	• **High risk**: 10+ yrs, unfavorable cytogenetic, residual disease in BM after induction (MRD - measured @ BCH by next gen sequencing, > 1x10^-4 post-therapy measured at two time points) • Refer to Smith, J Clin Oncol. 1996 Jan;14(1):18-24 for risk stratification based on age and presenting WBC count
AML	
Presentation	Non-specific/constitutional symptoms, cytopenias. Hyperleukocytosis (tumor lysis syndrome, DIC). **Extramedullary symptoms**: HA, lethargy, AMS, CN palsy, myeloid sarcomas/ chloromas.
Epidemiology	• **Down's Syndrome**: 10-20x risk of AML, transient myeloproliferative disorder. • **Therapy-related AML**: secondary malignancy, typically assoc. with alkylating agents and topoisomerase inhibitors
Notes	• **Favorable**: t(8;21)(q22;q22); RUNX1-RUNX1T1, inv(16)(p13.1q22) or t(16;16)(p13.1;q22); CBFB-MYH11, Mutated NPM1 without FLT3-ITD (normal karyotype), Mutated CEBPA (normal karyotype) • **Intermediate**: sub-stratified based on response to induction therapy (Minimal residual disease by flow cytometry) • **Adverse**: t(6;9)(p23;q34); DEK-NUP214, Monosomy 5 or del(5q); Monosomy 7; Complex karyotype; High allelic ratio FLT3-ITD
Hodgkin's Lymphoma	
Presentation	Lymphadenopathy, constitutional B-symptoms, mediastinal mass effect, splenomegaly
Epidemiology	**Bimodal**: Peak incidence late teenage years, most common childhood cancer in 15-19 yo; second peak in adults age >50. Association with EBV infection

Common Pediatric Cancers continued on next page →

Common Pediatric Cancers

Hematologic Cancers

Hodgkin's Lymphoma

Notes	Risk stratification based on Ann Arbor staging with Cotswolds modifications for HL: • **Stage I**: involvement of single lymph node (LN) region • **Stage II**: involvement of ≥2 LN regions on same side of diaphragm • **Stage III**: involves LN regions on both sides of the diaphragm • **Stage IV**: Diffuse or disseminated involvement of one or more extranodal organs or tissue beyond that designated E (contiguous extranodal disease), with or without associated lymph node involvement. • *All cases are subclassified to indicate the absence (A) or presence (B) of "B symptoms" (systemic symptoms of significant unexplained fever, night sweats, or unexplained weight loss exceeding 10% of body weight during the six months prior to diagnosis) **High Risk disease = IIIB and IVB** Poor prognosis associated with higher stage, presence of B symptoms, presence of bulky disease, extranodal extension

Non-Hodgkin's Lymphoma

Presentation	Varies by location and type. Lymphadenopathy, mediastinal mass, palpable mass, intussusception, cranial nerve palsy.
Epidemiology	Median age: 10 yrs, increase incidence with age. Increased risk in congenital and acquired immunodeficiency syndromes. Association with EBV infection
Notes about Grouping, Staging or Potential Prognostic Features	• Risk stratification based on Murphy (St. Jude's) staging system. • More Common Subtypes include: Burkitt lymphoma, Diffuse large B cell lymphoma, lymphoblastic lymphoma and anaplastic large cell lymphoma • Post-transplant lymphoproliferative disease frequently resembles non-Hodgkin lymphoma in a recipient of a solid organ transplant or stem cell transplant, and is also typically staged using Murphy (St. Jude's) staging system.

Musculoskeletal Tumors

Rhabdomyosarcoma

Presentation	Head & neck: orbital tumors (proptosis, ophthalmoplegia, parameningeal lesions. GU (botryoid RMS): hematuria, urinary obstruction, pelvic mass, constipation Extremities: painful mass +/- overlying erythema
Epidemiology	Most common soft tissue tumor in childhood, majority of cases <6 yrs, M>F. Associated with neurofibromatosis, Li-Fraumeni (anaplastic RMS), Beckwith-Wiedemann, and Costello syndromes
Notes	Prognosis based on histology, TNM stage, clinical group. 4 major histologic subtypes: • **Embryonal**: intermediate prognosis • **Botryoid**: variant of embryonal RMS, favorable prognosis • **Alveolar**: relatively poorer prognosis • **Anaplastic**

Osteosarcoma

Presentation	Localized bone pain, tender mass, pathological fracture. Predilection for long bone metaphysis (femur, tibia, humerus). Typically metastasizes to lung.
Epidemiology	Peak incidence 13-16 yrs, M>F, Most common primary bone malignancy. Associated with Li-Fraumeni, Rothmund-Thomson, Bloom and Werner syndromes
Notes	Metastatic disease at diagnosis; Low tumor necrosis percentage after initial chemotherapy.

Common Pediatric Cancers	
Musculoskeletal Tumors	
Ewing's Sarcoma	
Presentation	Localized pain/swelling. Tender soft tissue mass. Pathological fractures. Predilection for axial skeleton, pelvis and diaphysis of long bones. Metastases to lung and bone/marrow
Epidemiology	Peak incidence 10-15 yrs but wide age distribution, M>F, Caucasians>AA. Increased risk: Li-Fraumeni, MEN2
Notes	Prognosis based on presence of metastases, primary tumor location and size, age, the response to therapy, and certain chromosomal translocations.
Nervous System Tumors	
Treated by Neuro-Oncologists	
Medulloblastoma	
Presentation	Cerebellar mass, hydrocephalus, increased ICP. Midline tumors: gait ataxia or truncal instability; lateral cerebellar: limb dyscoordination. Dizziness, diplopia
Epidemiology	Peak incidence 5-9 yrs. Most common malignant brain tumor of childhood. Associated with Gorlin syndrome, familial adenomatous polyposis.
High-Risk Features	Age, extent of disease (modified Chang criteria), histopathologic subtype, and molecular subtype Tumors with WNT signaling pathway mutations have the best prognosis (>95% 5-year OS); "group 3" (MYC mutations) have the worst
Gliomas	
Presentation	Depending on location, size and rate of growth: Seizures, hemiparesis, ataxia, increased ICP, cranial neuropathies.
Epidemiology	Associated with NF1, Li-Fraumeni, Tuberous Sclerosis, von Hippel-Lindau, familial adenomatous polyposis
High-Risk Features	Several distinct entities based on histopathology. Typically prognostic factors include: histology/ grade, age at diagnosis
Treated by Non-Neuro Oncologists	
Neuroblastoma	
Presentation	Varies by location. Adrenal/abdominal; thoracic (respiratory distress, Horner's syndrome, nerve root/spinal cord compression). Mets causing pain, proptosis/raccoon eyes. Paraneoplastic symptoms (catecholamine production).
Epidemiology	Median age of diagnosis 18 mo, Caucasian>AA
High-Risk Features	MYCN amplification, metastatic (non MS), older age, crossing the midline
Retinoblastoma	
Presentation	Leukocoria (54%), strabismus, nystagmus, red eye, decrease vision, iris heterochromia
Epidemiology	Median age at diagnosis is 18 mo, later with unilateral disease. Majority present <5 yo. Germline mutations in RB1 (associated with sarcomas and melanoma)
High-Risk Features	Poor prognosis: delay in diagnosis >6 mo, h/o intraocular surgery, cataract, use of external beam radiotherapy, invasion of local anatomy, tumor anaplasia

Common Pediatric Cancers continued on next page →

Common Pediatric Cancers	
Kidney Tumors	
Wilm's Tumor	
Presentation	Abdominal mass, abd pain, hematuria, fever, HTN
Epidemiology	Median age at diagnosis 4 yo, typically <15 yo. Bilateral disease 5-7%. Increased incidence in: WAGR syndrome, Beckwith-Wiedemann, Denys-Drash, and Bloom syndromes
High-Risk Features	National Wilms Tumor Study (NWTS) staging system (post-resection and pre-chemotherapy) Worse prognosis based on anatomic extent of the tumor
Liver Tumors	
Hepatoblastoma	
Presentation	Asymptomatic abdominal mass, hemihyperplasia, sexual precocity (synthesis of ectopic gonadotropins), anorexia
Epidemiology	Children <3 yrs, Associated with low birth weight (<1000 g), Beckwith Wiedmann syndrome, trisomy 18, trisomy 21, Acardia syndrome, Li-Fraumeni syndrome, and familial adenomatous polyposis
High-Risk Features	Risk stratification based on: PRE-Treatment EXTent of disease (PRETEXT) group, histology, AFP level
Hepatocellular Carcinoma	
Presentation	Abdominal mass, anorexia, weight loss, jaundice
Epidemiology	Peak incidence 15-19 yrs, rarely diagnosed <5 yrs. Increased risk in: Alagille syndrome, glycogen storage diseases, biliary atresia, infantile cholestasis, perinatally acquired HepB, tyrosinemia
High-Risk Features	Risk stratification based on staging: location, resectability, and response to any pre-surgical therapy
Germ Cell Tumors	
Teratoma	
Presentation	• **Sacrococcygeal**: prenatal diagnosis via U/S, or caudal mass at birth. • **Ovarian**: abd mass, abd pain, distension, emesis, obstructive symptoms • **Testicular**: testicular mass, +/- pain
Epidemiology	• **Sacrococcigeal**: Congenital • **Ovarian**: increase incidence with age, peak incidence 15-19 yrs, can be bilateral • **Testicular** more common <5 yrs
High-Risk Features	Worse prognosis based on malignant transformation and anatomic extent of the tumor. Late presentation associated with worse prognosis (esp Sacrococcigeal)
Yolk Sac Tumor	
Presentation	• **Testis**: painless testicular mass, torsion, elevated AFP • **Ovary**: Abd/pelvic mass, abd pain, torsion, ascites • **Intracranial**: see germinoma
Epidemiology	Prepubertal children, M=F, pure yolk sac tumors median age 1.5 yrs. Bimodal distribution in puberty

Common Pediatric Cancers

Germ Cell Tumors

Germinoma	
Presentation	Depends on location. Intracranial (increased ICP and cranial nerve compression); suprasellar regions (hypothalamic/pituitary dysfunctions, optic nerve compression)
Epidemiology	Median age at diagnosis 10-12 yrs. Germinomas account for 60-65% of all pediatric intracranial GCTs.
High-Risk Features	Risk stratification based on histopathology

Common Chemotherapies

Class	Drugs	Mechanism	Used in	Pharma/ Metabolism/ Excretion	Side effects: Short-term	Side effects: Long-term	Antidote/ Co-treatment	Genomic Bio-marker
Alkylating agents	Cyclophos-phamide Ifosfamide Melphalan Busulfan Procarbazine Dacarbazine Temozolomide	Attaches an alkyl group to guanine in DNA; prevents replication and causes damage	NBL Sarcoma WT BTs Lymphoma	Antagonized by MGMT enzymes; cyclophos via urine, ifos via liver	N/V/D Mucositis Myelo-suppression Hemorrhagic cystitis SIADH	Secondary malignancy Infertility (high doses)	Mesna and hyper-hydration for cystitis	MGMT promoter methylation (gliomas)
Platinum Analogues	Cisplatin Carboplatin Oxaliplatin	"Alkylating-like" (no alkyl group); crosslinks w/ DNA, prevents replication and causes damage	Sarcomas WT BTs GCTs Testicular	Urine excretion	N/V/D Nephro-toxicity Electrolyte wasting (Mag, K)	Sensory neuropathy Ototoxicity	Hyper-hydration for renal protection	-
Anti-folate agents	Methotrexate Pemetrexed	Analog of folic acid, impairs DHFR, thus impairs DNA synthesis	ALL Lymphoma	Hepatic metabolism, but urinary excretion. Elimination is person-specific	Myelo-suppression Mucositis Transaminitis Kidney failure Encephalo-pathy	-	Hyperhydration, urine alkalinization, monitor serum levels, leucovorin	-
Anti-metabolites	6-Mercapto-purine Cytarabine (Ara-C) Gemcitabine	Nucleoside analogue, incorporated into DNA and interrupts replication	Leukemia Lymphoma IT for CNS disease	Kidney (6MP) Liver (cytarabine)	Myelosuppression N/V/D Mucositis Bowel necrosis Fevers (AraC) Neurotoxicity Infections (esp strep viridans)	-	-	TPMT genotype (6MP)
Topoisomerase inhibitors **Topo I inhibitors**	Topotecan Irinotecan **Topo II inhibitors** Etoposide (VP16)	Inhibits Topo I/ II during S phase, preventing DNA replication	Solid tumors	Liver (etoposide) Urine (topotecan)	Metallic food taste Myelosuppression Hypotension Diarrhea (irinotecan)	Secondary malignancy	Cefixime for irinotecan-induced diarrhea	UGT1A1 genotype (irinotecan)

Chemotherapies continued on next page →

Common Chemotherapies

Class	Drugs	Mechanism	Used in	Pharma/ Metabolism/ Excretion	Side effects		Antidote/ Co-treatment	Genomic Bio-marker
					Short-Term	Long-Term		
Anthracyclines Doxorubicin Daunorubicin Idarubicin Mitoxantrone		Antibiotic from Streptomyces bacteria; Intercalates between DNA/ RNA hybrids in replication.	Leukemia Sarcomas Lymphoma	Liver	Myelosuppression Mucositis Skin reactions (hand-foot syndrome)	Heart failure (dose-dependent)	Dexrazoxane may be used in limited cases for patients at highest risk of developing cardiotoxicity	-
Asparaginase PEG-Non-PEG (Erwinia)-		Bacterial enzyme, converts asparagine to aspartic acid and ammonia. Inhibits protein synthesis	ALL AML	PEG half life 5-7 days, Non-PEG half life <24 hours	Anaphylaxis Coagulo-pathy/ Thrombosis Hyper-ammonemia Encephalo-pathy Hemorrhagic pancreatitis Transaminitis	-	-	-
Vinca alkaloids Vincristine Vinblastine Vinorelbine		Inhibits mitotic M phase by preventing microtubule function	ALL Lymphoma Sarcoma, CNS NBL WT	Liver	Neurotoxicity Peripheral neuropathy SIADH Constipation Seizures Hypotension	-	Stool regimen	-

Legend:
Diseases: ALL, acute lymphoblastic leukemia; AML, acute myeloid leukemia; BTs, brain tumors; NBL, neuroblastoma; WT, Wilms tumor
Side effects: SIADH, syndrome of inappropriate ADH; N/V/D, nausea/vomiting, diarrhea
Genes: DHFR, dihydrofolate reductase; MGMT, O-6-methylguanine-DNA methyltransferase; UGT1A1, UDP glucuronosyltransferase 1; TPMT, thiopurine S-methyltransferase
Other: IT, intrathecal; PEG, polyethylene glycol

Common Targeted Therapies

Drug	Mechanism	Used In	Pharma/ Metabolism/ Excretion	Side Effects		Antidote/ Co-Treatment	Pharmaco-genomic Biomarkers
				Short-Term	Long-Term		
Imatinib	Kinase inhibitor of BCR-ABL fusion, PDGFR and c-Kit proteins	Ph+ ALL GIST CML	Liver	Nausea Diarrhea Myalgias	Cardiac toxicity, delayed linear growth (pre-pubescent)	-	BCR-ABL fusion PDGFR mutation
Dasatinib	Inhibitor of ABL, Src, c-Kit kinases	Ph+ ALL CML	Liver	Myelo-suppression Pleural effusion	Pulmonary hypertension	-	BCR-ABL fusion
Sorafenib	Multi-kinase inhibitor (BRAF, VEGFR, PDGFR, FLT3)	FLT3+ AML RCC Liver tumors	Liver	Hemorrhage Electrolyte wasting (low PO4, Ca, K) Myelo-suppressio Cardiac toxicity	-	-	FLT3 internal tandem duplication in AML

Common Targeted Therapies

Drug	Mechanism	Used In	Pharma/ Metabolism/ Excretion	Side Effects		Antidote/ Co-Treatment	Pharmaco-genomic Biomarkers
				Short-Term	Long-Term		
Crizotinib	Inhibitor of ALK, ROS1, and NTRK1 kinases	Lymphoma NBL Others	Liver	Nausea Vomiting Diarrhea	-	-	Mutation or fusion of ALK, ROS1, NTRK1
Rituximab	Monoclonal antibody against CD20 (B-cell lineage marker)	ALL Lymphoma	-	Infusion reactions Cytokine release syndrome Pulmonary toxicity	Reactivation of viruses	-	-
Dinutuximab (ch14.18)	Monoclonal antibody against GD2 glycolipid	NBL	-	Capillary leak syndrome Hypotension Neuropathic pain Hyper-sensitivity reactions	-	-	-
Chimeric antigen receptor (CAR) T cells	Engineered patient T cells expressing modified CD19 receptors, which kill B-lineage cells	B-ALL	-	Cytokine release syndrome (fevers, myalgias, capillary leak/ hypotension, resp. failure) Encephalo-pathy	B cell aplasia	Tocilizumab (IL6R antagonist) for severe CRS	-

Oncologic Emergencies

Tumor Lysis Syndrome (TLS)

Definition	• An oncologic emergency that is caused by massive tumor cell lysis and the release of large amounts of intracellular contents (**potassium, phosphate, and uric acid**) into the systemic circulation • Most often occurs after the initiation of cytotoxic therapy in patients with high-grade lymphomas (particularly the Burkitt subtype) and ALL • Can also occur spontaneously and with other tumor types that have a high proliferative rate, large tumor burden, or high sensitivity to cytotoxic therapy
Pathogenesis	• Rapid lysis of tumor cells releases large amounts of intracellular contents (potassium, phosphate, and nucleic acids) into circulation leading to hyperkalemia, hyperphosphatemia, secondary hypocalcemia, hyperuricemia. • Purines are metabolized to hypoxanthine and xanthine, and then to uric acid via xanthine oxidase. • Uric acid is poorly soluble in water leading to crystal precipitation and deposition in the renal tubules and AKI. • Allopurinol competitively inhibits xanthine oxidase, blocking the metabolism of hypoxanthine and xanthine to uric acid. Xanthine is less soluble than uric acid so allopurinol can exacerbate AKI. • Cancer cells have ~4X higher Phos than normal cells. Hyperphosphatemia can lead to secondary hypocalcemia and renal calcium phosphate precipitation. Hypocalcemia may also cause cardiac arrhythmias. • Elevated uric acid and phosphate worsen the severity of AKI (increases precipitation of each other)

Oncologic Emergencies continued on next page →

Oncologic Emergencies

Tumor Lysis Syndrome (TLS) cont.

Clinical Manifestation

- **Hyperuricemia**: Lethargy, nausea, and vomiting.
- **Hyperphosphatemia and hypocalcemia**: Anorexia, cramping, vomiting, spasm, tetany, seizures, altered consciousness, cardiac arrest.
- **Hyperkalemia**: Widened QRS; peaked T waves
- Uric acid and calcium phosphate deposition: Acute renal failure

Diagnostic Studies

- CBC, Chem 10, LFT's, LDH, Uric acid → Close attention to K, Ca, Phos, BUN/Cr and LDH.
- Obtain labs (chem 10, uric acid, LFTs) q4-8 hrs depending on severity.
- Urinalysis may shows many uric acid crystals but can be normal due to lack of output from the obstructed nephrons
- Monitor urine output closely

Treatment

- **Hydration**: goal of 3000 mL/m2/day, Consider D5W NS or D5W1/2NS, restrict potassium
- Benefits unclear for alkalinization of urine (pH 7-8); can consider if appropriate
- **Hyperuricemia**:
  - **Rasburicase**: Recombinant version of urate oxidase; leads to degradation of uric acid to allantoin (excreted renally)
    - *Test for G6PD first*. Contraindicated in patients with G6PD deficiency because hydrogen peroxide, a breakdown product, can cause methemoglobinemia and hemolytic anemia.
    - Order Uric acid, post-rasburicase (in order set)
  - **Allopurinol**: Competitively inhibits xanthine oxidase, blocking the metabolism of hypoxanthine and xanthine to uric acid, does not reduce the preexisting serum uric acid. Do not use if risk of AKI.
- **Hyperkalemia**: Calcium gluconate to reduce risk of dysrhythmia. Insulin plus glucose or beta-agonists for quick control. Kayexalate for excretion.
- **Hyperphosphatemia**: Hyperhydration
- **Hypocalcemia**: IV calcium but be careful to not worse calcium phosphate deposition if phos still high.

** Use Onc Tumor Lysis Syndrome order set: one for rasburicase and one for allopurinol

Fever and Neutropenia

Definition

- Absolute neutrophil count (ANC) <500 cells/uL **OR** ANC expected to decrease to <500 cells/uL during the next 48 hours **AND**
- Fever > 38.5C once or > 38.0C twice (separated by ≥1 hour) in a 24 h period.
- "**Functional neutropenia**" refers to patients whose hematologic malignancy results in qualitative defects (impaired phagocytosis and killing of pathogens) of circulating neutrophils (e.g. prior to starting chemo).
  - These patients should also be considered to be at increased risk for infection, despite a "normal" neutrophil count

Risk Stratification

"High Risk" Population

1. Patient with prolonged and profound neutropenia (ANC <100/mm^3 for >7-10 days)
   a. AML in all phases of therapy (except APML maintenance)
   b. ALL in all phases of therapy EXCEPT continuation
2. Patients with Down Syndrome with ANY oncologic diagnosis
3. Patients with clinical features of severe infection (i.e. septic shock, typhlitis)

"Standard Risk" Population

1. Solid tumor patients (most)
2. ALL: Continuation phase of therapy only
3. Patients with an anticipated duration of profound neutropenia lasting ≤ 7 days

Pathogenesis

Patients can have absolute or functional leukopenia (secondary to oncologic conditions and/or cytotoxic drugs). Impairs ability of host to defend against invasion by microorganisms.

Microbiology

Gram-positive infections predominate

- Coagulase-negative staph, strep pneumo, staph aureus, strep viridans, B. Cereus
- Risk factor for S. Virdans bacteremia: high-dose IV cytarabine

Gram-negative infections are also common

- Pseudomonas aeruginosa, stenotrophomonas maltophilia, E. coli, Serratia, Klebsiella

Oncologic Emergencies

Fever and Neutropenia

Clinical Manifestations

- **Fever**: Focal source of infection (skin/soft tissue/lungs/etc)
- **Typhlitis (neutropenic enterocolitis)**: Microbial infection leads to necrosis of layers of bowel wall.
  - Cecum typically affected (possibly secondary to diminished vascularization)
  - Can involve ascending color and terminal ileum.
- **Signs/symptoms**:
  - Abdominal pain (often RLQ), distention, cramping, nausea/vomiting, watery/bloody diarrhea, hematochezia.
  - If peritoneal signs and shock, consider bowel wall perforation
- **Work-up**: Plain film to r/o free air, Contrast CT, blood and stool cultures, and C. diff assay
- **Diagnosis**: CT with contrast demonstrating bowel wall thickening, mesenteric stranding, bowel dilatation, pneumatosis + fever + abdominal pain
- **Physical exam**: Thorough exam assessing for signs of infection including vitals, skin folds, line sites, oropharynx, perineum. Inflammation in neutropenic patients can be subtle.
  No rectal exam or rectal temperatures

Diagnostic Studies

Labs:
- CBC with differential.
- LFT's, amylase and lipase with abdominal symptoms
- Consider chemistries as clinically relevant (PN dependence, dehydration, etc.)

Cultures:
- Anaerobic and aerobic blood cultures should be obtained from each lumen of any indwelling catheters, and a peripheral vein. Obtained Q24hrs for temperature > 38.5C from one lumen thereafter.
- Urinalysis and urine culture: Clean-catch urine or catheter specimen (if < 2 years, consider catheter specimen).
- Skin, sputum, throat swabs and cultures as indicated
- CSF usually not obtained for analysis or culture unless clinically warranted (seizure, change in mental status)

Imaging:
- CXR in patients with respiratory symptoms. KUB with abdominal symptoms.

Treatment

Key Treatment Principles
- Empiric antibiotic regimen must provide reliable coverage against Pseudomonas
- Antipseudomonal coverage must remain active until ANC count recovery (even if a gram positive organism is isolated)
- Vancomycin ruleout for 48 hours to provide empiric coverage for B. Cereus

*** Use Onc Sepsis/ F&N order set*

High Risk Patient w/ Fever	Empiric Treatment	Cephalosporin Allergy
Hemodynamically stable	Cefepime 50mg/kg/dose q8h (max 2000mg/dose) AND Vancomycin x 48 hours	Aztreonam 30mg/kd/dose q6h AND Vancomycin x 48hours
+ Abdominal or Perirectal pain	Add metronidazole 7.5mg/kd/dose q6h	
Hemodynamically UNSTABLE	Meropenem 20mg/kg/dose q8h AND Vancomycin x 48 hours	
Patients receiving cefepime prophylaxis at time of fever	Meropenem 20mg/kg/dose q8 AND Vancomycin x 48h	
Carbapenem Allergy or Anaphylactic PCN allergy	Aztreonam 30 mg/kd/dose q6h AND Vancomycin q8h x 48h AND Tobramycin	
Fever lasting ≥ 5-7 days	Consider Micafungin 3 mg/kg/dose q24 (Obtain serum galactomannan & BD-glucan PRIOR to initiation)	

Oncologic Emergencies continued on next page →

Oncologic Emergencies

Fever and Neutropenia

Treatment

Standard Risk w/ Fever	Empiric treatment	Cephalosporin Allergy
Hemodynamically stable	Cefepime 50mg/kd/dose q8h	Aztreonam 30mg/kg/dose q6h AND Clindamycin 10mg/kg/dose
+ Abdominal or Perirectal pain	Add metronidazole 7.5mg/kd/dose q6h	
+ Skin/soft tissue infection/ mucositis	Add vancomycin	
Hemodynamically unstable	Use High Risk Algorithm	
Fever lasting ≥ 72 hours	Discontinue clindamycin (if receiving) and add Vancomycin	
Fever lasting ≥ 5-7 days	Consider Micafungin 3 mg/kg/dose q24 (Obtain serum galactomannan & BD-glucan PRIOR to initiation)	

Treatment Antibiotic Discontinuation Criteria

ALL, AML (except Continuation phase), Advanced stage Burkitt/B-cell lymphoma
- Blood cultures negative at 48 hours.
- Patient well appearing.
- ANC rising post-nadir: ANC > 200 X 2 d

All other diagnoses:
- Blood culture negative at 48 hours.
- Afebrile X 24 hours.
- Patient well appearing
- Counts rising post nadir and ANC > 200
- Discharge patient on oral Augmentin + Ciprofloxacin until ANC > 500
  Use clindamycin for penicillin allergies.

Prophylaxis

Antimicrobial

	ALL	AML
Agent of Choice	Levofloxacin	Cefepime
When to Initiate	During induction in all afebrile patients	During induction 1 in all afebrile patients with ANC <1000 and falling
When to Discontinue	ANC ≥ 200 post-nadir during induction	ANC>100 post-nadir and rising following each cycle of chemotherapy
Dosing	6 months to 5 years: 10 mg/kg/dose IV/PO q12 >5 years: 10mg/kg/dose IV/PO q24	50mg/kg/dose IV q12 hours (all ages)

Antifungal
- Patient population
  - AML: all patients during all phase of therapy
  - ALL: patients receiving doxorubicin during induction per DF 16-001 + relapsed patients
- Agents: Micafungin, voriconazole

PJP Prophylaxis
- Patient population: all oncology patients
- Agents: Bactrim (preferred), atovaquone, pentamidine

Antiviral
- Patient population: generally reserved for patients with a h/o HSV infection during prior cycles
- Agents: Valacyclovir

Oncologic Emergencies	
Anterior Mediastinal Mass/Superior Vena Cava Syndrome	
Pathogenesis	Compression of mediastinal structures by an anterior mediastinal mass leading to upper body venous congestion and airway obstruction.
Differential	**For anterior mediastinal masses: "4 T's"** **T**hyroid mass **T**hymoma **T**eratoma (malignant) (**T**errible) lymphoma/ T-ALL
Clinical	• Cough/dyspnea/wheezing (40-70% of pts). Arm, neck and/or facial swelling (>60%). Plethoric/ruddy facies (13-23%). Also, dysphagia, orthopnea, hoarseness. Symptoms exacerbated when lying supine. • Headache, anxiety, and altered mental status (secondary to CO2 retention). • Increased ICP- can cause life-threatening cerebral edema • Pleural effusion present in ~40-60%. • Shock if cardiopulmonary compromise; pericardial effusion possible.
Physical Exam	• Avoid supine positioning and sedation, patient may decompensate rapidly! • Facial edema, venous distension in the neck/chest wall, cough, arm edema, cyanosis, and facial plethora. • Symptoms may get worse with the Valsalva maneuver or lying supine.
Diagnostic Studies	• **Imaging**: CXR, thoracic and abdominal CT, echocardiogram (if suspicion for cardiac compromise) and chest ultrasound with Doppler (if suspicion for SVC thrombosis). • **Labs**: CBC, tumor lysis labs, consider tumor marker evaluation, BM aspirate if peripheral blasts present. • Diagnosis by least invasive method possible to avoid sedation (peripheral lymph node biopsy, bone marrow, pleurocentesis, pericardiocentesis).
Management	• Anesthesia and ORL consult. Consider ICU transfer. • Immediate supportive care: O2, elevate the head 30 degrees. • Empiric chemotherapy may be necessary based on specific circumstances. • Therapy depends on most likely diagnosis, but radiation therapy, steroids, chemotherapy and diuretics are options to consider. • Surgical resection of chemo/radio-resistant tumors (in rare cases). • Anticoagulation as appropriate if SVC syndrome is due to thrombus.
Spinal Cord Compression	
Pathogenesis	• Epidural compression can result from perivertebral tumors extending through intervertebral foramen as well as bulky metastatic disease in vertebral bodies. • Most common etiologies: sarcoma, neuroblastoma, germ cell tumors, lymphoma and CNS metastases. • Compression of venous plexus leads to cord edema, hemorrhage, and ischemia. • Prognosis is based on duration of symptoms and time to diagnosis and treatment; in general survival for patients with spinal cord compression is <1 year. • May occur at any spinal level (15% cervical spine, 60% thoracic spine, 25% lumbosacral spine).
Clinical	• **Focal back pain in a known oncology pain is considered spinal cord compression until proven otherwise.** • Back pain (80-90% of patients), weakness (35-75%), paresis, sensory abnormalities, paraplegia or quadriplegia, urinary and/or fecal incontinence, or constipation. • Prolonged cord compression causes irreversible paralysis, sensory loss and sphincter incompetence.
Physical Exam	Complete neurologic evaluation including rectal tone, with attention to level of deficit and sensory abnormalities. Pain is often aggravated by movement, straight-leg raise, neck flexion, recumbency or Valsalva maneuver.

Oncologic Emergencies continued on next page →

Oncologic Emergencies	
Spinal Cord Compression	
Diagnostic Studies	• MRI with and without gadolinium. Obtain emergently if back pain is associated with focal neurologic deficits or refusal/inability to walk • Following MRI, consider lumbar puncture with cytology studies • Spine radiographs are generally not helpful (positive in 1/3rd of cases)
Treatment	**Goal is rapid decompression of tumor** • Dexamethasone 0.23 – 0.5mg/kg IV q6hr (children) or 10mg IV bolus (adolescents/adults) followed by 6mg q6hr • Consult Neurosurgery to evaluate for surgical decompression and laminectomy • Consult Radiation Oncology to evaluate for emergent XRT. • Chemotherapy may be helpful in select tumors if specific tumor type is known or highly suspected and is likely therapy-responsive (e.g. lymphoma, neuroblastoma) • Surgical resection may be best option if tumor type unknown of it mass persists despite radiotherapy, steroids, and/or chemotherapy
Hyperleukocytosis and Leukostasis	
Definition	Definition varies by disease. Occurs more commonly with AML (10-20%) and very rarely in ALL • AML, WBC count >100,000 • ALL, WBC count >300,000 • Chronic phase CML, WBC count >600,000
Pathogenesis	• Increased blood viscosity as a direct complication of a large population of leukemic blasts that are less deformable than mature leukocytes • White blood cell plugs in the microvasculature causing symptoms of decreased tissue perfusion. • This causes local hypoxia, and can lead to increased production of cytokines, resulting in endothelial damage
Clinical	**Neurological** • Visual changes, headache, dizziness, tinnitus, gait instability, confusion, somnolence, and, occasionally, coma • Increased risk of intracranial hemorrhage (persists for at least a week after the reduction of white cell count) **Pulmonary** • Dyspnea, hypoxia, possible diffuse interstitial or alveolar infiltrates on imaging studies • Occasionally, patients develop dyspnea and worsening hypoxemia following the initiation of chemotherapy due to the lysis of leukemic cells trapped in the lungs (eg, acute lysis pneumopathy) • Note: Measured arterial pO2 can be falsely decreased in patients with hyperleukocytosis, since the WBCs in the test tube utilize oxygen. Pulse oximetry provides a more accurate assessment of O2 saturation in this setting **ID** • ~80 percent of patients with leukostasis are febrile, which may be due to inflammation associated with leukostasis or infection **Other** • Less common signs or symptoms include electrocardiographic signs of myocardial ischemia or right ventricular overload, worsening renal insufficiency, priapism, acute limb ischemia, or bowel infarction
Physical Exam	Careful neurologic exam including fundoscopic exam.
Diagnostic Studies	**Labs:** CBC with diff, tumor lysis labs (see above), coagulation panel • Measured arterial pO2 can be falsely decreased because WBCs in the test tube utilize oxygen • Pulse oximetry will be more accurate **Imaging:** CXR and/or non-contrast head CT/MRI for neurologic abnormalities

Oncologic Emergencies

Hyperleukocytosis and Leukostasis

Treatment	**Supportive care:** this is the most important initial treatment • **Hyperhydration** • Close monitoring for DIC (especially AML & APML patients) • Maintain platelets >20K given bleeding risk • Judicious use of pRBC transfusion as this increases viscosity **Leukopheresis:** variable implementation as a clear benefit for patient outcome is not established. Generally, may be considered as an option for: • AML, WBC count >100,000 • ALL, WBC count >100,000 • Contraindications may include hemodynamic instability (may be worsened by leukopharesis), patient unable to have central access, cardiovascular comorbidities **Low dose-chemotherapy**: for cytoreduction purposes • Generally "pre-induction" therapy with cytarabine or hydroxyurea • May rapidly lower WBC count and cause tumor lysis syndrome

Increased ICP

Definition	Normal ICP values vary with age but are generally 5-10 mmHg in infants and 10-15 mmHg in adolescents/adults. Symptoms generally when ICP >20 mmHg, though this can vary with age
Pathogenesis	Blockage of CSF flow, usually by compression of the third of fourth ventricle by an infratentorial tumor
Clinical	• **Infants**: personality/behavior changes, head holding or banging, vomiting, lethargy, loss of milestones, seizures, increased head circumference, bulging fontanelle, distension of scalp veins, strabismus • **Older children**: Headache (classically in the morning and occipital), vomiting (often without nausea), diplopia, ataxia, hemiparesis, dizziness, lethargy, speech disturbances, neck stiffness and coma
Physical Exam	• **Vital signs**: Classic Cushing's triad hypertension (systolic with widened pulse pressure), irregular respirations and bradycardia • **Exam**: complete neurologic exam with attention to mental status and cranial nerves • **Classic herniation syndromes**: ▪ Transtentorial: ipsilateral papillary dilation +/- contralateral hemiparesis ▪ Foramen magnum: depressed LOC, Cushing's triad
Diagnostic Studies	**Lab studies**: None needed. Do not obtain lumbar puncture given risk of herniation **Imaging studies**: Emergent CT or MRI
Treatment	• **See Critical Care chapter for detailed management** • Goals are to maintain cerebral perfusion, control ICP and prevent herniation or seizures • Transfer to ICU; involve Neurosurgery • Neuroprotective measures: elevate head of bed 30 degrees, normothermia, keep patient calm, maintain normoglycemia. • 3-5cc/kg bolus of 3% hypertonic saline • 0.5-1g/kg bolus of mannitol • Hyperventilation to reduce CO2 in severe cases • Intubation if concern for respiratory abnormalities

Stem Cell Transplantation

Types

- **Allogenic**: Healthy donor marrow replaces recipient's marrow
- **Autologous**: Patient's own bone marrow is harvest prior to conditioning and transplanted back

Timeline

- **Day -4 to -21**: conditioning (varies by protocol)
- **Day 0**: stem cell infusion; actual infusion is similar to a transfusion given over several hours with premedication.
- **Day 10 to 14**: generally WBC nadir with symptoms (mucositis)
- **Day +24 to +48**: Engraftment, varies by protocol but generally ANC >500 x3 days. Generally sooner if autologous

Diseases Commonly Treated w/ SCT

- SCT can be used for both malignant and non-malignant conditions
- **Autologous**: resistant cancers (lymphoma, neuroblastoma, brain tumors, Wilm's tumor) when toxic doses of chemotherapy are needed
- **Allogenic**: Potentially curative for leukemias, hemoglobinopathies, some metabolic conditions (adrenoleukodystrophy, mucolipidoses), bone marrow failure syndromes (Fanconi anemia, aplastic anemia), severe primary immunodeficiences
- Graft-versus-leukemia (donor lymphocyte vs leukemia) is primary mechanism of cure for leukemias

Autologous Transplants

- Primary aim is to deliver very high doses of chemotherapy, that would otherwise not be tolerated and to then "rescue" the patient w/ an infusion of their own stem cells
- Generally not used for diseases present in the bone marrow as hard to eliminate cells
- Generally better tolerated than allogeneic transplants
- No risk for GVHD

Sources of Stem Cells for Allogenic Transplants

- Peripheral stem cell mobilization: GCSF is given, followed by pheresis
- Bone marrow harvest: Multiple bone marrow aspirations are generally taken from pelvis
- Umbilical cord blood: Cord blood has relatively high proportion of hematopoietic stem cells

HLA Typing

Donor type	GVHD risk	GVL effect	Other
Identical twins	+	+/-	
Matched sibling donors	++	+++	Generally best outcomes
Partially matched alternative relative	++	+++	
Haploidentical	+++	+++	Parent/sibling with one identical chromosome 6; highest risk transplants
Matched unrelated donor (marrow/ peripheral blood)	+++/++	+++/+++	Generally the next choice after a matched sibling. Via BM registries. Ethnicity, gender, CMV status can matter.
Umbilical cord blood	+	++	Higher risk of infection, can be one or two donors (inc risk of GVHD with more donors)
Legend: no (-), low (+), medium (++), or high (+++)			

Stem Cell Transplantation

HLA Typing	• 'High resolution' typing is sent on the patient, any siblings and often parents. HLA genes are found on chromosome 6 and a set is inherited from each parent. • Typing includes HLA-A, HLA-B, HLA-C, HLA-DR, HLA-DP, HLA-DQ • In general, a donor/recipient should match at 9/10 or 10/10 loci (8/10 allowable for cord blood given decreased risk of GVHD) • Generally, a mismatch in HLA-A, HLA-B, HLA-C (Type I genes) increases graft rejection; a mismatch in HLA-DR, HLA-DP, HLA-DQ (Type II genes) increases GVHD risk.
Conditioning Regimens	Vary widely based on disease and co-morbidities • Myeloablative ▪ Most intense; requiring stem cell rescue and high chance of side effects ▪ Often uses Total Body Irradiation (TBI) and cyclophosphamide or busulfan and cyclophosphamide ▪ Use of ATG (anti-thymocyte globulin) is associated with a dec risk of GVHD • Reduced intensity conditioning ▪ Intermediate conditioning between myeloablative and non-myeloablative • Non-myeloablative ▪ Target recipient lymphocytes without aim of myeloablation
Chimerism	• After transplant, chimerism is measured at set intervals on bone marrow samples to see what percentage of marrow is donor or recipent's original marrow • If the donor percentage appears to be dropping, salvage donor lymphocyte infusions can be tried
Common Complications & Management	**Mucositis** • Occurs in most patients who receive myeloablative conditioning • Patients may require TPN given inability for PO intake **Veno-occlusive Disease** (aka Hepatic Sinusoidal Obstructive syndrome) • Occurs in ~14% of patients at 1-3 weeks post-transplant with mortality of up to 80% • Pathophysiology of hepatic endothelial damage leading to hepatic and renal injury • Clinically: weight gain with ascites, hepatomegaly and direct hyperbilirubinemia • Prophylactic vitamin E and ursodiol given to almost all patients • Treatment is defibrotide and supportive with careful fluid management, drainage of ascites/ pleural effusions. **Graft vs Host Disease**: transplanted immune cells recognize the recipient as foreign and react **Acute** • **Timeline**: from engraftment up to day +100. Severity graded I-IV • **Skin**: rash, graded based on area and severity. Ranges from mild maculopapular rash to generalized erythroderma • **GI**: most commonly with diarrhea+/- abdominal pain. Graded based on volume of diarrhea (or severe other symptoms) • **Liver**: mostly commonly presenting with rising bilirubin. Graded based on bilirubin level • Prevention regimen varies but generally involves prophylaxis cyclosporine (over several months) and methotrexate (several doses prior to engraftment). Patients at higher risk may get prophylactic steroids and lower risk may get mycophenolate mofetil in place of MTX. Balance between preventing GVHD and promoting GVL/preventing infection. • **Treatment**: Mild skin GVHD can respond to topical steroids. Otherwise, increased systemic immunosuppression with systemic steroids +/- other agents **Chronic** • Develops after 100 days • Can be mucocutaneous, or involve liver, lungs, muscles, GI tract or have hematologic manifestations • Severe chronic GVHD has a high mortality • Treatment usually involves systemic steroids +/- other agents. Patients with refractory disease may receive extra-corporeal pheresis

Stem Cell Transplantation continued on next page →

Stem Cell Transplantation	
Common Complications & Management	**Infections**: Remain a significant cause of morbidity and mortality • **Viral**: EBV, CMV, Adenovirus, HHV6, BK virus & JC virus (hemorrhagic cystitis) • **Fungal**: Candida, Aspergillosis, PJP • Empiric management post-SCT (often varies according to patient needs) ▪ Pre-engraftment • Frequently high dose Bactrim for a PJP cleanout pre-stem cell infusion • Fungal prophylaxis, usually fluconazole • Viral prophylaxis if HSV or CMV positive, usually with acyclovir • IVIG for IgG <400 • Ongoing treatment for any known chronic infections ▪ Post-engraftment to day +100 • Continue fungal prophylaxis, generally until off immunosuppression • Start PJP prophylaxis, generally initially with pentamidine and then Bactrim once transfusion independent (Bactrim can be mildly myelosuppressive) • IVIG for IgG <400 • Ongoing treatment for any known chronic infections • Not allowed to go to school/public indoor places for 6 to 9 months post-transplant

Order Sets - Use Whenever Possible!

- ☐ Onc Admit order set
- ☐ Onc new ALL order set (induction)
- ☐ Onc Anti-Emetics
- ☐ Onc Constipation plan
- ☐ Onc Sepsis (Fever & Neutropenia) plan
- ☐ Onc tumor lysis syndrome - one for allopurinol, one for rasburicase
- ☐ Onc platelets plan
- ☐ Onc pRBC plan
- ☐ Onc PJP prophylaxis
- ☐ Onc CVL occlusion plan
- ☐ Onc/ ICU intermittent electrolyte replacement plan

ONCOLOGY / SCT CARD

Dana-Farber Cancer Institute – Children's Hospital

Medical Directors
SCT – Leslie Lehmann, MD 632-4923 pg# 44023
ONC - Jennifer Mack, MD 632-6818 pg# 42860
JFC – Lewis Silverman, MD 632-5285 pg# 44034

Useful Numbers	**DFCI**	**CH**
Blood Bank		355-6260
Chemistry Lab		355-6733
Hematology Lab		355-6639
Heme/Path DF	632-3268	
Jimmy Fund Clinic	632-3293	
Lab Control		355-6351
Medical Records	632-3225	355-7546
Microbiology Lab		355-7485
Page - Direct	632-2337	355-7243
Page - Operator	632-3352	355-6363
Pharmacy (JFC/CH)	632-3785	355-8935
Pharmacy (24hr CH)		355-6807
Oncology/ HSCT CH pharmacist		pg# 0494
Pedi Psych-Soc Service	632-5425	

TUMOR LYSIS THERAPY:

Alkalinization; **D5W w/HCO3 75 mEq/L @ 3000 mL/m2/day (2xmaint)**
Goal= urine ph 7-8, adjust as needed
Hyperuricemia: Allopurinol: <6yo: 50 mg PO TID/ >6yo: 100 mg PO TID
IV needs pre-approval: 100 mg/m2 IV q8h- 3.3 g/kg IV q8h
Rasburicase 0.15-0.2 mg/kg x 1dose (max 5 doses)-evaluate daily

ANALGESICS (starting dose)

PCA: Pain SVC attending signs 1st order – onc resident orders adjustments
Codeine*- 0.5-1mg/kg/dose PO q4-6h
Fentanyl*- 0.5-2 mcg/kg/dose q1h- *consult Pain Team for PCA use*
Hydromorphone (Dilaudid)- 0.015 mg/kg/dose IV/SQ q3-4h
0.06 mg/kg/dose PO q3-4h
Meperidine*(Demerol) 1-1.5 mg/kg/dose IV/PO q3-4h
Methadone 0.1mg/kg/dose PO q4h x 2-3doses,
then q6-12h PRN (MAX: 10mg/dose)
Morphine* 0.1-0.2 mg/kg/dose IV/SQ q2-3h or 0.3 mg/kg/dose PO q3-4h
Morphine SR (MS Contin) (15mg &30mg tabs): daily **morphine IR** dose/BID
Oxycodone <50 kg: initial: 0.2 mg/kg q 3-4 h
≥50 kg: Moderate to severe pain: initial: 10 mg q3-4 h
Oxycodone SR (10mg & 20mg tabs): **daily oxycodone IR** dose ÷BID

Conscious sedation:
Fentanyl* 1 mcg/kg/dose x1-2/ rare 3rd. (MAX/dose 100 mCg)
Midazolam (versed) 0.05 - 0.1 mg/kg/dose IM/IV- may repeat x1 (MAX single dose: 2mg. MAX total dose: 6mg)
...reversal agents
Opioids: Naloxone (Narcan) 0.05-0.1 mg/kg/dose IM/IV/SQ/ET Q2-3min. Reversal w/ severe pain, dilute 1:10 / give in increments
Benzodiazepines: Flumazenil (Romazicon) 0.01 mg/kg/dose IV (MAX 0.2m repeat qmin to MAX 1mg/repeat q20min to MAX 3mg/hr)*Requires renal adjustment (consult formulary for calculations)

ANTIHYPERTENSIVES

Amlodipine:0.1 mg/kg PO QDAY. (MAX 10 mg/day)
Clonidine: PO 5-10 mcg/kg/day/BID-TID. (MAX 900 mcg/day)
Transdermal = total daily dose (100;200;300 mcg patch)-change q7day
Hydralazine*: starting PO: 0.25 mg/kg/dose q4-6h prn (MAX 100 mg/day)
Starting IV:0.1-0.2 mg/kg/dose IV q4-6h prn. (MAX 3.5 mg/kg/day)
Minoxidil: <12yo: 0.1-0.2 mg/kg/day QDAY. (MAX 5 mg/day-↑ q3 days)
>12 yo: initial dose: 5 mg PO QDAY- ↑ q3 days
Usual dose: 10-40 mg QDAY. (MAX 100 mg/day)
Nifedipine: 0.25-0.5 mg/kg/dose SL q 4-6h prn.
(MAX 10mg/dose)
Nifedipine SR**(Procardia XL)** (tabs 30 & 60 mg):daily nifedipine pm dose

ANTIMICROBIALS

Acyclovir (HSV) IV 750 mg/m2/day/q8h or
PO 80mg/kg/day/q6h. (MAX 1Gm/day)
(VZV) IV 1500mg/m2/day/q8h or PO 80 mg/kg/day/QID(MAX 4 Gm/day)
Ambisome: (liposomal amphotericin: IV 3-5 mg/kg q24h
Atovaquone: PO (1-3mo & >24mo) 30 mg/kg QDAY ;(4-24mo) 45 mg/kg QDAY
Aztreonam: IV 120 mg/kg/q6h. (MAX 8 Gm/day)
Cefepime*: IV 150 mg/kg/day/q8h (MAX 6 Gm/day)
Ceftriaxone: IV 50-75 mg/kg/day q24h. (Max 2 Gm/day; CNS 4 Gm/day - q12h)
Cephalexin: PO 25-100 mg/kg/day/q6h. (MAX 4G/day)
Ciprofloxacin: PO/IV 20-30/kg/day +q12h PO/IV . (MAX PO 2G/day; IV 800mg/day)
Clindamycin: PO 10 -30 mg/kg/day/q8h (MAX 1.8 Gm/day)
IV 24 -40 mg/kg/day/q8h (MAX 2.7 Gm/day)
Dapsone: PO 2 mg/kg QDAY (MAX 100 mg/day) or 4 mg/kg qWk (MAX 200mg/dose)
Famciclovir*: PO- adults dosage: 1500 mg/day/q8h
Fluconazole*: O/P/esophageal candidiasis: IV/PO Load: 6 mg/kg x1 dose
Gentamicin*: IV (>1mo <10yo) 7.5 mg/kg/day/q8h;
(>10yo) 6mg/kg/day/q8h (√ levels)
Meropenem* IV 60-120 mg/kg/day/q8h (MAX 6 Gm/day)
Metronidazole IV/PO 30 mg/kg/day/q6h (MAX 4 Gm/day); C.diff:20 mg/kg/day/q6h (MAX 2 Gm/day)
Micafungin: IV 3-4 mg/kg/day/q24h (MAX:150 mg)
Pentamidine:* Rx:
IV 4 mg/kg/day/q24h; PCP ppx: IV 4 mg/kg/day/q24h x 3 doses then-4 mg/kg/day q2wks; Neb:300 mg/day q2wk SCT -or Q mo
Trimethoprim-sulfamethoxazole: Rx IV 20 mg/kg/day/q6h (MAX 4 Gm)
PCP ppx: PO 5 mg/kg/day/BID (MAX 320 mg TMP/day):
Val**GAN**cyclovir:* <15kg Induction: PO 30-40 mg/kg/day/q12
maintenance: PO 15-20 mg/kg/dose/Q24h
>15kg induction: PO 1 Gm/m2/day/q12 (MAX 900 mg/DOSE)
maintenance: PO 500 mg/m2/DOSE/q24h (MAX 900mg/DOSE)
Val**A**cyclovir:* 40 -50 mg/kg/day/q8h (MAX 1G/dose)
ppx: 15 mg/kg/day/q24h (MAX 1 Gm/dose)
Vancomycin:* IV 40-60 mg/kg/day/q8h (MAX 1G/dose) (√ trough)
C.diff PO 500 mg/day/q6h (MAX 2 Gm/day)
Voriconazole:* IV 12 mg/kg/day/q12 (x 1day) then, 8 mg/kg/day/q12 (√ levels)
PO <40kg: 400 mg/day/q12 (x 1 day) then, 200 mg/day/q12 (√ levels)
≥40kg: 800 mg/day/q12 (x1day) then, 400 mg/day/q12 (√ levels)
***Renal adjustment required (consult formulary for renal dosage)**

Oncology/SCT Card continued on next page →

BLOOD PRODUCTS: All blood products must be irradiated, leuko-reduced
Platelet transfusions : infuse over 60 minutes
0 - <12 kg: 1 unit 36- <96 kg: 4-8 units
12-36 kg: 2-3 units > 96kg: call blood bank
PRBC 10-15 mL/kg (250-300 mL/unit) @ MAX rate: 5 mL/kg/hr

CONSTIPATION MEDS
...Maintenance
Docusate(Colace): PO (*10 mg/mL OR 50 & 100 mg/tab)*
10 x age (yrs)/QDay or QID (MAX 500 mg/day)
Lactulose: child: 2.5-7.5 mL PO QDay after breakfast
Adult: 15-30 mL/day PO QDay. (MAX 60 mL/day)
Miralax PO dosage: 0.3 Gm/kg/QDay (MAX17 Gm <30kg)
Senokot(Senna) PO dosage:
43.6 mg/mL (1.76 mg/mL sennoside) OR 187 mg/tab (8.6 mg/tab sennoside)
<6yo: 2.5-5mL(1 tab)/QDay or BID
6-12yo: 5-10mL(1-2 tabs) /QDay or BID
>12yo :10-15mL(2-3 tabs)/QDay or BID(MAX 30mL or 8 tabs/day)
...Evacuation
"*Chocolate Bomb*" PO: senna liquid 15-30 mL (adult MAX 90 mL) + mineral oil 5-15mL (>5yo)+ Milk of Magnesium 5-30 mL (adult MAX 60mL) mixed in 4oz ice cream
Lactulose PO infants: **1-3 mL/TID** child: **15-30 mL/TID** adult: **30-45mL q2h prn**
Magnesium Citrate (oral) : <6yo: 2 mL/**kg x1 dose**
6-12yo: 100-150 mL x1dose >12yo: 150-300 mL x1 dose
Mineral Oil (oral): 5-11yo 5- 20 mL >12 yo 15-45 mL x1 dose
Miralax: 10-30kg 8.5gm (MAX bid); adults 17gm (MAX bid)
Senokot(Senna) oral: <6yo: 20-30 mL**(4-6 tabs)** x1dose
6-12yo: 30-45 mL**(6-9 tabs)**x1dose >12yo: 60-90 mL**(12-18 tabs)**x1dose

GUT PROTECTION/ ANTACIDS

Maalox (200 mg MgOH; 225 mgALOH per 5 mL): PO 5-10 mL TID prn
Mylanta Cherry (400mg CaCO3- MgOH 135mg per 5mL): **400mg TID prn** (MAX 2.4 Gm/day)
Mylanta gelcaps: (550 mg CaCO3 125 mg MgOH per cap): 1-2 **PO TID prn**
Pantoprazole: 0.5 – 1 mg/kg/day/q24h (MAX 80 mg/day)
Ranitidine: PO 2mg/kg/dose q12h (MAX 300 mg/day)
IV 3-5mg/kg/day/q8h Adult: IV 150mg/day/8h.
Sucralfate(Carafate): 10-20mg/kg/dose PO q6h. (MAX 4 Gm/day)

MISCELLANEOUS

Benzytropine(Cogentin): IV/PO <3yo not recommended.
>3yo 0.02-0.05 mg/kg/dose QDAY or BID. (MAX 8 mg/day)
Cyclosporine (Neoral): conversion: 1mg IV = 2-2.5 mg PO
Magnesium supplements: 10-20 mg ELEM Mag/kg/dose PO BID-QID
Mg Gluconate: 500 mg tab- 27 mg ELEM Mag (2 meq Mag)
Mg Oxide: 400 mg tab- 241 mg ELEM Mag (20 meq Mag)
Mg Sulfate: 500 mg/mL- 49 mg ELEM Mag (4 meq Mag)
Potassium Iodide 1 Gm/ mL (SSKI) **(pre-MIBG)**
1gtt TID x5days (1 day before/ 4 days after injection)
Tacrolimus conversion: 1mg IV = 2mg PO
Alteplase (tPA): instill, draw back @1-4h,may repeat x1
Conc: 2mg/2mL; dose by line volume (see tPA chart)
Ursodiol: PO 7.5 mg/kg BID (MAX 300mg BID)
VZIG:1 vial/10 kg (max:5 vials) IM w/in 96h of exposure **round up**

MOUTH CARE: (begin if PMH mucositis/thrush)
Nystatin suspension **100,000 unit/mL** 2-5 mL/dose PO BID to QID
Clotrimazole troches 10 mg troche/dose PO 3-5 x per day

SUPPORTIVE CARE:
Filgrastim SQ 5 mCg/kg/day ÷ QDAY (24-36 hr post chemo/continue until post-nadir)
Pegfilgrastim SQ 6mg/QDAY x 1dose (>45kg only)

ANTIEMETIC ALGORITHM
Acute N/V- N/V from chemo/xrt) on Rx day & 24-48 hrs after
Delayed N/V- N/V from chemo/XRT >48 hrs after Rx

PROPHYLAXIS OF ACUTE SYMPTOMS:
Highly emetogenic: ondansetron, dexamethasone, lorazepam, scopolamine patch
Moderately/Mildly emetogenic: ondansetron

RESCUE FOR ACUTE SYMPTOMS: advance up ladder-
1. Ondansetron
2. Dexamethasone
3. Lorazepam
4. Scopolamine patch
5. Dronabinol
6. Metoclopramide **(w/ scopolamine or diphenhydramine)**
7. Pentobarbitol

PROPHYLAXIS OF DELAYED SYMPTOMS:
Highly emetogenic: ondansetron, dexamethasone (w/ wean)
Moderately emetogenic: none. As above if breakthrough w/in 24h
Mildly emetogenic: none

TREATMENT OF DELAYED SYMPTOMS:

1. Dexamethasone
2. Metoclopramide (w/ diphenhydramine)
3. Lorazepam
4. Dronabinol

ANTIEMETIC DOSING:

Aprepitant: use w/ ondansetron >45kg: 125 mg/day 1 then, 80mg Qday x 2days
Dexamethasone (Decadron): **Contraindicated w/ pulmonary XRT*
Day1: <1m2: 10 mg/m2; ≥1m2: 10-20 mg IV/PO QDAY
Subsequent doses:max 16 mg/day,consider BID
Diphenhydramine : - 0.5-1mg/kg PO/IV q6h. (MAX 50MG)
Dronabinol (Marinol): 2.5-5mg/m2/dose PO q3-4h
NB: *Contraindicated in <6yo,clinical depression;caution 6-12yo)*
Lorazepam: 0.025mg/kg IV/PO q6h (rare 0.05mg/kg). (MAX 2mg/dose)
Metoclopramide: **acute**: IV 1 mg/kg x1dose, then 0.05 mg/kg q4-6h **delayed**: 0.5 mg/kg/dose **IV/PO** q4-6h **(w/ diphenhydramine pm EPS)**
MAX: 7 mg/kg/day Give benadryl x 24h if >1dose/24h period
Ondansetron (Zofran): IV/PO unit dosing guidelines

Discontinue 48h post chemo vs. ineffective

Weight	24h dose	8hr dose
<5 kg	2mg	0.15mg/kg/dose
5-10 kg	4mg	(round)
10-15kg	6mg	2mg
15-20kg	8mg	
20-25kg	10mg	4mg
25-30kg	12mg	
30-40kg	16mg	6mg
40-50kg	18mg	
>50kg	28mg	8mg

Pentobarbitol (nembutal): 2mg/kg IV/PO q4-6h
Adult 50-100mg/ (MAX 100mg)
Scopolamine Patch: >40kg: 1.5mg patch behind ear q72h
*Requires renal adjustment (consult formulary for correct adjustments)

Consulting Psych

- What you write in order comments → what psych uses to prioritize urgency of consult.
- Reasons to page child psych on-call on nights/wknd: severe agitation, active SI w/plan/intent, psychosis, behavior interfering w/essential medical care

Depression and Anxiety

General Principles	• **TADS and CAMS**: large RCTs w/gov't oversight • Key findings: **Combination therapy of SSRI and CBT is superior to monotherapy w/ either.** CBT or SSRI is superior to placebo. No SSRI-associated suicidal events in either study. • Monitor carefully (weeks 1-4: weekly; weeks 5-12: every other week) after starting SSRI for increased suicidality.
Diagnosis	• Ddx: Adjustment disorder (needs psychotherapy only), Delirium, hypoactive type (wax/wane, acute onset, possibly 2/2 underlying medical illness or iatrogenic) • Major Depressive Episode: **2w of 5+ of SIGECAPs** (Sleep, interest loss, guilt/worthlessness, energy loss/fatigue, cognition/concentration, appetite change, psychomotor change, SI) + depressed mood/ anhedonia OR **irritability (**more common in kids)**
Treatment	• **SSRI first line** (helps ⅔ of pts in first trial **over 4-8 weeks**. ⅔ of nonresponders respond to 2nd trial) • **Sertraline (Zoloft) and Fluoxetine (Prozac)** are most common, least SE (used in TADS, CAMS). • Mild serotonergic side-effects (hyperhidrosis, nausea, headache, tremulousness, diarrhea) can happen w/ SSRI/SNRI initiation and/or uptitration. Usually goes away in 2-3d. • **NEVER** prescribe Paxil/paroxetine to teens. Black box warning for suicide.

Suicide

- If you don't directly ask about suicide, you won't hear about it. NEVER assume! You don't have to be depressed to be suicidal.
- ~4% of patients coming in to ED (for all complaints) are suicidal.
- Adolescents more likely to kill selves by firearm; children by strangulation

ASQ: Adolescent Suicide Screening Tool

1. In the past few weeks, have you wished you were dead?
2. In the past few weeks, have you felt that you or your family would be better off if you were dead?
   → Yes to 1 or 2 *(passive SI):* Counsel, supportive listening, referrals
3. In the past week, have you been having thoughts about killing yourself?
4. Have you ever tried to kill yourself?
5. Are you having thoughts of killing yourself right now?
   → **Yes to 3 or 5 *(active SI):* Immediate consult from ER/floor/outpt mental health clinician**

A/P Template for Patients Awaiting Inpatient Psych Placement

Assessment: __ is a _y/o M/F w/ PMHx __ who presents w/ concerning __ SI that makes him/her unsafe for discharge home. S/He has been medically cleared and is awaiting placement at an inpatient psychiatric facility. We will continue to provide a safe environment and follow along w/ psychiatry.

A/P Template continued on next page →

A/P Template for Patients Awaiting Inpatient Psych Placement

Plan:

 # Suicidal ideation
- Suicide precautions
- Utox and EKG
- Psych following, dispo to inpt psych facility when bed available
- Psych recs: 1:1 sitter w/i arm's reach, safety tray, room restriction, observed bathroom/shower use.

Agitation plan: (**update when formal psych recs available**)
- Mild: Verbal redirection and Ativan PO 0.5 mg PRN aggressive or dangerous behavior
- Moderate: Risperidone 0.25mg PO (may give 0.125mg after 30 min) OR haldol 2mg PO (may give 1mg dose after 30min)
- Severe: Haldol 2mg IM OR Olanzapine 2.5mg IM

 # Nutrition
- POAL

 # Dispo: pending placement to inpatient psych

Depression Medications

Serotonin Reuptake Inhibitors (SSRIs)

MOA	**5-HT-specific reuptake inhibitor**
Use	**Depression, Gen. anxiety disorder, Panic disorder, OCD, bulimia, social anxiety disorder, PTSD, premature ejaculation, premenstrual dysphoric disorder** ** It normally takes **4–8 weeks** for antidepressants to have full effect.
EX	**Fluoxetine** (Prozac)**, Paroxetine (**Paxil)**, Sertraline (**Zoloft)**, Citalopram** (Celexa)**, Escitalopram** (**Fl**ashbacks **par**alyze **se**nior **cit**izens) • **Paroxetine** → short half-life → **discontinuation syndrome** (flu-like sxs, dizzy, diaphoretic, "electric shock," + depression) • **Fluoxetine** → long half-life → no need to taper/good for poor compliance, **P450 inhibitor,** can ↑antipsychotics → ↑SEs • **Citalopram/Escitalopram** → Dose dependent QTc prolongation (usually minimal)
SE's	GI distress**, SIADH, sexual dysfunction (anorgasmia,↓libido), insomnia, anorexia, ↑suicidality in adolescents , QTc prolongation, mildly ↓Na (i.e. 128)** **Serotonin syndrome:** 2 meds that ↑ serotonin (**MAOis, SNRIs, TCAs, Opoids, Tramadol, Linezolid**) → ↑↑serotonin in brain. (ex: triptan/SSRIs) **3 A's**: neuromuscular **A**ctivity (clonus, hyperreflexia, hypertonia, tremor, seizure), **A**utonomic stim (hyperthermia, diaphoresis, diarrhea), and **A**gitation. • Tx: **cyproheptadine** (5-HT2 receptor antagonist) or **benzodiazepines**
Notes	No paxil/paroxetine in kids,

Serotonin-Norepinephrine Reuptake Inhibitors (SNRIs)

MOA	**Inhibit 5-HT** and **NE reuptake**
Use	**Depression, general anxiety disorder, diabetic neuropathy.** • **Venlafaxine** → also indicated for **social anxiety disorder, panic disorder, PTSD, OCD, menopausal depression** (b/c of NE effects) • **Duloxetine** → also used for **neuropathy (vs. Amitriptyline** is better in suicidal patient who might overdose)
EX	**Venlafaxine** (Effexor)**, Duloxetine** (Cymbalta), **desvenlafaxine, levomilnacipran, milnacipran.**
SE's	↑**BP** most common; also **stimulant effects, sedation, nausea**

Depression Medications	
Tricyclic Antidepressants (TCAs)	
MOA	Block reuptake of **NE and 5-HT. (-triptyline, -pramine –doxepin)**
Use	**Major depression, OCD** (clomipramine), **peripheral neuropathy, chronic pain, migraine prophylaxis**.
EX	**3°-Amitriptyline** (pain/migraines**), Imipramine** (enuresis), **clomipramine** (OCD)**, doxepin 2°-Nortriptyline, amoxapine, desipramine** (ADHD)
SE's	**Tri-C's**: **C**NS toxicity (**C**onvulsions/**C**oma), **C**ardiotoxicity (**arrhythmia** -Na+ channel inhib, ↑QT int), anti**C**holinergic (urinary retention); • **Sedation, α1-blocking effects** (postural hypotension), **anticholinergic SEs** (tachycardia, urinary retention, dry mouth) • 3° TCAs (amitriptyline) have more anticholinergic effects than 2° TCAs (nortriptyline). • **QRS duration >100 msec** → assoc. w. ↑risk of arrhythmias and/or seizures =indication for Tx: **NaHCO3**-stabilizes myocardium, alkalinize urine • **Confusion/hallucinations** in elderly due to anticholinergic side effects (use nortriptyline)
Monoamine Oxidase Inhibitors (MAOi)	
MOA	**Nonselective MAO inhibition → ↑levels of amine neurotransmitters (NE, 5-HT,dopamine)**
Use	**Atypical depression** (hypersomnia, ↑appetite, heavy extremities, ↑sensitivity to interpersonal rejection)**, anxiety.** • **Selegiline** → only antidepressant that comes in dermal patch form (good for patient that cannot tolerate p.o.)
EX	**Phenelzine, Isocarboxazid, Tranylcypromine, (MAO T**akes **P**ride **I**n **S**hanghai**), Selegiline (selective MAO-B inhibitor – Parkinson's, Transdermal).**
SE's	**Hypertensive crisis** (tyramine (cheese, wine)→↑↑BP, HA, sweating, N/V, photophobia, autonomic inst, stroke/death Tx: **Nitroprusside, Phentolamine** **Serotonin Syndrome -** contraindicated w/ SSRIs, TCAs, Tramadol, Linezolid, St. John's wort, meperidine, dextromethorphan • Wait 2 weeks after stopping MAO inhibitors before starting serotonergic drugs or stopping dietary restrictions.
Notes	Rarely used anymore -- Linezolid is a weak MAO-I, and warrants avoidance of norepi and serotonergic drugs (big problem in CF patients w/ antidepressants) otherwise hypertensive urgency and/or serotonin syndrome are a risk. This should be emphasized.
Norepinephrine-Dopamine Reuptake Inhibitors	
MOA	**↑norepinephrine and Dopamine via unknown mechanism**
Use	**MDD w/ sexual side effects from SSRI's, MDD w/ wt gain/hypersomnia** (**bupropion is PRO** penis, not **BU**limic). **Smoking cessation.**
EX	**Bupropion (**Wellbutrin)
SE's	**Seizures (in anorexic/bulimic/seizures in past), stimulant effects** (tachycardia, insomnia**), headache, No** sexual side effects

Depression Medications continued on next page →

Depression Medications	
α2-Adrenergic Receptor Antagonists	
MOA	**α2-antagonist (↑release of NE and 5-HT), potent 5-HT2 /5-HT3 receptor antagonist** and **H1 antagonist** (sleepy/appetite effects)
Use	**Major depression** (especially in patient w/ **weight loss and/or insomnia**) → EX: cancer patient w/ N/V, ↓appetite, + MDD
EX	**Mirtazapine** (Remeron)
SE's	**Sedation (**desirable in depressed patients w/ insomnia**), ↑appetite, wt gain** (may be desirable in elderly/ anorexic), **dry mouth.**
Notes	Adrenergics like guanfacine and clonidine are very useful in hyperactive ADHD and sometimes PTSD/ irritability in general. Mirtazapine/Remeron is a multi-receptor drug and most of its psychotropic effect is from 5-HT activity, actually.
Serotonin Receptor Antagonists and Agonists	
MOA	**Primarily blocks 5-HT2, α1-adrenergic, and H1 receptors; also weakly inhibits 5-HT reuptake.**
Use	**Insomnia (**high doses are needed for antidepressant effects)
EX	**Trazodone** (Desyrel) and **Nefazodone** (Serzone)
SE's	**Sedation, nausea, priapism, postural hypotension.** Called tra**ZZZ**o**BONE** → **b/c sedative and male-specific side effects.**
Nicotinic ACh Receptor Partial Agonist	
Use	**Smoking cessation**.
EX	**Varenicline**
SE's	**S**leep disturbance, mood changes, suicidality, cardiovascular events

Antipsychotic Medications	
Typical Antipsychotics (1st generation)	
MOA	Block **D2 receptors** (↑[cAMP]) → Low/High Potency can cause **QT prolongation**(450 = number you are looking for)
Use	**Schizophrenia** (positive sxs), **psychosis, bipolar disorder, delirium, Tourette syndrome, Huntington disease, OCD**.
Low Potency	**Chlorpromazine,**(**C**orneal deposition)**, Thioridazine**(re**T**inal deposition) → **C**heating **T**hieves are **LOW Blocks HAM** – **H**istamine (sedation) **M**uscarinic (dry mouth, constipation), **α**1 (orthostatic hypoTN)

Antipsychotic Medications

Typical Antipsychotics (1st generation) cont.

High Potency

Trifluoperazine, Fluphenazine, Haloperidol → **T**ry to **F**ly **H**igh

- **Llibido, osteoporosis, amenorrhea, gynecomastia** Tuberoinfundibular: block dopa→↑ prolactin→ ↓GnRH → ↓ FSH/LH
- **Extrapyramidal symptoms -** Nigrostriatal: ACTH/dopamine in balance → block dopamine →↑ACTH

ADAPT	Time	Extrapyramidal Symptoms	Treatment
Acute **D**ystonia	Hrs-days	Muscle spasm, torticollis, stiffness, oculogyric crisis	IM: (1) **Benztropine**. (2) **Diphenhydramine** (antihistamine and anticholinergic effects)**,** (3) **Lorazepam** (at muscle)
Akathisia	Days - mo	Restlessness, ↑risk for suicide	**Propranolol** (hint: ask MOA of drug – beta blockade)
Parkinsonism	Days-mo	Bradykinesia, tremor, rigidity, masklike facies,	**Benztropine** (NOT L-dopa b/c ↑dopamine→↑ psychosis) **Trihexyphenidyl,** maybe **amantadine**
Tardive dyskinesia	Mo-yrs	Repetitive orofacial movements - **dopamine hypersensitivity**	**STOP** antipsychotic (may worsen when first stop) **START** atypical → **Quetiapine** or **Clozapine**

- **Neuroleptic malignant syndrome**: **Fever** (>103), **Rigidity**, ↑**CPK** → rhabdo, AKI, (HINT: **N M S** → **F R C)** → due to **Dopamine dysreg**
  - Causes: typical/atypical antipsychotics, antiemetics, antiparkinson med w/drawal, infection, surgery
  - **FEVER**: Fever, Encephalopathy (AMS), Vitals unstable, ↑Enzymes, Rigidity (lead pipe), leukocytosis
  - **VS**. Serotonin Syn → **NMS (↑↑Rigidity), SS (↑DTRs/clonus, GI sxs)**
  - Tx; (**1) STOP drug** (most important intervention) (2) **Hydrate, cooling blankets**
    - No response to stopping drug →(3) **Dantrolene** (inhib Ca2+ release)/ **Bromocriptine/ Amantadine** (4) **EC**T

Notes

IV and IM = more QTc and torsades risk, PO is much less.
Our hospital has policy that only can get IV haloperidol while on telemetry (ICUs and 8E)

Atypical Antipsychotics (2nd Gen)

MOA

Blocking **D2 receptor** AND **serotonin 2A receptor blockade**

Use

Schizophrenia (positive/negative sxs), **bipolar disorder, OCD, anxiety disorder, depression, mania, Tourette syn**

Antipsychotic Medications continued on next page →

Antipsychotic Medications

Atypical Antipsychotics (2nd Gen) cont.

SE's	ALL SE's: Metabolic side effects → sleepy and fat, → W/u: EKG, Lipids, BMI, Others: **Asenapine, Iloperidone, Lurasidone, Paliperidone** • **Olanzapine** → **O**besity (metabolic syndrome) • **Risperidone** → ↑prolactin (↓dopamine activity in tuberoinfundibular pathway→ gynecomastia, galactorrhea, amenorrhea) • **Quetiapine** → best for movement disorders (ex: Parkinson's) • **Ziprasidone** → starts w/ **Z** worst for the **qTC,** ↓metabolic effects • **Aripiprazole** → **light and "ari**" → doesn't put you to sleep/lead to weight gaint; **partial agonist** at D2 • **Clozapine** → **D4 blockade** is primary effect, must watch **cloz**ly → monitor WBC and absolute neutrophil counts ▪ 3 good: **best efficacy** (if nothing else working), ↓**risk of suicide** in schizophrenia **(lithium only other), Lewy Body Dem** ▪ 6 bad **(1) Agranulocytosis** (CBC before/wkly for 1st 6 mo→ look at WBC/↓ANC on diff (<1500 → Tx: **STOP**) **(2) Myocarditis** (EKG, troponins, etc) **(3)**↓**Seizure threshold** (most common) **(4) Wt gain** (worse then olanzapine) **(5) Sedation (6) Sialorrhea**

Mood Stabilizers

Lithium

MOA	Not established; possibly related to **inhibition of phosphoinositol cascade → inositol = buzzword**
Use	**Mood stabilizer for bipolar disorder; blocks relapse and acute manic events.** • Drug of choice in acute mania and as prophylaxis for both manic/depressive episodes in **bipolar & schizoaffective** disorders. • It is also used in **cyclothymic disorder** and **unipolar depression**. Excellent at low doses for anti-suicidality
SE's	**LMNOP—L**ithium SEs**: M**ovement **(tremor), N**ephrogenic Diabetes Insipidus Hyp**O**thyroidism**, P**regnancy problems **(Ebstein anomaly)** • Almost exclusively **excreted by kidneys;** most is reabsorbed at PCT w/ Na+. **Skin: acne, psoriasis** • ↑ Li+ levels: **NSAIDs, Aspirin**, **Thiazides, ACEi/ARBs, Metronidazole,** Dehydration, Salt depr, Sweating (salt loss), ↓renal fxn • ↓LI+ levels: K**+ sparing diuretics, Theophylline**, CCB/Furosemide may ↑/↓ Acute Lithium toxicity**: tremor,** diarrhea**,** vomiting, weakness, **polyuria, polydipsia**, **ataxia,** cognitive impairment Chronic Lithium toxicity: **nephrogenic diabetes insipidus, thyroid dysfunction, hyperparathyroidism** • Prior to starting: ECG, BUN, creatinine, Ca2+, u/s,, thyroid function tests, CBC, and a pregnancy test • Contraindications: chronic kidney disease, heart disease, hyponatremia or diuretic use Therapeutic range: **0.8-1.2** mEq/L

Valproic Acid (Depakote)

MOA	↑Na+ channel inactivation, ↑GABA concentration by inhibiting GABA transaminase
Use	**Bipolar** (acute mania, mixed features, rapid cycling)**, Migraine prophylaxis, Myoclonic seizures,**
SE's	**Hepatotoxicity** (measure LFTs)/↑**ammonia, Hemorrhagic Pancreatitis, ↓plts, neural tube defects**, **tremor, wt gain/PCOS, hair loss**

Mood Stabilizers	
Carbamazepine (Tegretol)	
MOA	Blocks Na+ channels
Use	**Bipolar** (esp. mania w/ mixed features and rapid-cycling)**, Antiepileptic, Trigeminal neuralgia**
SE's	**cyt P-450 inducer (**HINT: ↓Warfarin effects → bleed, ↓OCP → pregnancy), **blood dyscrasias** (agranulocytosis (↓ANC), aplastic anemia), **liver toxicity, teratogenesis, SIADH, Stevens-Johnson syndrome** (HINT: SJS <30% body, TEN >30%)**, Diplopia, ataxia**
Buspirone (BuSpar)	
MOA	Stimulates **5-HT1A receptors.**
Use	**Generalized anxiety disorder** → I'm always **anxious** if the **bus** will be **on** time, so I take **bus**pir**on**e.
SE's	Does <u>not</u> cause sedation, addiction, or tolerance. Takes 1–2 weeks to take effect. Does not interact w/ alcohol (vs barbiturates, benzodiazepines)..
Benzodiazepines	
MOA	**Facilitate GABA-A action by ↑freq of Cl− channel opening. ↓REM sleep.** **"Frenzodiazepines" ↑frequency. Benzos, barbs, and alcohol all bind theGABA-A receptor, which is a ligand-gated Cl− channel.** Most have long half-lives/active metabolites **(excep: Al**prazolam**, T**riazolam**, O**xazepam**, M**idazolam→ **short acting/↑addictive pot).**
Use	**Anxiety, akathisia, spasticity, status epilepticus (Lorazepam, diazepam), eclampsia, detoxification (**esp. alcohol withdrawal–DTs**), night terrors, sleepwalking, general anesthetic** (amnesia, muscle relaxation), **hypnotic** (insomnia).
EX	**Diazepam** (Valium)**, Clonazepam** (Klonopin), **Lorazepam** (Ativan)**, temazepam, oxazepam,** (LOT – safe for liver), **midazolam** (Versed)**, triazolam, chlordiazepoxide** (long acting, used to treat EtOH w/drawal, but not in liver failure)**, Alprazolam** (Xanex)**.**
SE's	**Dependence, Additive CNS depression effects w/ alcohol** (drowsiness, impaired intellect, motor coordination, amnesia) • Less risk of respiratory depression and coma than w/ barbiturates. <u>Overdose tx</u>: **Flumazenil (**competitive antagonist at GABA benzodiazepine receptor**)** • Can precipitate **seizures** by causing acute benzodiazepine withdrawal → withdrawal can be life threatening
Barbiturates	
MOA	**Facilitate GABAA action by ↑duration of Cl− channel opening → ↓neuron firing (**barb**idurat**es→ ↑**durat**ion**).** **Contraindicated in porphyria.**
Use	**Sedative for anxiety, seizures, insomnia, induction of anesthesia (thiopental).**
EX	**Phenobarbital, pentobarbital, thiopental, secobarbital**
SE's	**Respiratory/cardiovascular depression** (can be fatal); **CNS depression** (exacerbated by alcohol use); **dependence** • **Drug interactions (induces cytochrome P-450)** <u>Overdose Tx</u>: **supportive (assist respiration and maintain BP)**

Mood Stabilizers continued on next page →

Mood Stabilizers	
Nonbenzodiazepine hypnotics	
MOA	Act via the **BZ1 subtype** of the **GABA receptor.** Effects reversed by **flumazenil.** Sleep cycle less affected as compared w/ benzodiazepine hypnotics
Use	**Insomnia.** Should be used short-term (weeks-months). SEs = sleep-walking.
EX	**Zolpidem, Zaleplon, esZopiclone. "All ZZZs put you to sleep."**
SE's	**Ataxia, headaches, confusion.** Short duration because of **rapid metabolism by liver enzymes.** Unlike older sedative-hypnotics, cause only **modest day-after psychomotor depression and few amnestic effects.** **↓dependence risk vs. benzodiazepines**

Other Psych Drugs	
Stimulants	
MOA	↑catecholamines in the synaptic cleft, especially **norepinephrine and dopamine**..
Use	**ADHD, narcolepsy** (modafinil)**, appetite control**
EX	**Methylphenidate** (Ritalin, Concerta), **Dextroamphetamine** (Adderall)**, methamphetamine, Atomexetine** (Straterra), **Modafinil** (Provigil)
SE's	Hypertension, Weight Loss, Insomnia, exacerbation of tics, ↓seizure threshold
Notes	Straterra not technically a stimulant, in its own class.
Acetylcholinerasterase Inhibitors	
MOA	Inhibits ACHE → ↑ACh in synaptic cleft
Use	**Mild-moderate dementias** (neurocognitive disorders) → ex: Alzheimer's (Donepezil/Rivastigmine)
EX	**Donepezil** (Aricept), **Galantamine** (Razadyne), **Rivastigmine** (Exelon)
MNDA (Glutamate) Receptor Antagonist	
MOA	Antagonist at NMDA (glutamate) receptor
Use	ADHD, narcolepsy (modafinil), appetite control
EX	**Memantine** (Nemenda)

Meds That Cause Psych Symptoms	
Psychosis	Sympathomimetics, analgesics, antibiotics (e.g., isoniazid, antimalarials), anticholinergics, anticonvulsants, antihistamines, corticosteroids, antiparkinsonian agents.
Agitation/ Confusion/ Delirium	Benzos, antipsychotics, anticholinergics, antihistamines, antidepressants, antiarrhythmics, antineoplastics, corticosteroids, nonsteroidal anti-inflammatories (NSAIDs), antiasthmatics, antibiotics, antihypertensives, antiparkinsonian agents, thyroid hormones

Meds That Cause Psych Symptoms	
Depression	Antihypertensives, antiparkinsonian agents, corticosteroids, calcium channel blockers, NSAIDs, antibiotics, peptic ulcer drugs.
Anxiety	Sympathomimetics, antiasthmatics, antiparkinsonian agents, hypoglycemic agents, NSAIDs, thyroid hormones.
Sedation/Poor Concentration	Antianxiety agents/hypnotics, anticholinergics, antibiotics, antihistamines.
Selected Meds	**Procainamide, quinidine**: Confusion, delirium **Albuterol**: Anxiety, confusion **Isoniazid**: Psychosis **Tetracycline**: Depression **Nifedipine, verapamil**: Depression **Cimetidine**: Depression, confusion, psychosis **Steroids**: Aggressiveness/agitation, mania, depression, anxiety, psychosis

Psychotherapies			
Modality	**Duration**	**Patient**	**Focus**
Cognitive Behavioral Therapy (CBT)	Time limited	• Anxiety, mood, personality, somatic symptom, eating disorder • Maladaptive thoughts, avoidance behavior, ability to participate in homework	• Combines cognitive/behavioral tech • Challenges maladaptive thoughts • Targets avoidance w/ behavioral techniques (relaxation, exposure)
Dialectical Behavioral Therapy (DBT)	Variable	Borderline personality disorder; self-injury	• Improves emotion regulation, mindful awareness, distress tolerance • Manages self-harm
Interpersonal Psychotherapy	Time limited	Depressed w/ relationship conflicts	• Links current relationships conflicts to depressive symptoms
Supportive Psychotherapy	Ongoing	Lower functioning; in crisis, psychotic	• Therapist as guide • Reinforces coping skills/builds adaptive defenses
Motivational Interviewing	Variable	Substance use disorder	• Addresses ambivalence and enhances motivation to change • Nonjudgmental; acknowledge resistance
Biofeedback	Variable	• Prominent physical symptoms • Pain disorders	• Improves awareness and control over physiological reactions • Lowers stress levels, integrates mind/body

Electroconvulsive Therapy	
Def	Small electric current to produce generalized seizure for 20-30 seconds under general anesthesia
Indications	Conditions: unipolar/bipolar depression, catatonia, bipolar mania Indications: **treatment resistance, psychotic features,** emergent conditions (**pregnancy, refusal to eat/drink**, imminent risk for **suicide**), pharmacotherapy contraindicated due to comorbid illness/poor tolerability, **History of ECT response**.

Electroconvulsive Therapy continued on next page →

Electroconvulsive Therapy	
Safety	No absolute contraindications Increased risk: severe cardiovascular disease, recent MI, space-occupying brain lesion, recent stroke, unstable aneurysm
Side effects	Most common: amnesia (anterograde or retrograde → anterograde resolves rapidly, retrograde persists -- rare w/ uni-lateral ECT and many experts think repeated gen anesthesia may be major contributor

Capacity Assessment	
Patient (18+)/Family Must...	**Assessment**
Communicate a clear and stable choice	Ask patient to indicate a choice. Frequent reversals may indicate lack of capacity.
Understand relevant information	Ask patient to explain understanding of information given by physician (diagnosis, prognosis, proposed intervention, risks/ benefits of intervention and alternatives, including no intervention)
Appreciate the situation and its consequences	
Manage the information in a rational manner	Does patient weigh risks/benefits logically?
Is there true imminent risk?	EX: patient indicating they are suicidal but meet all 4 criteria above.
Capacity vs competency -- capacity is a one-time assessment by a clinician, competency is a legal decision based on accumulated evidence that requires court hearing/proceeding	

Asthma – ED/Inpatient*	
History to Elicit	Time of onset, causes/triggers, symptom severity, prior treatments before presentation, last time of medications, last dose of oral steroids and past requirements for oral steroid doses.
Exam	Tachypnea, hypoxia, altered mental status, accessory muscle use, URI symptoms, wheezing, prolonged expiratory phase, eczema, rash **Red flags**: dehydration, cyanosis/pallor, decreased aeration, AMS, admission w/i 1 year, ICU admission w/i 3 years, PCP/ED visit w/i 72 hours
Etiology	Trigger → Production of IgE antibodies, overstimulation of mast cells/eosinophils → Inflammation, airway smooth muscle constriction, mucus production, edema → hyper-responsiveness of airway, obstruction, air-trapping → airway remodeling
Work-up	Assess severity w/ amount of dyspnea, RR, retractions, inspiratory vs. expiratory wheezes, and SpO2. I Not routinely recommended: CXR (unless prolonged fever, asymmetry post-albuterol, severe symptoms, hypoxemia, aspiration concern), viral testing, blood gas
Treatment	

Albuterol	For mild-severe exacerbation MDI or nebulizer, base frequency on severity For MDI must use an aerochamber. In general, use w/ face mask (<6 mos = small orange facemask, 6 mos-6 yrs = medium yellow facemask, >6 years = large blue facemask)
UniNeb	For moderate-severe exacerbation 3 albuterol + 3 ipratropium over 1 hr
Systemic Corticosteroids	For moderate-severe exacerbation Dexamethasone Prednisone, prednisolone, or methylprednisolone
Epinephrine	For severe exacerbation Administer by EpiPen if able
Magnesium Sulfate	For severe exacerbation Administer w/ 20 cc/kg bolus of normal saline before dose to decreased risk of hypotension
Terbutaline	For severe exacerbation
Heliox (80% He + 20% O2)	For severe exacerbation Contraindications: Requiring FiO2 >0.6 to maintain SpO2 >92%, Need for PPV, PTX, pneumopericardium, pneumoperitoneum

Asthma – Outpatient*	
Order Sets	"Asthma admit plan" (includes albuterol, Unineb, etc orders)
History to Elicit	Symptoms, nocturnal awakening, missed school, hospitalizations (ED, ICU, ETT), triggers, controllers, albuterol use, adherence, atopic history, vaccines, requirement for oral steroid courses.
Presentation	SOB, coughing, wheezing, chest tightness • **Exam:** Tachypnea, hypoxia, altered mental status, accessory muscle use, URI symptoms, wheezing, prolonged expiration, eczema, rash
Etiology	Trigger → Production of IgE antibodies, overstimulation of mast cells/eosinophils → Inflammation, airway smooth muscle constriction, mucus production, edema → hyper-responsiveness of airway, obstruction, air-trapping → airway remodeling
Workup	PFTs +/- provocation test, other testing as suggested by differential diagnosis (immune work-up, GERD evaluation, allergy testing, sweat test, etc.)

Asthma continued on next page →

Asthma – Outpatient*

Severity Classification				
Variable	**Intermittent**	**Mild**	**Moderate**	**Severe**
Symptom frequency	≤2 d/wk	>2 d/wk	Daily	Throughout day
Nighttime awakenings	0-4 yr: 0 ≥5 yr: ≤2/mo	0-4 yr: 1-2/mo ≥5 yr: 3-4/mo	0-4 yr: 3-4/mo ≥5 yr: ≥1/wk	0-4 yr: >1/wk ≥5 yr: >7/wk
Interference w/ activity	None	Minor	Some	Extreme
SABA use	≤2 d/wk	0-4 yr: >2d/wk ≥5 yr: >2/wk	Daily	Throughout day
FEV1% predicted	>80%	>80%	60-80%	<60%
Treatment	Step 1	Step 2	Step 3	Step 3

Stepwise Approach to Asthma Treatment						
Age	**Step 1**	**Step 2**	**Step 3**	**Step 4**	**Step 5**	**Step 6**
0-4	SABA PRN	Low dose ICS	Medium dose ICS	Medium dose ICS + (LABA OR montelukast)	High dose ICS + (LABA OR montelukast)	High dose ICS + (LABA or montelukast) + PO steroids
5-11	SABA PRN	Low dose ICS	Low dose ICS + LABA or LTRA OR Medium dose ICS	Medium dose ICS + LABA	High dose ICS + LABA	High dose ICS + LABA + PO steroids
>12	SABA PRN	Low dose ICS	Low dose ICS + LABA OR Medium dose ICS	Medium dose ICS + LABA	High dose ICS + LABA	High dose ICS + LABA + PO steroids

Bronchiolitis*

Presentation	URI symptoms → cough, wheezing/rales, increased WOB, peak symptoms 4-7 days of illness **Exam**: rhinorrhea, cough, tachypnea, retractions, nasal flaring, grunting, crackles, wheezing
Differential	Viral URI, asthma exacerbation, PNA, croup **Red Flags:** apnea, respiratory failure, pneumothorax, bacterial PNA superinfection, dehydration
Workup	Assess severity (mental/hydration/respiratory status); no routine indication for labs or CXR but consider if concern for bacterial superinfection
Treatment	**Outpatient**: Supportive w/ bulb suction, hydration, tylenol/motrin **Inpatient** (if <2 mos, supp O2 req, unable to take PO, increased WOB): Wall suction, IVF, chest PT, supp O2 to maintain SpO2 >90%, spot check SpO2 **ICU** (if hypoxia respiratory failure): Wall suction, IVF, chest PT, supp O2 to maintain SpO2 >90%, CPAP/BiPAP, consider albuterol, HTS, rac epi though little evidence to support benefits of therapy

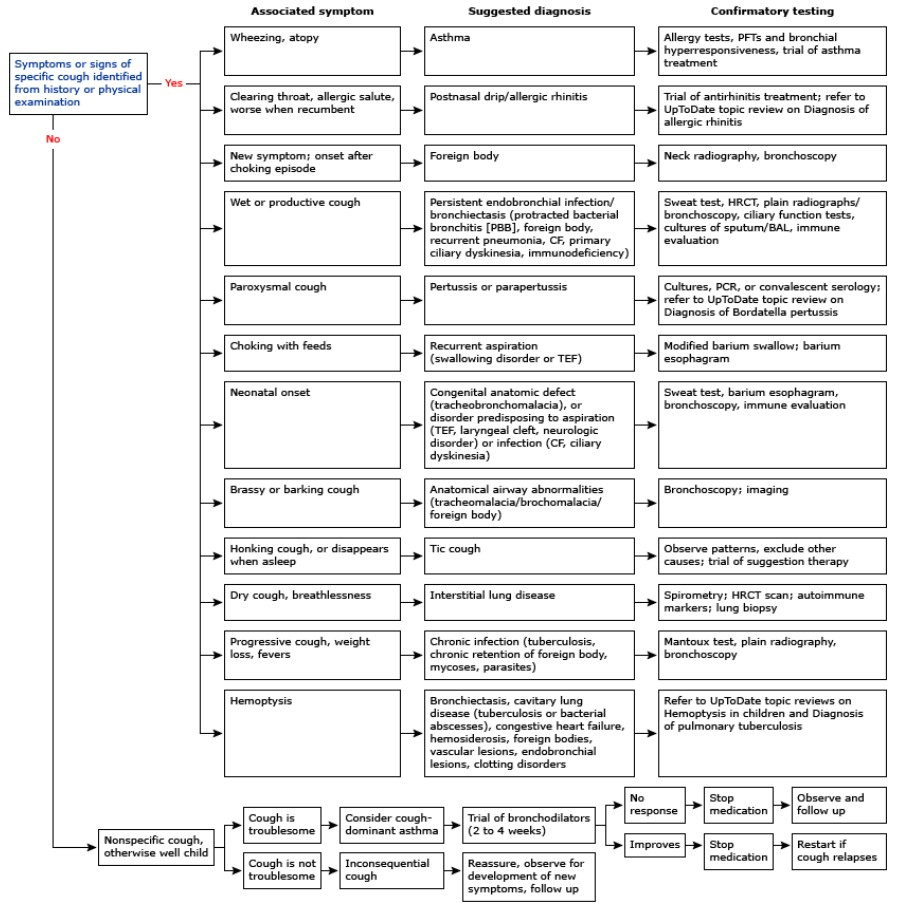
Bronchiolitis*	
Prevention	**Palivizumab** for 1st year of life if: HD significant congenital heart disease, CLD of prematurity (<32 weeks + supp O2 for 1st 28 days of life), born at <29 weeks gestation, anatomic pulmonary disorders, immunocompromised

Cough	
Definition	Acute (less then 4 weeks) or chronic (>4 weeks)
History to Elicit	Age and circumstances of onset, nature of cough, triggers, associated symptoms, history of atopy/ eczema, history of recurrent infections, history of travel
Exam	Look for increased work of breathing, wheezing, atopy, boggy turbinates, conjunctivitis, dysmorphisms, cardiac abnormalities
Differential Diagnosis	

Infant	Chlamydia, viral (RSV, CMV, rubella), bacterial (pertussis), pneumocystic jiroveci, tracheoesophageal fistula, vascular ring, airway malformation (bronchogenic cyst, CPAM), pulmonary sequestration, CF, reactive airway disease/asthma, reflux, aspiration, interstitial lung disease, PCD, immuno-deficiency, toxic exposures
Preschool to School age	Inhaled FB, myoplasma, bacterial (pertussis), reactive airway disease/ asthma, CF, bronchiectasis, PCD, viral, passive smoke inhalation, reflux, aspiration, interstitial lung disease, allergic rhinitis, sinusitis, croup, hyper-
School age to Adolescence	Reactive airway disease/asthma, infectious, CF, psychohenic/habit cough, cigarette smoking, interstitial lung disease, reflux, aspiration, smoking, allergic rhnitis

Cough continued on next page →

Cough



Croup*

Presentation	Inspiratory stridor, barking cough, hoarseness, retractions in setting off URI symptoms **Red Flags:** AMS, cyanosis
Differential	Parainfluenza virus, bacterial tracheitis, FB obstruction, peritonsillar abscess, anaphylaxis
Workup	CXR not required but if obtained will show “Steeple Sign” w/ tapering of upper trachea
Treatment	Dexamethasone, supportive care, +/- racemic epinephrine (repeat q15 minutes)

Cystic Fibrosis*

Clinical Manifestations

Pulmonary	Chronic airway disease w/ infection (H flu, S. aureus, P aeruginosa, Burkholderia, Steno, MRSA, atypical), bronchiectasis, gas trapping, hypoxemia, hypercarbia
Sinus	Sinus infections, nasal polyposis
GI	Meconium ileus, constipation, distal intestinal obstructive syndrome, deficiencies in A, D, E, K
Endocrine	CF related diabetes, osteoporosis from vitam D deficiency
MSK	Hypertrophic osteoarthropathy
Reproduction	Congenital absence of vas deferens
Renal	Nephrolithiasis due to chronic metabolic acidosis
Hematologic	Recurrent venous thrombosis due to chronic inflammatory state

Diagnosis

- **Diagnostic Criteria:** CF in 1+ organ system AND evidence of CFTR dysfunction through either elevated sweat chloride, two disease causing mutations, or abnormal nasal transepithelial potential difference
- **Sweat Test:** **≤6 mos:** normal ≤29 mmol/L and abnormal ≥60 mmol/L, **≥6 mos:** normal ≤39 mmol/L and abnormal ≥60 mmol/L
- **Newborn Screen:** Massachuesetts NBS measures immunoreactive trypsinogen (IRT) by radioimmunoassay or enzyme-linked immunoassay
- **CFTR Genetic Analysis**

Pulmonary Exacerbations

Symptoms: Increased cough, change in sputum color/quantity, decreased appetite, weight, tachypnea

Chronic Pulmonary Treatment

- **Agents to increase mucus clearance:** Pulmozyme, albuterol, inhaled hypertonic saline, chest PT
- **Anti-inflammatory therapy:** Azithromycin if P. aeruginosa
- **Persistent Pseudomonas Colonization:** Inhaled tobramycin and aztreonam
- **Vaccines:** pneumococcal, yearly influenza
- **Supplemental O2:** If intermittent or chronic hypoxemia
- **Nutritional support:** pancreatic enzymes, replacement of fat-soluble vitaminas, nutritional counseling
- **CFTR modulators:** Ivacaftor "Kalydeco" (CFTR potentiator for C551D mutation) and Lumacaftor/ Ivacaftor "Orkambi" (CFTR potentiator + corrects the Phe508del mutation and increases amount of functional CFTR at surface)
- **Annual Screening:** OGTT if >12, abdominal US w/ Doppler, audiogram

Treatment CF Exacerbations

Lab monitoring: Qweek (CBC diff, LFTs, CRP), Qmon/Thurs (BUN/Cr, Abx trough)

Class	Antibiotic	Dose	Side Effects	Monitoring
Amino-glycoside	Tobramycin	IV 10 mg/kg q24 *OR* INH 300 mg BID *OR* Podhaler 4 caps INH BID	Ototoxicity Nephrotoxicity Phototoxicity	Peak/trough w/ 2nd dose, goal peak is 20-40, tough < 1 (IV only)
	Amikacin	IV 30 mg/kg q 24 or INH 250mg BID		Peak AFB= 20-30 PSA or Short term dosing =40-60 Trough < 2.5
B lactams	Meropenem Imipenem	IV 40 mg/kg q8 (max 2g q8)	Transaminitis GI intolerance	
	Ceftaroline (5th generation cephalosporin)	15 mg/kg/dose IV Q8 (max 600 mg IV Q8hrs)		

Cystic Fibrosis continued on next page →

Cystic Fibrosis*

Class	Antibiotic	Dose	Side Effects	Monitoring
Oxazolidinones	Linezolid	10 mg/kg PO TID (if < 12 yrs) or 600 mg PO BID (if >/= 12 yrs)	Serotonin syndrome (w/ concurrent SSRI, avoid aged chees, meat, red wine, fava beans)	
Sulfonamide	Trimethoprim - Sulfamex-thoxasole (TMP- SMX, or Bactrim)	5 mg/kg PO BID	Photosensitivity, SJS	
Polycationic	Polymyxin E (Colistin)	IV 5 mg/kg q8 OR INH 75 or 150 mg BID	Pulmonary toxicity (respiratory failure following inhalation, bronchoconstriction, Nephrotoxicity) Paraesthesias	
Glycopeptide	Vancomycin	IV 15 mg/kg q8	Nephrotoxicity, red man syndrome, eosinophilia, DRESS	No peak, goal trough 15-20 (for continuous vanc: q24 until goal level 20-30)
Tetracycline	Tigecycline** Minocycline	IV 100 mg/kg x1 loading dose then 50 mg IV Q12 >8 years: Initial: 4 mg/kg loading dose then 2 mg/kg/dose Q12 Adults: 100 mg PO BID	Photosensitivity, pancreatitis, hepatotoxicity, acute, intracranial hypertension, renal failure, photosensitivity	

Hemoptysis

Definition	Acute bleeding >240 cc in 24 hours or recurrent bleeding of >100 cc daily for several days
Management	• Call for help • Airway: Stop BiPAP, if intubated MV w/ PEEP (tamponade effect) • Breathing: Assess site of bleeding on auscultation and place on that side • Circulation: stop all chest PT and medications that could affect clotting (ibuprofen), consider transfusion • Interventions: attmept to identify bleeding source, hemostasis interventions, chest CT, bronchial artery embolization, transexamic acid, ECMO

Pneumothorax

Types	Spontaneous, traumatic, tension
Presentation	Chest pain, SOB, no symptoms, decreased breath sounds, hypoxia, if tension (hypotension, tachycardia, JVD)
Workup	CXR (If concern for tension physiology, skip CXR and go straight to management)
Management	• ABCs, supplemental O2 if hypoxia • Unstable: chest tube placement • Tension: needle decompression 2nd ICS at MCL • Stable/Small: observation • Stable/Large: chest tube or pigtail catheter, VATS w/ pleurodesis if continued air leak

Pneumonia*	
Presentation	Fever, cough, dyspnea, pleuritic pain, respiratory distress
Etiology	• **Neonatal**: GBS, E. coli, K. pneumoniae, HSV • **Infants**: viral, S. pneumoniae, C. trachomatis • **Pre-school age**: viral, S. pneumoniae, S. pyogenes, S. aureus, B. pertussis • **School-aged**: M. pneumoniae, C. pneumoniae, S. pneumoniae, S. aureus
Differential	Asthma, pleural effusion/empyema, FB aspiration
Workup	CXR, respiratory viral panel including flu, blood culture if inpatient, ESR/CRP, procalcitonin
When to Hospitalize	Moderate-severe respiratory distress, SpO2 <90%, infants <6 mos, concern for virulent pathogen (MRSA), unable to tolerate PO intake
Treatment	• Outpatient: amoxicillin • Inpatient: ampicillin • Alternatives: add azithromycin if concern for atypicals, vancomycin if concern for s. aureus • Duration: 10 days, 2-4 weeks if parapneumonic effusion

Pleural Effusions	
Presentation	• Pain w/ inspiration, hypoxemia, hypercarbia • **Exam**: decreased breath sounds, dullness to percussion
Differential	**Transudative**: Decreased plasma oncotic pressure (nephrotic syndrome, cirrhosis, hypoal- **Exudative**: Increased capillary permeability (parapneumonic effusions, TB, AI disease, **Chylothorax**: Secondary to lymphatic abnormalities
Workup	• Imaging: CXR, US, CT • Diagnostic thoracentesis (consider if >10 mm fluid from lung to chest wall, need for definitive diagnosis, respiratory compromise) ▪ Light's Criteria: Exudative if 1+ of (1) Pleural fluid protein:serum protein ratio ≥0.5, (2) Pleural fluid LDH:Serum LDH ratio >0.6, (3) Pleural fluid LDH >66% ULN of normal serum LDH
Treatment	• Transudative: address underlying problem • Chylothorax: Drainage, restrict to medium chain TGs as main source of dietary fat • Paraneumonic effusions (pleural fluid + pneumonia, abscess or bronchiectasis) ▪ Uncomplicated: Antibiotics ▪ Complicated: Antibiotics + drainage +/- fibrinolytics +/- VATS • Consider chest tube if: persistent fever, toxic appearing, large effusion, complicated pleural effusion or empyema

Obstructive Sleep Apnea	
Presentation	• Snoring (>3 nights/wk), labored breathing, morning headaches, daytime sleepiness, learning difficulties • **Exam**: tonsillary hypertrophy, adenoidal faces, micrognathia, HTN, overweight
Differential	Central sleep apnea, narcolepsy
Workup	Polysomnography to assess severity via apnea-hypopnea index (AHI) → >5 AHI warrants treatment
Treatment	**CPAP,** adenotonsillectomy if adenotonsillar hypertrophy, topical intranasal steroids or montelukast

Tuberculosis

Symptoms

Pulmonary	Chronic cough >3 wks w/ weight loss, fever, diaphoresis, miliary TB
CNS	Meningitis, communicating hydrocephalus, stroke, increased ICP,
Abdominal	Ascites, abdominal pain, jaundice, chronic diarrhea
MSK	Joint effusion, Pott's disease
Derm	Warty/papulonecrotis lesions, erythema nodosum
Renal	Sterile pyuria, hematuria
Ocular	Iritis, neuritis, conjunctivitis

Workup

Bacteriologic Diagnosis	Infants: 3 early morning gastric aspirates for AFB, Cx, PCR Children/Adolescents: 3 sputum for AFB, Cx, PCR
Clinical Diagnosis	Recent close contact w/ known infectious case + positive tuberculin skin test (TST) or interferon-gamma release asay (IGRA) + suggestive findings on CXR or exam

Treatment

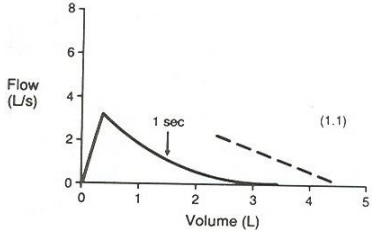
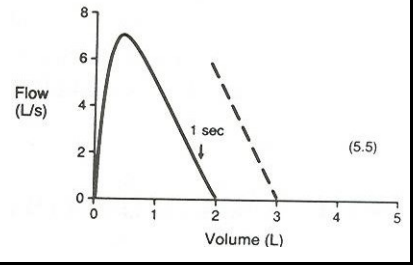
General	Rifampin, INH, pyrazinamide, ethambutol (RIPE) 2 mo → rifampin and INH (RI) for 4 mos
TB Meningitis	RIP + streptomycin (SM) 2 mo → RI for 7-10 mo
Osteoarticular	RIPE 2 mo → RI 7-10 mos
Relapse	RIPA + SM 2 mo → RIPE 1 mo → RIE 5 mo

Pulmonary Function Tests

Lung Function Definitions

Forced vital capicity (FVC)	Measures total amount of air you can exhale w/ force after you inhale as deeply as possible
Forced expiratory volume 1 (FEV1)	Measures the amount of air you can exhale w/ force in one breath. The amount of air you exhale measured at 1 second
Forced expiratory flow 25% to 75%	This measures the air flow over the middle half of the FVC
Peak expiratory flow (PEF)	The maximum flow rate obtained during a forced exhalation. It is usually measured at the same time as your forced vital capacity (FVC)
Total lung capacity (TLC)	This measures the total volume of air in your lungs after you inhale as deeply as possible
Functional residual capacity (FRC)	This measures the amount of air in your lungs at the end of a normal exhaled breath
Expiratory reserve volume (ERV)	This measures the difference between the amount of air in your lungs after a normal exhale (FRC) and the amount after you exhale w/ force (RV)

Obstructive vs. Restrictive Lung Disease

	Obstructive	Restrictive
Definition	The airways are narrowed, usually causing an increase in the time it takes to empty the lungs	Either a loss of lung tissue, a decrease in the lungs' ability to expand, or a decrease in the lungs' ability to transfer oxygen to the blood
FVC	Decreased	Decreased
FEV1	Decreased	Decreased
FEV1/FVC	Decreased	Normal or increased
TLC	Normal	Decreased
Differential Diagnosis	Asthma, bronchiectasis, bronchiolitis obliterans, cystic fibrosis, alpha 1 antitrypsin deficiency	Chest wall: ankylosing spondylitis, kyphosis, obesity, scoliosis Drugs: amiodarone, methotrexate, nitrofurantoin Interstitial lung disease: pneumonia, hypersensitivity pneumonitis, idiopathic pulmonary fibrosis, sarcoidosis, exposures (asbestos, beryllium) Neuromuscular disorders: Guillain-Barre syndrome, muscular dystrophy, myasthenia gravis
Extent of Defect	% of predicted FEV1: Normal >80%, Mild 60-80%, Moderate 40-60%, <40%	% of prediced TLC: Normal >80%, Mild 70-80%, Moderate 60-70%, Severe <60%
Pattern		

Bronchoprovocation Testing

- Response to bronchodilator: significant if FEV1 improved by >12-15%
- Cold air challenge: 12-15% decrease in FEV1 is indicative of airway responsiveness
- Exercise challenge: 12-15% decrease in FEV1 is indicative of airway responsiveness

Common Rheumatology Labs	
CRP	• Acute phase reactant, produced by liver in response to tissue injury/inflammation • Level rises ~ 4-6 hours after injury/infection, peak at ~24-72 hours, then falls after appropriate treatment
ESR	• Acute phase reactant, non-specific marker of inflammation. • Measures height of plasma layer vacated by RBC as cells settle in tube of anticoagulated blood in 1 hour. • Slower rise and slower fall compared to CRP • May be elevated due to anemia or hypergammaglobulinemia • May fall quickly in DIC or other conditions that consume or decrease production of fibrinogen
RF	• IgM autoantibody that reacts to Fc portion of IgG antibodies • Present in 5-10% of children w/ JIA; NOT useful as screening test for rheumatic disease in children • Useful only for predicting erosive disease in polyarticular JIA • Higher titers can be seen in Sjogren's Syndrome • Circulating immune complexes may give false positive RF results
ANA	• Autoantibodies directed against nuclear or perinuclear antigens. • Conditions associated w/ (+) ANA: ▪ Autoimmune: autoimmune hepatitis, SLE, MCTD, JIA, PBC, UC, MG, Graves', Hashimoto's ▪ ID: chronic infections (malaria, SBE), RPR, viral (HIV, HSV, EBV, HCV, B19) ▪ Systemic inflam.: lymphoproliferative disorders, interstitial pulmonary fibrosis, asbestosis • Medications associated w/ (+) ANA and drug-induced lupus (+anti-histone Ab): ▪ Procainamide (90%) ▪ Hydralazine (65%) ▪ Anti-TNF agents (especially infliximab) ▪ INH ▪ Quinidine ▪ Phenytoin ▪ Sulfasalazine ▪ Minocycline ▪ Lithium ▪ Chlorpromazine • Titers do not correlate w/ disease severity
ANCA	• Ab targeting antigens in cytoplasmic granules of neutrophils; highly sensitive for vasculitides that have predominant pulmonary and renal involvement • Not useful for screening patients w/ possible vasculitis due to false positive and negative results. • **Cytoplasmic (c-ANCA)**: antibody to proteinase-3 & positive in about 90% of patients w/ Granulomatosis w/ Polyangiitis (formerly Wegener's granulomatosis) • **Perinuclear (p-ANCA)**: antibody to myeloperoxidase & associated w/ microscopic polyangiitis, Churg-Strauss, Ulcerative colitis • Titers often do not correlate w/ disease severity

Autoantibody Associations		
ANA	• SLE • juvenile RA • dermatomyositis	• scleroderma • psoriatic arthritis • MCTD
RNP	• SLE • overlap conditions	• > 95% of MCTD
Smith	• 30% of juvenile SLE, 60% of adult SLE • High specificity	• Remains positive when SLE in remission
dsDNA	• 70-80% of SLE • High specificity	• Associated w/ SLE activity and lupus nephritis
Scl-70	• 30% of diffuse scleroderma • 15% of limited scleroderma	• Assoc. w/ pulmonary fibrosis

Autoantibody Associations		
Centromere	15-40%; Limited systemic sclerosis, pulm HTN	
SSA/Ro SSB/ LA	• Sicca/Sjogren's syndrome • Cutaneous lupus	• Neonatal lupus/congenital heart block
Sm	Autoimmune hepatitis	
Jo-1	• 20% of DM/PM • Associated w/ ILD	• Mechanic hands • Most frequent Ab in anti-synthetase syndrome
Mi-2	• 7% of DM/PM • Associated w/ acute onset of disease	• Shawl sign • Good prognosis
RF	• RA • SjS	• Cryoglobulinemia • chronic (HCV) or indolent (eg, SBE) infections
CCP (ACPA)	• 70-80% of RA • More specific for RA than RF	• predicts erosive disease • rarely in SLE, sjogrens, or psoriatic arthritis
Pm-Scl	Sclerodermatomyositis (Pm-Scl = polymyositis-scleroderma)	
Scl-70	Systemic sclerosis (Scl-70 = topoisomerase I)	
ANCA	• cANCA (granulomatosis w/ polyangitis) • pANCA (microscopic polyangiitis, PN, SLE, IBD, CF, PSC, HSP, KD, Churg-Strauss)	

Evaluation of Rheumatic Disease	
Symptoms of Rheumatic Disease	
Symptom	**Associated Disease**
Fatigue	SLE, JDM, MCTD, Vasculitis, JIA
Weakness	JDM, SLE related myositis, MCTD, deep localized scleroderma
Back pain	Enthesitis related arthritis, Juvenile ankylosing spondylitis
Chest Pain	Juvenile rheumatoid arthritis, SLE (pericarditis/costochondritis), Takayasu arteritis
Arthralgias	JIA, SLE, Rheumatic fever, JDM, vasculitis, scleroderma, sarcoidosis
Signs of Rheumatic Disease	
Arthritis	JIA, SLE, vasculitis, HSP, MCTD, scleroderma, rheumatic fever, reactive arthritis
Oral ulcers	SLE, Behcet disease (plus genital ulcers), PFAPA syndrome
Malar rash	SLE (spares nasolabial folds), JDM, KD, Parvo B19
Purpura	Vasculitis (ex: ANCA-assoc.), HSP
Gottron pap.	JDM (plus heliotrope rash, periungual telangiectasias)

Common Rheumatology Medications			
Medication	**Indication**	**MOA**	**SE**
Hydroxychloroquine	JDMS, SLE, Sjogren's	Alters pH of lysosomes, decreasing immune recognition of autoantigens	Retinopathy, N/V, alopecia, hemolytic anemia in G6PD deficiency
Azathioprine	DM/PM, SLE, vasculitis	Antimetabolite	Bruising, myelosupp, lymphoproliferative d/o
Methotrexate	RA, JIA, Psoriatic arthritis, JDM, vasculitis	Dihydrofolate reductase inhibitor	Hepatotoxicity, Stomatitis, Pancytopenias, ILD, Alopecia, Fever
Sulfasalazine	RA, JIA, UC, Crohn's	TNF and IL-1 suppressor	Hepatotoxicity, SJS, Stomatitis, Hemolytic anemia
Leflunomide	RA, JIA, Psor. arthritis	Pyrimidine synthesis inhibitor	Hepatotoxcity, Cytopenias
Abatacept, Rituximab, Tocilizumab	RA, SLE neph, GPA, MPA, RA	Non-TNF biologics	Increased infections due to Immunosuppression, HA, N/V, HTN, infusion reaction, fever, rash, PML
Adalimumab, Etanercept, Infliximab	RA, JIA, Psoriatic arthritis, AS psoriasis, IBD, vasculitis (TA, DADA2)	TNF inhibitors	Infection, Reactivation of TB, Demyelination, CHF, Malignancy
Cyclophosphamide	Vasculitis, scleroderma, ILD	Alkylating agent	Immunosuppression, Hemorrhagic cystitis, Cancer (esp skin, bladder)

Vasculitis				
Vasculitides by Vessel Size				
	Age	**Symptoms/Signs**	**Biopsy/Labs**	**Treatment**
Large Vessel				
Temporal (Giant Cell) Arteritis	• Only age > 40 yo • Carotid arteries	• Unilat. Headache • Jaw claudication • Polymyalgia rheumatica	• Elevated ESR • Granulomatous • inflammation	• High-dose steroids • anti-IL6 biologics
Takayasu's arteritis	• Asian Females • Aortic arch	• Pulseless Disease" • Fever, night sweat, arthritis, weight loss, fatigue	Elevated ESR	Steroids
Medium Vessel				
Polyarteritis nodosa	• Young adults • Immune complex	• Constitutional symptoms • Renal failure, acute MI, bloody diarrhea, peripheral neuropathy.	Transmural fibrinoid necrosis	• Steroids • anti-TNF biologics • Anti-metabolites

Vasculitis

Vasculitides by Vessel Size

	Age	Symptoms/Signs	Biopsy/Labs	Treatment
Medium Vessel				
Kawasaki Disease	Children (higher in Asian pop.)	• **CRASH**: Conjunctivitis, Rash, Adenitis, Strawberry tongue, Hand/foot swelling • Coronary artery aneurysms.	• Complete: clinical • Incomplete: clinical + labs (see below) • Cardiac echo	• IVIG • Aspirin • Steroids
Buerger's Disease (Thromboangiitis obliterans)	Heavy smokers	• Claudication • Gangrene • Autoamputation of digits	Segmental thrombosing vasculitis	Smoking cessation
Small Vessel				
Microscopic polyangitis	• Penicillin use • Strep infections • SLE	• Glomerulonephritis • Palpable purpura • Skin, lung, brain, GI, kidney	• p-ANCA • No granulomas	• Steroids • Cyclophos • Rituximab
Granulomatosis w/ Polyangitis (Wegener's)	• Necrotizing vasculitis • Affects lung/kidney	• Hemoptysis • Hematuria, RBC casts • Chronic sinusitis, ear infections, mastoiditis	• c-ANCA • Necrotizing granulomas in lung/ airway • Necrotizing glomerulonephritis	• MTX • Steroids • RTX/CYC +PD steroids • Pheresis (severe)
Eosinophilic granulomatosis w/ polyangiitis (Churg-Strauss)	Affects heart, GI, and kidneys	• Palpable purpura • Asthma • Sinusitis • Periph. Neuropathy	• p-ANCA • Eosinophilia • No granulomas	• HD pred • Cyclophos • Mepolizumab
Henoch-Schonliein Purpura (HSP)	• Most common vasculitis in children • IgA mediated	• Palpable purpura • Arthritis/arthralgias • Abdominal pain • Melena • Renal disease (IgA nephro)	• Urinalysis • Renal/skin biopsy • Abd U/S: intussusception	• Supportive • NSAIDs • Hydration • Steroids • (abd. pain)

Henoch-Schonlein Purpura

Etiology	• No clear etiology • Frequently preceded by upper respiratory infections (esp streptococcus, staphylococcus, and parainfluenza) or immunizations
Pathophysiology	• Deposition of IgA-containing immune complexes in vessel walls of affected organs and in kidney mesangium activates alternative complement pathway (w/ deposition of C3) • HSP nephritis and IgA nephropathy are histologically identical

Vasculitides continued on next page →

Henoch-Schonlein Purpura

Clinical Manifestations	• Palpable purpura: symmetrically over dependent areas (elbows, feet, buttocks)
	  ▪ Present in all cases, but may not be presenting symptom
	• Arthralgias/arthritis: oligoarticular, large lower extremity joints (knees, hips, ankles)
	  ▪ Occurs in ¾ of cases
	• Abdominal pain: diffuse pain, worse after meals, often w/ nausea or vomiting
	  ▪ Occurs in 2/3 of cases
	  ▪ 3-4% of HSP patients develop intussusception
	• Renal disease: hematuria is most common, but proteinuria/hypertension may be seen
	  ▪ Occurs is 20-50% of cases
	  ▪ Usually delayed 1-2 weeks after onset
	  ▪ <15% children have long-term kidney damage, <1% develop renal failure

Diagnosis	• Palpable purpura (w/o thrombocytopenia or coagulopathy), and ≥1 of the following:
	  ▪ Abdominal pain
	  ▪ Arthritis/arthralgias
	  ▪ Biopsy w/ leukocytoclastic vasculitis (skin) or glomerulonephritis w/ IgA deposition (renal)
	• Urinalysis: helps determine the presence of renal involvement
	• CBC: platelets should be normal/elevated (versus alternative etiologies of petechiae/purpura)
	• IgA level is NOT helpful in determining diagnosis
	• Imaging: Abdominal ultrasound: if concerned for intussusception

Treatment	• HSP is self-limited • Main-stay of treatment is supportive care (hydration, pain control) • NSAIDs are recommended for joint symptoms • Corticosteroids for severe or persistent abdominal pain or purpura • Reduces symptoms, not disease duration so must taper steroids slowly • Minimum course 4-6 weeks • Severe renal involvement associated w/ combination of hematuria and proteinuria • Biopsy-proven crescentic glomerulonephritis on biopsy necessitates immunosuppression • Steroids, cyclophosphamide, azathioprine, rituximab • Follow-up as outpatient w/ screening for urinary abnormalities and elevated blood pressure (to evaluate for progressive renal involvement)

Kawasaki Disease

Epidemiology	• Acute, self-limited systemic vasculitis of medium-sized arteries in infants/children • Average age of onset ~ 2 years w/ 80% occurring in those < 4 years old • Incidence in US: 17-18/100,000, M:F = 1.6:1 • Incidence doubled for Asian Americans, highest incidence in Japan • Increased rates in winter & spring
Pathophysiology	• May be related to infectious triggers • Vasculitis begins as a neutrophilic infiltrate; plasma cells producing IgA in vessel walls
Clinical Manifestations	Classical criteria = fever ≥ 5 days w/ ≥ 4/5 classical criteria, w/o alternative diagnosis

Conjunctivitis	Bilateral bulbar conjunctival injection (non-exudative & limb sparing)
Rash	Polymorphous rash
Adenopathy	Cervical lymphadenopathy (≥1 lymph node, > 1.5 cm in diameter).
Serositis	Injected/fissured lips, injected pharynx, or strawberry tongue.
Hand/Feet	Erythema of palms/soles, edema of hands/feet (acute), periungual desquamation (convalescent)

Kawasaki Disease

Complete KD	Fever ≥ 5 days and ≥ 4 principal clinical features OR fever ≥ 4 days and 5 clinical features	
Incomplete KD	• Fever ≥ 4 days plus ≥ 2 cardinal features, elevated ESR/CRP, ≥ 3 supplemental labs • Supplemental labs: Anemia for age / ALT > 50 units/L Platelet count ≥ 450,000 after 7th day of fever / WBC > 15,000/mm^3 UA w/ > 10 WBC per hpf (sterile pyuria) / Albumin < 3.0 g/dL • Must have abnormal echo to make the diagnosis	
Other Clinical Findings	**Neuro**	Irritability, hearing loss, facial nerve palsy
	Cardiac	Coronary artery aneurysms, depressed myocardial function, pericardial effusion, prolonged PR interval ▪ Risk factors for CA aneurysms include: male, <1 y/o, prolonged fever, elevated CRP, low platelets, low albumin levels on diagnosis
	GI	Pain, vomiting/diarrhea, hepatitis, acute acalculous distention of the gallbladder
	MSK	Arthritis, arthralgias (pleocytosis of synovial fluid)
	GU	Urethritis/meatitis, hydrocele
Diagnostic Studies	Echocardiogram w/i 24 hours (abnormal echo= coronary artery Z score ≥ 2.5)	
Treatments	• IVIG (2g/kg) infused over 12 hours→ repeat, if febrile, 36 hours after first infusion. ▪ Aspirin: high dose (30-50 mg/kg/d divided QID) until afebrile x 48 hours ▪ Then low dose (3-5 mg/kg/d). (consider starting w/ low dose for age ≤ 6 mo) • Corticosteroids: trials indicate that steroids may be effective as primary/rescue therapy. • Repeat echo post-treatment, either before or after discharge, to observe improvement • Patients w/ severe CA dilation may need long-term anticoagulation therapy • Under study: infliximab, cyclosporine, other immunomodulatory agents	

Polyarteritis Nodosa

Epidemiology	• Vasculitis w/ aneurysms affecting small and medium muscular arteries, w/ transmural inflammation, sparing veins • Can have systemic or cutaneous forms • Rarely caused by loss-of-function mutation in adenosine deaminase 2
Symptoms	• Systemic: fever, weight loss, fatigue • Multisystem involvement (see diagnostic criteria)
Diagnosis/ Clinical symptoms of Cutaneous PAN (not formalized)	• Subcutaneous nodular, painful, non-purpuric lesions, +/- livedo reticularis, w/o systemic involvement (but can have elevated acute phase reactants, myalgia, arthralgia, non-erosive arthritis) • Tissue biopsy with necrotizing non-granulomatous vasculitis • Labs: Negative ANCA; may see + ASO (up to ⅓ of cases are triggered by a strep infection)

Vasculitides continued on next page →

Polyarteritis Nodosa	
Diagnosis/ Clinical symptoms of Systemic PAN	• EULAR/PRINTO/PRES Criteria: biopsy for histopathology/immunofluorescence (necrotizing vasculitis) OR angiography (aneurysms, stenosis, occlusions), AND ≥ 1 of: ▪ Skin: livedo reticularis, tender subcutaneous nodules, superficial/deep skin infarctions ▪ Rheum: Myalgia or muscle tenderness ▪ Cardio: HTN ▪ Neuro: Peripheral neuropathy, sensory or motor mononeuritis multiplex ▪ Renal: proteinuria, hematuria, RBC casts, GFR <50% normal for age • Labs: ANCA negative
Differential Diagnosis	• Systemic inflammatory dz (SLE, RA, systemic sclerosis) • Infection (bacterial, endocarditis, chronic viral hepatitis) • Embolic or thrombotic dz, drug-induced vasculitis
Possible Complications	• Acute: organ failure (cardiac, pulmonary, renal), thrombi, hemorrhage, infection • Chronic: HTN, ischemic cardiomyopathy, CKD, mesenteric arteritis, hearing loss, orchitis
Laboratory Studies	• Cr, CK, LFTs, von Willebrand factor antigen (marker of vessel inflammation /damage, HBV and HCV serologies, HIV, UA, ESR, CRP, BCx • Rheumatologic workup may include ANCA, ANA, C3/4, cryoglobulins
Treatment	• Mild (normal renal function, no significant/life-threatening complications): ▪ Steroids, may add Azathioprine or MTX • Moderate to severe (ex: kidney involvement, proteinuria, neuro/cardiac/GI complications): ▪ Steroids plus Cyclophosphamide, with eventual switch from Cyclophosphamide to Azathioprine or MTX ▪ TNF inhibitors useful as well, especially in cutaneous PAN and DADA2 • Pheresis considered in organ threatening disease • HTN: ACE Inhibitor

Connective Tissue Disorders		
SLE		
Clinical	Rash (malar, discoid), photosensitivity, serositis, nephritis, oral/nasal ulcers, seizure, psychosis, arthritis	
Lab markers	• Cytopenias (+) anti-RNP (30%) • +anti-dsDNA (40-60%, assoc w SLE activity and lupus nephritis) • +anti-Smith (30%, w/ high specificity, remains + in remission) • +anti-SS-A (Ro, 40%) • +anti-SS-B (La, 10-15%, more specific than Ro)	
Polymyositis		
Clinical	Proximal muscle weakness +/- tenderness	
Lab markers	• CK • Aldolase • LDH	• AST and ALT (rarely nl unless "burnt out") • +anti-JO (20%, a/w ILD, mechanic hands) • +anti-mi2 (5-7%, a/w acute onset, shawl sign, good prognosis)
Dermatomyositis		
Clinical	• Proximal muscle weakness +/- tenderness • Rash (heliotrope on upper eyelids Shawl sign on back • V-sign on chest) • Gottron's papules or scaly eruption over extensor surfaces such as knuckles (pathognomonic)	

Connective Tissue Disorders		
Dermatomyositis		
Other	• In adults ~ 25% a/w malignancy; rarely associated in children • ILD in 10%, upper esophageal involvement (dysphagia) in 25%; may cause life-threatening aspiration	
Lab markers	• +anti-JO (20%, a/w ILD, mechanic hands) • +anti-mi2 (5-7%, a/w acute onset, shawl sign, good prognosis)	
Sjogren's		
Clinical	• Sicca sx (dry mouth/eyes) • Vasculitis	• Interstitial nephritis • Neuropathy; 5% lifetime risk of NHL
Lab markers	• (+) ANA • +anti-SS-A (Ro, 70%)	• +anti-SS-B (La, 50-70%, more specific) • +RF
Scleroderma		
Clinical	• Skin tightening & thickening prox to forearms • Nail fold capillary dilatation & dropout • ILD & later stages PAH	• GI dysmotility • Renal crisis (tx w/ ACE-I)
Lab markers	• +anti-Scl 70 (30%) • +anti-centromere (15%)	
CREST		
Clinical	• Calcinosis • Raynaud's phenomenon • Esophageal dysmotility	• Sclerodactyly • Telangiectasias
Lab markers	• PAH +anti-centromere (60%) • +anti-Scl 70 (15%)	
Behcet Disease		
Epidemiology	• Young adults • Turkish, Middle Eastern, or Asian descent	
Clinical	• Recurrent/painful oral apthous ulcers • Genital ulcers • Eye lesions (esp uveitis)	• Skin lesions (ex: erythema nodosum, acneiform lesions) • Thromboses
Skin Testing	Pathergy (exaggerated skin ulceration w/ minor trauma – ex: needlestick)	
Mixed Connective Tissue Disease		
Clinical	• Overlapping features of SLE • Polymyositis • Systemic sclerosis • Raynaud phenomenon • Swollen fingers	• Arthritis • Inflam myopathy • Pleuritic • Pulm fibrosis, etc.
Lab Markers	Anti-U1-RNP (Ribonucleoprotein) Antibodies	
Treatment	• NSAIDs • Corticosteroids	• ACE-I • Supportive measures

Connective Tissue Disorders continued on next page →

Immunologic Markers by Disease	
SLE	ANA (95%), Anti-dsDNA (60%), Anti-Smith, False-positive RPR/VDRL, Anti-Histone (drug-induced)
RA	RF (75%), ACPA, ANA (<50%), HLA-DR4
Poly/Dermatomyositis	ANA, Anti-Jo-1
Scleroderma, CREST syndrome	Anti-scl-70 (anti-topoisomerase), ANA, Anticentromere (CREST)
Mixed Connective Tissue Disease	Anti-RNP (ribonucleoprotein)
Sjogren Syndrome	Anti-Ro (anti-SSA) ANA, Anti-La (anti-SSB) ANA

Systemic Lupus Erythematosus	
Definition	Multiorgan system autoimmune disorder with markedly variable presentations/course
Epidemiology	• F>M • Most often after age 8 yo • Median age of onset for juvenile SLE 12-13 yo • More common in people of Asian, African, and Hispanic race/ethnicity vs Caucasian
Other presenting symptoms	• Fever • Weight loss • Anorexia • Raynaud's • LAD • HSM • HTN
Neonatal Lupus Erythematosus (NLE):	• 1-2% of Infants born to mothers w/ anti-Ro and/or anti-La antibodies (transplacental) • Auto-Ab interfere w/ development of cardiac conduction system → permanent AV block • Flat/erythematous, annular, photosensitive rash that spontaneously resolves ~6 mo of age (as maternal Abs dissipate) • No increased risk of autoimmune diseases later in life

SLICC Criteria (not validated in children/adolescents)	
4+ criteria, including 1+ clinical and 1+ immunologic (serial or simultaneously), w/o alternative explanation OR SLE nephritis with +ANA/+dsDNA	
Acute cutaneous lupus	Malar rash, bullous, TEN variant, photosensitive rash
Chronic cutaneous lupus	Discoid, hypertrophic/verrucous, panniculitis, mucosal, chilblains, erythem. timidus
Non-scarring alopecia	Diffuse thinning or hair fragility with visible broken hairs
Oral/Nasal Ulcers	Palate, buccal, tongue, or nasal
Joint Disease	Synovitis in 2+ joints (swelling/effusion) OR 2+ joint tenderness+ ≥30m AM stiffness
Serositis	Pleurisy or pericardial pain ≥1d, pleural or pericardial effusion, pleural or pericardial rub, pericarditis on TTE
Renal	≥ 500 mg protein/day or RBC casts
Neuro	Seizures, psychosis, mononeuritis multiplex, myelitis, peripheral/cranial neuropathy,
Hemolytic anemia	Autoimmune (direct Coombs+), thrombotic MAHA (TTP, HUS)

Systemic Lupus Erythematosus

SLICC Criteria continued	
Leuko/lymphopenia	Leukopenia <4000/mm^3, lymphopenia <1000/mm^3
Thrombocytopenia	<100,000/mm^3, including ITP, TTP
Immuno	ANA (+) , Anti-dsDNA (+) or >twofold reference range on ELISA
Low complement	Low C3, C4, or CH50
Direct Coombs test	Positive in absence of hemolytic anemia
Antiphospholipid	Lupus anticoagulant, RPR (false positive), anticardiolipin Ab, or beta 2-glycoprotein I

Treatment

Initial	Hydroxychloroquine (≤ max 5 mh/kg/d, need regular ophtho evals for visual field testing and color
Mild	No renal/organ involvement→hydroxychloroquine, NSAIDS - arthralgia, Dapsone - derm, MT - arthritis. Can use LD prednisone (<0.35 mg/kg/d), but if needs >3 mo consider second-line agent (ex: MMF)
Mod	Renal/organ involvement → consider MMF, azathioprine, rituximab, systemic steroids
Severe	Substantial renal/neuro disease → cyclophosphamide
Flares	Steroids + MMF, or cyclophosphamide if already on MMF/azathioprine

Inflammatory Myopathies

	Polymyositis	Dermatomyositis	Inclusion Body Myositis
Path	CD8+ T cells	CD4+ T Cells	Inflam/neurodegen
Clinical	Symmetric proximal muscle weakness (shoulders)	• Symmetric proximal muscle weakness • Gottron papules, heliotrope (periorbital) rash,"shawl+face 'rash,"mechanics hands"	Distal >> Proximal muscle weakness
Labs	Increased CK, ANA (+)		
	Anti-MI-2/MJ	Anti-Jo-1 (Anti-tRNA-synthetase)	Anti-cN1A
	Bx: Endomysial inflam	• Bx: Perimysial inflam/atrophy (myopathic) • Von Willebrand Factor Ag	• Basophilic rimmed vacuoles • Regged-red fibers
Assoc.	Autoimmune (Crohn's, Vasculitis, Sarcoidosis, MG)	• Lipodystrophy, Calcinosis, ILD, GI bleed • Juvenile DM *NOT* assoc. w/ malignancy like adults	
Treatment	Steroids (prednisone) followed by long-term immunosuppression (MTX, cyclosporine)		Not steroid responsive

Connective Tissue Disorders continued on next page →

Sjogren Syndrome	
Path	Inflammatory autoimmune disorder of exocrine glands (salivary/lacrimal glands)
Exocrine Features	• Keratoconjunctivis sicca → dry mouth, salivary hypertrophy, Xerosis of skin • Xerophthalmia (dry eyes, conjunctivitis, sensation of sand in eyes) • Xerostomia (dry mouth, dysphagia, enlarged parotid glands, dental caries)
Extraglandular Features	Arthritis/arthralgias, Raynaud phenomenon, Cutaneous vasculitis, ILD
Lab tests	• Anti-SSA (Anti-Ro) Abs and Anti-SSB (Anti-La) Abs • Schirmer Test – objective signs of decreased lacrimation • Salivary gland biopsy w/ focal lymphocytic sialoadenitis
Treatment	
Dry eyes	Artificial tears, cyclosporine drops
Dry mouth	Muscarinic agonists – pilocarpine, cevimeline
Arthritis	Hydroxychloroquine or methotrexate

Polymyalgia Rheumatic (PMR)	
Clinical	• Age >50, bilateral pain + morning stiffness > 1 mo • 2 of the following: ▪ neck/torso ▪ shoulder/proximal arms ▪ prox thigh/hip ▪ constitutional sxs (fever, malaise, wt loss) • PE: decreased active ROM in the shoulders, neck, and hips
Assoc	Giant Cell Arteritis (temporal arteritis) - HA, jaw claudication, vision loss, tender over temporal artery
Diagnosis	ESR > 40 mm/h (sometimes >100 mm/h), CRP, normocytic anemia possible
Treatment	Glucocorticoids (Prednisone 10-20 mg daily) → 2-4 wks →gradual taper

Approach to Joint Disease	
Inflammatory vs. Non-inflammatory	**Inflammatory** - swollen, erythematous, tender joint, worse w/ prolonged inactivity ("jelling"), morning stiffness, improves w/ NSAIDs/steroids and movement
	Non-inflammatory - trauma/degeneration → pain w/ motion, improvement w/ rest, brief morning stiffness, bony deformity possible, mildly swollen, can have effusion
Distribution	Monoarticular, oligoarticular (≥2), polyarticular (>4)
Joint Involvement	• Peripheral vs. axial • Large vs. small • Symmetric vs. asymmetric
Timing	Acute vs. chronic (>2 mo), episodic vs. constant, migratory vs. localized
Precipitation	Infection (GI/GU), use, meds/diet, trauma, unprotected sex, IV drugs, family history

Juvenile Arthritides							
Subtype	**Age**	**F: M**	**% JIA**	**Pattern**	**Extra-articular**	**Labs**	**Treatment**
Systemic	1-5	1:1	5-15	Polyarticular (U/L ext, neck, hips)	Fever, rash, pericarditis/ pleuritis	Anemia, WBC, ESR/CRP, Plts/ferr	MTX/anti-TNF C/s IL1/6 inhib
Oligo	2-4	3:1	40-50	Knee, ankle, finger	Uveitis (30%)	ANA(+), +/- ESR/ CRP	NSAIDs, intra-articular steroids, MTX
Poly RF(-)	2-4, 10-14	3:1 10:1	20-35	Sym/Asym small/large joints	Uveitis (10%)	ANA(+) ,RF(-), ESR/CRP, anemia	MTX/NSAIDs Anti-TNF
Poly RF(+)	9-12	9:1	<10	Sym polyarthritis	Rheumatoid nodules, fever	RF(+), ESR/CRP, mild anemia	Early and aggressive
Psoriatic	2-4, 9-11	2:1	5-10	Asym. small/ med joints	Uveitis (10%), Psoriasis (50%)	ANA(+), ESR/ CRP, mild anemia	NSAID/steroids MTX, anti-TNF
Enthesitis	9-12	1:7	5-10	Lower limb, axial	Acute ant. Uveitis, reactive arth, IBD	HLA-B27 (80%)	NSAID/steroids Sulfasal,anti-TNF

Seronegative Spondylarthritides	
Psoriatic	
Clinical	10-20% of patients w/ psoriasis, arthritis precedes skin disease in 15% of patients, dactylitis, anterior uveitis, enthesitis, nail pitting, onycholysis
Arthritis Patterns	Asym/inflam arthritis of DIP joints, symm arthritis indistinguishable from RA, Severe/mutilating arthritis "arthritis mutilans," or spondyloarthritis
Lab Testing	+ HLA-B27, RF/ANA negative (i.e. "seronegative"), XR – "pencil in cup"
Treatment	NSAIDs, celecoxib, MTX, leflunomide, or TNF-α inhibitors
Ankylosing spondylitis	
Path	Chronic inflammatory disease of the spine/pelvis → eventual bone fusion
Risks	Men > women, insidious onset at age <40, whites > blacks/latinos
Clinical	Low back pain worse w/ inactivity and improves w/ exercise, + nocturnal pain sacroiliitis, dec spine mobility (Abnormal Schober Test), chest expansion/spine mobility, Hip/ shoulder pain, Enthesitis, Dactylitis, Anterior uveitis, limited chest expansion and spinal mobility → restrictive patten (VC/TLC but normal FEV1/FVC)
Complications	Cardiovascular (aortic regurgitation, conduction disturbances), Osteoporosis/vertebral fractures (osteoclast activity from chronic inflam), Cauda equina
Diagnosis	+ HLA-B27, RF/ANA negative (i.e. "seronegative"), XR Pelvis – sacroillitis/SI joint fusion, XR L-spine – vertebral fusion ("bamboo spine").
Treatment	PT/exercise, NSAIDs or celecoxib (scheduled continuously), TNF-α inhibitors

Joint Disease continued on next page →

Seronegative Spondylarthritides

Reactive arthritis

Clinical	Triad: conjunctivitis, urethritis, arthritis (can't see, pee, climb a tree), mucocutaneous lesions and enthesitis (achilles tendon pain) are common as well
Lab Testing	HLA-B27 +, Synovial fluid analysis is usually sterile
Treatment	NSAIDs are 1st-line

Juvenile Idiopathic Arthritis

Definition	Chronic, inflammatory arthritis, of unknown etiology in children.
Epidemiology	• Children <16 y/o, w/ arthritis (swelling/effusion) in ≥1 joints for >6 weeks • Classified based on the number of joints involved in the first 6 months of presentation • Oligoarthritis (1-4 joints), Polyarthritis (5 or more joints)
Differential	Must exclude SLE, infectious arthritis, IBD, hematologic process or malignancy
Clinical	• Symptoms worse in the morning or after long periods of sitting/rest and improves w/ movement (gelling phenomenon). • Systemic onset JIA:fevers (daily, high spiking fevers w/ normal temperatures the rest of the day – Quotidian fever). Arthritis may or may not be present at disease onset, making diagnosis difficult. MAS may be present at diagnosis or later in disease course.

Characterization

	Systemic JIA	Oligoarticular JIA	Polyarticular JIA
% of JIA	10-15%	50%	30-40%
Sex	F = M	F>M	F>M
Age	<17 yo	Peaks 2-3, rare >10	Bimodal peak: 2-5, 10-14
Fever, Rash, HSM, LAD	Yes	No	No
Uveitis	Rare	20% (assoc. ANA+)	Less frequent
Labs: **- Leukocytosis** **- Anemia** **- Inc. ESR** **- + ANA** **- + RF** **- Inc. Ferritin**	 Marked Marked Marked X Rare Marked	 X X Mild Low titer X X	 X Mild Mild Low titer 10-20% Mild
Destructive arthritis	>50%	Rare	>50%
Responsive to: **- MTX** **- TNF inhib** **- IL-1/6 inhib**	 Poor-Moderate Poor Excellent	 Excellent Excellent Poor	 Excellent Excellent Poor

Juvenile Idiopathic Arthritis

Diagnostic Studies	JIA is diagnosis of exclusion; need to rule out infection, leukemia, & other systemic diseases or malignancies.	
Treatment	• Patients require regular screening eye exams, especially in pts w/ pauciarticular JRA • Biologic agents may be required ▪ TNF-alpha inhibitors (Etanercept, Infliximab, Adalimumab) ▪ Anakinra (IL-1 receptor antagonist, appropriate in Systemic Onset JIA only) ▪ Abatacept (inhibits T cell activation) ▪ Rituximab (antibody against B cell marker CD20) • Varies based on subtype of JIA	
	Oligoarticular	Treated w/ intra-articular steroid injections and/or MTX
	Polyarticular & Systemic onset JIA	Usually require systemic immunosuppressive therapy ▪ Steroids, methotrexate, sulfasalazine, leflunomide, biologic response modifiers (targeting TNF, IL-1 or IL6)

Septic Arthritis

Pathology	Joint infection (typically bacterial) → Staph. aureus, N. gonorrhoeae (unprotected intercourse)
Risks	Underlying joint disorders (ex: RA, gout, pseudogout, osteoarthritis) increase risk for 2° joint infection, Prosthetic joints, Skin infection, IV Drug use, Alcoholism, DM, Recent joint surgery
Clinical	• Monoarticular arthritis → pain/tenderness, redness, warmth, restricted ROM • > 50% occur in the knee, but may affect wrist, hips, or ankles • Gonococcal: young/sexually active, asymmetric/migrating polyarthritis (knees, wrists, and ankles) + pustules/papules on hands/feet
Diagnosis	Fever, ESR/CRP, synovial fluid analysis (cell count, Gram stain, cx)

Joint Aspirate Analysis

	Normal	OA	RA	Septic Joint
Appearance	Clear	Clear	Translucent/opaque	Opaque
WBC count	<200	200-2,000	2,000-100,000	50,000-150,000
PMNs	<25%	25%	Often >50%	>80-90%

Treatment	Surgical drainage/irrigation of the joint +/- antibiotics

Macrophage Activation Syndrome (MAS)

Definition and Pathology	• Multisystem inflammatory process (cytokine storm), which can be a complication of JIA, SLE, KD as well as viral illnesses such as EBV • Similar pathophysiology to Hemophagocytic Lymphohistiocytosis (HLH) • May be triggered by viral infections/meds leading to dysregulation of immune system w/ insufficient cytotoxic T & NK cell response and eventually to cytokine storm & over-activation of macrophages
Clinical	• High fevers • HSM • Pancytopenia • Lymphadenopathy • DIC

Joint Disease continued on next page →

Macrophage Activation Syndrome (MAS)	
Labs	• Very high ferritin levels • High LDH • Normal CRP • Elevated TGs and high AST/ALT
Natural History	High mortality rate (~25%) if not treated quickly
Treatment	• High dose steroids • IVIG • Cyclosporine • Anakinra

Autoinflammatory Diseases & Periodic Fever Syndromes	
Presentation	• ≥3 recurrent episodes of unexplained fever in a 6 month period, w/ each episode occurring at least 7 days apart (some autoimmune disorders do not present w/ fever; see below) • Recurrent episodes of inflammation (rash, serositis, arthritis, meningitis, uveitis) • LAD + splenomegaly • Elevated ESR/CRP • NO high-titer autoantibodies
Pathology	• Aberrant antigen dependent activation of the innate immune system (vs. adaptive immune dysfunction in autoimmune dz) • Equally common in M and F
Most Commonly Described Periodic Fevers	• Familial Mediterranean Fever (FMF) • TNF Receptor-associated Periodic Syndrome (Hibernian Fever) • Hyper IgD Syndrome (HIDS) • Periodic Fever, Aphthous stomatitis, Pharyngitis, cervical Adenitis (PFAPA) • Cryopyrin-Associated Periodic Syndromes (CAPS) include: ▪ Familial Cold Autoinflammatory Syndrome (FCAS) ▪ Muckle-Wells Syndrome (MWS) ▪ Chronic Infantile Neurologic Cutaneous & Articular syndrome or Neonatal Onset Multisystem Inflammatory Disorder (CINA/NOMID)

Periodic Fever Syndromes

	FMF	TRAPS	HIDS	MWS	CINCA/NOMID	PFAPA
Inheritance	AR	AD	AR	AD	AD/sporadic	Sporadic
Protein Defect	Pyrin	TNF receptor	Mevalonate kinase	Cryopyrin	Cryopyrin	Unknown
Ethnicity	Jewish, Turkish, Italian, Arab	Any	Dutch, French	Northern European	Any	Any
Duration	1-3 days	>7-14 days	3-7 days	2-3 days	Continuous w/ flairs	3-4 days
Interval Between Events	Variable	Variable (days- wks)	Fixed (4-8 wks)	Variable URI trigger	N/A	Fixed (2-8 wks)
Age of Onset	School age	School age	Infancy	School age	School age	Early adulthood

Autoinflammatory Diseases & Periodic Fever Syndromes

Periodic Fever Syndromes

	FMF	TRAPS	HIDS	MWS	CINCA/ NOMID	PFAPA
Clinical	Serositis-, Peritonitis -, Erysipelas-like lesions	Conjunctivitis Painful skin lesions Migratory myalgias	Cerebellar atrophy Painful cervical LAD	Sensorineural hearing loss Conjunctivitis	Saddle nose Rec. aseptic meningitis Mental retardation	Multiple fever spikes per a day
Notes	Most common inherited PFS	Increased risk of vasculitis (HSP)	May last through adulthood	Occasionally assoc. W/ Amyloidosis	Improved w/ IL-1 antagonist	Possibly cured w/ tonsillectomy
Treatment	Colchicine	Steroids Etanercept	Colchicine Steroids	IL-1 Antag	IL-1 Antag	Tonsillectomy

Autoinflammatory Disorders W/O Fever	• Deficiency of the interleukin-1 receptor antagonist (DIRA) • Pyogenic arthritis, pyoderma gangrenosum, and acne (PAPA) • Juvenile systemic granulomatosis (Blau Syndrome) • Chronic atypical neutrophilic dermatitis w/ lipodystrophy and elevated temperature (CANDLE) • Chronic recurrent multifocal osteomyelitis (CRMO) • Stimulator of interferon genes (STING)-associated vasculopathy w/ onset in infancy (SAVI) • Congenital sideroblastic anemia w/ immunodeficiency, fevers, and developmental delay (SFID)
Differential	Must also consider recurrent infections, malignancies, cyclic neutropenia and systemic onset JRA when evaluating a patient w/ recurrent fevers
Diagnosis	Careful H&P (r/o malignancy, infection, cyclic neutropenia, systemic onset JRA) → may confirm w/targeted genetic testing

Toxicology

Key Resources

- **Poison Control: 1-800-222-1222**
- BCH Toxicology Fellow/Attending (on call 24/7)
- BCH Chemistry Fellow (daytime hours, can help interpret labs and select specialized testing)
- Hazmat Team: Boston Fire Department
- MSDS: Material Safety Data Sheets
- www.maripoisoncenter.com
- www.aapcc.org

Approach to Poisoned Patient

Stabilization	Airway, Breathing, Circulation, Disability, Drugs/D-Stick, Decontamination
Physical Exam	• Vital signs • **Neuro**: MS, tone, clonus, abnormal movements • **Eyes**: pupils, EOM. • **Mouth**: corrosive lesions, odors • **CV**: rate, rhythm, perfusion • **Resp**: rate, depth of respirations, air entry, wheeze • **GI**: motility (?bowel sounds), corrosive effects (i.e. vomiting) • **Skin**: color, bullae, burn, sweat, track marks
History	• **AMPLE**: **A**llergies, **M**eds/Toxins (everyone in home), **P**ast medical history, **L**ast meal, **E**vents • **Known toxin**: amount, time since ingestion, early sx, home tx, • **Concern for poisoning**: h/o pics or ingestions, meds in home, recent illnesses, visitors/events
Basic Labs	Consider ABC, co-oximetry, CBC, D-stick, EKG, Chem 10, LFTs, Serum osmolarity, UA, tox screens (urine/serum)
Tox Screens	• Substances included, limits of detection vary hospital to hospital • Urine drug screens rarely inform acute management decisions • **Urine tox screens**: detect amphetamines, barbiturates, benzos, cocaine, opioids, +/- THC ▪ Qualitative (+/-) ▪ Does not detect ecstasy; false + and false - (esp benzos, synthetic opioids) common ▪ ADHD drugs: adderall → positive amphetamine • Urine THC - must order separately at BMC • **Expanded opioid panel, urine (BMC)**: detects buprenorphine, oxycodone, methadone, fentanyl • **Extended tox screen**: GC/MS, urine better than serum, send out test • **Meconium tox**: amphetamines, THC, cocaine, opiates, PCP • **Serum tox**: acetaminophen, ASA, EtOH, TCAs (qualitative – level reported except TCA's) • **Specific drug levels**: can request for agents not on tox screens (digoxin, lithium, AEDs, iron, etc.)
Management	• Can I decontaminate? • Can I enhance the elimination of the toxin? (www.extrip-workgroup.org) • Is there an antidote? • How can I provide the best, targeted supportive care?

Toxidromes

	HR & BP	Resp.	Temperature	Pupils	Bowel Sounds	Diaphoresis
Anticholinergic **Anticholinergics** –Atropine, scopolamine, glycopyrrolate benztropine, trihexyphenidyl **Antihistamines** – Chlorpheniramine, Cyproheptadine, Doxylamine, Hydroxyzine, Dimenhydrinate, Diphenhydramine, Meclizine Promethazine	↑	No change	↑	Dilated	↓	↓
Cholinergic Organic Phosphorous Compounds: Carbamates • Arecholine, Pilocarpine, Urecholine (Betanechol), Carbachol, Choline, Metacholine, Mushrooms	No change	No change	No change	Pinpoint	↑	↑
Opioid Morphine • Codeine • Tramadol • Heroin • Meperidine • Diphenoxylate • Hydromorphone • Fentanyl • Methadone • Propoxyphene • Pentazocine • DXM • Oxycodone • Hydrocodone	↓	↓	↓	Pinpoint	↓	↓
Sympathomimetic Caffeine, cocaine, amphetamines, methamphetamines, Ritalin, LSD, Theophylline, MDMA	↑	↑	↑	Dilated	↑	↑
Sedative-Hypnotic anti-anxiety agents, muscle relaxants, antiepileptics and preanesthetic medications –Barbituates –Benzodiazepines	↓	↓	↓	No change	↓	↓

Source: www.60secondem.com

Acetaminophen Overdose

Toxic Dose	200 mg/kg (7.5-10 g in older pts) as a single acute overdose
Pathophysiology	Saturation of glucuronidation/sulfate conjugation pathway → ↑ metabolism via P450 pathway and depletion of glutathione → build up of toxic NAPQI → hepatotoxicity +/- renal toxicity
Symptoms	See chart below
Evaluation	Acetaminophen levels (at ≥ 4 hours post-ingestion, LFTs, coags, electrolytes, BUN/Cr, UA w/ tox screen (serum and urine), urine pregnancy for females)
Management	• Activated charcoal if w/i 1-2 hrs of ingestion and no contraindications (unprotected airway and decreased LOC) • Goal: Initiate NAC ≤ 8 hours of ingestion (or ASAP if >8 hours post-ingestion) • APAP level → apply NOMOGRAM → estimate risk of hepatotoxicity • ***KEY POINT: NOMOGRAM can only be used for: single acute ingestion, known time of ingestion, ingestion w/i 24hrs of presentation. Also, caution if co-ingestants that may affect GI motility*** ▪ Risk of hepatotoxicity → give N-acetyl cysteine ▪ IV: loading dose of 150mg/kg over 1 hour, then 50 mg/kg over 4 hours, then 100 mg/kg over 16 hours; check APAP levels, LFTs, coags 2 hours before 16h infusion is scheduled to end ▪ PO/NG: Loading dose 140mg/kg, then 70mg/kg 14hrs x24 hours ▪ Guidelines for stopping NAC: clinically well, improving LFTs, normalizing coags, APAP level<10 (if patient does not meet guidelines, continue NAC (100mg/kg IV over 16 hours) until they meet criteria.)
Rule of 150	• Potentially toxic dose: 150mg/kg • Treatment line: 150mcg/mL at 4 hours • Loading dose of NAC 150mg/kg over one hour

Acute APAP Toxicity: 4 stages

	Symptoms	Labs
Stage 1: 0-24 hours	N/V, diaphoresis, malaise **May be asymptomatic**	Labs, PE generally normal
Stage 2: 24-72 hours	Initial symptoms resolve RUQ pain, liver enlargement/tenderness	↑ AST/ALT, ↑ PT/INR, renal dysfunction, ↑ amylase
Stage 3: 72-96 hours	N/V, diaphoresis return ▪ Jaundice, hepatic encephalopathy, hyperammonemia, bleeding, hypoglycemia, lactic acidosis ▪ Renal failure, multi organ failure, death	LFTs peak
Stage 4*: 4-14 days	Recovery phase Slow normalization of symptoms and lab values (Symptoms typically normalize well before transaminases do)	Slow normalization

Aspirin Overdose

Toxic Dose	150 mg/kg
Pathophysiology	• Stimulates medullary respiratory center → ↑RR, hyperpnea, respiratory alkalosis • Inhibits Kreb's cycle enzymes → lactic acidosis, ketoacidosis • Inhibits platelet function + vitamin-K dependent clotting factors → coagulopathy

Aspirin Overdose	
Symptoms	• Mild toxicity: GI upset, tinnitus and tachypnea • Moderate toxicity: fever, diaphoresis, tachycardia, agitation, confusion • Severe toxicity: coma, pulmonary edema, seizures
Evaluation	Serum salicylate level (normal <30 mg/dL), ABG (primary respiratory alkalosis, primary anion-gap met acidosis), glucose (elevated - early, low - late), Electrolytes (hyper/hyponatremia, hypokalemia) +/- LFTs, CBC, coags, UA, serum/urine tox screen. EKG may show widened QRS, AV block, v. arrythmias
Management	• GI decontamination: activated charcoal (consider repeat dose, prone to bezoar formation) • Aggressive fluid resuscitation (lots of insensible losses) • Urine alkalinization: goal serum pH 7.45-7.55 to enhance ion trapping; can use D5 W150 mEq/L Na-bicarb • Potassium repletion • Follow salicylate levels q1-2 hours • Hemodialysis (ASA level >90-100mg/dL (acute) overdose, >60 mg/dL chronic), severe acidosis or electrolyte disturbances, renal failure, pulm edema, neurologic symptoms, deterioration despite interventions)

Beta-Blocker Overdose	
Toxic Dose	"One pill can kill" in toddlers
Pathophysiology	Adrenergic antagonist → ↓ sympathetic outflow
Symptoms	Bradycardia, hypotension, bronchospasm, coma, seizures, hypoglycemia
Evaluation	DS (hypoglycemia), EKG (brady, AV block, accelerated junctional rhythm), serum/urine tox
Management	• GI decontamination: activated charcoal (consider whole bowel irrigation) if indicated and no contraindications • Atropine for bradycardia/hypotension; fluids +/- pressors for hypotension • Glucagon bolus: 0.15 mg/kg then infusion of 0.05-0.1 mg/kg/hr • Hyperinsulinemia/euglycemia (HIE) therapy: sometimes used in severe BB OD

Calcium Channel Blocker Overdose	
Toxic Dose	"One pill can kill" in toddlers; individual drug selectivity for cardioactive vs vasoactive effects lost in significant overdose
Pathophysiology	Block L-type Ca channel blockers (affect myocyte contractility, SA nodal AP initiation)
Symptoms	Bradycardia, hypotension, coma, seizures, dihydropyridine CCBs (amlodipine, nifedipine, etc) can present w/ TACHYcardia and relative hypotension.
Evaluation	DS (hyperglycemia), EKG (bradycardia, AV block, accelerated junctional rhythm, wide QRS, ST ⊗'s), serum/urine tox
Management	• GI decontamination: activated charcoal (consider whole bowel irrigation) if indicated and no contraindications • Atropine for bradycardia/hypotension; fluids +/- pressors for hypotension • IV calcium chloride or calcium gluconate • HIE (hyperinsulinemia/euglycemia) therapy: 1 unit/kg bolus of regular insulin then 0.5-1+unit/kg/hr infusion • Intralipid 20%: 1.5ml/kg during 2-3 mins, followed by 0.25 ml/kg/min IV (consult Tox)

Anti-Depressants: SSRI's and SNRI's	
Toxicity	SSRI's: less toxic than MAOI's or TCA's; most fatalities due to co-ingestion SNRI's: greater toxicity vs. SSRI's (but less than MAOI's or TCA's)
Pathophysiology	Inhibit serotonin +/- norepinephrine reuptake (primarily in CNS)
Symptoms	• Vomiting, CNS depression, tachycardia • Serotonin syndrome: altered mental status, neuromuscular hyperexcitability (clonus, rigidity, hyperreflexia), autonomic instability (hyperthermia, tachy, HTN) → can lead to rhabdo, seizures, renal failure, DIC
Evaluation	Electrolytes, serum/tox screen, EKG (↑QTc, rare ↑ QRS w/ some SNRI's); levels not helpful
Management	• Decontamination and supportive care • Benzos and/or serotonin antagonists (cyproheptadine) for serotonin syndrome, consider cooling and paralysis for severe serotonin syndrome

Anti-Depressants: TCAs	
Toxic Dose	"One pill can kill" in toddlers
Pathophysiology	Peripheral and central anti-cholinergic, peripheral alpha-1 adrenergic blockade, inhibits CNS NE and serotonin reuptake, blocks cardiac fast Na channels, blocks GABA receptors
Symptoms	• Anticholinergic toxidrome (see toxidrome chart) • Neurotoxicity (seizures, coma) • Cardiovascular toxicity (arrhythmias, refractory hypotension, widened QRS
Evaluation	Electrolytes, CK, D-stick, urinalysis, tox screens, TCA level not useful (other than to confirm ingestion), EKG (prolonged QRS (>100ms a/w seizure, dysrhythmias), sinus tach, vent arrhythmias, lead aVR prominent R waves)
Management	• Gastric decontamination, close monitoring, EKGs • NaHCO3 titrated to serum pH 7.45-7.55 (indicated for QRS > 100ms w/ other signs of TCA toxicity, vent. arrythmias, CV collapse, seizures). Mechanism: increase pH à increase non-ionized TCA = cannot bind sodium channels. Also increases gradient across cardiac cell membranes à attenuates TCA-induced blockade of rapid sodium channels. • Supportive care (treat refractory hypotension w/alpha-agonist pressors)

Anti-Depressants: Buproprion	
Toxic Dose	"One pill can kill" in toddlers
Pathophysiology	Dopamine and NE reuptake inhibitor w/ some serotonin reuptake blockade; contraindicated in eating disorder patients given ↑ seizures
Symptoms	Seizures, agitation, HTN, tachycardia, arrhythmias
Evaluation	Levels not helpful, electrolytes, EKG (QRS and QTc prolongation)
Management	Supportive care, benzos for seizures, admit for >24 hours to monitor for late onset seizures if ingested Wellbutrin SR, ↑ QRS treated w/ IV sodium bicarb (though may not be as effective)

Iron	
Toxic Dose	• < 20mg/kg **elemental iron** usually asymptomatic • 20-60 mg/kg: variable response • > 60 mg/kg: greatest risk of serious toxicity (death reported at 60-300+ mg/kg)

Iron

Pathophysiology	Direct caustic effect on GI mucosa → hemorrhagic necrosis; multisystem toxicity 2/2 mitochondrial poison; iron absorbed at duodenum/jejunum
Symptoms	If no significant GI symptoms w/i first 6 hrs after overdose, very low likelihood of significant toxicity

Phase I (30min – 6h)	**GI sx**: vomiting, diarrhea, GI bleeding
Phase II (6h – 24h)	Latent period: apparent improvement
Phase III (4h-4days)	**Hepatotoxicity**: hepatocellular injury, AG metabolic acidosis (↑ lactic acid), coma, seizures, multi-organ failure, shock **Labs**: ↑ bili, ↑ LFTs, ↑ glucose, ↑ PT/INR, ↑ BUN
Phase IV (2-8 wks)	**Late effects**: possible bowel obstruction

Evaluation	KUB (radio-opaque pills), Fe level, VBG/ABG, lytes, BUN/Cr, glucose, LFTs, PT/INR, CB
Management	Support ABC's, replace fluid/blood losses, GI decontamination, IV deferoxamine (severe sx, iron level > 500 mcg/d w/ clinical symptoms, sig AG met acidosis)

Lead*

Toxic Dose	No safe lead level exists
Pathophysiology	Interferes w/ interactions of divalent cations and sulfhydryl groups leading to widespread physiologic effects and clinical toxicity.
Symptoms	• Lower levels: Abdominal pain, constipation, anorexia, vomiting, dev delays, aggression, hyperactivity • Higher levels: drowsiness, clumsiness, ataxia • Severe levels: decreased consciousness, coma, seizures, death (usually 2/2 cerebral edema)
Evaluation	Lead levels, CBC (microcytic anemia + basophilic stippling of RBC), FEP (free erythrocyte protoporphyrin), BUN/Cr, AST/ALT, x-ray (radio-opaque flecks)
Management	• Prevention is key: screening and lead levels at WCC (9-12 mo, 2 years) • Gastric decontamination: whole bowel irrigation • Chelation therapy (depending on lead levels) • See: https://www.cdc.gov/nceh/lead/acclpp/actions_blls.html • **Seminal Article**: CDC. Managing elevated blood lead levels among young children: Recommendations from the Advisory Committee on Childhood Lead Poisoning Prevention, Atlanta: CDC; 2002 • BCH has a separate Environmental Health clinic and service that can assist w/ management

Drugs of Abuse

Ethanol

Hx/PE	Euphoria, loss of coordination, ataxia, slurred speech, nystagmus, nausea, vomiting, hypoglycemia (especially in young children), seizures, coma, respiratory depression
Dx	Blood ethanol level, D-stick
Management	Supportive; secure airway if unresponsive, no gag reflex

Drugs of Abuse continued on next page →

Drugs of Abuse	
Marijuana	
Hx/PE	Pupils unchanged, injected conjunctivae, tachycardia, increased appetite, euphoria, anxiety, time-Space distortions, panic reaction, psychotic reaction; can cause ataxia and significant sedation in toddlers. Edibles particularly problematic in young children.
Dx	Urine drug screen (note, synthetic cannabinoids not detected on standard urine toxicology screens)
Management	Supportive care, can treat w/ anxiolytics if needed
Stimulants (Amphetamines, Cocaine, Ecstasy/MDMA, "Bath Salts")	
Hx/PE	Tachycardia, hyperthermia, mydriasis, diaphoresis, restlessness, tremors, panic, agitations, psychosis, seizures
Dx	Urine drug screen; EKG (cocaine may cause QRS widening); troponin if chest pain; CK if concern for rhabdo; electrolytes (hyponatremia w/ MDMA)
Management	Supportive care including fluids, avoid beta blockers in HTN due to unrestrained alpha-agonism, benzos for agitation, HTN, and tachycardia
Opioids	
Hx/PE	Respiratory depression (hallmark), miosis, CNS depression, hypotension, hypothermia, pulmonary edema
Dx	Urine drug screen (synthetic opiaoidsnot tested for – methadone,buprenorphine, fentanyl, etc); EKG (methadone can cause QTc prolongation)
Management	Naloxone for severe respiratory/CNS depression - titrate dosing to severity of presentation (may precipitate withdrawal in chronic users); otherwise supportive
Notes	Opioids are one of the "one pill can kill" medications in toddlers

BCH Wards Tips	
Primary Diagnoses	• Eating disorders • Anovulatory uterine bleeding • Some primary care patients
Format	• Table rounds. Intern fills out and presents eating disorder grid (will be reviewed first day) • Do NOT write notes daily, but are expected to examine patients daily and present thoughtful plans.

BCH Adolescent Clinic Tips	
Goal Skills	• Taking an effective social history • Addressing confidentiality • Discussing topics such as sex, contraception, substance use, and weight • Performing respectful genital exams • Strength-based approaches to management
Format	• Scheduled w/ same preceptor multiple times • Try to schedule patients for return visits w/ you
Resources Available	• Mental health • Psychopharm support • Nutrition • Resource specialist for social needs

BMC Adolescent Clinic Tips	
Population	• 12-22 y/o • Primarily from Dorchester, Roxbury, Hyde Park, South Boston, and the South End • First point of medical contact for adolescents new to the United States • Primary languages spoken: English, Haitian Creole, Spanish, and Cape Verdean Creole
Format	• Scheduled w/ same preceptor multiple times • Try to schedule patients for return visits w/ you
Subspecialty Programs	• CATALYST (for adolescents and young adults w/ substance use) • Teen prenatal and Teen Tot programs (to serve young parents and their children) • CATCH (providing gender affirming care to youth of all ages) • Sexual assault follow-up clinic • Menstrual Disorders Clinic • Integrated behavioral health social workers, patient navigators, and a family planner.

HE^{2}ADS^3 Assessment	
Green = essential questions Blue = as time permits Red = optional or when situation requires	
Home	• Who lives w/ you? Where do you live? Do you have your own room? • What are relationships like at home? • To whom are you closest at home? • To whom can you talk at home? • Is there anyone new at home? Has someone left recently? • Have you moved recently? • Have you ever had to live away from home? (Why?) • Have you ever run away? (Why?) • Is there any physical violence at home?
Education and Employment	• What are your favorite subjects at school? Your least favorite subjects? • How are your grades? Any recent changes? Any dramatic changes in the past? • Have you changed schools in the past few years? • What are your future education/employment plans/goals? • Are you working? Where? How much? • Tell me about your friends at school. • Is your school a safe place? (Why?) • Have you ever had to repeat a class? Have you ever had to repeat a grade? • Have you ever been suspended? Expelled? Have you ever considered dropping out? • How well do you get along w/ the people at school? Work? • Have your responsibilities at work increased? • Do you feel connected to your school? Do you feel as if you belong? • Are there adults at school you feel you could talk to about something important? (Who?)
Eating	• What do you like and not like about your body? • Have there been any recent changes in your weight? • Have you dieted in the last year? How? How often? • Have you done anything else to try to manage your weight? How much exercise do you get in an average day? Week? • What do you think would be a healthy diet? How does that compare to your current eating patterns? • Do you worry about your weight? How often? • Do you eat in front of the TV? Computer? • Does it ever seem as though your eating is out of control? • Have you ever made yourself throw up on purpose to control your weight? • Have you ever taken diet pills? • What would it be like if you gained (lost) 10 pounds?
Activities	• What do you and your friends do for fun? (w/ whom, where, and when?) • What do you and your family do for fun? (w/ whom, where, and when?) • Do you participate in any sports or other activities? • Do you regularly attend a church group, club, or other organized activity? • Do you have any hobbies? • Do you read for fun? (What?) • How much TV do you watch in a week? How about video games? • What music do you like to listen to?

HE^{2}ADS^3 Assessment	
Drugs	• Do any of your friends use tobacco? Alcohol? Other drugs? • Does anyone in your family use tobacco? Alcohol? Other drugs? • Do you use tobacco? Alcohol? Other drugs? • Is there any history of alcohol or drug problems in your family? Does anyone at home use tobacco? • Do you ever drink or use drugs when you're alone? • (Assess frequency, intensity, patterns of use or abuse, and how youth obtains or pays for drugs, alcohol, or tobacco)
Sexuality	• Have you ever been in a romantic relationship? • Tell me about the people that you've dated. *OR* Tell me about your sex life. • Have any of your relationships ever been sexual relationships? • Are your sexual activities enjoyable? • What does the term "safer sex" mean to you? • Are you interested in boys? Girls? Both? • Have you ever been forced or pressured into doing something sexual that you didn't want to do? • Have you ever been touched sexually in a way that you didn't want? • Have you ever been raped, on a date or any other time? • How many sexual partners have you had altogether? Have you ever been pregnant or worried that you may be pregnant? (females) • Have you ever gotten someone pregnant or worried that that might have happened? (males) • What are you using for birth control? Are you satisfied w/ your method? • Do you use condoms every time you have intercourse? • Does anything ever get in the way of always using a condom? • Have you ever had a sexually transmitted disease (STD) or worried that you had an STD?
Suicide and Depression	• Do you feel sad or down more than usual? Do you find yourself crying more than usual? • Are you "bored" all the time? • Are you having trouble getting to sleep? • Have you thought a lot about hurting yourself or someone else? • Does it seem that you've lost interest in things that you used to really enjoy? • Do you find yourself spending less and less time w/ friends? • Would you rather just be by yourself most of the time? • Have you ever tried to kill yourself? • Have you ever had to hurt yourself (by cutting yourself, for example) to calm down or feel better? • Have you started using alcohol or drugs to help you relax, calm down, or feel better?
Safety	• Have you ever been seriously injured? (How?) How about anyone else you know? • Do you always wear a seatbelt in the car? • Have you ever ridden w/ a driver who was drunk or high? When? How often? • Do you use safety equipment for sports and or other physical activities (for example, helmets for biking or skateboarding)? • Is there any violence in your home? Does the violence ever get physical? • Is there a lot of violence at your school? In your neighborhood? Among your friends? • Have you ever been physically or sexually abused? Have you ever been raped, on a date or at any other time? (If not asked previously) • Have you ever been in a car or motorcycle accident? (What happened?) • Have you ever been picked on or bullied? Is that still a problem? • Have you gotten into physical fights in school or your neighborhood? Are you still getting into fights? • Have you ever felt that you had to carry a knife, gun, or other weapon to protect yourself? Do you still feel that way?

Goldenring JM, Rosen DS. Getting into adolescent heads: an essential update. Contemp Pediatr. 2004;21:64

Contraception

Shared Decision Making Contraceptive (SDM) Counseling

- Collaborative process, allows patients and their providers to make healthcare decisions together, taking into account the best scientific evidence available, as well as the patient's values and preferences
- Provider role: knowledge of the medical information
- Patient role: expert regarding their own values and preferences

Applying Shared Decision Making Principles to Contraceptive Counseling Visits

Establish Rapport

- "What brings you in today? What's happening with your birth control?"
- "Why did you decide to choose an IUD?"
- Ask interactive open-ended questions. The HEADSS assessment is a great way to establish rapport for new patients.

Assess Patient Preferences

- "What are important features that your birth control should have?"
- "What did you like/dislike about the birth control methods you used in the past?"
- "Different types of IUDs affect your period differently. Some make your period a bit heavier, lighter, sporadic, or may take your period away. Which do you think will be best for you?"
- Use probing questions to help draw out patient preferences. *See above section:* How to discuss preferences with AYSs for more details.

Tailor Information and Discussion to Patient Preferences/ Needs

- Your patient says they want a method where they will still have a regular period. ➔ Counsel them on the contraceptive ring, patch, pill, and copper IUD and NOT on the shot, implant or LNG IUDs
- Your patient says they want a method that is easy to keep private. * ➔ Counsel them on the contraceptive ring, implant, shot and IUD and NOT on the pill or patch
- Your patient has heavy periods and doesn't want them to be any heavier. ➔ Provide information on any method other than the Copper IUD
- Your patient says they absolutely want to have a period every month. ➔ Provide more information on the LNG 15 and 19.5mg IUDs, and Copper IUD, and NOT on the LNG 52mg IUD.
- Use patient's identified preferences for discussing particular methods. Being knowledgeable of contraceptive mechanisms of action, side effects, and delivery routes is important to provide this tailored information. See Chapter 3 for more details.

Discuss Contraception Side Effects

- "Patients who begin the birth control pill may have breast tenderness or a mild headache during the first month. These usually go away."
- "With the LNG 52mg IUD, you may have spotting for about 4 months after placement, then your period will become lighter. After a year with this IUD, some patients stop getting their period."
- Many patients feel they do not receive adequate information about side effects, and that providers often overlook possible side effects in counseling discussions [17, 18, 51]. It is important to discuss the specific side effects that patients should expect with the contraception type that is aligned with their preferences. For more information on the different IUD side effects see Chapters 3 and 7.

Identify Misconceptions About Specific Contraception Type

- "I'm sorry that your friend had a bad experience with the vaginal contraceptive ring and weight gain. This isn't typical with most ring users. I support you in using this method because it aligns with your preferences. If you experience weight gain, you can absolutely choose a different option."
- "I hear your concern that your friend had worsening acne with her IUD. We usually don't see this in the majority of patients, so it's not likely that it will happen to you."
- Respectfully addressing myths or misconceptions about IUD types helps to keep conversations open, while providing patients with accurate information. For more information on IUD myths and misconceptions, see Chapter 4.

Ensure Access to Method Discontinuation at Any Time

- "If you decide you don't like this birth control, you can switch to something else at any time."
- "If you decide that you want to stop your birth control, I'm always here to talk about it and to support you."
- "If for whatever reason you decide that you don't want the IUD anymore, I will remove it."
- Patients should be informed at the time of insertion that they can have their IUD removed at any time, and for any reason.
- IUD removal should be provided with the immediacy as "same-day" IUD placement is provided.

Contraception

For more information on contraceptive methods, minor consent laws, as well as medical eligibility criteria and selected practice recommendations, please see the below resources:

- https://www.bedsider.org/
- https://www.reproductiveaccess.org
- https://www.cdc.gov/reproductivehealth/contraception/mmwr/mec/summary.html
- https://www.cdc.gov/reproductivehealth/contraception/mmwr/spr/summary.html
- www.guttmacher.org/state-policy/explore/minors-access-contraceptive-services
- https://youngwomenshealth.org/2009/01/28/pros-and-cons-contraceptive-methods/

Emergency Contraception*

Ella (ulipristal acetate)	
Notes	**Most effective EC pill** to prevent pregnancy **up to 5 days after unprotected sex** Do NOT give if starting any form of hormonal contraception (progestin inactivates ulipristal)
Access	**Prescription ONLY**. Safe to call in prescription w/o pregnancy test or seeing patient.
Plan B One-Step (levonorgestrel 1.5 mg)	
Notes	• Work best to prevent pregnancy for the **first 3 days after unprotected sex** • Works less well in patients who are overweight or obese
Access	• **Sold (at cost) to anyone of any age at most pharmacies (w/o Rx),** though access is still difficult for adolescents. • Safe to call in prescription w/o pregnancy test or seeing patient.
Copper IUD (ParaGard)	
Notes	• Most effective form of EC (>99%), effective up to 7 days after unprotected sex. • Can provide up to 12 years of highly effective contraception after placement.
Access	Must be placed in a clinic setting by a trained provider

For more information on Emergency Contraception, see:

- https://www.reproductiveaccess.org/wp-content/uploads/2014/12/emergency-contraception.pdf
- https://www.mass.gov/info-details/emergency-contraception-get-the-facts
- https://www.bedsider.org/methods/emergency_contraception

Mays A. IUD Counseling: What's choice got to do w/ it? In: Optimizing IUD Delivery for Adolescents and Young Adults. Coles MS, Mays A, editors. New York, NY: Springer; 2019.

Tanner Staging

	Breast	Pubic Hair	Genitals	Pubic Hair
Stage 1	Small nipples. No breast. 	No pubic hair. 	No signs of puberty. Scrotum, testes, and penis as in childhood. 	No pubic hair. 
Stage 2	Breast and nipples have just started to grow. The areola has become larger. Breast tissue bud feels firm behind the nipple. 	Initial growth of long pubic hairs. These are straight, without curls, and of light color. 	Initial growth of scrotum and testes. The skin on the scrotum has become redder, thinner, and more wrinkled. The penis may have grown a little in length. 	Few hairs around the root of the penis. The hairs are straight, without curls, an of light color. 
Stage 3	Breast and nipples have grown additionally. The areola has become darker. The breast tissue bud is larger. 	The pubic hair is more widespread. The hair is darker, and curls may have appeared. 	The penis has now grown in length. Scrotum and testes have grown. The skin of the scrotum has become darker and more wrinkled. 	Hairs are darker and curlier and still sparse, mostly located at the penis root. 
Stage 4	Nipples and areolas are elevated and form an edge towards the breast. The breast has also grown a little larger. 	More dense hair growth with curls and dark hair. Still not entirely as an adult woman. 	The penis has grown in both length and width. The head of the penis has become larger. The scrotum and testes have grown. 	More dense, curly, and dark hair. The hair growth is reaching the inner thighs. 
Stage 5	Fully developed breast. Nipples are protruding, and the edge between areola and breast has disappeared. 	Adult hair growth. Dense, curly hair extending towards the inner thighs. 	Penis and scrotum as an adult. 	Pubic hair extends upwards to the umbilicus. It is dense and curly. 

Morris NM, Udry JR. Validation of a self-administered instrument to assess stage of adolescent development. J Youth Adolesc. 1980;9(3):271–280pmid:24318082

Vaginal Discharge and Infections	
****Treatments change frequently. Check CDC Treatment Guidelines/ "CDC STD Tx Guide" app.****	
Normal (leukorrhea)	
Signs and Symptoms	• Clear, white, or grey discharge • No offensive odor • No burning or itching
Diagnosis	• pH ≤ 4.5 • Wet mount: epithelial cells w/ no or few leukocytes
Treatment	Reassurance
Candida Vaginitis	
Signs and Symptoms	• Curd-like white clumped discharge; intense burning and pruritis • No odor
Diagnosis	• pH < 4.5 • KOH: No fish odor, budding yeast and pseudohyphae; WBC
Treatment	• Fluconazole 150 mg PO (single dose) • Miconazole or clotrimazole applicator cream
Trichomoniasis	
Signs and Symptoms	Pruritis, malodorous, frothy, yellow-green or cream colored discharge, dysuria.
Diagnosis	• pH > 4.5 • KOH: Fish odor may be present • Wet mount: WBC and pear shaped organism w/ motile flagella
Treatment	• Metronidazole 2g PO (single dose) or 500mg PO BID for 7 days • Partner: treat and refrain from intercourse for 7 days
Bacterial Vaginosis	
Signs and Symptoms	Malodorous, increased mild grey-white discharge. Mild or absent pruritis or burning
Diagnosis	• pH > 4.5 • KOH: Fish odor • Wet mount: >20% clue cells-epithelial cells covered w/ gram negative rods
Treatment	• Metronidazole 500mg PO BID for 7 days or • Metronidazole gel 0.75% one applicator (5g) intravaginally daily for 5 days. • Partner: treat if recurrent infection
Gonorrhea	
Signs and Symptoms	• Majority asymptomatic. • Grey-white cervical discharge
Diagnosis	DNA probe or culture
Treatment	• CTX 250mg IM + 1g azithromycin (co-trx chlamydia and covers resistant gonorrhea) • Evaluate and treat contacts w/i prior 60 days. Refrain from intercourse x7 days

Vaginal Discharge and Infections continued on next page →

Vaginal Discharge and Infections	
Chlamydia	
Signs and Symptoms	• Asymptomatic. • Yellowish vaginal discharge
Diagnosis	DNA probe or culture
Treatment	• Azithromycin 1g PO x1 • Doxycycline 100mg PO BID for 7 days • Evaluate and treat contacts w/i prior 60 days. Refrain from intercourse x7 days
Retained Tampon	
Signs and Symptoms	Malodorous discharge
Diagnosis	History and PE
Treatment	Remove tampon
Allergic Vaginitis	
Signs and Symptoms	Local pain, vaginal erythema
Diagnosis	History of exposure to deodorant spray or scented tampons
Treatment	Cessation of sensitizing agent

Genital Ulcers and Warts	
Genital Herpes	
Signs and Symptoms	Grouped vesicles, painful shallow ulcers, tender inguinal adenopathy
Diagnosis	• Tzanck smear and viral culture • Antigen testing to determine HSV 1 vs HSV2 can give more information about recurrence prognosis
Treatment	**First episode**: Acyclovir 400mg TID 5-10 d Valacyclovir 1g BID 7-10 d **Recurrent episodes**: Acyclovir 400mg TID 5 d Valacyclovir 500 mg BID 3 d **Daily suppressive therapy**: Acyclovir 400 PO BID Valacyclovir 500mg-1g PO daily
Genital Warts	
Signs and Symptoms	• Single or multiple soft fleshy papillary or sessile painless growths around genitals • No inguinal lymphadenopathy
Diagnosis	• **Initial**: clinical presentation • **Final**: Pap test revealing typical cytologic changes

Genital Ulcers and Warts	
Genital Warts	
Treatment	• **Goal**: remove exophytic warts; exclude cervical dysplasia before treatment • **Medication** (not in preg): podophylin 0.5% gel BID x3 days then off 4 days and repeat up to 4 times • Imiquimod 5% cream 3x/wk on alternate days until resolution (<16 wks) • **Prevention**: Gardasil 9-valent vaccine (HPV(6, 11, + 7 others)
Syphilis	
Signs and Symptoms	• **Primary**: Indurated, well defined, usually single painless ulcer "chancre." • **Secondary**: weeks to months later; systemic infection w/ rash, fever, HA, malaise, anorexia, adenopathy • **Latent** → Leads to Tertiary in 25%: CNS, cardiac manifestations; gummatous lesions.
Diagnosis	• **Initial**: FTA-ABS, MHA-TP, dark-field microscopy or DFA test of exudate or tissue • **Final**: VDRL, RPR (reverse sequence screening @ BCH) • False seronegatives seen in first 3 months; presumptive tx recommended
Treatment	**Primary and Secondary**: Benzathine Penicillin G: 2.4 mil. U IM x1 Doxycycline 100mg BID x14d for allergy/preg **Latent**: infected but no sx Benzathine Penicillin G: 2.4 million U IM weekly x3 wks **Partner**: evaluate if contact w/i 3 mo for primary, 6 mo for secondary, 1 year for latent
Chancroid	
Signs and Symptoms	• Multiple, ragged, painful, non-indurated ulcers • Painful suppurative inguinal adenopathy
Diagnosis	• **Initial**: clinical presentation, neg syphilis and HSV • **Final**: culture of *haemophilus ducreyi*
Treatment	• Azithromycin 1g PO x1 dose • CTX 250 mg IM x1 dose • Ciprofloxacin 500 mg BID 3d • Erythromycin 500 mg TID 7d • **Partner**: evaluate and treat contacts w/i 10 days of symptoms

Pelvic Inflammatory Disease	
Pathophysiology	Infection of upper genital tract (cervix, uterus, fallopian tubes, ovaries)
Etiology	N. gonorrhea, C. trachomatis or other anaerobic organisms
Symptoms	Pelvic pain, dyspareunia, vaginal discharge, fever, and menstrual irregularities associated w/ lower abdominal tenderness, adnexal tenderness, and/or cervical motion tenderness
Physical Exam	Uterine, adnexal, or cervical motion tenderness +/- LQ or RUQ tenderness
Evaluation	STI testing (GC/CT, consider trich) Consider CBCd, ESR, RPR, urine hCG, UA, UCx.

Pelvic Inflammatory Disease continued on next page →

Pelvic Inflammatory Disease	
Management	**Inpatient**: ▪ IV regimen A: cefoxitin 2g IV q6h plus doxycycline 100mg PO BID ▪ IV regimen B: clindamycin 900 mg IV every 8 hours plus gentamicin 2.0 mg/kg IV loading dose then 1.5 mg/kg IV every 8 hours ▪ Following A, B: doxycycline 100mg PO BID for 14 days or erythromycin 500mg PO QID for 14 days ▪ Alternative regimens: Levofloxacin +/- Metronidazole; Ofloxacin +/- Metronidoazole; Amp/ Sulbactam + Doxy **Outpatient**: ▪ Ceftriaxone 250 mg IM in a single dose PLUS doxycycline 100 mg PO BID for 14 days w/ or w/o metronidazole 500mg PO BID for 14 day **Partner**: Evaluation and treatment of contacts w/i prior 60 days recommended. Refrain from intercourse in the meantime

Heavy or Irregular Menstrual Bleeding	
Definition	Abnormalities in the frequency, duration, volume, and/or timing of menstrual bleeding
Ddx	Anovulatory bleeding (most common cause in adolescents), pregnancy (must rule out even w/o report of sexual activity), coagulopathy
Symptoms	•Menses prolonged or cycle shortened w/ frequent menses (normal menses happen every 21-45 days) •Flow moderate to heavy •May present w/ anemia leading to orthostasis, fatigue, or exercise intolerance •Other changes may include weight change, visual changes, headache, heat or cold intolerance, skin changes (hirsutism or acne), palpitations, cyclic abdominal pain
Evaluation	•CBC w/ diff, urine hCG, gonorrhea and chlamydia testing, coagulation studies, von Willebrand panel, TSH, LH, FSH, prolactin, free/total testosterone, DHEAS •Pelvic ultrasound if mass palpable, uterine abnormality suspected, or patient is not responding to typical therapies •Ask about personal and family history of bleeding
Management	•OCPs (ethinyl estradiol-norgestrel) p BID (or occasionally TID/QID) until bleeding stops, then daily iron supplements as needed for anemia. •Anti-emetic as needed for nausea associated w/ hormone therapy

Amenorrhea	
Definition	•**Primary**: Absence of menses by age 15 or absence of menses 3 years following thelarche •**Secondary**: Absence of menses for three cycles or for six months w/ prior normal menses
Pathophysiology	•**Primary w/o secondary sex characteristics (no breast development) but normal genitalia (uterus and vagina)**: Turner syndrome, abnormal X chromosome, mosaicism, pure gonadal dysgenesis, 17 a-hydroxylase deficiency, hypothalamic failure secondary to inadequate gonadotropin- releasing hormone (GnRH) release, constitutional delay of puberty. •**Primary w/ normal breast development but absent uterus**: Androgen insensitivity, congenital absence of uterus (MRKH). •**Primary w/ no breast development and no uterus**: 17,20 desmolase deficiency, agonadism, 17 -hydroxylase deficiency w/ 46 XY karyotype

Amenorrhea	
Pathophysiology cont.	• **Primary and secondary w/ normal secondary sex characteristics**: Hypothalamic causes (idiopathic, phenothiazines, heroin, stress, exercise, weight loss, chronic illness, craniopharyngioma, tuberculous granuloma, meningoencephalitis, polycystic ovary syndrome), pituitary causes (Sheehan's syndrome, aneurysm, empty sella, tumors), ovarian causes (premature ovarian insufficiency), uterine causes (Asherman syndrome), pregnancy.
Symptoms	May see absence of secondary sex characteristics in conjunction w/ amenorrhea
Physical Exam	• Height, weight • Webbed neck, low set ears, broad shield-like chest in Turner's syndrome • Signs of malnutrition, androgen excess, thyroid dysfunction • Tanner stage, breast exam and pelvic exam
Evaluation	• Pregnancy test, TSH, FSH, prolactin, ultrasound to evaluate for presence of uterus • **Primary w/o secondary sex characteristics or absent uterus**: Karyotype: androgen insensitivity, mullerian agenesis, 46XY steroid enzyme defects, agonadism; FSH; Testosterone level. • **Primary and secondary w/ normal secondary sex characteristics**: Urine pregnancy; FSH; Testosterone level; prolactin level – if elevated, need MRI of head to evaluate for prolactinoma; Progestin withdrawal test: Positive response indicates the production of estrogen w/o normal cycling such as inPCOS (if evidence of hyperandrogenism or elevated testosterone). Negative test w/ low FSH suggests low estrogen state as is seen in hypothalamic amenorrhea from nutritional deficiency. Negative test w/ high FSH indicates ovarian insufficiency
Management	• **PCOS**: hormonal contraception or cyclical provera 10mg/day x 10d to induce bleeding • **Irreversible hypopituitarism or ovarian insufficiency**: Premarin 0.625-2.5 mg/day or transdermal estrogen and Provera 10mg/day medroxyprogesterone 10-14 days per month. • **Hypothalamic amenorrhea related to nutritional deficiency**: energy re-balance/weight

Welt, C. Etiology, diagnosis, and treatment of secondary amenorrhea. www.uptodate.com. Literature review current through: Feb 2019. | This topic last updated: Mar 21, 2018.

Anorexia Nervosa	
PowerPlans	• Restrictive Eating Power Plan and Admission Orderset • Restrictive eating EBG
Definition	• Restriction of energy intake relative to requirements, leading to a significantly low body weight in the context of age, sex, developmental trajectory, and physical health • Significantly low weight is defined as a weight that is less than minimally normal or, for children and adolescents, less than minimally expected • Intense fear of gaining weight or of becoming fat, or persistent behavior that interferes w/ weight gain, even though at a significantly low weight. • Disturbance in the way in which one's body weight or shape is experienced, undue influence of body weight or shape on self-evaluation, or persistent lack of recognition of the seriousness of the current low body weight.
Clinical Manifestations	Weight loss, abdominal pain, bloating, constipation, cold intolerance, lanugo, fatigue, weakness, delayed puberty
Physical Exam	Low body temp, bradycardia, low blood pressure, orthostatis, lanugo, dry skin and hair, scalp hair thinning, scaphoid abdomen, palpable stool, breast atrophy, hypoestrogenized vaginal mucosa

Eating Disorders continued on next page →

Anorexia Nervosa	
Evaluation	• CBC w/ differential, UA, urine pregnancy, chem 10, LFT, TFT, and EKG • Weight (compared to prior growth charts; calculate IBW based off of 50% BMI for age (unless previously tracking on different percentile))
Inpatient Management	• Goal is to medically stabilize (weight >80% of IBW), VSS (HR >50, no longer orthostatic), electrolytes stable (monitor potassium, phos and mag) • Refeed gradually to target meal plan while monitoring for refeeding syndrome (watch for edema, low phos) • Weight increase of 0.2kg/day, supplement if not gaining weight; 1750-2000kcal diet to be increased by 250 kcal per day until goal calories met, meals per EBG (set time for meal, replace w/ 120% ensure if <75% complete (either PO or via NG)) • Bed rest while orthostatic • No physical activity while inpatient; can earn wheelchair rides, bathroom privileges, etc. • Check electrolytes daily and supplement w/ PhosNaK and/or MVI if abnormal (at Children's the protocol is to start both supplements at admission) • Psychiatry and nutrition consult • Sitter needed if active SI

Bulimia Nervosa	
Definition	• Recurrent episodes of binge eating. An episode of binge eating is characterized by both of the following: ▪ Eating, in a discrete period of time (eg, w/i any two-hour period), an amount of food that is definitely larger than most people would eat during a similar period of time and under similar circumstances ▪ A sense of lack of control over eating during the episode (eg, a feeling that one cannot stop eating or control what or how much one is eating) • Recurrent inappropriate compensatory behavior to prevent weight gain, such as self-induced vomiting; misuse of laxatives, diuretics, enemas, or other medications; fasting; or excessive exercise • The binge eating and inappropriate compensatory behaviors both occur, on average, at least once a week for three months • Self-evaluation is unduly influenced by body shape and weight • The disturbance does not occur exclusively during episodes of anorexia nervosa.
Clinical Manifestations	See anorexia nervosa, plus esophagitis and cavities
Physical Exam	See anorexia nervosa, plus calluses on fingers, cavities, and tooth decay
Evaluation	See anorexia nervosa
Inpatient Management	See anorexia nervosa, plus purging precautions (no bathroom privileges; must use bedside commode, room searches)

Acute Refusal of Food Intake Disorder (ARFID)	
PowerPlans	ARFID protocol and PowerPlan
Definition	• Persistent failure to meet appropriate nutritional and/or energy needs associated w/ one (or more) of the following: ▪ Significant weight loss ▪ Significant nutritional deficiency ▪ Dependence on enteral feeding or oral nutritional supplements ▪ Marked interference w/ psychosocial functioning • Disturbance not better explained by lack of available food • **No evidence of a disturbance in body image**
Pathophysiology	• Patients w/ autism, ADHD, and intellectual disabilities are more likely to develop ARFID • Often have co-occurring anxiety disorder; high risk for other psychiatric disorders
Symptoms	See anorexia nervosa plus fear of choking or vomiting, limited range of preferred foods becomes narrower over time, will only eat certain textures of food
Evaluation	See anorexia nervosa
Inpatient Management	• ARFID protocol • Often requires enteral nutrition (many patients will go home on enteral feeds)

Additional Resources: Society for Adolescent Health & Medicine Resident Curriculum

Analgesia, Sedation, and Paralysis

Analgesics

Agent	Onset	Duration	Bolus Dose	Notes
Morphine	20 mins	3-5 hours	IV: 0.05-0.1 mg/kg/dose q1-2h	Can be associated w/ histamine release leading to hypotension, pruritus, flushing
Hydromorphone (Dilaudid)	15 mins	5 hours	IV: 0.015 mg/kg/dose q3h	
Fentanyl	Immediate	30-60 minutes	IV: 1-2 mcg/kg/dose q1h	Minimal hemodynamic instability w/ bolus doses. Large/rapid bolus doses can lead to muscle rigidity, interfering w/ ventilation - administer NMB or naloxone, support breathing

Sedatives

Agent	Onset	Duration	Dose	Notes
Midazolam (Versed)	1-5 min	2-6 hours	IV: 0.05-0.1 mg/kg/dose q1 -2h	Dose dependent hypotension and respiratory depression
Lorazepam (Ativan)	15-30 min	8-12 hours	IV: 0.05 mg/kg/dose q4h-q12h	Same adverse effects as midazolam, longer duration of action
Ketamine	30 sec	5-10 minutes	Intubation Dosing: IV:1-2 mg/kg/dose (load) + 0.5 mg/kg/dose q5min PRN Conscious Sedation: IV: 0.2 - 1.0 mg/kg (load) + 0.5 mg/kg q10min PRN	Dissociative (causes trance-like state associated w/ amnesia - but patients still move). Myocardial depressant but also increases catecholamine release. Mild analgesic. Bronchodilator.
Dexmedetomidine	5 min	1-2 hours	0.2-2 mcg/kg/hr	Dose dependent bradycardia is common. Can also cause hypertension or hypotension
Propofol	30 sec	5-10 minutes	25-150 mcg/kg/min, bolus 1-2 mg/kg Only credentialed ICU/ anesth in non-intubated patients. Attendings can bolus (or fellow under direct supervision). Infusion not to last longer than 12 hours in children.	Dose dependent hypotension (vasodilation and myocardial depression). Prolonged/high dose infusions increase risk of propofol infusion syndrome (cardiac failure, arrhythmias, rhabdo, lactic acidosis, among other problems). Children at higher risk

Paralytics

Agent	Onset	Duration	Dose	Notes
Rocuronium	60-90 sec (high dose); 2-3 minutes	30-60 min	IV: 0.6-1.2mg/kg/dose	High dose (1.2mg/kg) has more rapid onset but also longer duration, should be used for rapid sequence intubation
Vecuronium	1-2 min	20-60 min	IV: 0.1 mg/kg/dose or infusion of 0.1mg/kg/hr	

Analgesia, Sedation, and Paralysis

Paralytics

Agent	Onset	Duration	Dose	Notes
Cisatracurium	1-3 min	25-44 min	IV: 0.2 mg/kg/dose or infusion	Undergoes nonenzymatic degradation in circulation, thus duration of action remains same in patients w/ liver/renal dysfxn
Succinylcholine	30-60 sec	5-10 min	IV: 1 mg/kg/dose	Depolarizing NMB (patient will fasciculate). Can cause bradycardia. Contraindicated in presence of hyperkalemia, major trauma/ burns, rhabdomyolysis

Ventilation

Non-invasive Positive Pressure Ventilation

Interface	Nasal mask, facemask, RAM nasal cannula depending on patient. Consult w/ RT at both BCH and BMC to evaluate patient early for best interface for NIPPV.
Continuous Positive Airway Pressure (CPAP)	• Provides continuous airway pressure (PEEP). No "breaths" delivered, patient MUST be spontaneously breathing • Indications include: hypoxic respiratory failure, obstructive sleep apnea, upper airway obstruction • Mechanism: Alveolar recruitment improved, which improves oxygenation through better V/Q matching • FiO2 can be adjusted to improve oxygenation as well
Bilevel Positive Airway Pressure (BiPAP)	• Provide inspiratory pressure (IPAP), compared to PIP, and expiratory pressure (EPAP), compared to PEEP • Indications include: hypoxic, hypercarbic or mixed respiratory failure • Mechanism: in addition to alveolar recruitment, delta pressure (IPAP - EPAP) influences tidal volume to improve ventilation (Minute Ventilation = Tidal Volume x Respiratory Rate); IPAP can also reduce work of breathing • In addition to adjusting IPAP and EPAP, you can adjust FiO2 to improve oxygenation • Although you can set a mandatory breath rate in certain BiPAP modes, machine breaths that are not aligned w/ patient efforts do not result in good tidal volumes due to the noninvasive interface - not a good choice for patients w/ inconsistent respiratory drive. Not a good choice for patients w/ altered mental status or who cannot protect their airway (ie. no cough or gag) from aspiration.

Mechanical Ventilation

MBR	Mandatory breath rate: number of breaths the ventilator will deliver to patient per minute (or ensure patient receives breath if patient not triggering the ventilator)
RR	MBR plus whatever spontaneous breaths the patient takes (breaths above MBR may or may not be supported depending on mode)
PIP	Peak inspiratory pressure: highest pressure the patient will see during the respiratory cycle
PEEP	Positive end expiratory pressure: pressure the lungs see during expiration (helps keep the alveoli open during expiration and prevent collapse)
TV	Tidal Volume: maximum volume delivered to the patient during inspiration
IT	Inspiratory time: time over which tidal volume is delivered

Ventilation continued on next page →

Ventilation

Mechanical Ventilation

ET	Expiratory time: time over which exhalation occurs, generally longer than IT (basically what is left over after you have a certain number of breaths per minute w/ a certain Ti)
MAP	Mean-airway pressure: (Ti x PIP) + (Te x PEEP) / (Ti + Te)

Modes of Ventilation

1. AC (assist-control)	• Every breath is machine supported and has the same parameters (PIP, PEEP, Ti), whether patient-triggered or machine-triggered • Breaths can be triggered by patient (assisted breaths) or elapsed time if patient not able to trigger (controlled breaths) • Risk of overventilation if patient's spontaneous respiratory rate is high for other reasons (fever, agitation) or if ventilator is inappropriately triggering • Can set to pressure control or volume control
2. SIMV (Synchronized Intermittent Mandatory Ventilation)	• Machine will synchronize breath delivery to align w/ patient's effort, but if patient is not triggering breaths frequently enough, machine provides mandatory breath rate to patient • Often paired w/ pressure support ventilation (SIMV + PSV) to support breaths above mandatory breath rate • Can set to pressure control or volume control • Pressure Control: set pressure, tidal volume changes based on compliance ($\Delta V/\Delta P$) • Volume Control: set volume, pressure changes
3. Pressure Regulated Volume Control (PRVC)	• Ventilator adjusts pressure depending on exhaled tidal volume every 3rd breath • Optimizes lowest pressure possible to achieve set tidal volume by constant adjustments
4. Pressure Support	• No mandatory breath rate, no inspiratory time set • When patient triggers a breath, machine delivers a set level of pressure above PEEP • Inspiratory time of breath determined by patient-driven inspiratory flow (flow cycling) - if patient is "satisfied" stops inhaling then the ventilator will stop inspiratory flow and cycle into exhalation

General Principle

- Improve oxygenation (increase pO2) by recruiting alveoli and optimizing V/Q matching - usually done by optimizing PEEP, MAP, FiO2, I:E ratio
- Both atelectasis and overdistension must be avoided
- Improve ventilation (decreased pCO2) by increasing alveolar ventilation - adjust variables that influence RR, TV
- Remember lungs need to empty in order for new air from outside (pCO2 = 0) to enter - particularly in patients w/ obstructive physiology (asthma), this may require longer expiratory times

Troubleshooting Desaturations on Ventilator (DOPE)

- **D**islodgement (of ETT)—mask ventilate, call staff assist
- **O**bstruction (mucus plug)—suction, call nursing & RT
- **P**neumothorax—obtain CXR, consider needle decompression if concern for tension physiology
- **E**quipment Failure—bag-ETT ventilate, call RT

Acute Respiratory Distress Syndrome	
Definition	Acute respiratory failure not fully explained by cardiac etiology or fluid overload ▪ Excludes patients w/ perinatal pulmonary disease ▪ CXR w/ pulmonary infiltrates (does not have to be bilateral) ▪ Increased oxygenation index
Pathogenesis	• No unifying pathophysiology for ARDS - can be direct injury (pneumonia, traumatic contusion) or indirect (systemic inflammation from sepsis) • Overall, insult causes alveolar cell damage filling of airspaces w/ exudate. Over ~3 weeks, granulation tissue formation occurs which leads to remodeling and fibrosis • Alveolar collapse leads to V/Q mismatch
Clinical Presentation	• Respiratory distress out of proportion to underlying disease • Hypoxemia • Decreased lung compliance
Diagnostic Studies	• Chest XR: commonly see bilateral infiltrates, although not required for diagnosis • ABG: high A-a gradient • PaO2 to FiO2 ratio is < 300
Treatment	Lung protective ventilatory strategies: reduce ventilator-induced lung injury ▪ Maintain TV 4-6cc/kg, use PEEP to improve oxygenation (continue increasing PEEP if FiO2 above 0.6). Target SpO2 88-94% (wean if >98%), keep FiO2 < 0.6 ▪ Permissive hypercapnia (pH 7.15-7.30), PaCO2 60s

Shock	
Definition	Metabolic demands of body>delivered oxygen to tissues ▪ Oxygen delivery (DO2) = content of arterial oxygen (CaO2) x cardiac output (CO) ▪ CaO2 = (1.34 x **Hgb** x % **O2 Sat**) + (0.003 x PaO2) ▪ CO = **SV** x **HR**, SV determined by preload, afterload, and contractility.

Type of Shock	Causes	Physiology	Findings	Treatment
Hypovolemic	Dehydration Hemorrhage Osmotic diuresis Third-spacing fluid Burns	Not enough fluid in vasculature → decreased preload & CVP → low CO → decr. O_2 delivery	Dry mucous membranes, oliguria, weak pulses w/ delayed capillary refill	Fluid resuscitation, stop fluid losses if possible (e.g. treat bleeding). Rapid transfusion protocol if hemorrhage Rapid infuser in ICUs, ED, OR

Shock continued on next page →

Shock

Type of Shock	Causes	Physiology	Findings	Treatment
Distributive	Septic shock Anaphylactic shock (anaphylaxis & septic shock cause vasodilation & cap. permeability) Neurogenic shock (loss of sympathetic innervation to vascular tone)	Poor tone & leaking of vasculature → low SVR → relative hypovolemia/ preload, low DBP. Contractility may be depressed later in sepsis presentation, CVP will vary.	Pounding pulses & brisk capillary refill if capillaries are leaky→ warm extremities (** not always true in pediatric septic shock) Low DBP (especially neurogenic) Widened pulse pressure.	Vasopressors (new guidelines are epinephrine for "cold" and norepinephrine for "warm," may also see dopamine and vasopressin) *Anaphylactic: EPI *Neurogenic: NE
Cardiogenic	Arrhythmias; Myocarditis; CHF; Cardiomyopathy; Trauma; **Cardiac tamponade; **Pulmonary embolism	Poor contractility or ability to relax → Ineffective systolic output → Decreased cardiac output w/ initial low CVP and high SVR	Weak pulses w/ narrow pulse pressure due to low systolic blood pressure; Pallor; Cold extremities; Delayed capillary refill; **Signs of heart failure (respiratory distress, hepatomegaly, JVD)**	LIMIT fluid resuscitation (5-10cc/ kg); Inotropic agents (low dose dopamine, or epinephrine, less commonly dobutamine); Can consider milrinone if BP normal to decrease afterload
	**Obstructive causes of shock that affect the heart's ability produced adequate cardiac output	Pulmonary embolism, cardiac tamponade	Tamponade - Pulsus paradoxus or electrical alternans, narrow pulse pressure w/ increased diastolic	Specific to underlying cause.

Labs

VBG w/ Lactate
- Assess pH and bicarb to determine degree of metabolic acidosis due to anaerobic metabolism - note, bicarb on blood gas is calculated based on the pH and pCO2 - obtain chemistry to measure directly
- Increased lactate associated w/ inadequate tissue O2 delivery in shock states (but can also be elevated if not cleared appropriately, for example in liver failure)

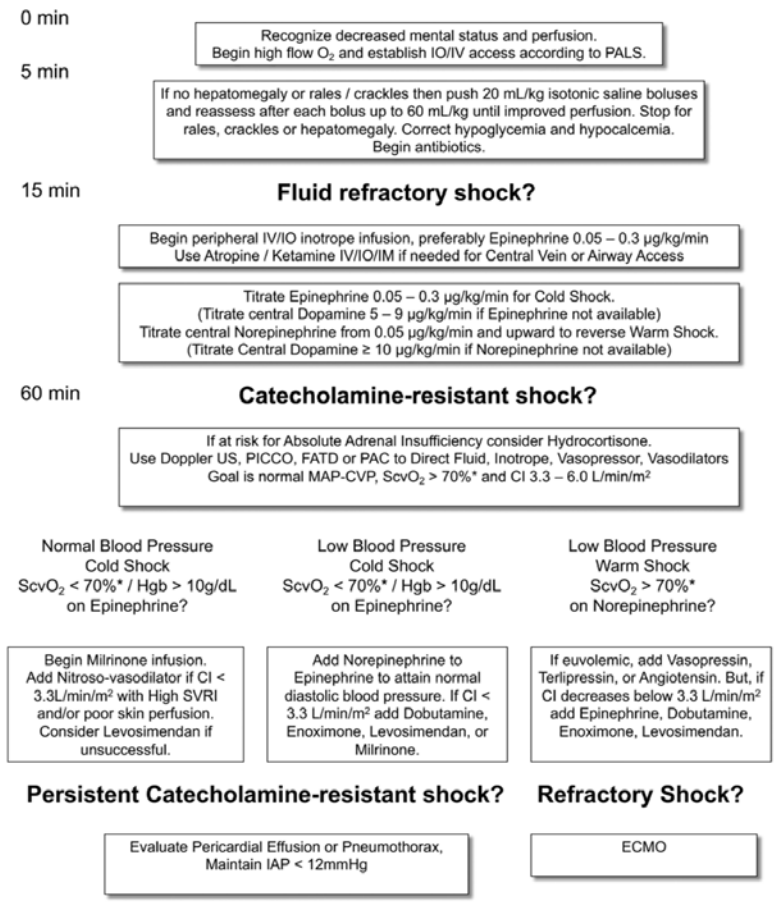
Mixed venous saturation (ScvO2) / arterial-venous o2 difference
- Normal is 70-75%, low in earlier shock (inadequate delivery for utilization), high is concerning for organ dysfunction (impaired o2 utilization by cells due to injury (usually a bad sign)
- Only interpretable from central line terminating in distal SVC, preferably RA; not useful from peripheral VBG
- True pulmonary arterial saturation (SvO2) no longer routinely utilized

CBC and Blood Culture
- WBC count to assess infection
- Hemoglobin to assess adequacy of oxygen carrying

Chem 10 w/ LFTs
- Chemistry to assess solutes (Na, K, Cl, gluc), bicarb, renal function (BUN/Cr), intravascular volume status (BUN:Cr ratio)
- LFTs to assess liver damage

Shock

Septic Shock Treatment Algorithm



Davis AL, Carcillo JA, Aneja RK et al. American College of Critical Care Medicine clinical practice parameters for hemodynamic support of pediatric and neonatal septic shock. Critical care medicine. 2017 Jun 1;45(6):1061-93.

Consideration: There are times when blood products may be indicated in acute resuscitation if there are abnormal hemoglobin/hematocrit values but generally crystalloid is used over colloid and there is no benefit to albumin over crystalloid.

Vasopressors & Ionotropes			
Agent	**Dose range (mcg/kg/min)**	**Mechanism**	**Considerations**
Dopamine	1-20 (1-5 mostly affects DA; 6-10 β_1; 11-20 alpha 1)	DA, β_1, α_1,	• Lower doses primarily cause inotropy and chronotropy (β1); DA-mediated splanchnic vasodilation of uncertain clinical significance • Higher doses will increase SVR and chronotropy, could decrease CO • Can be used w/ norepinephrine for distributive or hypovolemic shock as higher doses increase SVR
Epinephrine	0.05-1	β_1, $\beta_2 > \alpha_1$	• Increases CO, SVR w/ effects on CO > effects on SVR • Due to strong inotropic effects, preferred agent for cardiogenic shock
Norepinephrine	0.01-1	$\alpha_1 > \beta_1 > \beta_2$	Primarily increases SVR, minimal change to HR
Milrinone	0.25-1	Phosphodiesterase inhibitor	• Positive inotrope and decreases SVR (SVR effect more prominent - BP likely to decrease even if CO increases) • Useful for cardiogenic shock (CHF) w/ normal or high BP to reduce afterload and increase CO

Hypertensive Crisis	
Definitions	• **Hypertensive Urgency**: severe elevation in blood pressure W/O evidence of acute end organ damage • **Hypertensive Emergency**: BP>Stage II HTN for age W/ evidence of acute end organ damage
Etiology	• **Neonates**: renovascular disease, congenital renal anomalies, BPD, coarctation • **Children**: renovascular disease, glomerulonephritis, endocrine disease • **Adolescents**: renovascular disease, drugs (cocaine, amphetamines, Serotonin Syndrome)
Clinical Manifestations	• **Hypertensive encephalopathy**: headache, altered MS, vision changes, seizures, acute stroke • **Myocardial ischemia**: acute chest pain, dyspnea, orthopnea, cough. Can hear diffuse, fine crackles at lung base, S3 gallop. • **Aortic Dissection**: Chest, abdominal pain, end-organ dysfunction. • Retinal hemorrhages and exudates • **Malignant nephrosclerosis**: leading to acute renal failure, hematuria, and proteinuria • **Posterior Reversible Encephalopathy Syndrome (PRES)**: Encepholopathic or seizing patient in setting of acute hypertensive crisis w/ neuroimaging findings of reversible vasogenic subcortical edema w/o infarction. Edema usually seen in parietal and occipital lobes
Diagnostic Studies	• 4 Extremity BP's • Fundoscopic Exam. • Chem 10 to evaluate for renal impairment • CBC and +/- reticulocyte count and smear to look for microangiopathic anemia • UA to look for hematuria, proteinuria • EKG to look for evidence of LVH or myocardial ischemia • CXR if chest pain or SOB (look for cardiac enlargement, pulmonary edema) • Head CT or MRI if abnormal neurologic exam or mental status • Consider tox screen, pregnancy test, endocrine testing to look for underlying cause

Hypertensive Crisis

Treatment

Hypertensive Urgency:
- Reduce BP slowly over 24-48 hours
- IV Hydralazine/Labetalol OR PO Isradipine/Clonidine

Hypertensive Emergency:
- Reduce BP by 10-20% over first hour, reduce by no more than 25% in first 8 hours
- IV Hydralazine or Labetalol bolus, followed by Nicardipine or Labetalol infusion

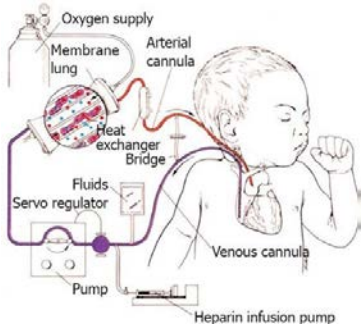
Medication	Dosage	Indications	Notes
Hydralazine	Start 0.1-0.2 mg/kg/ dose [max 20mg], max 0.5 mg/kg Q4H – onset in 10 min, duration 4-6 hrs	Short-term control of symptomatic hypertension	Not for use in LV dysfunction. Potential exists for prolonged hypotension
Labetalol	0.25-1 mg/kg/dose (max 40 mg) as frequently as q5-10 min, or continuous 0.25-1 mg/kg/hr	• Short-term control of symptomatic hypertension • For pheochromocytoma use after initiation of an alpha blocker so as to not precipitate hypertensive crisis.	Not for use in myocardial dysfunction
Nicardipine	Loading dose 5-10 mcg/kg then 0.5-3.5 mcg/kg/min. Peak effect at 30 min, lasting up to 4 hours	Consider use w/ renal dysfunction.	Not for acute heart failure or coronary ischemia. Caution in infants w/ calcium-dependent myocardium

ECMO

Definition

An extracorporeal circuit designed to provide prolonged pulmonary (VV ECMO) or cardiopulmonary (VA ECMO) support by removing blood from the native vascular system, performing gas and heat exchange and reinfusing the oxygenated blood into the body.
- **Venovenous (VV ECMO)** – Drains systemic venous deoxygenated blood, oxygenates it and removes carbon dioxide, and returns oxygenated blood to the systemic venous system. Provides pulmonary support (blood still goes through native heart and lungs) and is effective in respiratory failure w/ **intact cardiac function**.
- **Venoarterial (VA ECMO)** – Drains systemic venous deoxygenated blood, oxygenates it and removes carbon dioxide, and returns oxygenated blood to systemic arterial system. Provides cardiopulmonary support (some blood bypasses native heart and lungs) and is effective in patients w/ **cardiopulmonary failure**.

ECMO continued on next page →

ECMO	
Definition	 VA ECMO. Maslach-Hubbard A, Bratton SL. Extracorporeal membrane oxygenation for pediatric respiratory failure: History, development and current status. World J Crit Care Med 2013; 2(4): 29-39
Indications	• Hypoxemic respiratory failure w/ PaO2/FiO2 < 100 or Oxygenation Index (OI) > 40 despite optimized ventilator settings (PIP > 35 cm H20, PEEP > 10 cm H20, MAP > 18 cm H20; failure of high frequency ventilation) (OI = FiO2 * Mean Airway Pressure * 100/PaO2, note, multiply by 100 because FiO2 is correctly expressed as a decimal, even though colloquially referred to as a percentage) • Persistent hypercapneic respiratory failure w/ arterial pH < 7.2 refractory to all ventilation modes. • Refractory cardiogenic shock • Cardiac arrest • Failure to wean from intraoperative cardiopulmonary bypass • VA ECMO or ventricular assist device may be used as a bridge to cardiac transplantation • VV ECMO is potential bridge to lung transplantation in certain circumstances
Relative Contra-indications	• Lack of reversible etiology of critical illness • Poor pre-existing functional status *multiorgan failure is probably more of a consideration than functional status • Contraindications to systemic anticoagulation (i.e. massive IVH in neonates)
Pre-ECMO Initiation	1. Type and cross, arterial blood gas, electrolytes, CBC, coags, lactic acid, LFTs and chem 10 2. Head US in neonates to rule out severe IVH 3. Echocardiogram to evaluate cardiac function and for structural CHD
Titration	• Titrate to achieve an arterial O2 saturation > 90% for VA ECMO and > 80% for VV ECMO (there is mixing of oxygenated and deoxygenated blood w/i the RA during VV ECMO) and mixed venous O2 saturation of >70% for VA ECMO • Target normal lactates and arterial BP (measures of perfusion)
Complications	• Bleeding is the most common complication (30-40% by some estimates), can be life-threatening and may require immediate surgical intervention, brief cessation of heparin infusion or use of plasminogen inhibitors (i.e. aminocaproic acid) • Thromboembolism is infrequent, but can be catastrophic, especially in VA ECMO where embolization is systemic. Sudden changes in circuit pressure gradients are concerning for thromboembolism • Vessel perforation, dissection and occlusion of vessels resulting in distal ischemia (latter can be seen in femoral arterial cannulation, treated w/ placement of a distal perfusion cannula)

Acute Abdominal Pain	
Differential	
GI	Appendicitis, trauma, pancreatitis, intussusception, malrotation ± volvulus, inflammatory bowel disease, gastritis, bowel obstruction, irritable bowel syndrome, abscess, hepatitis, perforated ulcer, Meckel diverticulum, cholecystitis, choledocholithiasis, constipation, gastroenteritis (particularly with associated mesenteric adenitis)
Renal	Urinary tract infection, pyelonephritis, nephrolithiasis
GU	Ectopic pregnancy, ovarian cyst/torsion, tubo-ovarian abscess, pelvic inflammatory disease, testicular torsion
Oncologic	Wilms tumor, neuroblastoma, rhabdomyosarcoma, lymphoma
Other	Henoch-Schonlein purpura, lower lobe pneumonia, sickle cell anemia, diabetic ketoacidosis, juvenile idiopathic arthritis, incarcerated hernia, Streptococcal pharyngitis
Workup	
History	Course and characterization, diarrhea, emesis, melena, hematochezia, fever, last oral intake, menstrual history, vaginal symptoms, urinary symptoms, respiratory symptoms, travel history, diet, pertinent family history
PE	• Vital signs, toxic appearance, rashes, arthritis, jaundice • Thorough abdominal exam (if concern for appendicitis, check for psoas sign, obturator, Rovsing's) • Rectal exam with stool Hemoccult • Bimanual exam in sexually active females • Genital exam
Studies	• KUB to assess for obstruction, constipation, free air, gallstones • Abdominal/pelvic ultrasound • Consider abdominal CT • Pelvic MRI for appendicitis if institutionally available
Labs	• Laboratory studies • CBC, chemistry, electrolytes, liver and kidney function, ESR, CRP, amylase, lipase, gonorrhea/ Chlamydia, urine pregnancy
Treatment	• NPO, fluids • "GI cocktail" - multiple antacids • Consider nasogastric decompression • Serial abdominal exams • Surgical/gynecologic/GI evaluation • Pain control and antibiotics as indicated

Blunt Abdominal Trauma	
Sources	**BCH EBG** (Trauma, abdominal)**, CHOP Clinical Pathway,** Fleisher GR, Ludwig S, eds. (2010) Textbook of Pediatric Emergency Medicine. 6th ed. Philadelphia: Lippincott Williams & Wilkins.
Assessment	1. Abdominal wall abrasion, erythema, ecchymosis or seat belt sign 2. Any abdominal tenderness/pain 3. Evidence of thoracic wall trauma 4. Absent or decreased breath sounds
If #1 or >2 of the above present	• FAST assessment limited compared to adults • Abdominal CT with IV contrast • Labs: CBC, LFTs, lipase, UA, type and screen • Surgical consult

Abdominal Trauma continued on next page →

Blunt Abdominal Trauma	
Treatment	• Any traumatic findings: admit to trauma surgery service • No traumatic findings: observe 4 hrs after CT, reevaluate including: PO challenge, vital signs, repeat abdominal/thoracic exams • If symptoms worsening, consider imaging • If symptoms improved, discharge to home with return instructions

Appendicitis	
Sources	**BCH EBG** (appendicitis)**, CHOP Clinical Pathway**
Definition	Inflammation of the appendix caused by obstruction of the lumen
Patho	• The appendix is a blind pouch in the RLQ that can become obstructed with a fecalith or lymph tissue. Once it becomes obstructed, it becomes inflamed and edematous which eventually leads to necrosis and perforation. • Inflammation can also occur as a result of bacterial invasion without obstruction.
Clinical	• Pain begins in periumbilical region (referred pain) and then moves to RLQ • Anorexia, nausea, vomiting, and fever • Young children may not have classic signs and therefore many present with perforation! • Perforation will occur between 24-48 hours after symptom onset if not diagnosed. ▪ Perforation can present with high fevers and peritoneal signs
Physical Exam	• Pain on palpation in periumbilical region that migrates to RLQ • Rovsing's sign: palpation of LLQ causes pain in RLQ • Psoas sign: increased abdominal pain when patient flexes right hip against resistance • Obturator sign: increased abdominal pain when patient's right leg is raised with knee flexed and then internally rotated at the hip. • Rectal exam: may have tenderness if have retrocecal appendix. • If perforated: guarding and/or rebound

Studies	• If female, obtain urine HCG
	• CBC: poly-predominant leukocytosis is strongly associated with appendicitis
	• UA may show mild pyuria
	• KUB: not indicated in most. may show fecalith, localized ileus, free air (if perforated), SBO in young child without prior surgical history is appendicitis unless proven otherwise
	• Start with US:
	  ▪ US: increased diameter, thickened wall, echogenicity surrounding appendix, appendicolith. Interpretation heavily influenced by pre-test probability.
	  ▪ CT with IV contrast or MRI: increased diameter, fat streaking

Treatment	• NPO • Consult surgery • IV antibiotics: Zosyn. If allergic to penicillin: Clindamycin + Gentamicin • Urgent appendectomy • If perforated: antibiotics with interval appendectomy

Acute Chest Pain	
Sources	**BCH EBG** (chest pain)**, CHOP Clinical Pathway,** Uptodate
Differential	• **Can't miss:** Acute coronary syndrome, pericarditis, pneumothorax, pulmonary embolism, aneurysm • **MSK**: costochondritis, musculoskeletal strain/trauma, precordial catch (Texidor's twinge) • **Cardiac** (1% of children) ▪ Ischemia: severe aortic and pulmonary stenosis, hypertrophic or dilated cardiomyopathy, history of Kawasaki disease and subsequent coronary thrombosis, anomalous coronary arteries, familial dyslipidemia and medication or drug induced vasospasm (i.e. cocaine abuse) ▪ Arrhythmia: SVT or ventricular tachyarrhythmias ▪ Inflammatory: myocarditis, pericarditis ▪ Mitral valve prolapse ▪ Aortic dissection (consider in Marfan, Ehlers-Danlos, Turner, or Noonan) • **Pulmonary**: pneumonia, asthma, upper respiratory infection causing coughing, hyperventilation, pneumothorax, pleuritis and pulmonary embolism • **GI**: GERD, esophagitis, esophageal spasm. Also consider foreign body ingestion, gastritis, pancreatitis, cholecystitis, peptic ulcer disease, Mallory-Weiss tears, Boerhaave syndrome and hiatal hernias • **Psych**: anxiety, panic attacks • **ID**: Shingles (herpes zoster infection) • **Heme**: Severe anemia, Sickle cell anemia-related VOE or acute chest syndrome
History	• Location, chronicity, duration, frequency, severity, quality, radiation of pain • Precipitating or alleviating factors • Association with exertion, syncope, or palpitations • History of inflammatory disorders, hypercoagulable states, connective tissue disease • Family history of early thromboembolic disease, sudden death, drowning or congenital heart disease.
Physical Exam	• Complete cardiorespiratory and abdominal exam • Examination of skin overlying area of pain • Palpation for reproducible pain • Concerning findings: ▪ Non-innocent heart murmurs (>III/VI in intensity, diastolic, harsh quality, no positional change or louder standing than supine) ▪ Clicks, rubs or gallops ▪ Abnormal S2 ▪ Stigmata of connective tissue disease ▪ Hepatomegaly ▪ Pallor, diaphoresis, or poor perfusion
Studies	• EKG • CXR for suspected pulmonary or cardiac disease • CT w/PE protocol if high suspicion for PE • Consider CBC, inflammatory markers, D-dimer, troponin, BNP as indicated

Acute Scrotal Pain	
Sources	**CHOP Clinical Pathway,** Brenner, JS, Ojo A. UpToDate: Causes of scrotal pain in children and adolescents
History	• Pain (Onset, Duration, Location, Migration, Severity) • Anorexia/Nausea (Last meal) • Vomiting (Time of onset, Last episode, Number of episodes) • Urine (Dysuria, Quantify urine output, Hesitancy, Urgency, Hematuria) • Sexual History (Sexually active?, History of STIs, Urethral discharge) • Fever • Trauma

Acute Scrotal Pain continued on next page →

Acute Scrotal Pain			
Physical Exam	• Abdomen (Focal tenderness, Guarding/rebound, CVA tenderness) • Genital (Tanner stage, Inguinal canal abnormality, Scrotal tenderness, Lie of testicles, Tenderness of testicles, Abnormal color of scrotum, Differences in size, Presence/absence of cremasteric reflex)		
Studies	• Imaging: Scrotal US with doppler • Labs: UA and UCx, GC/CT in sexually active patients. • Urgently consult urology if there is suspicion for torsion, without waiting for imaging results		
Condition	**Definition/Pathogenesis**	**Clinical Presentation**	**Treatment**
Testicular Torsion	• Rotation of the spermatic cord of the testis → diminished blood flow → infarction • ~30% of acute scrotal pain is testicular torsion	• Acute, severe pain • Swollen, high-riding testis, diffusely tender, possibly w/ horizontal lie • Absent cremasteric reflex • Overlying erythema	• Surgical emergency: surgical exploration, detorsion and fixation of the bilateral testes • Pain control
Torsion of the Testicular Appendage	Rotation of appendix testis (small vestigial structure on the anterosuperior aspect of the testis) → localized infarction	• Localized pain to upper pole of the testis only • Classic "blue dot" sign	• Pain medication, scrotal support and rest • Pain should resolve in a few days, if not patient needs re-evaluation
Epididymitis	Inflammation of the epididymis	• Indolent pain and swelling of epididymis • Dysuria • Penile discharge • Fever • US: Increased blood flow	• Supportive care • Sexually active adolescents: treat like STD • In prepubertal children, may be bacterial or aseptic (traumatic, viral) • Antibiotics if UCx positive
Orchitis	• Inflammation of the testes • Viral (mumps, rubella, coxsackie, echovirus, lymphocytic choriomeningitis virus, parvovirus) and bacterial (brucellosis) infections	• Generalized scrotal swelling, pain, and tenderness • Erythema and shininess of the overlying skin • Increased blood flow on US	• Supportive care • Support of the inflamed testis • NSAIDs and ice packs
Trauma	Blunt vs. penetrating trauma → can cause hematocele, hematoma, testicular rupture, or traumatic epididymitis	• Swelling, pain, and tenderness • Bruising or abrasions • High index of suspicion for concomitant torsion	• Penetrating wounds, rupture, or large hematoceles require surgical repair • Antibiotics for wounds • Otherwise, supportive care
Vasculitis	Occasionally occurs as part of IgA vasculitis or HSP	• Acute or insidious pain • Signs of systemic illness (fever, abd pain, rash) • US can distinguish from torsion	• Supportive care • NSAIDs and ice packs • Steroids helpful in severe HSP
Incarcerated Inguinal Hernia	Herniation of bowel or omentum into the scrotum	• Pain and scrotal mass • Audible bowel sounds • US shows herniated bowel	• Surgical intervention • Pain control

Atraumatic Limp

Sources	**BCH EBG** (limp/irritable hip)**, CHOP Clinical Pathway (septic arthritis),** UpToDate: Approach to the child with a limp, UpToDate: Overview of the causes of limp in children, Kocher MS, Zurakowski D, Kasser JR. Differentiating between septic arthritis and transient synovitis of the hip in children: an evidence-based clinical prediction algorithm. J Bone Joint Surg Am 1999; 81:1662.
Differential Diagnoses	• **"Big Four" inflammatory causes**: Septic Arthritis, Transient Synovitis, Lyme Arthritis, Osteomyelitis • **Other inflammatory causes**: Myositis, Oncologic, Abscess, Appendicitis , JIA • **Non-inflammatory causes**: Toddler's fracture, Legg-Calvé-Perthes disease, Slipped capital femoral epiphysis (SCFE), Overuse injuries (Osgood-Schlatter, Sinding-Larsen-Johansson, Patellofemoral syndromes), Torsion of the testicle , Foot foreign body, Poor shoe fit • **Red flags**: pain at rest, non-weight bearing, pain at night, and pain away from joints; systemic symptoms such as weight loss, fevers; anemia or petechiae
Workup	• **General approach**: exam → XR any suspected joint → if XR negative, consider labs and use Kocher Criteria • **Physical Exam**: ▪ Evaluate for swelling, erythema, fluctuance, point tenderness ▪ Evaluate ROM or pain on ROM ▪ Observe how the child naturally holds the leg ▪ Observe gait ▪ Rule out foreign body on the sole of the foot • **Imaging**: X-ray films • **Labs** (if fever, inability to weight bear, or clinical concern for septic arthritis): ▪ CBC, ESR/CRP, BCx, Lyme Titers • **Kocher Criteria**: ▪ Fever > 38.5 ▪ Non-weight bearing ▪ ESR >40 ▪ WBC >12K **Chance of Infection Based on number of positive Kocher Criteria** 0 — <0.2% 1 — 3% 2 — 40% 3 — 93.1% 4 — 99.6%
Management	**If Kocher criteria >1, consult ortho and consider** ▪ Obvious effusion → tap joint ▪ Irritable hip → hip ultrasound → if effusion, tap joint ▪ If no effusion → MRI to look for osteomyelitis **Analyze Joint Fluid** ▪ Labs: WBC and differential, Gram Stain, Culture ▪ >50k WBC or gram stain positive → treat as septic arthritis ▪ 25k-50k WBC → possible septic joint, could also be Lyme arthritis or synovitis ▪ <25k WBC → transient synovitis
Discharge Criteria	• Non-toxic appearing • Weight bearing, with rare exception • Have discussed cases of diagnostic uncertainty with orthopedics • Reliable caretaker and ability to return if needed • Discharge with: NSAIDs, signs/symptoms warranting return, 24hr follow-up

Animal Bites

Sources	AAP Red Book, UpToDate
Bacteria	• **Cat/Dog**: Pasteurella, anaerobes • **Cat**: Bartonella henselae • **Human**: Strep, Staph, anaerobes, Eikenella

Animal Bites continued on next page →

Animal Bites	
Clinical Presentation	• **Dog**: abrasions, lacerations, puncture wounds, tissue avulsion, or crush injuries • **Cat**: abrasions, scratches, lacerations, or deep puncture wounds • **Human**: bruising, abrasions, lacerations in pattern of human teeth; in adolescents, often occur with closed-fist injury • **Snake**: varies by species, fang marks with evidence of local envenomation (redness, swelling, oozing) or venom spreading (lymphadenopathy, remote swelling, systemic toxicity) • **Rodent**: similar to cat injuries
Workup	• Wound cultures are not indicated in clinically uninfected bite wounds • Gram stain, aerobic/anaerobic wound Cx from the depth of an infected puncture or laceration • Aerobic/anaerobic BCx in patients with an infected bite wound and evidence of systemic infection • Plain films to identify bone or joint disruption in deep bite wounds, or to identify subcutaneous gas and/or bony/soft tissue changes if wound is infected • Head CT for deep bite wounds to the scalp, especially in children <2 yrs of age • For snake bites, urgently consult Poison Control (1-800-222-1222) and toxicology
Management and Treatment	Wound care ▪ Control bleeding, assess neurovascular status ▪ Apply local anesthetics for cleaning and closure ▪ Clean with 1% povidone iodine or 1% benzalkonium chloride and irrigate with copious amounts of saline ▪ Primary closure (laceration repair) if: • Dog bite or other cosmetically important bite (face) • Clinically uninfected • <12 hours old on body, <24 hours old on face • NOT located on hand or foot • Sutures needed for hemostasis ▪ Secondary closure (no repair) for all other bite wounds (i.e. cat or human, puncture wounds, and wounds in immunocompromised hosts) ▪ Do NOT use adhesive to close bite wounds Antibiotic prophylaxis if >8 hours old, deep, crush injury, IC host, face/hand/genitalia wound, close to bone/joint, wound requires closure: ▪ PO: Augmentin, ▪ IV: Unasyn, Zosyn, TMP-SMX+clindamycin ▪ Human: 5-7 days*** ▪ Cat/dog: 7-10 days*** Assess tetanus status ▪ Give tetanus Ig+toxoid if <2 primary immunizations ▪ Give tetanus toxoid if completed primary series but no booster >5 years Rabies prophylaxis for bites by wild animals or if high prevalence of rabies

Brief Resolved Unexplained Event (BRUE)	
Sources	**BCH EBG** (BRUE)**, CHOP Clinical Pathway**
Presentation	Report of 1 or more of the following symptoms that are now resolved: ▪ Cyanosis or pallor ▪ Absent, decreased, or irregular breathing ▪ Marked change in tone ▪ Altered level of responsiveness
Workup	• History of eye deviation, responsiveness, rhythmic movements → consider Neurology consult • New murmur → EKG, CXR → if abnormal, consult cardiology • Family history of long QT syndrome, sudden cardiac or unexplained death in 1st or 2nd degree relative before age 35, unexplained drowning or car accident, sibling with h/o SIDS, ALTE, or BRUE → EKG → if abnormal, consult cardiology • History of paroxysmal cough, pertussis exposure → CBC, pertussis PCR • Weight concern → further workup for FTT as indicated • NAT concern → see Suspected Child Abuse section

Brief Resolved Unexplained Event (BRUE)	
Management and Treatment	• Determine if patient meets low risk criteria: ▪ Age >60 days ▪ Born >or= 32 weeks GA and corrected GA >or= 45 weeks ▪ No CPR by trained provider ▪ Event <1 min ▪ First event ▪ No concerning H&P as above • Low risk → ED observation on continuous CV monitor and pulse ox for at least 1 hour including 2 observed feedings by RN or MD • High risk → Admit to inpatient, continuous CV monitor and pulse ox for at least 6 hours (no more than 24 hours) including 2 observed feedings by RN or MD and 2 sleep/awake cycles • Provide CPR training kit to parents/guardians on discharge

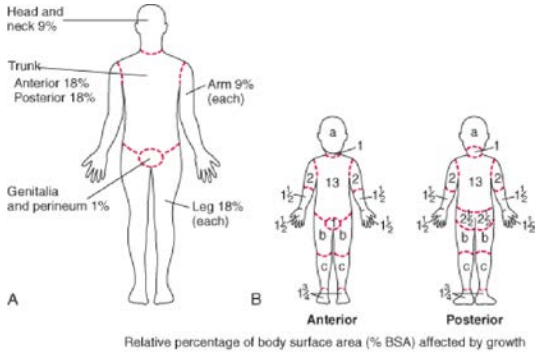
Burns			
Sources	**CHOP clinical pathway**		
Classification	**Definition**	**Symptoms**	**Description/Treatment**
1st degree	Superficial (epidermis)	Erythema, pain	Includes sunburn, minor scalds Does not require fluid replacement; not included in estimate of surface area burned Usually heals without scarring in 3-5 days
2nd degree	Superficial partial thickness	Intense pain Blisters, pink to cherry-red skin, moist, weepy	Nails, hair, sebaceous glands, nerves intact Can progress to deep partial- or full- thickness burns Spontaneous re-epithelialization in 2-3 weeks
	Deep partial thickness	Intense pain Dry and white in color	Disruption of nails, hair, sebaceous glands, nerves Skin grafting may be required based on size
3rd degree	Full thickness	Charred black color ± areas dry or white Pain intense or absent, depending on nerve involvement	Skin grafting required
Pathogenesis	Burn injury → increased capillary permeability → third spacing, edema, fluid loss.		
Estimating Burn Size	• Estimate proportion of total body surface area involved • Rule of 9's for adults and older adolescents: ▪ 9% for each arm ▪ 18% for each leg ▪ 9% for head ▪ 18% for front torso ▪ 18% for back torso • Rule of 9's does not apply to children due to differing body proportions, see modification for children on next page • Palm of child's hand = 0.5% of total body surface area, can use to estimate burn size:		

Burns continued on next page →

Burns

Estimating Burn Size

Modified Lund and Browder chart



Relative percentage of body surface area (% BSA) affected by growth

Body Part	Age 0 yr	1 yr	5 yr	10 yr	15 yr
a = 1/2 of head	9 1/2	8 1/2	6 1/2	5 1/2	4 1/2
b = 1/2 of 1 thigh	2 3/4	3 1/4	4	4 1/4	4 1/2
c = 1/2 of 1 lower leg	2 1/2	2 1/2	2 3/4	3	3 1/4

Workup

- Mechanism of burns (flame, chemical, electrical)
- Closed vs. open space exposure
- Condition of other victims, such as death at the scene
- Duration of exposure
- Associated trauma, such as falls
- Tetanus immunization status
- Always consider non-accidental trauma (See Suspected Child Abuse)

Treatment

- Treatment is based on the depth of burn, proportion of TBSA involved, and if there is airway involvement or other injuries:
  - **Airway**:
    - Assess for signs of inhalation injury or respiratory distress, snoot in nares, carbonaceous sputum, stridor
    - Consider intubation for >30%TBSA burned
  - **Breathing**:
    - Assume carbon monoxide poisoning with severe/closed space burns
    - Assess stability of the airway
    - If airway injury, early intubation (use smaller cuffed ETT than necessary for age given continued swelling that will occur)
  - **Circulation**:
    - For burns >15%BSA or any evidence of inhalation → Parkland formula
    - Initial bolus of 20 cc/kg NS
    - Parkland fluid resuscitation formula: good estimate for losses, but underestimates needs of young children. Provides fluid requirements to be added in addition to normal maintenance fluid requirements
    - [TBSA burned (%)] x [wt (kg)] x [4mL] = total mL resuscitation required over first 24 hrs → Give ½ in 1st 8 hours, remainder in next 16 hrs
- Assess urine output:
  - Urine output <1mL/kg/hr → 20 mL/kg bolus of crystalloid
  - Urine output = 1-3 mL/kg/ht → continue parkland formula
  - Urine output >3 mL/kg/hr →decrease rate to 2/3 Parkland formula
- Pain control: IV narcotic therapy often necessary (can give IM morphine or IN fentanyl prior to placing IV)
- Wound care:
  - Cleanse affected area with lukewarm sterile water.
  - Wipe away loose tissue with sterile gauze
  - Leave unruptured bullae intact (do not rupture)
- Admit if: partial thickness burns of >10% TBSA or > 2% full-thickness burns, hands, joints
- Refer to Shriners for further care: http://www.shrinershq.org/Hospitals/Boston

Cervical Spine Injury

Workup & Treatment	• Place patient in C-collar prior to history and physical
	• Assess for:
	  ▪ Altered mental status or neurologic deficit
	  • If present, obtain lateral c-spine films in collar. Consider CT if high clinical concern for neurologic deficit or severe mechanism of injury
	  ▪ Distracting injuries (any upper torso fracture or other injury that may alter the patient's pain perception)
	  ▪ Midline cervical tenderness
	  ▪ Dangerous mechanism: struck by motor vehicle; motor vehicle crash with rollover, ejection or death of another passenger; diving; fall from greater than 3 feet.
	  ▪ Presiding risk for C-spine injury (e.g. Trisomy 21)
	• If any of the above are present, obtain lateral C-spine film
	• If none of the above are present, defer imaging and remove collar. If pain with active ROM, return patient to collar, obtain cervical spine films
	  ▪ If imaging abnormal, consult orthopedics/neurosurgery
	  ▪ If imaging normal, reassess patient, and if persistent midline neck tenderness, place in long-term C-collar ("Miami J") → refer to spine clinic → usually able to discharge

Deep Neck Space Infections

Peritonsillar Abscess

Sources	**CHOP Clinical Pathway**
Definition	Suppurative collection in tonsils with extension into the peritonsillar space
Epidemiology	Most common in adolescents
Etiology	Polymicrobial, S. pyogenes is most common, less common – anaerobes, S. aureus
Pathogenesis	Pharyngitis → progresses to abscess
Clinical	Fever, pharyngitis, unilateral pain, muffled (hot potato voice), trismus, drooling
Workup	• **History**: Fever duration, neck ROM, PO intake, foreign body, trauma hx, recent ENT surgery, recent abx • **Exam**: Peritonsillar fullness. Drooling, displacement of uvula away from affected side, peritonsillar fluctuance, ipsilateral cervical lymphadenopathy • **Labs**: Not routinely indicated • **Imaging**: Not routinely indicated

Treatment	• Drainage by ORL:
	  ▪ Bedside needle aspiration in older children may be appropriate
	  ▪ Incision and drainage
	• Antibiotics – Clindamycin or Ampicillin-Sulbactam

Complications	Airway obstruction, aspiration PNA, sepsis, jugular vein thrombosis or thrombophlebitis (Lemierre syndrome), carotid rupture, other deep neck space infections, mediastinitis

Parapharyngeal Abscess

Definition	Suppurative collection in the area of the lateral neck from the skull to the hyoid bone.
Etiology	Polymicrobial, S. pyogenes, S. aureus, anaerobes.
Pathogenesis	Spread of infection into lateral aspect of neck from pharyngitis, tonsillitis, parotitis, otitis, mastoiditis and dental infections.
Presentation	Symptoms can be subtle. Fever, pharyngitis, neck stiffness, dysphagia/odynophagia, muffled (hot potato voice) trismus, drooling, respiratory distress or stridor.

Deep Neck Space Infections continued on next page →

Deep Neck Space Infections	
Parapharyngeal Abscess	
Workup	• **History**: Fever duration, neck ROM, PO intake, foreign body, trauma hx, recent ENT surgery, recent abx, chest pain • **Exam**: Induration and swelling below the angle of the mandible, medial bulging of the pharyngeal wall • **Labs**: CBC w/diff, aerobic and anaerobic BCx, rapid strep and throat culture, chem if decreased PO, fluid culture if abscess drained • **Imaging**: ▪ Low suspicion → XR lateral neck → If normal, does not rule out infection ▪ High suspicion → Neck CT with contrast (only way to diagnose parapharyngeal abscess)
Treatment	• Airway compromise → secure airway, emerg. surgical drainage, IV antibiotics • Mature abscess (>2.5 cm2) → surgical drainage + IV antibiotics • Phlegmon → IV antibiotics, re-image in 24-48 hours • Antibiotics: Ampicillin-sulbactam or clindamycin
Complications	See “Peritonsillar Abscess” on previous page
Retropharyngeal Abscess	
Sources	**CHOP Clinical Pathway**, UpToDate: Retropharyngeal infections in children, UpToDate: Peritonsillar cellulitis and abscess.
Definition	Deep neck abscess in the potential space between the posterior pharyngeal wall and the deep cervical fascia ▪ Occurs in young children (<5 years) ▪ Retropharyngeal lymph nodes regress as children age, making RPA unlikely in older children
Etiology	S. pyogenes, S. aureus, anaerobes
Pathogenesis	Spread of infection from nasopharynx via lymph system to retropharyngeal lymph nodes → phlegmon → abscess formation
Presentation	Fever, decreased PO, pharyngitis, drooling, dysphagia, neck stiffness (refusal to extend or pain with neck extension), torticollis, trismus
Workup	• History, Physical, Labs: See “Parapharyngeal Abscess” above • **Imaging** ▪ Low suspicion → XR lateral neck • Greater than 7 mm at C2 (roughly ½ the width of the vertebral body) or 14 mm at C6 in children • Greater than 22 mm at C6 in adults ▪ High suspicion → Neck CT with contrast
Treatment	• Airway compromise → secure airway, emergency surgical drainage, IV antibiotics • Mature abscess (>2.5 cm2) → surgical drainage + IV antibiotics • Phlegmon → IV antibiotics, re-image in 24-48 hours • Antibiotics: Ampicillin-sulbactam or clindamycin
Complications	See “Peritonsillar Abscess” on previous page

Dehydration	
Sources	**BCH EBG** (Gastroenteritis), **CHOP Clinical Pathway**
Definition	• Dehydration = cellular water loss • Hypovolemia or volume depletion = reduced effective circulating volume

Dehydration

Presentation

- Mottled cool extremities, sunken fontanelle in infants, receded eyes, hyperpnea; sensorium usually remains intact until moderate dehydration; weak cry or stupor suggests shock
- Symptoms of underlying etiology will be present (diarrhea, fever, etc.)
- Regarding dehydration specifically, fussiness, thirst, and lethargy may be present
- See table below for additional physical examination findings.

Physical Findings of Volume Depletion

Findings	Mild (3-5%)	Moderate (6-9%)	Severe (>10%)
Pulse	Full, normal rate	Rapid	Rapid/weak/absent
Systolic Press.	Normal	Normal to low	Low
Respirations	Normal	Deep (rate ↑)	Deep, tachypnea
Buccal mucosa	Tacky/slightly dry	Dry	Parched
Ant. fontanelle	Normal	Sunken	Markedly sunken
Eyes	Normal	Sunken	Markedly sunken
Skin turgor	Normal	Reduced	Tenting
Skin	Normal	Cool	Cool/mottled
Urine output	Normal/mildly dec	Markedly reduced	Anuria
Systemic signs	Increased thirst	Listlessness	Grunting, coma

Differential

- ↑ output (gastroenteritis (most common), diabetes mellitus, diabetes insipidus)
- ↓ intake (gingivostomatitis, viral or bacterial pharyngitis, nausea/vomiting)
- ↑ insensible losses/metabolic demand (bacterial infections with fever such as PNA, meningitis, UTI)

Workup

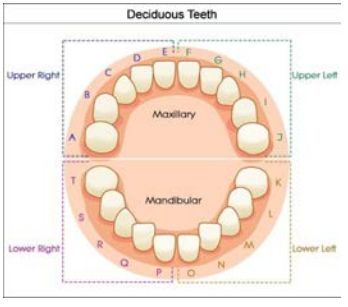
- Important to establish degree of dehydration: mild (3-5%), moderate (6-9%), or severe (>10%) to guide therapy
- BCH/CHOP guidelines provide an **Assessment Tool**
  - 10-point (1 point each):
    - Ill-appearing or decreased activity
    - Tachycardia for age
    - Tachypnea or abnormal respirations
    - Decreased urine output
    - Sunken eyes
    - Decreased or absent tears
    - Dry mucous membranes
    - Abnormal pulses
    - Cap refill >2 sec
    - Decreased skin turgor
  - Scoring: <3 = mild, 3-6 = moderate, >6 = severe
- **Labs**
  - Mild or moderate dehydration → may not require laboratory testing
  - Moderate or severe dehydration → D-stick, chemistry, UA (for urine spec grav)
  - Serum bicarbonate (<17 mEq/L cutoff) most helpful in differentiating moderate-to-severe hypovolemia from mild

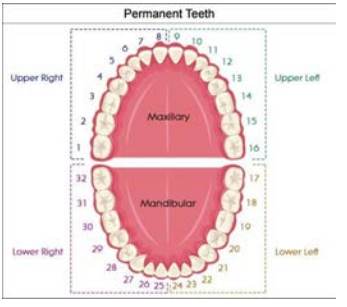
Treatment

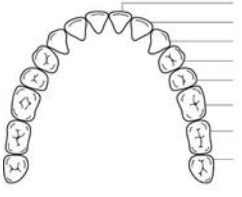
- **Mild**: Initiate oral rehydration therapy (ORT)
  - 5-10 mL every 3-5 minutes via bottle, cup, syringe
- **Moderate**: Initiate ORT, consider IVF
  - Similar outcomes but fewer complications and higher satisfaction with ORT in RCTs comparing IV fluids and ORT groups
  - If ORT fails → obtain D-stick* → 2x 20 mL/kg NS boluses -OR- 20 mL/kg D5NS bolus + 20 mL/kg NS bolus → start 1.5-2x mIVF → transition back to ORT as tolerated
- **Severe**: Initiate IVF
  - Goal 40 mL/kg total within 1 hour: obtain D-stick* → 2x 20 mL/kg NS boluses -OR- 20 mL/kg D5NS bolus + 20 mL/kg NS bolus → start 1.5-2x mIVF
  - Consider alternative diagnosis (septic shock) if persistent hemodynamic abnormalities after 60 mL/kg
- **ORT failure**:
  - >1 emesis despite ondansetron
  - Refusal to drink for >30 min
  - No improvement in Dehydration Score, VS despite child drinking
- **Ondansetron** (available in liquid, oral-disintegrating, or tablet forms)
  - 8-15kg = 2 mg PO
  - 15-30 kg = 4 mg PO
  - 30 kg = 8 mg PO

***Best practice is to first obtain a D-stick, as DKA may present with moderate-severe dehydration, can mimic gastroenteritis, and may be worsened with administration of glucose

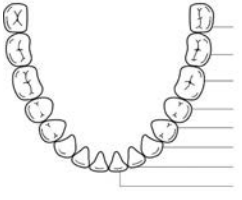
Dental Emergencies



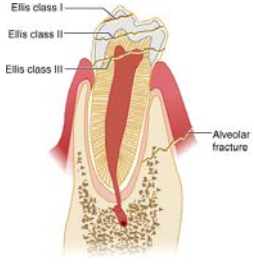




Upper Teeth	Erupt
Central incisor	7-8 yrs.
Lateral incisor	8-9 yrs.
Cuspid (canine tooth)	11-12 yrs.
First bicuspid	10-11 yrs.
Second bicuspid	10-12 yrs.
First molar	6-7 yrs.
Second molar	12-13 yrs.
Third molar (wisdom tooth)	17-21 yrs.



Lower Teeth	Erupt
Third molar (wisdom tooth)	17-21 yrs.
Second molar	12-13 yrs.
First molar	6-7 yrs.
Second bicuspid	10-12 yrs.
First bicuspid	10-11 yrs.
Cuspid (canine tooth)	11-12 yrs.
Lateral incisor	8-9 yrs.
Central incisor	7-8 yrs.



Avulsion	The tooth is completely displaced from the alveolar ridge; the periodontal ligament is severed, and fracture of the alveolus may occur.
Fracture	• **Infraction**: cracked tooth • **Enamel only (Ellis I - uncomplicated)**: tooth chipped, pain absent but may be elicited with manipulation. • **Enamel and dentin (Ellis II - uncomplicated)**: tooth chipped with exposed dentin, sensitive to touch and temperature. • **Complicated crown fracture (Ellis III - complicated)**: exposure of the pulp and central artery, increased risk of infection. • **Root fracture**: May not also involve the crown. If the crown is not involved, root fracture suggested by mobility of the crown • **Alveolar fracture**: causes dislocation of multiple teeth that move with palpation.
Luxation Injuries	Involve the supporting structures of the teeth, including the periodontal ligament and alveolar bone • **Concussion**: The tooth is neither loose nor displaced; it may be tender with the pressure of biting because of inflammation of the periodontal ligament. • **Subluxation**: The tooth is loose, but not displaced from its socket; the periodontal ligament fibers are damaged and inflamed. • **Intrusion**: The tooth is driven into the socket, compressing the periodontal ligament and fracturing the alveolar socket. • **Extrusion**: The tooth is centrally dislocated from its socket; the periodontal ligament is lacerated and inflamed. • **Lateral luxation**: The tooth is displaced anteriorly, posteriorly, or laterally; the periodontal ligament is lacerated, and the supporting bone is fractured.

Dental Emergencies	
Workup	• Determine if tooth is primary or permanent • Indication for urgent Dental consult Avulsed permanent tooth (after reimplantation whenever possible) ▪ Extrusion >3 mm or interfering with bite ▪ Laterally luxated (displaced) teeth that interfere with bite (if not interfering with bite, will often spontaneously revert) ▪ Intruded primary teeth ▪ Fractured teeth when dental pulp is exposed (bleeding from central core of tooth) ▪ Suspected dental root or alveolar fracture (e.g. tooth mobility, pain out of proportion when tooth is wiggled) ▪ Suspected jaw fracture (posterior tooth fracture, jaw tenderness, and/or malocclusion) to obtain panoramic radiographs • Imaging: consider XR to search for swallowed or buried (in laceration) tooth
Treatment	• Reimplantation (while awaiting arrival of dental team…) ▪ Avulsed permanent teeth should be reimplanted immediately, ideally within 15 minutes and up to one hour ▪ Store in cold milk or saliva if unable to reimplant ▪ Handle the tooth carefully by the crown to prevent damage to the periodontal ligament ▪ Remove debris by gentle rinsing with saline or tap water; do not attempt to sterilize or scrub the tooth ▪ Reimplant manually ▪ Keep the tooth in place by having the child hold it or bite on a gauze pad or clean towel. • Uncomplicated fracture of permanent tooth: ▪ Store tooth fragments in tap water to prevent discoloration ▪ Dental follow-up within a few days to bond fracture piece or smooth a fracture • Other injuries (infraction, concussion, subluxation) warrant outpatient dental referral • General aftercare ▪ Soft diet for up to 10 days and limit sucking (pacifier or digit) ▪ Continue brushing with a soft-bristled toothbrush ▪ Avoid flossing until healing has occurred ▪ Chlorhexidine mouthrinse for luxation of permanent teeth ▪ Tetanus prophylaxis, for dirty wounds, avulsed teeth, deep lacerations, or marked luxation injuries

Epistaxis	
Sources	Messner AH. Management of epistaxis in children. In: UpToDate, Post TW (Ed), UpToDate, Waltham, MA. (Accessed on January 25, 2016.) Acknowledgements: Ali Baker
Pathogenesis	The anterior nasal septum is highly vascularized (Kiesselbach's plexus) and is subject to exposure due to location.
Etiology	• Trauma (including nose-picking) • Mucosal irritation: allergic rhinitis, viral URI, dry environment • Tumor: nasopharyngeal angiofibroma, pyogenic granuloma, papilloma • Vascular abnormality • Coagulopathy • Inflammatory: Granulomatosis with polyangiitis (GPA), formerly called Wegener's
Clinical Presentation	• Active bleeding or dried blood • Nasal mucosa: may be dry, cracked, pale, boggy, or have prominent vessels • If there is active bleeding, look for vessels involved • Exclude masses, polyps, foreign bodies • Exclude underlying bleeding disorder: ecchymosis, petechiae
Workup	No studies are routinely required • Hematologic and coagulation studies if history suggests personal or family history of bleeding disorder • CT or MRI if malignancy is suspected

Epitaxis continued on next page →

Epistaxis

Treatment	• Sustained pressure on nostrils/anterior plexus • Apply local vasoconstrictor: phenylephrine (0.25%) or oxymetazoline (0.05%, Afrin) • Anterior nasal packing • ORL consult for severe epistaxis • Chemical cautery (silver nitrate) or electrocautery of actively bleeding vessel

Febrile Infant

Sources	**BCH EBG** (FUO, Fever 0-1 months, Fever 0-90 days, Fever 1-2 months, Fever/UTI 2-24 months), **CHOP clinical pathway**		
Pathogenesis	The anterior nasal septum is highly vascularized (Kiesselbach's plexus) and is subject to exposure due to location.		
Definition	Temperature ≥38.0 (100.4 C) in infant ≤90 days Temperature ≥38.5 (101.3 C) in child >3 months		
Etiology	• Rates of serious bacterial infection (SBI) in febrile infants/young children range from 7-38% of infants aged 0-28 days seen in emergency department for fever. • UTI is the most common (5.9%), followed by bacteremia (1%), meningitis (0.3%).		
Pathogenesis	• **Bacterial**: UTI, pneumonia, bacteremia, meningitis, enteritis, osteomyelitis • **Viral**: Enterovirus, HSV, influenza, RSV, rotavirus, aseptic meningitis • **Neonate**: (within first 7 days of life) often vertical transmission • **Less common**: recent immunizations, malignancy, medications (antibiotics, antineoplastic drugs, biologics), immunological (Kawasaki), immunodeficiency (HIV, SCID, humoral deficiency), hereditary autoinflammatory syndromes of periodic fever, other periodic fever syndromes		
Most Common Pathogens by Age	**Age**	**Bacteremia/Meningitis**	**Other pathogens**
	0-28 days	Group B Strep Gram negative enterics (E. coli, Klebsiella) Listeria	HSV Conjunctivitis: Ghonorrhea, Chlamydia, S. aureus Pneumonia: Chlamydia, S. aureus Diarrhea: Salmonella
	28-90 days	GBS (Late onset) Gram negative enterics Strep Pneumo H. flu N. meningitides	Pneumonia: Chlamydia, Staph aureus, Pertussis, RSV and other viruses Diarrhea: Salmonella
	3-36 mos	Strep Pneumo H. flu N. meningitides	UTI: E. coli, other GNR, enterococcus
Clinical Presentation	• **Non-specific symptoms**: poor feeding, lethargy or irritability. They may have hypothermia instead of fever • **History**: Full pre- and perinatal history including, GBS status, need for intrapartum antibiotics, evidence of maternal HSV or other infections • **Physical exam**: bulging fontanelle (Meningeal signs unlikely in infants), respiratory distress or focal lung findings, conjunctivitis, oral lesions, vesicles, cellulitis, rash, vomiting, diarrhea, swelling of a joint or extremity • Otitis media/URI symptoms, if present, do not preclude need for further eval.		
Treatment	• Empiric therapy while awaiting culture results (see below table) • In patients with positive UA or cultures, therapy should be tailored appropriately		

Febrile Infant

Empiric Antibiotic Treatment Based on Age	Age	Empiric Antibiotics	Other antigens to consider
	<or=14 days	Ampicillin + Cefotaxime	Gentamicin can replace Cefotaxime Add acyclovir if CSF pleocytosis or ill-appearing
	15-28 days	Ceftriaxone (50 mg/kg)	Add ampicillin and acyclovir if CSF pleocytosis or ill-appearing Meningitic dose (100 mg/kg/day) if CSF pleocytosis
	>29 days	Ceftriaxone	Meningitic dose if CSF pleocytosis Consider vancomycin if suspicion for pneumococcal meningitis

Foreign Body Aspiration

Sources	**No BCH EBG, No CHOP pathway**
Presentation	• In acute period, children may have chest pain, wheezing, cough, resp distress • In subacute/chronic period after aspiration, children may present with pneumonia (often in the RML as a result of right main-stem FB aspiration)
Workup	• Physical Exam: ▪ Stridor, hoarseness, inspiratory wheeze suggest upper airway location (wheeze may be monophonic and focal) ▪ Asymmetric lung aeration and/or focal decreased breath sounds suggest lower airway location • Diagnostic Studies: ▪ AP and Lateral CXR and soft tissue neck films ▪ Expiratory film or lateral decubitus films if lower airway location is suspected (air trapping seen in obstructed lung)
Management	• If complete upper airway obstruction present, perform back blows (child <1 yr of age) or Heimlich maneuver (child >1 yr of age) to dislodge object → PALS Blind/finger sweeping of the mouth should be avoided • Consult Ear-Nose-Throat (ORL) or general surgery for flexible or rigid bronchoscopy in all cases of suspected foreign-body aspiration to visualize the trachea and bronchi and remove object if seen

Foreign Body Ingestion

Sources	**CHOP clinical pathway**
Pathogenesis	• Average GI transit time is 3.6 days • **Anatomical narrowings**: cricopharyngeus muscle, aortic crossover of esophagus, lower esophageal sphincter, pylorus, duodenal sweep, ileocecal junction ▪ Objects > 25 mm diameter unlikely to pass pylorus ▪ Objects > 6 cm length unlikely to pass duodenal sweep • **Button batteries**: caustic injury from high pH → injury at anode (narrow portion) of batter → stricture formation (can happen within 2 hours) → aortoenteric fistula is feared complication • **Magnets**: Multiple in different bowel segments can adhere and erode through bowel wall causing perforation
Presentation	Depends on age, location, and nature of FB • **Esophagus**: refusal to eat, dysphagia, drooling, respiratory symptoms • **Stomach**: asymptomatic unless causing gastric outlet obstruction • **Intestine**: asymptomatic unless retained/obstructing, dependent on location
Workup	• Start with XR AP single view neck, chest, abdomen • XR lateral for coins, battery, magnet OR if esophageal or unknown location

Foreign Body Ingestion continued on next page →

Foreign Body Ingestion

Treatment

Depends on symptoms, location, and nature of FB. General principles:

- **Button batteries**: EMERGENT GI/surgery consult, urgent endoscopic removal if esophageal or gastric, otherwise admit and close observation with serial XRs
- **Blunt objects** (e.g. coins): GI/surgery consult if symptomatic, non-urgent endoscopic removal if esophageal, otherwise observation (consider admit vs. outpatient f/u)
- **Sharp objects**: GI/surgery consult if symptomatic, urgent endoscopic removal if esophageal or gastric, otherwise admit and close observation with serial XRs
- **Magnets**: 1 magnet? → treat like blunt object; 2 magnets? → remove if gastric or proximal, otherwise admit and close observation with serial XRs
- **Food Impaction**: GI consult, consider glucagon, urgent endoscopic removal with biopsies to evaluate for EOE

Laceration Repair

Equipment

- **Basics**: light, mask, sterile gloves & gown, betadine (or other cleansing solution)
- **Irrigation**: sterile bowl, sterile water, 20-50 cc syringes with splash guard (all except water come in irrigation kit)
- **Local anesthesia** or digital block
- **Suture tray** (sterilized and packaged together): forceps, scissors, needle holder, hemostats, sterile gauze
- **Suture material**: Nonabsorbable sutures (monofilament nylon, polypropylene) vs. Absorbable sutures (Vicryl, fast absorbing gut -- use for deep wounds and in small children when suture removal would be just as traumatic as placement
  - Sole of foot or over large joints (knee): 4-0 or 3-0
  - Scalp, trunk, extremity: 4-0; Face: 6-0 or 5-0
- **Alternatives to sutures**: Dermabond (tissue adhesive) +/- Steri-Strips: use for linear wounds with minimal tension. No removal needed. Staples: Best for scalp wounds. Requires remover.

Table 7. Suture Selection.

Face	5-0 to 6-0
Scalp	3-0 to 5-0
Chest	3-0 to 4-0
Back	3-0 to 4-0
Abdomen	3-0 to 4-0
Extremities	4-0 to 5-0
Joints	3-0 to 4-0
Oral	3-0 to 5-0 *absorbable*

General Technique

1. Set-up your equipment
2. Local anesthesia
   - LET gel (lidocaine, epinephrine, tetracaine) – apply for 15-20 minutes (surrounding skin should be blanched)
   - 1% lidocaine (10mg/mL): onset 2-5 minutes, lasts 15-20 minutes. Toxic dose 5mg/kg (0.5cc/kg)
   - 1% lidocaine with epinephrine (1:200,000): onset 2-5 minutes, duration ~60 minutes. Do not use in digits, penis, pinna, tip of nose
   - Use buffered lidocaine if available (buffered with sodium bicarbonate)
3. Conscious sedation if needed
4. Wound preparation: Expose, explore (for foreign bodies), irrigate, clean periphery
5. Suture/Close
   - **Simple interrupted** - most common stitch, closes superficial layer
   - **Deep subcutaneous** - reduces tension of deep wounds
   - **Buried horizontal dermal** - closes deep layer in shallow lacs
   - **Horizontal/vertical mattress**- reinforce SC tissue, relieves wound-edge tension
   - **Corner stitch** - repair flap-type, corner lacerations

Laceration Repair

General Technique cont.

6. Clean and dry: Apply topical antibiotic ointment and cover with dry sterile gauze
   - **Tetanus prophylaxis:** if have not received tetanus prophylaxis in preceding 5 years or if they have not finished primary series.
   - **Antibiotic prophylaxis:** if wound is a bite wound, there is exposed cartilage/joint, or a contaminated wound (esp. on plantar surface)

Table 5. Timing of Suture or Staple Removal

Wound location	*Timing of removal (days)*
Face	3 to 5
Scalp	7 to 10
Arms	7 to 10
Trunk	10 to 14
Legs	10 to 14
Hands or feet	10 to 14
Palms or soles	14 to 21

Mild Traumatic Brain Injury (Concussion)

Sources	**BCH Minor Head Trauma EBG**
Definition	• Traumatic brain injury induced by biomechanical forces; may be caused by direct blow to head/face/neck or blow causing impulsive force transmitted to the head • Neuropathologic changes may result, but these reflect a functional disturbance (no changes on neuroimaging) • Patient must present with history or physical exam signs of minor head injury AND • In children < 2 years: be alert or awaken to voice or light touch • In children ≥ 2 years: have normal mental status, normal neurologic exam, and no evidence of skull fracture
Pathogenesis	• Linear forces: acceleration/deceleration injuries. Less likely to cause LOC, more commonly cause skull fractures, intracranial hematoma, cerebral contusion • Rotational forces: commonly cause LOC, associated with diffuse axonal injury and concussion
Presentation	• Likely indicators of concussion (any/all of below) ▪ Disorientation or confusion immediately after the event ▪ Impaired balance within 1 day after injury ▪ Slower reaction time within 2 days after injury ▪ Impaired verbal learning and memory within 2 days after injury • Signs/symptoms: broad range, categorized within somatic, vestibular, oculomotor, cognitive, emotional/sleep ▪ Headache most common > dizziness > difficulty concentrating > confusion • Loss of consciousness NOT necessary for diagnosis of concussion
Workup	• History: Mechanism of injury, loss of consciousness, whether infant cried immediately, seizure activity, level of alertness after injury, headache, vision changes, and vomiting. • Physical: Full neurological exam, scalp abnormalities (hematoma, tenderness or depression), signs of basilar skull fracture (e.g. periorbital ecchymosis, Battle's sign, hemotympanum, CSF otorrhea or rhinorrhea), bulging fontanelle in infants. • **Use a post-concussion symptom checklist** at time of evaluation - both for facilitating history and tracking recovery (different checklists available based on age of patient)

MTBI (Concussion) continued on next page →

Mild Traumatic Brain Injury (Concussion)

Workup cont.

- PECARN algorithm to determine need for imaging:
  - **For children less than 2 years:**
    - Any altered mental status or palpable skull fracture
    - *Other considerations
      - Non-frontal scalp hematoma
      - LOC ≥5 seconds
      - **Severe mechanism of injury
      - Acting abnormally per parent
  - **For children 2 years and older:**
    - Any altered mental status or signs of a basilar skull fracture (retro-auricular or periorbital bruising, CSF otorrhea or rhinorrhea, hemotympanum)
    - *Other considerations:
      - Any loss of consciousness
      - History of vomiting
      - **Severe injury mechanism
      - Severe headache

* If 1-2 of above is present, monitor 4-6 hours and obtain head CT if symptoms worsen or don't improve; If ≥3 above are present, head CT is recommended; If none is present, head CT not recommended

**Severe mechanism of injury: Motor vehicle crash with patient ejection, death of another passenger or rollover, pedestrian or bicyclist without helmet struck by motorized vehicle, falls (>3 feet children < 2 years or > 5 feet for children ≥ 2 years) or head struck by high impact object.

Treatment

- Intracranial injury or depress, basilar, diastatic skull fx → NSGY consult & admit
- Simple skull fx (i.e <3 mm, non-depressed, single bone) → consider admit if young (<6 mo), d/c home if normal mental status, able to PO, no social concern
- Dx of concussion with negative imaging:
  - DO NOT return to play same day, risk of second-impact syndrome (2nd injury before full recovery → possible cerebral vascular congestion → diffuse cerebral edema)
  - Physical rest: avoid "bed rest," but limit activity to level that does not provoke/increase sx
  - Cognitive rest: academic adjustments as needed to reduce symptom exacerbation
  - **Complete cognitive rest and avoidance of screen time NOT recommended**
  - PT for patients suffering from vestibular or oculomotor dysfunction
  - No sports until asymptomatic and cleared by a physician, emphasize individualized course, warn of possible persistent symptoms beyond 1 month (See *Graduated Return-to-Sport Program*)
  - Refer if: Symptoms > 4 weeks, lack of progression, confounding by coexisting conditions

Graduated Return-to-Sport Program

	Aim	Activity	Goal
1	Symptom-limited activity	Daily activities that do not provoke symptoms	Gradual reintroduction of work and/or school activities
2	Light aerobic exercise	Walking or stationary cycling at slow-to-medium pace; no resistance training	Increase heart rate
3	Sport-specific exercise	Running or skating drills; no activities with risk of head impact	Add movement
4	Noncontact training drills	Harder drills (eg, passing drills and team drills); may begin progressive resistance training	Exercise, coordination, and increased thinking during sport
5	Full-contact practice	After medical clearance, participate in full, normal training activities	Restore confidence and allow coaching staff to assess functional skills
6	Return to sport	Normal game play	Full clearance/participation

Recommend **48 hr of relative physical and cognitive rest before beginning the program**. No more than 1 step should be completed per day. If any symptoms worsen during exercise, the athlete should return to the previous step. Consider prolonging and/or altering the return-to-sport program for any pediatric and/or adolescent patient with symptoms over 4 wk.

Sexual Assault (<12 yo)	
Sources	**BCH EBG, CHOP Clinical Pathway, UpToDate**
Workup	Medically cleared? ▪ Consider trauma or GYN eval ▪ Work up altered medical status Occurred <72 hours: ▪ **Do not interview the child → defer interview and GU exam** ▪ Document parent/guardian statements only ▪ Child's spontaneous statements documented as quotes in evidence kit ▪ Urgently consult CPT, Social Work, Children's Advocacy Center ▪ Forensic evidence collection by ED provider using pediatric kit if patient consents ▪ Baseline testing (discuss with CPT): Urine NAAT for Gonorrhea/Chlamydia/Trichomonas, RPR, Hep B Core Ab, Hep B Surface Ab/Ag, Hep C Ab, HIV-1/2 Combo Ag/Ab, urine HCG for pubertal females ▪ File 51A (with Social Work) Occurred >72 hours: ▪ Complete history and physical exam, if patient/family consent ▪ Consult Social Work ▪ Baseline testing (see above) ▪ File 51A (with Social Work)
Treatment	• Urine NAATs require confirmation prior to treatment with antibiotics • Pre-pubertal children should NOT receive STI prophylaxis • Update Hep B, tetanus vaccines as needed • Emergency contraception (if urine HCG negative): ▪ 0-72 hours: Levonorgestrel (Plan B) 1.5 mg PO once ▪ 72-120 hours: Ulipristal (Ella) 30 mg PO once (if no unprotected sex to 10 days prior and no hormonal birth control for 5 days after) • Determine need for HIV PEP (see Clinical Pathway)

Sexual Assault (>12 yo)	
Sources	**BCH EBG, CHOP Clinical Pathway**
Workup	Medically cleared? ▪ Consider trauma or GYN eval ▪ Work up altered medical status Occurred <120 hours (5 days): ▪ Ask for patient consent to receive SANE (Sexual Assault Nurse Examiner) services: 617-647-0710 (BARCC also paged simultaneously) ▪ Forensic evidence collection by SANE or ED provider if patient consents ▪ Urine HCG for all females ▪ STI testing (if patient consents): Urine NAAT for Gonorrhea/Chlamydia/Trichomonas, RPR, Hep B Core Ab, Hep B Surface Ab/Ag, Hep C Ab, HIV-1/2 Combo Ag/Ab Occurred >120 hours (5 days) ago: ▪ Contact Social work ▪ Call BARCC (Boston Area Rape Crisis Center): 617-492-7273 ▪ File 51A (with Social Work)
Treatment	STI prophylaxis: ▪ Gonorrhea + Chlamydia (ceftriaxone 250mg IM x1, azithromycin 1g PO x1) ▪ Trichomonas (metronidazole 2g PO x1) Emergency contraception (if urine HCG negative): ▪ 0-72 hours: Levonorgestrel (Plan B) 1.5 mg PO once ▪ 72-120 hours: Ulipristal (Ella) 30 mg PO once (if no unprotected sex to 10 days prior and no hormonal birth control for 5 days after) Determine need for HIV PEP (see Clinical Pathway)
Discharge Planning	Contact PCP if patient consents, discuss need for CPT and Child Advocacy Center f/u, ensure appropriate HIV PEP meds/scripts and f/u plan if necessary, use BCH custom d/c instructions

Suspected Child Abuse	
Sources	**No BCH EBG; CHOP clinical pathway**
Presentation	**Skeletal injuries** • Long bones: epiphyseal/metaphyseal fracture seen as “bucket handle” or “corner fracture” at the end of long bones, spiral fractures • Ribs: posterior nondisplaced rib fractures due to squeezing of the rib cage (may not be visible on plain film until callus formation) • Skull: fractures >3mm wide, complex fractures, bilateral fractures, non-parietal fractures. These suggest forces greater than those sustained from minor household trauma **Bruises** • Unusual/protected areas (chest, abdomen, back, buttocks) • Patterned • Multiple bruises or bruises in different stages of healing, do not fit the history and developmental stage **Burns** • Multiple burn sites • Well-demarcated edges • Stocking/glove distributions • Absence of splash marks • Symmetrically burned buttocks or lower legs **Head trauma** • Subdural hematomas • Retinal hemorrhages • Skull fractures (see above)
Workup	• Consult CPT, Social Work • Skeletal survey (<2yo) • Noncontrast head CT: good for intracranial hemorrhage and skull fractures • Brain MRI: If asymptomatic • Dilated indirect ophthalmoscopy exam for retinal hemorrhages • Bone health labs (if fractures): Ca, Mg, Phos, Alk Phos, intact PTH, 25 Hydroxyvitamin D • Bleeding disorders labs (if bruising/bleeds): PT/PTT,consider vWF, Factor VIII, IX

Syncope	
Differential	• Common conditions ▪ Vasovagal ▪ Breath holding spells ▪ Orthostatic hypotension ▪ Toxic exposure • Life-threatening ▪ Arrhythmias: ventricular arrhythmias, long QT syndrome (LQTS), Brugada syndrome, catecholaminergic polymorphic ventricular tachycardia (CPVT), congenital short QT syndrome, pre-excitation syndromes such as WPW (which can lead to SVT with a rapid ventricular response) ▪ Structural: hypertrophic cardiomyopathy, severe aortic stenosis, coronary artery anomalies, arrhythmogenic right ventricular cardiomyopathy (ARVC), dilated cardiomyopathy ▪ Acute myocarditis ▪ Pulmonary hypertension ▪ Vasovagal (neurocardiogenic) ▪ Heat illness ▪ Anaphylaxis • Other: hypoglycemia, SVT, bradycardia, POTS
Workup	• History and physical exam ▪ Precipitating factors: exercise, acute arousal, postural change, pain or emotion for ▪ Description of event ▪ Past medical history ▪ Family history of early cardiac death (<50 years), arrhythmias, cardiomyopathy, sudden drownings or unexplained car accidents ▪ Exam: orthostatic vitals

Syncope	
Workup cont.	• Labs and imaging ▪ EKG ▪ D-stick if recent syncope ▪ Hematocrit if risk for anemia ▪ Toxicology screens for suspected exposures ▪ Urine pregnancy test for postmenarchal women ▪ Consider chemistry, thyroid testing • Suspect neurologic etiology? → consider neurology consult/referral, EEG, neuroimaging • Suspect cardiac etiology? → consider cardiology consult/referral, echocardiogram, ambulatory EKG monitoring

Trauma		
ATLS	Primary Survey ▪ Assessment of **ABC**: **A**irway, **B**reathing, **C**irculation ▪ **D**isability/neurologic assessment: AVPU (alert, verbal stimuli response, painful stimuli response, unresponsive; pupil size, symmetry, reactivity) ▪ **E**xposure and environmental control: undress patient completely, take precautions to prevent hypothermia	
Secondary Survey	**Definition**	Head to toe assessment, including history and full physical exam
	Head	Any scalp/skull injury, periorbital or post-auricular bruising
	Eye	• Corneal reflex • Fundoscopic exam
	Neck	• C-spine tenderness or deformity • Trachea midline • Hematoma • Bruit
	Chest	• Clavicle deformity or tenderness • Breath sounds, heart sounds • Chest wall symmetry, paradoxical movement, rib deformity, fracture
	Abdomen	• Serial exams to evaluate tenderness, distension, ecchymosis • Shoulder pain suggests subdiaphragmatic process • Orogastric aspirates with blood or bile • Splenic laceration suggested by left upper quadrant rib tenderness, flank pain, flank ecchymoses, “seatbelt sign”
	Pelvis	Tenderness, symmetry, deformity, stability
	GU	• Laceration, ecchymoses, hematoma, bleeding • Rectal tone, blood, displaced prostate • Blood at urinary meatus → don’t catheterize, suggests urethral injury
	Back	Evaluate for step offs along spinal column, tenderness
	Extremities	• Neurovascular: pulse, perfusion, pallor, paresthesias, paralysis, pain • Motor/sensory exam
	Skin	Lacerations, abrasions, contusions

Rotation Specific Entities	
BMC	Black binder in work room contains all clinical practice guidelines/approaches
BWH	All clinical practice guidelines are available online via BWH PikeNotes

Gestational Age					
Early Preterm*	**Late Preterm****	**Early Term**	**Full Term**	**Late Term**	**Postterm**
< 34 0/7	34 0/7 - 36 6/7	37 0/7 - 38 6/7	39 0/7 - 40 6/7	41 0/7 - 41 6/7	42 0/7 +

* Use Fenton growth chart for late preterm. If between 37 0/7 and 37 6/7, chart on Fenton, Olsen and WHO and take better number.
** **"Great pretenders"** - ↑ risk of resp distress, apnea, temp. dysregulation, poor feeding.

Normal Infant Feeding

- All babies typically lose up to 2-3% of BW/day, no more than 10-12% down from BW before discharge. Babies born by c-section may lose more weight than vaginal births (Mom and therefore baby get IV fluids during delivery). Usually start gaining on DOL4. Baby should regain BW by 10-14 days and should gain 20-30g/day for first month, or 5 oz per week ("an ounce a day and time off for weekends").
- Babies usually awake for first 5-6 hrs and then sleepy for 24 hrs. Start waking up on DOL2 and are hungry. Sometimes if baby is not getting enough with feeds, shuts down and appears sleepy.

Breastfeeding

Newborns who are **breastfed need to eat every 2-3 hours,** on demand. If showing hunger cues, feed. It's never too soon. No such thing as newborn "using mother as a pacifier." Cluster feeding (at breast for several hours) happens on Day 2-3, as baby tries to get milk to come in. Mother tired and frustrated. Baby hungry and frustrated. Parents need reassurance that this is NORMAL.

Breastfeeding Tips

- Respond to **infant feeding cues** (early → late: stirring, turning head, mouth opening, hand in mouth, stretching, crying). Skin-to-skin contact to encourage milk production (milk usually come in in 3-5 days). Hand expression especially for colostrum. Can feed to baby via spoon or syringe. Hand-express milk if engorged.

Normal Infant Feeding

Breastfeeding

Breastfeeding Tips cont.

- **Infant latch**: Line up baby nose to nipple. Stroke baby lips with nipple. Aim nipple to roof of baby's mouth. Support baby's neck at the shoulders so head tips back and b**ring baby onto breast (not breast to baby).**
  - Signs of a good latch: lips flanged outward, **most of areola hidden** in mouth, nose free.
  - Breast milk can sit out 8h if freshly pumped, or 5 days in refrigerator.
- For determining if mom's meds are safe during breastfeeding: **LactMed** (part of NIH ToxNet), **Hale's Medications & Mother's Milk** (physical book in BMC workroom or HalesMeds.com. Physical book in BWH nursery)

Contraindications to breastfeeding

Absolute: infant w/galactosemia, mom w/**HIV** or HTLV-1/2, mom actively using **illicit drugs, including marijuana or EtOH** (exception: moms in methadone program, see "NAS"), HSV lesion on breast. OK to feed expressed milk: mom w/varicella or active Tb.

Mothers can hand express and/or pump to stimulate milk production. Holding baby skin to skin also stimulates because of hormone release. Expressed breast milk can sit out 8h if freshly expressed, or 5 days in refrigerator.

Formula Feeding

- Formula fed babies eat **every 3-4 hours** (if sleeps > 4 hours, wake baby up). Infant stomach is size of a blueberry on DOL1 → apricot at DOL7. Volume increases gradually over first several days. DOL1: 10-15 mL per feed, DOL2: 15-30 mL/feed; DOL3: 30-45 mL/feed, DOL4: 45-60 mL/feed. Give baby what last took and if not settled, feed more. Follow baby's cues.
- Formula, in 60 mL bottles as supplied by hospital, needs to be consumed within 1 hour of starting the feed and then discarded.

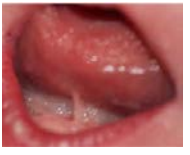
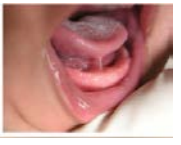
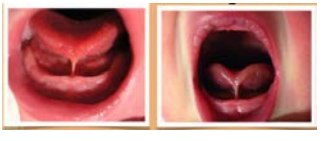
Tongue Ties

Type	Exam	Image	Mgmt
Normal	• Tongue appears flat and broad • Tongue extends over bottom teeth • Can swipe finger under tongue uninterrupted	N/A	N/A
Type I: Mild	Posterior tie on tongue, may be submucosal	N/A	Generally nothing

Feeding continued on next page →

Normal Infant Feeding

Tongue Ties cont.

Type	Exam	Image	Mgmt
Type 2: Moderate	Tie is proximal to 50% of length of tongue		Consider lactation consult
Type 3: Severe	Tie is distal to 50% of length of tongue May create a hump or cupping		Frenulectomy if interfering with feeding
Type 4: Complete	Tie extends to tip of tongue		Likely frenulectomy

Anticipatory Guidance/Discharge Teaching

Feeding	**Feed on demand**, only breastmilk or formula, **8-12x in 24h - "8 or more in 24."** Wake up baby after 3-4 h to feed.
Normal Voiding/ Stooling	Should have **as many wet diapers as is days of life**, up to 6-8 after 1 week of life. Should have **at least 2-3 stools/day.**
Cord Care	Keep **cord clean (sponge bath), dry, and uncovered by diaper**. Will fall off on its own about 10 days.
Circumcision Care	Leave dressing on for 24h. Use petroleum jelly (a ping-pong ball- sized dollup) on penis with every diaper change. Written for tylenol x 2 doses in hospital but most babies do not need it and do fine with being skin to skin for comfort.
Safe Sleep	Baby should sleep on back in own crib with tight fitted sheet. NO loose blankets, stuffed animals, positioning aids. No propping on side. Swaddling is good. Tuck swaddle blanket under baby, or use velcro swaddler.
Tummy Time	Give baby time on tummy. As newborn, can lie on parents chest. Person holding baby should put baby down if feeling sleep. Don't sleep with baby.
Illness	• Visitors should wash hands before handling baby. Avoid crowds, passing baby among visitors, and people with colds, especially for first few months. Tell older sibs to touch baby's feet, not hands and face (newborns can't yet put their feet in mouths). • **Infant fever (taken rectally) is > 100.4:** Seek medical attention if baby seems "off:' eating less than usual, making fewer wet diapers, is fussy or lethargic.

Hyperbilirubinemia

Definition

Infants ≥ 35 wks GA: TB > 95th percentile (2004 AAP Guidelines/Bhutani nomograms)

Pathophys

↑ RBC turnover, ↓ clearance (UGT1A1 activity), ↑ enterohepatic recirculation. **Within first 24 hours of life = ALWAYS pathologic.**

Indirect	Direct - ALWAYS pathologic
• **Breastfeeding jaundice**: first week of life due to insufficient feeding • **Breast milk jaundice**: persistent after first week of life, unknown mechanism, ?substance in milk blocks bilirubin breakdown • **ABO or Rh incompatibility**: suspect if set-up, previous child with hemolytic disease of the newborn, fetal hydrops, jaundice in the first 24 hours of life • Red cell membrane defects (spherocytosis and elliptocytosis) • G6PD deficiency • Sepsis • Decreased clearance – Crigler-Najjar syndrome, Gilbert syndrome • Intestinal obstruction	• Anatomic (intestinal obstruction, cysts, tumors, **biliary atresia**) • **Infection/sepsis** • Metabolic • Gestational alloimmune liver disease (neonatal hemochromatosis

Evaluation

- **Healthy infants**: Obtain routine transcutaneous bili (TcB)i @ DOL2 and plot on bilitool.org. If ABO/ Coombs set-up, check TcB @ 12HOL and 24HOL.
  - Determine **follow-up frequency** based on **risk for developing severe hyperbili** (use risk zone, which is generated by nomogram + GA + presence of hyperbili risk factors [jaundice in first 24 hours, ABO incompatibility/positive direct Coombs, GA 35-36w, sibling required phototherapy, cephalohematoma, exclusive breastfeeding, East Asian race])
  - Determine **phototherapy threshold** based on **neurotoxicity risk** (use GA + presence of neurotoxicity risk factors [isoimmune hemolytic disease, G6PD, asphyxia, lethargy, temp instability, sepsis/acidosis, albumin <3.0)
    - If above phototherapy threshold, check total serum bili (TSB). Once TSB is used, TcB may not be used again.
- Consider checking CBC, retics, hemolysis labs (LDH, haptoglobin, smear), G6PD activity.

Management

Reconsider early discharge (before 72 HOL) if bili high ntermediate risk+. Phototherapy as per bilitool curves. If near exchange levels: aggressive phototherapy, aggressive hydration (IV+PO). IVIG for isoimmune hemolytic disease. Call blood bank before exchange transfusion

Infant of a Diabetic Mother (IDM)

Increased Risks

LGA (BW ≥ 4000g or ≥ 90th percentile for GA) → birth injury (shoulder dystocia, clavicular fracture), preterm birth, **RDS/TTN, hypoglycemia** (maternal hyperglycemia → infant hyperinsulinism → hypoglycemia; resolves in 2-4d), hypertrophic cardiomyopathy (of interventricular septum), **hyperbili, polycythemia** (Hct > 65% → hyperviscosity → exchange transfusion if symptomatic)

Congenital Anomalies

Transpo of great arteries, double outlet RV, VSD, truncus arteriosus, hypoplastic L heart syndrome, **small L colon syndrome** → functional lower bowel obstruction (contrast enema is diagnostic and curative)

Management

Obtain glucose at 2-4HOL, then pre-feed until glucoses stabilize. Consider checking Hct in first hours of life. Check Ca++/Mg if jittery or seizure

IDM continued on next page →

Infant of a Diabetic Mother (IDM)

Hypoglycemia

Glucose (mg/dl)	< 25	25-39	≥ 40
Management	**Admit to NICU** and give 2 cc/kg bolus of D10W followed by infusion of D10	• Feed 10-15 mL colostrum/ formula and re-check • **May give glucose gel 2x (with feed) in first 24HOL before transferring to NICU**	Check 3 **pre-feed POC glucoses ≤3 hours apart;** if normal routine care

- RF: IDM, LGA, SGA, late preterm or post-term, <2500g, discordant twin, maternal medications (e.g., propranolol)
- After 48 HOL, glucose levels should be >60
- If hypoglycemia persists, send critical labs. Consider diazoxide if hyperinsulinism.

Newborn ID

Early Onset Sepsis

Pathophys	GBS >> GNRs (especially E. coli, also Klebsiella), some Gm+ (Listeria, enterococci, Gp D Strep). Risk of GBS sepsis is 40x higher with heavy maternal colonization.
Sepsis RFs	Preterm labor (<37w), maternal intrapartum fever > 100.4 or inadequately treated GBS, PROM (>18h), infant w/tachycardia/tachypnea/respiratory distress/temp instability
Treatment	• **BMC Algorithm**: Use Kaiser Neonatal Sepsis calculator to guide necessity of evaluation (full vs. limited) and/or for antibiotics • BWH algorithm currently in development • **Empiric abx**: Ampicillin + Gentamicin x 48 hrs. Substitute cefotaxime/cefepime if suspect meningitis.

Hepatitis B

- Up to 90% of infants infected perinatally or in the first year of life will develop chronic HBV infection.
- OK for HepB+ moms to breastfeed.

Maternal HBsAg	BW > 2000g	BW < 2000g
Positive	Vaccine + HBIG within 12h (concurrently, different anatomic sites)	
Unknown	• Test mother • HepB vaccine in first 12h • HBIG ASAP if mom positive	• Test mother • HepB vaccine in first 12h • HBIG ASAP if mom positive or if results not available within 12h
Negative	HepB vaccine at birth, within 24 hrs * if parents refuse, discuss again during nursery stay. If still refuses, at BMC must sign informed refusal form.	Delay 1st dose of HepB vaccine until 1 mo of age or hospital discharge, whichever is first

HIV

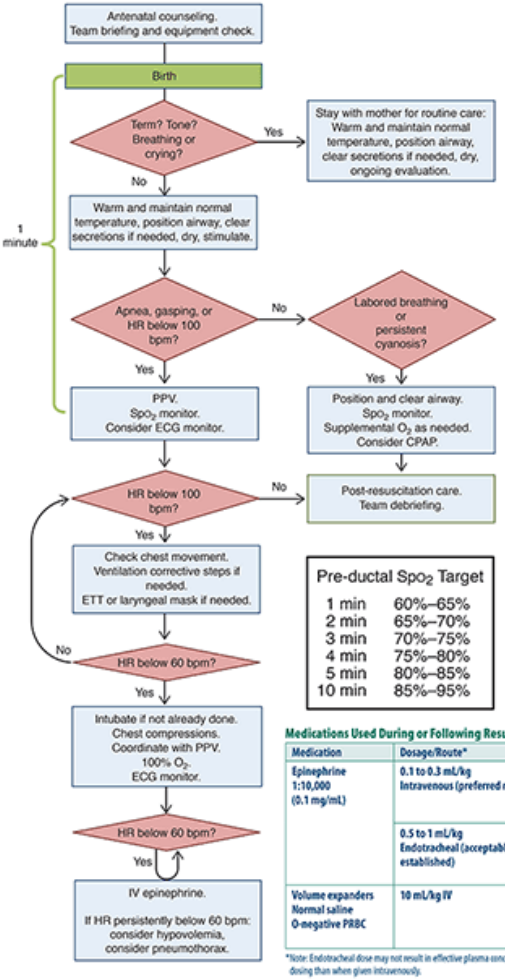
Management	Consult ID. Get maternal history, lab reports: If mom on ARV and infant low risk for acquiring HIV, testing performed at 14 days, 21 days, 1-2 months, and 4-6 months. If mother not on ARVs or mom diagnosed during pregnancy, also test at birth.

Newborn ID	
HIV cont.	
Treatment	**Post-exposure prophylaxis ASAP** (within 6 hours of delivery) with **zidovudine (**dosage based on GA at birth and weight) + **nevirapine if mother not on ARVs**
HSV	
Pathophys	HSV acquired Intrauterine (rare), **perinata**l (85% of infections; ↑ risk: **PROM**, fetal scalp monitor/ forceps, vaginal delivery, primary infxn in mother -- but **majority of infants w/HSV born to mothers without known hx of HSV**)
Presentation	**Fever or other nonspecific signs of sepsis**, **coalescing vesicles on erythematous base**, seizures/focality on neuro exam, hepatomegaly, ascites
Workup	• **Asymptomatic**: Swab neonate from cleanest spot to least clean (same swab): conjunctivae, mouth, nasopharynx, rectum @ 24HOL for PCR and culture • **Symptomatic**: LP: CSF lymphocyte pleocytosis/elevated protein, consider **EEG, PCR and culture of unroofed vesicle**
Treatment	IV Acyclovir 60 mg/kg per day divided q8h (initiate w/ any clinical suspicion; no need to start in asymptomatic infants) Duration depends on severity. Monitor renal function and ANC 2x/week.

Neonatal Abstinence Syndrome (NAS)	
Path	Behavioral dysregulation seen 2/2 drug withdrawal in infants chronically exposed in utero to opiods (methadone, buprenorphine, morphine, oxycodone, hydromorphone, heroin) and other substances (nicotines, benzodiazepines, SSRIs). Skyrocketing incidence.
Presentation	• Irritability, hypertonia, tremors, poor sleep, poor feeding, vomiting, diarrhea, autonomic dysfunction (sweating, sneezing, tachypnea,fever), weight loss. Sx diminished in preterm infants 2/2 developmental immaturity of CNS. • Timing of withdrawal depends on half life: Heroin - <24 hours, Methadone or Buprenorphine: 24-72 hours.
Management	• **First line**: **Non-pharmacologic.** ▪ Parent rooming in, Skin-to-skin, decreased stimulation, clustered care, swaddling, pacifiers. BMC: Give mother NAS info packet on admission. ▪ Breastfeeding for eligible mothers on methadone or buprenorphine **(No relapses in the past 4 weeks, adequate prenatal care, treatment program)** ▪ **24kcal/oz formula** if not breastfeeding • **Withdrawal (inability to eat/sleep/console, autonomic sx): Pharmacologic** (at BWH, transfer to NICU) • First-line opioid replacement therapy: morphine, methadone • Second line therapy: Clonidine, phenobarbital • 60-70% of infants exposed to opioids will need therapy. Increased risk with methadone and polypharmacy. • Monitor for at least 5-7 days for infants exposed to methadone or buprenorphine

Neonatal Resuscitation Program® - Reference Chart

The most important and effective action in neonatal resuscitation is ventilation of the baby's lungs.



A Airway
- Place head in "sniffing" position.
- Suction mouth, then nose.

B Breathing
- If apneic, gasping, or HR <100 bpm, give PPV at 40–60 breaths/min.
- Listen for rising heart rate for first 15 seconds of PPV.
- If HR not rising and chest not moving with PPV, do MR. SOPA until chest moves with PPV for 30 seconds.
- Attach pulse oximeter; consider cardiac monitor.
- Intubate or place laryngeal mask and give PPV for 30 seconds prior to starting compressions.
- Use CO_2 detector after intubation or insertion of laryngeal mask.

C Circulation
- Start compressions if HR is <60 bpm after 30 seconds of PPV with chest movement. Check HR every 60 seconds.
- Cardiac monitor is preferred method for assessing HR during CPR.
- Give 3 compressions: 1 breath every 2 seconds. Use 100% oxygen.
- Compress one-third of the anterior-posterior diameter of the chest.

D Drugs
- Give epinephrine if HR is <60 bpm after 60 seconds of CPR.
- Caution: epinephrine dosage is different for ET and IV routes.

MR. SOPA Corrective Steps

M and R	Mask adjustment, reposition airway
S and O	Suction mouth and nose, open mouth
P	Pressure increase
A	Alternative airway (ET tube or laryngeal mask)

Endotracheal Intubation

Gestational Age (weeks)	Depth of Insertion at Lips (cm)	Weight (g)	ET Tube Size (ID, mm)
23–24	5.5	500–600	Size 2.5 <1,000 g or <28 weeks
25–26	6.0	700–800	
27–29	6.5	900–1,000	Size 3.0 1,000–2,000 g or 28–34 weeks
30–32	7.0	1,100–1,400	
33–34	7.5	1,500–1,800	Size 3.5 >2,000 g or >34 weeks
35–37	8.0	1,900–2,400	
38–40	8.5	2,500–3,100	
41–43	9.0	3,200–4,200	3.5–4.0

Shaded table adapted from Kempley ST, Moreira JM, Petrone FL. Endotracheal tube length for neonatal intubation. *Resuscitation*. 2008;77(3):369–373.

Medications Used During or Following Resuscitation of the Newborn

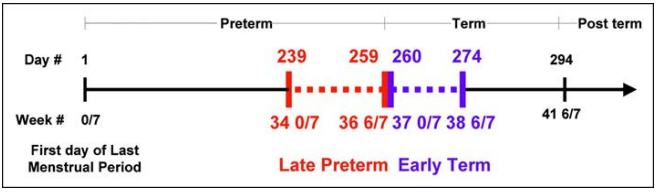
Medication	Dosage/Route*	Wt (kg)	Total Volume (mL)	Precautions
Epinephrine 1:10,000 (0.1 mg/mL)	0.1 to 0.3 mL/kg Intravenous (preferred route)	1 2 3 4	0.1–0.3 0.2–0.6 0.3–0.9 0.4–1.2	Give rapidly; follow IV dose with 0.5–1 mL normal saline flush. Repeat every 3 to 5 minutes if HR <60 with chest compressions.
	0.5 to 1 mL/kg Endotracheal (acceptable until IV established)	1 2 3 4	0.5–1 1–2 1.5–3 2–4	After ET dose, may give IV epinephrine as soon as IV route is established.
Volume expanders Normal saline O-negative PRBC	10 mL/kg IV	1 2 3 4	10 20 30 40	Not responding to steps of resuscitation and has signs of shock or history of acute blood loss. Give over 5 to 10 minutes.

*Note: Endotracheal dose may not result in effective plasma concentration of drug, so vascular access should be established as soon as possible. Drugs given endotracheally require higher dosing than when given intravenously.

Neonatal Resuscitation Program® Quick Equipment Checklist

This checklist includes only the most essential supplies and equipment needed at the radiant warmer for most neonatal resuscitations. Tailor this list to meet your unit-specific needs. Ensure that an equipment check has been done prior to every birth.

Warm	• Preheated warmer
	• Warm towels or blankets
	• Temperature sensor and sensor cover for prolonged resuscitation
	• Hat
	• Plastic bag or plastic wrap (<32 weeks' gestation)
	• Thermal mattress (<32 weeks' gestation)
Clear airway	• Bulb syringe
	• 10F or 12F suction catheter attached to wall suction, set at 80 to 100 mm Hg
	• Meconium aspirator
Auscultate	• Stethoscope
Ventilate	• Flowmeter set to 10 L/min
	• Oxygen blender set to 21% *(21%-30% if <35 weeks' gestation)*
	• Positive-pressure ventilation (PPV) device
	• Term- and preterm-sized masks
	• 8F feeding tube and 20-mL syringe
Oxygenate	• Equipment to give free-flow oxygen
	• Pulse oximeter with sensor and cover
	• Target oxygen saturation table
Intubate	• Laryngoscope with size-0 and size-1 straight blades (size 00, optional)
	• Stylet (optional)
	• Endotracheal tubes (sizes 2.5, 3.0, 3.5)
	• Carbon dioxide (CO_2) detector
	• Measuring tape and/or endotracheal tube insertion depth table
	• Waterproof tape or tube-securing device
	• Scissors
	• Laryngeal mask (size 1) and 5-mL syringe
Medicate	Access to
	• 1:10,000 (0.1 mg/mL) epinephrine
	• Normal saline
	• Supplies for placing emergency umbilical venous catheter and administering medications
	• Electronic cardiac (ECG) monitor leads and ECG monitor



APGAR Scoring			
	0	1	2
HR	Absent	<100	>100
Color	blue, pale	pink body, blue extremities	all pink
Respiratory Effort	none	Weak cry; hypoventilation	good cry
Tone	limp	some flexion	active movement
Reflex Irritability	no response	grimace	cry/cough/sneeze

Special Circumstances Chart		
Condition	**History/Physical**	**Recommendations**
Blockage of Airway		
Choanal Atresia	• Pink when crying, cyanotic when quiet • Inability to pass ng tube one or both sides	Oral airway, intubation
Meconium/ Mucus Blockage	• Meconium stained amniotic fluid • Poor aeration	• Deep suction, intubation PRN if persistent poor ventilation despite suctioning
Pharyngeal Airway Malformation	• Persistent retractions • Poor aeration	• Prone positioning • Posterior nasopharyngeal tube
Impaired Lung Function		
Congenital Diaphragmatic Hernia	• Asymmetric lung sounds • Persistent cyanosis/bradycardia • Scaphoid abdomen	• CXR • Intubation. Avoid positive pressure ventilation/CPAP via the mask • Place orogastric tube
Pleural Effusion/Ascites	• Diminished aeration • Poor oxygenation and ventilation	• Immediate intubation • Needle thoracentesis/paracentesis • Chest tube (posterior) • Possible volume expansion • Fluid analysis (cell count, protein, glucose, pH, triglycerides, Gram stain and culture)

Special Circumstances Chart

Condition	History/Physical	Recommendations
Impaired Lung Function cont.		
Pneumonia/Sepsis	• Poor aeration • Persistent cyanosis/bradycardia	• CXR • Antibiotics • Intubation as needed • Volume resuscitation as needed • Pressors as needed
Pneumothorax	• Asymmetric lung sounds • Persistent cyanosis/bradycardia	• CXR if stable • Transillumination • Needle thoracentesis • Chest tube if recurrent (anterior)
Impaired Cardiac Function		
Congenital Heart Disease	• Persistent cyanosis • "Comfortable" tachypnea • +/- Murmur	• CXR, EKG, 4 ext BP's, pre/post-ductal sats, hyperoxia test • Consider volume and prostaglandins (0.01 to 0.1 mcg/kg/min gtt) • Echocardiogram, cardiology consult
Fetal/Maternal Hemorrhage	• Pallor • Poor response to resuscitation • History of delivery	• Volume resuscitation • Transfusion (STAT O neg. blood)

Access

Use NICUTools.org to determine line length based on BW/length

Umbilical Arterial Catheter (UAC)

Indications
- Hypotension
- Frequent lab draws (i.e. extreme prematurity, PPHN, sepsis)

Length
- High line (T6-T10)
  - Length / 3
  - Umbilicus to shoulder + 2 cm + stump, or
  - (BW(kg) X 3) + 9 cm
- Low line (L3-L5) - rare to use

Catheter Size: 3.5F or 5.0F single lumen (2.5F available)

Precautions:
- Monitor feet for discoloration
- Monitor for RBC in the urine or HTN
- NO dopamine, platelets or blood products

Fluids for UAC: Must contain 0.5 Units Heparin/ml
- Must run at 1 ml/hr minimum (sometimes OK 0.8 ml/hr)
- NS, ½ NS, NaAcetate, ½ NaAcetate, ½ NS + ½ NaAcetate (NOT: free water with heparin only)

Duration: 7 days (max of 10 days)

Miscellaneous: Remove when start feeding. May give trophic feeds (max 10ml/kg/d) with UAC in place

Umbilical Venous Catheter (UVC)

Indications:
- Hypotension requiring pressors
- TPN or fluids requiring high dextrose (>D12.5) or Calcium

Length
- High Line (at/just above diaphragm on KUB)
  - Length / 5
  - Umbilicus to diaphragm + cord stump, or
  - [(BW(kg) X 3) + 9cm]/2 + (1-2 cm)
- Low Line
  - Insert to a point of blood return, radiographically should be below the liver edge: 2-5 cm insertion)
- Low Line is NOT for prolonged use

Catheter Size: 3.5F or 5.0F double lumen

Precautions:
- If the line is dislodged, check a babygram to confirm central placement.

Fluids for UVC:
- At least one carrier fluid must contain 0.5 Units Heparin/ml
- TPN, Dextrose, etc.

Duration: 7 days (max of 10 to 14 days)

Miscellaneous: May feed with UVC in place

Neonatal Respiratory Disorders

Apnea of Prematurity	
Etiology	Prematurity < 34 weeks
Symptoms and Diagnostics	• Periods of 10 to 20 seconds of apnea followed by bradycardia and desaturations. • Must exclude all other potential causes (sepsis, IVH, etc).
Management	• Caffeine (loading dose 20mg/kg of caffeine citrate, then 5 mg/kg/day maintenance, may increase up to 10mg/kg/day) • CPAP/Intubation if severe • Consider septic work up if sudden onset of spells despite proper therapy
BPD/CLD	
Etiology	• Prematurity • Severe Pulmonary Disease
Symptoms and Diagnostics	• NICHD Criteria for mild, moderate, severe BPD: based on GA and oxygen requirement • Diagnosis made after 36 weeks
Management	• **Vent**: Minimize barotraumas, low FiO2 • **Tx**: Supplemental O2, diuretics, bronchodilators, consider steroids, Vitamin A (preventative) • **Monitoring**: Consider echo at 36 weeks to look for pulmonary hypertension • Post-discharge follow up
PPHN	
Etiology	Risk Factors: • Asphyxia • Sepsis • Severe lung disease • Meconium aspiration • Pulm. vascular disease
Symptoms and Diagnostics	• Hypoxia/Hypoxemia • Hypotension • CXR: Meconium aspiration or “black” lungs due to lack of pulmonary blood flow • Cardiac workup to rule out congenital heart disease • +/- ECHO (often with R→L shunting at PDA or PFO)
Management	• Decrease PVR and increase pulmonary blood. • **Goals**: Post-ductal Sat > 94%, pCO2 30-35, pH 7.45 – 7.5, Mean Arterial Pressure > 45-50 mm Hg, aggressive sedation, maintain HCT>40 • **Oxygenation Index (OI):** OI=FiO2xMAP/PaO2 If OI > 20 → iNO If OI > 40 – 60 → consider ECMO
RDS/HMD	
Etiology	Surfactant deficiency
Symptoms and Diagnostics	• Hypoxia • **CXR**: “ground glass”, low lung volume, and air bronchograms
Management	• CPAP vs. Intubation • Surfactant Administration if intubated, 2nd dose if still intubated after 12 hours • Minimize barotrauma and FiO2
TTN	
Etiology	• Delayed resorption of fluid • Usually term infants • Birth by C-section

Neonatal Respiratory Disorders

TTN cont.	
Symptoms and Diagnostics	• Tachypnea, respiratory distress, mild hypoxia • CXR: Prominent vasculature, fluid in fissures.
Management	• Usually improves in 4-6 hours. • Question diagnosis if O2 needs increase or symptoms greater than 24 hours.

Abbreviations:
- BPD/CLD: bronchopulmonary dysplasia/chronic lung disease
- PPHN: persistent pulmonary hypertension of the newborn
- RDS/HML: respiratory distress; Syndrome/hyaline membrane disease
- PVR: pulmonary vascular resistance
- TTN: transient tachypnea of the newborn.

Neonatal Cardiology

***Refer to Cardiology chapter for full discussion of congenital heart disease, including cyanotic heart lesions and use of prostaglandins.

Blood Pressure Range for Premature Infants

- Very controversial topic since there is no good normative data in the literature.
- Rough rule of thumb:
  - In the first 1-2 days of life goal MAP≈GA (i.e. 24 wk infant goal MAP≈24 mm Hg)
    - Some evidence that goal MAP should be≈30 mm Hg even for ELBW
  - After the first few days of life, goal MAP≈GA+5
  - Closely monitor urine output, pulses, and perfusion. Monitor trends in BUN/creatinine
- For infants with PPHN, goal MAP should be based on pulmonary blood flow and urine output. (i.e. sometimes 45-50 mm Hg)

Patent Ductus Arteriosus (PDA)

Etiology	• Failure of ductal tissue to close in the premature infant • Affects ~ 60% of infants <28 weeks
Signs and Symptoms	• Continuous machinery-like murmur • Hypotension, widened pulse pressure, palmar/axillary pulses, hyperactive precordium • Metabolic acidosis • Worsening oxygenation and ventilation, pulmonary edema due to over circulation
Diagnosis	Echocardiogram
Management	• Symptomatic Support (i.e. pressors, ventilator management) • Medical Therapy (Indomethacin or Ibuprofen or Tylenol): contraindicated if large IVH, severe oliguria, NEC • Surgical Ligation • Wait and See

Neonatal Hematology

Anemia
(Definition depends on gestational and chronologic age; Evaluation and Management depends on the etiology)

Likely Etiologies	**Latrogenic** (i.e. frequent blood draws) **Hemorrhagic**: Placental Abruption, Umbilical Cord disruption at delivery, Fetal-Maternal, Intraventricular, Head Trauma (cephalohematoma, subgaleal), NEC, Twin-twin transfusion **Hemolytic:** Rh incompatibility, ABO incompatibility
Evaluation	**Anemia at Birth**: Delivery History, Physical Exam, CBC, Retic, Type and Coombs, Blood Smear, Consider HUS or more extensive head imaging, Kleihauer-Betke on mother, Bilirubin
Management	***Transfusion criteria for term and premature infants is very controversial and facility dependent.*** **Preterm:** • If intubated and acutely ill: Hct of 35 – 40 • If a "feeder and grower": Hct + Retic ≥ 30 **Term:** • If acutely ill: consider transfusing to goal Hct>40 • If hemodynamically stable: Hct>25

Polycythemia
(Venous Hct > 65)

Likely Etiologies	• **Increased fetal production** • Placental insufficiency • Thyrotoxicosis • Gestational diabetes mellitus	• Genetic disorders (Trisomy 21, Beckwith-Wiedemann) • **Hypertransfusion** • Delayed cord clamping • Twin-twin transfusion
Evaluation	• Repeat venous or arterial CBC • Monitor for hypoglycemia • Follow bilirubin and electrolytes	**Monitor for symptoms**: • Lethargy • Hypoglycemia • Respiratory distress • Neurologic symptoms
Management	**Partial exchange transfusion (normal saline) if**: • Venous Hct>65% with symptoms • Hct>70% and asymptomatic • Observed HCT **NOTE**: Ideally use UVC to perform a partial exchange	

Thrombocytopenia
(Plt < 150)

Likely Etiologies	**Increased Destruction/Consumption:** • Autoimmune • Alloimmune (NAIT) • Infection/DIC/NEC • Drug induced/toxicity • Hypersplenism • Kasabach-Merrit Syndrome • Following transfusion	**Decreased Production:** • Thrombocytopenia-absent radius • Fanconi anemia • Trisomy 13, 18, 21 **Miscellaneous:** • Asphyxia • Pre-eclampsia • Type 2B von-Willebrand
Evaluation	• Repeat Platelet Count • Look up maternal history and platelet count • Exam for evidence of bleeding	• Coagulation studies • Consider HUS • Consider sending maternal platelets
Management	The decision to transfuse platelets depends on the etiology and how symptomatic the patient is (i.e. bleeding, hypotension, mechanical ventilation, procedures)	

Neonatal Hematology

Thrombocytopenia cont.
(Plt < 150)

Management cont.

Platelet goals:

GA	Symptomatic	Asymptomatic
Term	>50K-100K	>20K-30K
Pre-term	>100K	>50K

Neonatal Alloimmune Thrombocytopenia:
- Goal Plts> 20K to 30K if no active bleeding (transfuse antigen negative platelets)
- Check HUS
- Consider Steroids and IVIG
- Maternal Platelet typing

Neonatal Neurology

Intraventricular Hemorrhage Screening (IVH)

Indications for Head Ultrasound (HUS)
- GA<32 wks
- BW<1500 grams
- Anything suspicious for IVH (low HCT, low Plts, unstable BP, cardiopulmonary arrest, pneumothorax, prolonged hypotension, asphyxia)
- Pre/during ECMO.
- Timing on DOL 3, 7-10, 30, 60 (consider HUS in 1st 24 hrs in very sick ELBW infants)

Grade	Head US Findings
I	Germinal Matrix Hemorrhage (GMH)
II	IVH without ventricular dilation
III	IVH with ventricular dilation
IV	Grade III with parenchymal hemorrhage

Retinopathy of Prematurity (ROP) Screening

Routine exams indicated for
- BW <1500
- GA < 30 6/7 wks
- Infants 1500-2000 grams or >31 wks, but with "unstable" clinical course (mechanical ventilation, exchange transfusion, TORCH, ECMO, etc.)

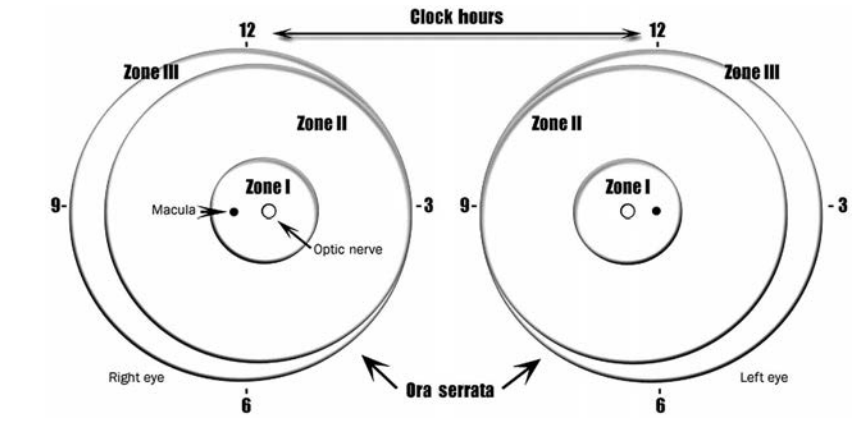
Timing

Generally:
- If GA at birth <28 weeks, then 1st exam at 31 weeks CGA
- If GA at birth ≥28 weeks, then 1st exam at 4 weeks chronologic age

Neonatal Neurology continued on next page →

Neonatal Neurology

Retinopathy of Prematurity (ROP) Screening cont.



Stages of Retinopathy of Prematurity (ROP)	
I	Mildly abnormal blood vessel growth. Many children who develop stage I improve with no treatment and
II	Moderately abnormal blood vessel growth. Many children who develop stage II improve with no treatment
III	Severely abnormal blood vessel growth. The abnormal blood vessels grow toward the center of the eye instead of following their normal growth pattern along the surface of the retina. Some infants who develop stage III improve with no treatment and eventually develop normal vision. However, when infants have a certain degree of Stage III and "plus disease" develops, treatment is considered. "Plus disease" means that the blood vessels of the retina have become enlarged and twisted, indicating a worsening of the disease. Treatment at this point has a good chance of preventing retinal detachment.
IV	Partially detached retina. Traction from the scar produced by bleeding, abnormal vessels pulls the retina
V	Completely detached retina and the end stage of the disease. If the eye is left alone at this stage, the baby

"Retinopathy of Prematurity (ROP)." National Eye Institute [NEI], of the U.S. National Institutes of Health. 28 May 2009 <http://www.nei.nih.gov/health/rop/#5>.

Therapeutic Cooling

- ***Protocols are site specific!
- Below are materials prepared by BWH
- BMC protocol varies and can be accessed via the BMC infonet

Hypothermia Eligibility Criteria	**Standard Eligibility Criteria:** • ≥ 34 weeks gestation • Any one of the following: ▪ Sentinel event prior to delivery ▪ Apgar score ≤ 5 at 10 minutes ▪ Requires PPV, intubation or CPR at 10 minutes ▪ pH ≤ 7.1 (from cord or blood gas within 60 minutes of birth) ▪ Abnormal base excess ≤ -10 mEq/L (from cord or blood gas within 60 minutes of birth)

Neonatal Neurology	
Therapeutic Cooling cont.	
Hypothermia Eligibility Criteria cont.	**Standard Eligibility Criteria:** • Any one of the following: ▪ Neonatal encephalopathy score ≥ 4 ▪ Seizure or clinical concern for seizure **Reasons to Exclude:** • Absolute contraindication: <34 weeks gestation • Relative contraindications: severe IUGR <1750 grams, severe congenital anomalies/genetic syndromes/known metabolic disorders, major intracranial hemorrhage, overwhelming sepsis, uncorrectable, clinically significant coagulopathy

Neonatal Neurology continued on next page →

Therapeutic Hypothermia: System Overview

System	Overview of Management
Cardiovascular	1) Monitor with 3-lead EKG per routine. Expect bradycardia (< 100 bpm) when temperature < 34 °C 2) Vascular access o Establish peripheral IV access immediately (avoid scalp IVs) o Insert UVC (double lumen) if dependent on clinical scenario (For hypotension, arterial line monitoring is preferred prior to inotropic support being initiated)
Fluid and Electrolytes	1) Maintenance fluid o Total fluid volume of 60 ml/kg/day o Use Standard TPN @ 50 ml/kg/d with dextrose containing IV fluid, until custom TPN is available o Maintain GIR no less than 4 mg/kg/min at all times 2) After 24 hours of therapeutic hypothermia, if the infant is physiologically stable, the attending may initiate non-nutritive feeding of **10 mL/kg/day with mother's milk. This should not be advanced until after infant is rewarmed**
Respiratory	1) Ventilator Support – provide any respiratory support as needed o Avoid hypocapnia, and hyperoxia 2) Maintain air humidifier in normothermic range (37ºC)
Infectious Disease	1)Evaluate for Suspected Sepsis – start antibiotics after cultures obtained o Antibiotics should consist of Ampicillin and Cefotaxime (Cefepime may be used, if Cefotaxime not available)
Neurological	**1) Request Neurology Consultation, if not already requested** Sedation: maintain adequate sedation with Morphine. **The following guideline can only be deviated from with attending approval** o Loading dose 0.05 mg/kg IV (repeat PRN x 1 for shivering, severe irritability tachycardia HR > 120) o Start continuous infusion: 0.01 mg/kg/hr IV drip. DO NOT INCREASE THE INFUSION RATE o Reduce rate to 0.005 mg/kg/hr after 12 hours o Avoid Benzodiazepines for distress 2) Neuromonitoring: o Obtain full channel EEG on admission (to be ordered stat by neurology) o Continue full channel EEG for 24 hours or longer if seizures detected ▪ If no seizures and EEG recording considered low risk, may switch to aEEG after 24 hours (refer to aEEG CPG for details) o Neuromonitoring (either EEG or aEEG) should be continued until 6 hours after rewarming completed 3) Seizure control (Refer to Neonatal Seizure CPG for further details) o **1st choice agent for treating seizures is Phenobarbital** • Load: 20 mg/kg IV; repeat if seizures persist 20 minutes after load complete • Check serum levels 2-12 hours after load o If 2nd agent required: Fosphenytoin 20 mg/kg load o If 3rd agent required: Midazolam – load with 0.05 mg/kg IV and then infusion of 0.15 mg/kg/hour for 12 hours, taper over another 12-24 hours 4) Cranial ultrasound imaging should be ordered STAT (But do not need to wait for HUS to start therapeutic hypothermia) 5) MR imaging (NICU MRI Guidelines) ▪ If considering re-direction of care or early Exit, consider a MRI at 24-48 hours o Routine MRI – HIE protocol on DOL #4 (after re-warming) o Follow-up MRI on/after DOL #10- #21 6) Complete and document Neonatal Encephalopathy Neurological Examination at least once daily during hypothermia and re-warming, and at discharge
Skin	1) Monitor for subcutaneous fat necrosis (erythema, purple color, painful nodules, especially on the back and buttocks). May occur during hypothermia or after rewarming 2) If present monitor for hypercalcemia
Laboratory/ blood work	1) Lab schedule should be determined based on assessment of the infant's condition and evaluated daily and as needed- below is a **suggested lab plan**: o On admission: Blood gas, lactate, CBC, PT, PTT, INR, Fibrinogen, blood cx o 6 hours: BMP, Mg, ALT, AST o 24 h: CBC, PT, PTT, INR, Fibrinogen, BMP, Mg, P, ALT, AST o Daily BMP o Phenobarbital levels (only if patient was loaded for clinical seizures)

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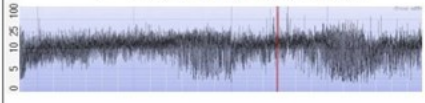
Department of Pediatric Newborn Medicine

New England Neonatal aEEG
and Neuroimaging Workshop

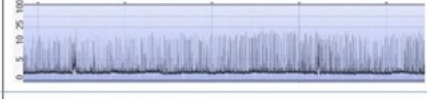
A- Background Pattern:

- **Continuous (C):**
  - lower amplitude > 5 mcV
  - maximum amplitude > 10 mcV

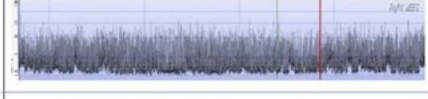


- **Discontinuous (DC):**
  - lower amplitude < 5 mcV
  - maximum amplitude > 10 mcV

- **Burst-suppression (BS):**
  - minimum amplitude without variability at ≤ 2 mcV and bursts with amplitude >25 mcV



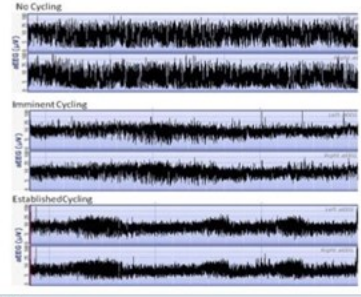
- **Low voltage (LV):**
  - lower amplitude < 5 mcV
  - maximum amplitude <10 mcV



- **Inactive, flat (FT):**
  - primarily inactive (isoelectric tracing) background < 5 mcV

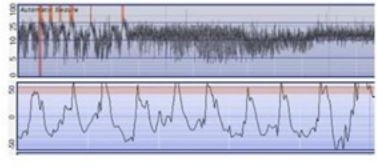
B- Cycling;

1. **No Cycling**
2. **Imminent Cycling:** Some, but not fully developed, cyclic variation of the lower amplitude
3. **Established Cycling:** Clearly identifiable sinusoidal variations between discontinuous and more continuous background activity, with cycle duration >20 min.

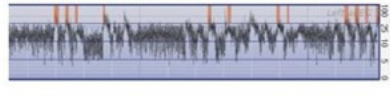


C- Seizures

1- **Seizures:** an abrupt, transient, sharp rise in the lower margin, often accompanied by a smaller rise in the upper margin, with narrowing of the bandwidth. This has to be associated with evolving, repetitive waveforms hat gradually build up and then decline in frequency, morphology, or amplitude on cEEG



2- **Status epilepticus:** Continuously ongoing seizure activity for >30 minutes.



Hypothermia Eligibility Criteria

Standard Eligibility Criteria	Present
A. ≥34 weeks' gestation	☐
B. Any one of the following	
a. Sentinel event prior to delivery	☐
b. Apgar score ≤ 5 at 10 min	☐
c. Requires PPV, Intubation or CPR at 10 min	☐
d. pH ≤ 7.1 (from cord or blood gas within 60 min of birth)	☐
e. Abnormal Base Excess ≤ - 10 mEq/L (from cord or blood gas within 60 min of birth)	☐
C. Any one of the following	
a. Neonatal Encephalopathy Scale Exam Score ≥4	☐
b. Seizure or clinical concern for seizure	☐

Reason to Exclude	Present
1. Absolute Contraindication (<34 weeks Gestation)	☐
2. Relative Contraindication (Severe IUGR <1750 gm, Severe congenital anomalies/genetic syndromes/known metabolic disorders, Major intracranial hemorrhage, Overwhelming sepsis, Uncorrectable, clinically relevant coagulopathy)	☐

All standard Criteria present- (A+B+C) Yes ☐ No ☐

If Yes and no reason to Exclude- **Immediately start Hypothermia Protocol** (Passively cool until active hypothermia initiated)

Evaluation for Hypothermia

Required for All Evaluated	Performed
1. Post-natal blood gas (<60 min from birth)	☐
2. Neonatal Encephalopathy Scale Exam (Repeat at set intervals if <4)	☐
Exam 1 ☐ Exam 2 ☐ Exam 3 ☐ Exam 4 ☐	
3. aEEG monitoring	☐
4. Direct communication of decision to treat or not to treat with;	☐
Family ☐ Obstetrical Team ☐	
5. All components of assessment documented in patients' medical record	☐

Considered for All Evaluated

Neurology Consult (Mandatory if encephalopathic, queried seizures, or decide to actively/passively cool) ☐

Encephalopathy Exam and aEEG Assessment

Neonatal Encephalopathy Scale Exam

Repeated exams required for patients being evaluated, and initial Score <4

a. Exam 1 (30 min after birth/admission) Score_____
b. Exam 2 (1 hour after Exam 1) Score_____
c. Exam 3 (1 hour after Exam 2) Score_____
d. Exam 4 (5 hours after birth) Score _____

Neonatal Encephalopathy Scale Score ≥4 at any time point Yes ☐ No ☐

aEEG Assessment

	Abnormal	Normal
Lower Margin	< 5 µV ☐	> 5 µV ☐
Upper Margin	< 10 µV ☐	>10 µV ☐
Cycling	Absent ☐	Present ☐
Seizures	Present ☐	Absent ☐

aEEG Pattern‡

CNV ☐ DNV ☐ BS ☐ LV ☐ FT ☐

‡Patterns Defined in EEG Neuro-monitoring in the NICU CPG, and Laminated Cards on aEEGs

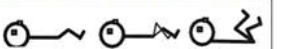
Findings from Evaluation

1. Does infant meet all **standard criteria**	Yes ☐	No ☐
2. Does the Infant have an **encephalopathy score ≥ 4**	Yes ☐	No ☐
3. Does the Infant have an **abnormal aEEG**	Yes ☐	No ☐
4. (If consulted)- Does Neurology recommend treatment	Yes ☐	No ☐
5. Is there a **reason to exclude** infant	No ☐	Yes ☐

Initiate Therapeutic Hypothermia Yes ☐ No ☐

Neonatal Encephalopathy Examination Scoring Sheet

Date	1 Time	2 Time	3 Time	4 Time	
1- Observe spontaneous activity	0 2 3	0 2 3	0 2 3	0 2 3	Normal Decreased= decreased frequency or amplitude of spontaneous facial and extremity movements Absent
2- Observe for Heart rate	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	Normal Tachycardia = resting HR 160-180. Only occasionally decreased to 120 Bradycardia= resting HR 80-90. Only occasionally increases to 120 Variable= resting HR varies considerably without a consistent baseline
3- Observe for respiration	0 2 3	0 2 3	0 2 3	0 2 3	Normal Periodic Breathing= 3 or more respiratory pauses ≥ 3 sec separated by normal breathing and < 20 sec. Often associated with shallow breathing Apnea= no breathing for ≥ 20 sec or < 20sec with HR changes or O2 desaturation
4- Observe for posture	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	Normal **Mild Distal Flexion =** Fingers and toes in flexion, incomplete extension of fingers when stroked on dorsal surfaces. Thumbs flexed, adducted, opposed across palms "cortical thumb" **Strong Distal Flexion=** Fingers and toes in strong flexion, incomplete extension of fingers when stroked on dorsal surfaces. Thumbs flexed, adducted, opposed across palms "cortical thumb" Decerebrate= Head, neck and back are arched in extension (opithotonus), elbows are extended, wrists are pronated and hips are abducted.
5- Observe for level for consciousness	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	**<u>Use Auditory stimulation, Visual stimulation and Tactile stimulation to assess level of consciousness</u>** Normal Hyperalert Full wakefulness with eyes open/ staring but decreased frequency of blinking/ tracking. Spontaneous motor activity normal or decreased with lowered threshold to all stimulus types Irritable lowered threshold with excessive responses to all stimulus types. Can be seen with varied states including hyperalert, lethargy or obtundations Lethargic Slightly delayed but complete response to stimuli with slightly increased threshold for eliciting responses and decreased spontaneous activity Obtunded Delayed and incomplete response with marked increased threshold to all sensory stimuli and little or no motor activity. Stupor No spontaneous eye opening to tactile stimulation elicits poorly sustained eye opening. Responds only to strong noxious stimuli. Absent gag and cornel reflex Coma No eye opening with vigorous tactile stimulation

6- Tone Assessment	0	0	0	0	Normal
	2	2	2	2	Hypotonic= Focal or generalized decreased resistance to passive movement. Associated with greater extension of extremities than normal
	3	3	3	3	Flaccid= "Flat on the mat" appearance. Maybe associated with frog-leg posturing with arm and hips/legs lying in abduction\
					A- Arm Recoil: Quickly extend (straighten) both arms; put next to body. Count to two. Let go. Repeat 3 times.
					Normal: Arms flexes and remains flexed  **Hypotonia:** 
					B- Leg Recoil: Take both ankles, bend hips+ knee. Quickly extend when infant not pushing. Let go. Repeat 3 times.
					Normal: Complete Fast Flexion  **Hypotonia:** 
					C- **Vertical Suspension: Hold baby upright by placing hands under axillae**
					Normal: No Slip through **Hypotonia:** Slip Through
					D- **Head Lag: Pull baby to sit by the wrists and support head slightly.**
					Normal: Lifts head in line with body  **Hypotonia:** 
					E- Ventral Suspension: Hold baby horizontal under the belly. Look at posture of back, arms, legs and head.
					Normal: Back straight, head in line with body, limb flexed  **Hypotonia:** 
7- Reflexes					**a- Sucking reflex**
	0	0	0	0	Normal
	1	1	1	1	Weak
	2	2	2	2	Weak/Uncoordinated
	3	3	3	3	Absent
					b- Moro Reflex
	0	0	0	0	Normal
	1	1	1	1	Exaggerated
	2	2	2	2	Weak/Incomplete
	3	3	3	3	Absent
					c- Light Reflex
	0	0	0	0	Normal
	1	1	1	1	Dilated
	2	2	2	2	Constricted
	3	3	3	3	Unequal/ Fixed dilated
Total NE Score					

Neonatal Infectious Disease

TORCH Infections

When to be concerned

- IUGR/SGA (<10th% for age)
- Failed Hearing Screen
- Blueberry muffin rash
- Hepatosplenomegaly
- Unexplained direct hyperbilirubinemia

Infection	Lab
Toxoplasmosis	Newborn Screen
Other (Syphilis)	Maternal Screen
Rubella	Maternal Screen
Cytomegalovirus	Urine Shell Vial for CMV/ buccal CMV PCR
HSV	Maternal history Surface cultures on the baby HSV PCR from Blood and CSF
HIV	Maternal history/screen HIV PCR in infant available

HepB

See Newborn Nursery section

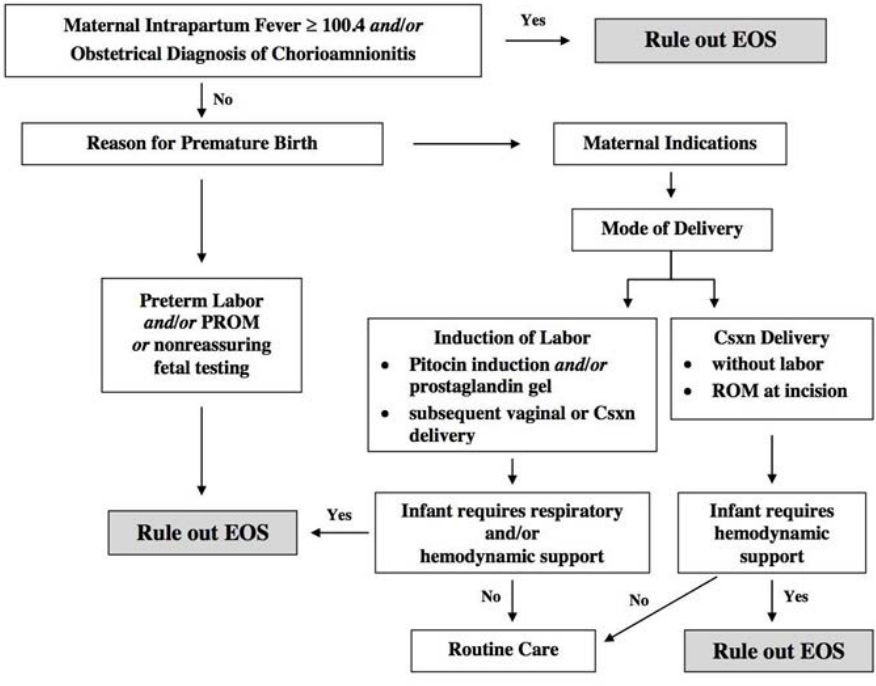
Human Immunodeficiency Virus (HIV)

- Get Mom's history, lab reports and call ID consult anytime night or day.
- **TREATMENT SHOULD BE INITIATED AS SOON AS POSSIBLE!**

Sepsis Evaluation in the Neonate

- BMC Tool: Kaiser Permanente Sepsis Calculator (for infants >34 weeks)
  https://neonatalsepsiscalculator.kaiserpermanente.org/
- Use CDC National Incidence for Incidence of Early Onset Sepsis

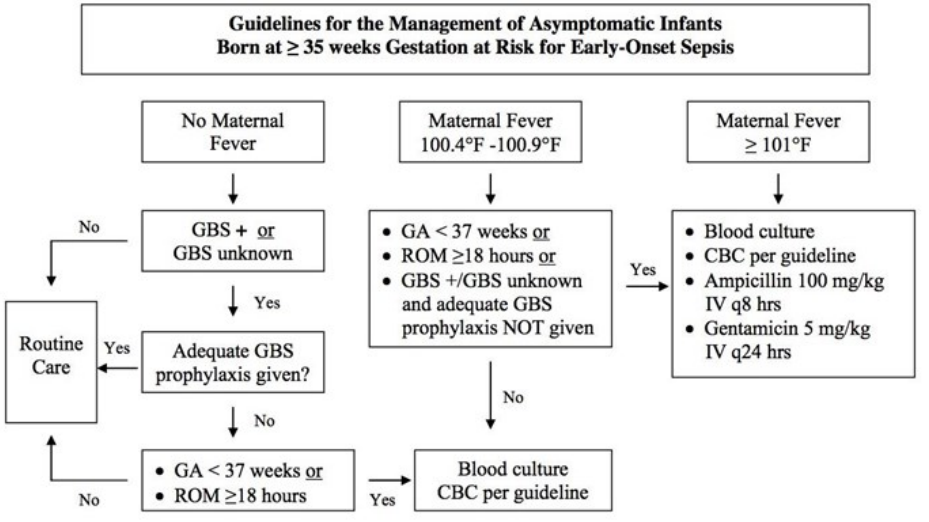
Guideline for Evaluation of Infants Born ≤ 34 Weeks Gestation for Risk of Early-Onset Sepsis



- ***Maternal indications for preterm delivery:*** **pregnancy-induced hypertension; pre-eclampsia; other maternal medical condition (i.e., cancer, renal disease). Also include longstanding *in utero* fetal growth restriction, particularly in multiple gestations**
- ***Respiratory support*: supplemental oxygen for > 1 hour after birth; CPAP support; mechanical ventilation**
- ***Hemodynamic support*: volume administration or pressor support given for poor perfusion and/or low blood pressure for gestational age**
- ***Non-reassuring fetal testing*: testing prompted by concerns such as decreased fetal movement. This does not refer to fetal testing for indications such as maternal PET, mono-mono twins, etc.**
- ***Rule out EOS*: obtain blood culture and CBC/diff and antibiotics as below. *Routine Care* = no blood culture; CBC only if needed to address non-infectious concern (ie, anemia, or PET-induced neutropenia/thrombocytopenia, etc.)**
- ***Standard antibiotics to rule out EOS are ampicillin and gentamicin:* Consider the addition of *cefotaxime* pending blood culture results, if infant is hemodynamically unstable and any of the following are present:**
  - **PROM**
  - **Maternal treatment with any antibiotic for > 4 hrs PTD**
  - **Abnormal WBC indices (WBC < 5.0, ANC < 2000, and/or I/T > 0.3)) not attributable to maternal pre-eclampsia or *in utero* growth restriction (birth weight <10th percentile for gestational age)**
  - **Prolonged (>48 hrs) use of cephalosporins for culture-negative, presumed EOS is *strongly discouraged***

BRIGHAM AND WOMEN'S HOSPITAL

Revised June 3, 2013



Adequate GBS prophylaxis =
penicillin G, ampicillin or cefazolin given ≥ 4 hours prior to delivery

Inadequate GBS prophylaxis =
any antibiotic given < 4 hours prior to delivery or any other antibiotic for any duration

CBC Recommendations by Postnatal Age:

- **< 1 hour**: do not obtain CBC
- **1-4 hours**: CBC not recommended. If obtained, repeat at 6-12 hours to guide treatment decisions.
- **> 4 hours**: obtain CBC with blood culture

Following values should raise concern for infection:
- WBC < 5000
- ANC < 2000
- I/T ratio ≥ 0.3

ADDITIONAL NOTES

1. Chorioamnionitis is an obstetrical clinical diagnosis made on the basis of clinical findings, laboratory data and fever. If obstetrical staff diagnose chorioamnionitis, the infant should be evaluated for sepsis and receive empiric antibiotic treatment.
2. Maternal fever that occurs within one hour of delivery should be treated like intrapartum fever, and the infant should be evaluated as outlined above.
3. Women with a previous infant with GBS disease should receive intrapartum GBS prophylaxis.
4. Blood cultures should consist of aerobic and anaerobic bottles with minimum 1 cc blood in each bottle.
5. To facilitate family bonding and initiation of breastfeeding, the sepsis evaluation can be delayed for up to one hour after birth, at the discretion of the obstetrical and neonatal caregivers.

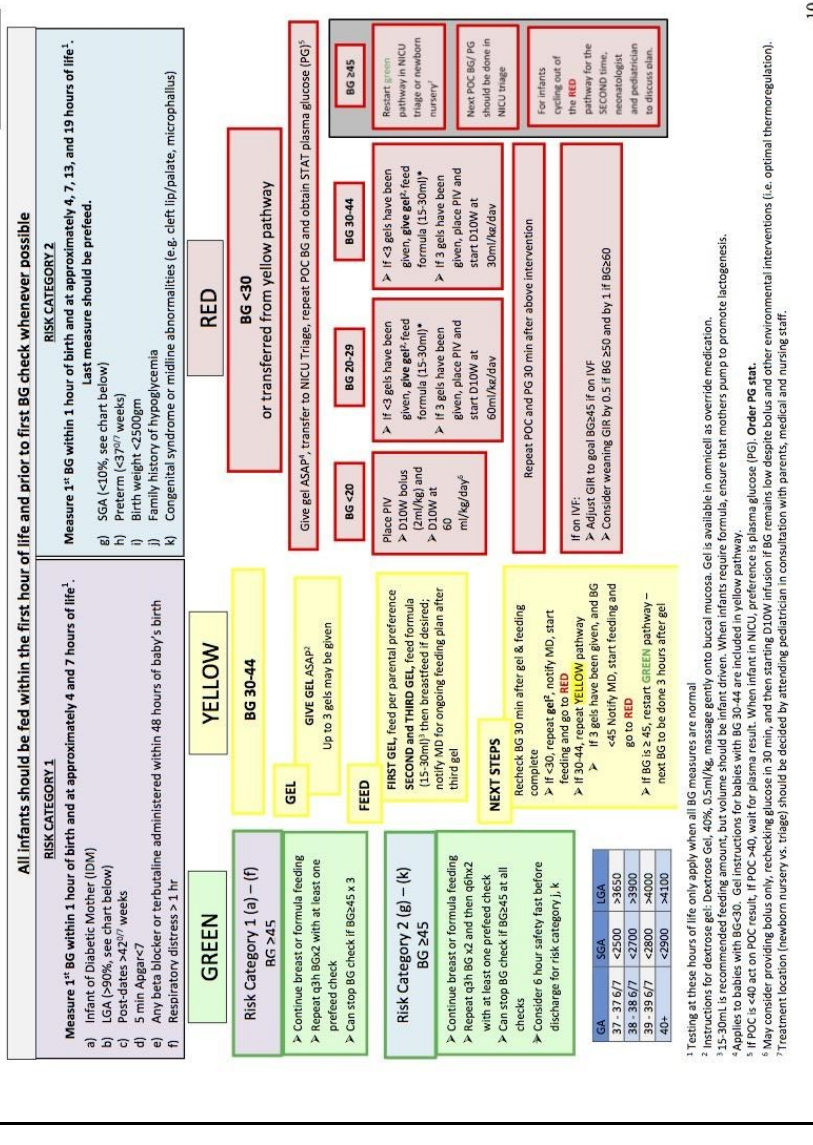
These are guidelines only and should not substitute for clinical judgment.

BRIGHAM AND WOMEN'S HOSPITAL

Updated 7/30/2014

Neonatal Endocrinology

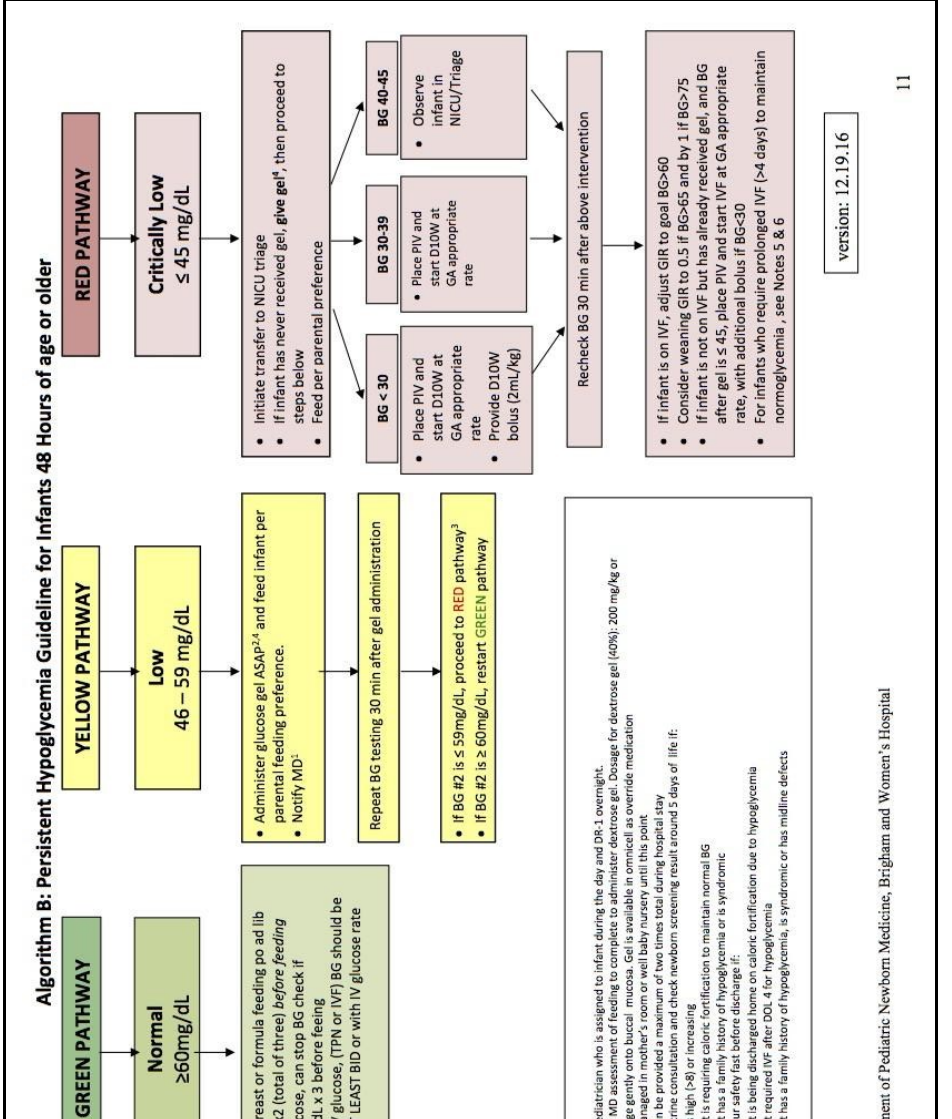
Hypoglycemia



Neonatal Endocrinology continued on next page →

Neonatal Endocrinology

Hypoglycemia



Neonatal Gastroenterology

Emesis in the Infant

Medical DDx

- Anxiety, excitement, imitation
- Celiac disease
- Congenital adrenal hyperplasia
- Esophageal dysmotility
- Excessive crying
- Food allergies
- Gastroenteritis
- Gastroesophageal reflux
- Improper feeding
- Inborn errors of metabolism
- Infection: Sepsis, UTI, meningitis
- Ingestion maternal blood or mucus
- Kernicterus
- Milk protein allergy
- Necrotizing enterocolitis
- Overfeeding

Surgical DDx

- Annular pancreas
- Appendicitis
- Atresia/stenosis/webbing
- Duplications
- Esophageal atresia
- Functional ileus
- Hernias
- Intussusception
- Malrotation with midgut volvulus (if bilious)
- Meconium ileus
- Meconium plug syndrome
- Necrotizing enterocolitis w/perforation
- Pyloric stenosis
- Testicular torsion
- Tracheoesophageal fistula
- Tumors
- Ulcers
- Vascular rings

Evaluation

Initiate your evaluation in a stepwise fashion for an infant in the NICU, and always start with a KUB before proceeding to any further imaging studies (the following is a suggestive work up depending on your suspicion)

Plain films:

- KUB, left lat. decubitus, possible prone
- Contrast study (upper vs. lower):
  - if concern for malro/volvulus-upper
  - if concern for jejunal/ileal atresia-lower
- Septic evaluation if concern for symptoms of NEC or sepsis
- Bowel rest
- Anti-reflux medications
- Surgical consult

Additional studies depending on etiology/ clinical presentation:

- CBC with diff
- Chem 10
- Blood gas
- Lactic acid
- LFT's, amylse, lipase
- Blood culture
- Urinalysis and culture
- Stool guaiac
- Consider metabolic and endocrine work-up
- Ultrasound for intussusception

Common Obstructive Causes of Vomiting

Bilious or Non-Bilious

- Intestinal atresia
- NEC
- Meconium plug
- Meconium ileus
- Malrotation
- Volvulus
- Hirschsprung Disease

Likely Non-Bilious

- Pyloric stenosis
- Intussusception
- Reflux

Acute Abdomen in the Neonate

"High" Obstruction

- Esophageal atresia
- Duodenal atresia
- Duodenal web
- Annular pancreas
- Malrotation
- Jejunal atresia

- **Main symptom**: vomiting
- **Radiograph**: no distal bowel gas (complete obstruction)

Neonatal Gastroenterology continued on next page →

Neonatal Gastroenterology

Acute Abdomen in the Neonate

"Low" Obstruction	• Ileal atresia • Meconium ileus • Meconium plug • Hirschsprung Disease • Anal atresia	• **Main symptom**: constipation • **Radiograph**: dilated small bowel loops and microcolon (unused colon, obstruction proximal to colon)
"Acquired" Disease	• NEC • Hypertrophic pyloric stenosis • Incarcerated inguinal hernia	• Gastroenteritis • Sepsis • Perforated stress ulcer

Indirect Hyperbilirubinemia

All infants

- Jaundice in the first 24 hours of life should ALWAYS be considered pathologic and prompt an immediate serum bilirubin level (both total and direct).

Infants ≥ 35 wks GA

- www.bilitool.org (interactive web resource that incorporates the AAP guidelines)

Premature Infants < 35 weeks gestational age:

Gestational Age (corrected)	Initiate Phototherapy at Total	Exchange Transfusion at Total
<28 0/7	5	11
28 0/7 - 29 6/7	6	12
30 0/7 -31 6/7	8	13
32 0/7 - 33 6/7	10	15
34 0/7- 34 6/7	12	17

Management	Refer to AAP guidelines for levels of phototherapy and exchange transfusion. If the levels are elevated to the high risk/exchange transfusion, then: • Aggressive Phototherapy • Aggressive Hydration (IV + PO) • IVIG (if Coombs positive) • Consider steroids • Consider/anticipate exchange transfusion (call blood bank)

Selected GI Disorders

NEC

Etiology	• Precise etiology unclear • Affects 10% of premature infants with increased incidence at lower gestational age • **Risk Factors:** ▪ Prematurity ▪ IUGR ▪ Perinatal asphyxia ▪ PDA ▪ Shock/Hypotension ▪ Umbilical Arterial Catheter ▪ Cyanotic Heart Disease

Neonatal Gastroenterology

Selected GI Disorders

NEC

Symptoms and Diagnostics	**Symptoms** • Abdominal distention/discoloration/tenderness • Heme positive stools • Grossly bloody stool • Feeding intolerance: gastric aspirates (large +/- bilious) • Non-specific systemic symptoms: Lethargy, apnea, temperature instability, unexplained acidosis, hyperglycemia, poor perfusion • Lab abnormalities: Hyponatremia, hyperkalemia, metabolic acidosis, leukocytosis or leukopenia, thrombocytopenia • Radiographic abnormalities: Pneumatosis, portal venous gas, free air **Diagnostics** • KUB with left lat. decub. • CBC with differential & blood culture • Electrolytes
Management	**Make NPO** • Place replogle tube • Antibiotics • Surgery consult (STAT if free air) • Start IVF/TPN • Supportive care • Monitor Labs and KUB's every 6 to 8 hours depending on infant status

Malrotation (+/- Mid-Gut Volvulus)

Etiology	• Developing bowel fails to undergo the usual counterclockwise rotation (4th to 10th week of embryogenesis). Peritoneal bands (normally attaching bowel to the central body axis) compress the duodenum, causing partial obstruction. • Volvulus results in intestinal obstruction. • Superior mesenteric artery may be compressed, leading to ischemia.
Symptoms and Diagnostics	• **Classic**: Newborn <1 month old with bilious vomiting. Other presentations with intermittent abdominal pain and/or vomiting. Associated with diaphragmatic hernia, omphalocele, gastroschisis. • **KUB**: usually unremarkable, may demonstrate small bowel obstruction. • **UGI** (diagnostic study of choice): abnormal position of duodenal-jejunal junction (DJJ). Volvulus classically appears as a spiral corkscrew of the duodenum • **Ultrasound**: may show volvulized small bowel, seen as a "whirled" appearance.
Management	**Emergent Surgical Treatment—Modified Ladd's Procedure** • Division of the peritoneal bands (Ladd bands) around the duodenum • Colon placed on the left and the duodenum on the right to broaden the mesentery • Appendectomy is performed to avoid future confusion with abdominal pain

Duodenal Atresia

Etiology	• Embryogenic • 1 per 5000 live births • 25% have Trisomy 21
Symptoms and Diagnostics	• Bilious vomiting hours after birth without abdominal distension • KUB with "double bubble" sign – gaseous distension of stomach and proximal duodenum
Management	• NPO, NG suction • Surgical Consult • Duodenoduodenostomy

Selected GI Disorders continued on next page →

Neonatal Gastroenterology

Selected GI Disorders

Jujonoileal Atresia	
Etiology	• Mesenteric vascular accident during fetal life • 1 per 3000 live births
Symptoms and Diagnostics	• Bilious vomiting hours after birth with abdominal distension • Failure to pass meconium • Hyperbilirubinemia • KUB with air-fluid levels
Management	• NPO, NG suction • Surgical Consult • Resection and anastomosis

Meconium Ileus	
Etiology	5% of newborns with cystic fibrosis, and in 1 per 5,000 to 10,000 live births
Symptoms and Diagnostics	• Abdominal distension and vomiting hours after birth • Failure to pass meconium • KUB – distension, air-fluid levels • Contrast enema – microcolon, +/- impacted meconium pellets
Management	• NPO, NG Suction • Water soluble contrast enema • Surgical enterostomy if needed

Nutrition and Fluid Management

*****Nutrition and Fluid Management is also site specific. Here are some general guidelines from BMC's Nutrition Survival Guide.**

Calculating Glucose Infusion Rate (GIR): (% Dextrose x mL/kg/day) / 144

Fluid Requirements (ml/kg/day)

Birth Weight (g)	Day 1-2	Day 3	> Day 5
<1000	100	140	150
1001-1250	80-100	120	150
1251-1500	80	100-120	150
1501-2000	65-80	100	150
>2000	65-80	100	150

Nutrition and Fluid Management

Suggested Enteral Feeding Guidelines		
Birth Weight (g)	**Initial Rate (ml/kg/day)**	**Advance (mL/kg)**
<750	10	10 mL/kg/d
750-1000	10	10 mL/kg/d or 10 mL/kg BID
1001-1500	10	10-15 BID
1501-2000	30	15 BID
Goal Volume		130-150
*For infants > 2 kg and advancing on NG/OG feeds, they may follow the guide for 1501-2000 grams		

Times after birth (hrs)	Expected Volume per feed (mL)	Expected cc/kg/day	
		34-36 weeks (2.0-2.5 kg)	>/= 37 weeks (>/= 2.5 kg)
0-24 (DOL 0)	~5-10	~20-30	~0-20
24-48 (DOL 1)	~10-20	~60	~20-40
48-72 (DOL 2)	~20-30	~80	~60
72-96 (DOL 3)	~30-60	~100	~80

When To Use What		
Supplement	**When**	**Amount**
FeSO4	Full feeds & greater than DOL 14	2 mg/kg (formula) 4 mg/kg (MM only)
Liquid HMF	To supplement MM when < 35 weeks	Max is 2 pkts/50 mL (not for discharge)
Neosure Powder	To supplement MM when >35 wks & >2 kg	Per site specific recipe
Vitamin D	MM fed babies	1 mL Polyvisol/day = 400 IU/day

Enteral Feeding Options

- Breast milk is best!
- <35 weeks, use Special Care 20 if parents decline donor milk: catered for premature needs
- >35 weeks and >2 kg, use Neosure if parents decline donor milk: transitional and post-discharge formula for up to 10-12 months CGA (standard dilution is 22 kcal/oz)
- Fortify to 24 kcal/oz in conjunction with advance to 80 mL/kg of feeds

Nutrition and Fluid Management continued on next page →

Nutrition and Fluid Management

Absolute Contraindications for Breastfeeding	
Infant Characteristics	Diagnosed with galactosemia
Mother Characteristics	• HIV infection • Antiretroviral medications • Active, untreated, tuberculosis • Human T-cell lymphotropic virus type I or type II infection • Using or is dependent upon an illicit drug • Taking certain prescribed cancer chemotherapy agents. • Undergoing certain radiation therapies; however, some nuclear medicine therapies require only a temporary interruption in breastfeeding.

Department of Pediatric Newborn Medicine
Clinical Guideline

Clinical Guideline:	**Parenteral Nutrition Guideline**
Effective Date:	3/13/2015; Revised 5/30/2015; Revised 10/7/2015; Revised 3/7/2016; Revised 9/2/2016; Revised 2/27/2017

INITIATION OF PARENTERAL NUTRITION

Weight at birth	When to initiate
<1800 g	**Neonatal Premix Stock PN** ("Standard PN") ASAP either Central or Peripheral Access to be run at **60 mL/kg/day**
≥1800 g	Clinical judgment: <50 mL/kg/day enteral feedings by 48-72 hours of life and no plan to advance per protocol
Therapeutic Hypothermia (TH)	Start with Standard PN, order custom PN at first AM rounds (refer to TH guidelines)

New order:	Through order sets > Neonatal Parenteral Nutrition
Renewal:	Select "Reorder" on order screen and adjust components from yesterday's order (Do NOT select "Modify")
Titration:	Select "Yes" or "No" if volume may be adjusted for feeding advance and/or total fluid adjustment

MACRONUTRIENT PARENETERAL NUTRITION ADVANCES AND GOALS

	Standard PN (<1800g, TH) *When @ 60 mL/kg/day*, provides:*	Custom PN Day 1	Daily Advances	Goal
Feeding Volume mL/kg/day	*Refer to Enteral Nutrition Clinical Practice Guideline*			
Lipids g/kg/day†	-	1 (5 mL/kg/day)	↑ 1 g/kg/day	3 (15 mL/kg/day)
Glucose Infusion Rate (GIR)** *Central Max D30%; Peripheral Max D12.5%*	GIR: 4.17	GIR: 4-6	For Glucose <120, ↑ GIR 1-2	~12
Trophamine (AA) g/kg/day	3	≥1800g: 3 <1800g: 4	(To goal Custom PN Day 1)	≥1800g: 3 <1800g: 4

**While on Standard PN, provide additional IV fluids to meet hydration needs; †Lipid Volume: 1 g/kg/day Lipids is equivalent to 5 mL/kg/day; **Avoid cumulative GIR from all IV fluids <4-5 mg/kg/min*

APPROVABLE PN SOLUTIONS:

Osmolarity*:	Peripheral ≤ 1050 mOsm/L (Central ≤2000 mOsm/L)	**Sterile Water:**	Must be > 0 mL

Dextrose and Trophamine are the most osmotic and largest volume additives in a PN solution, therefore:

- Try minor adjustments in Dextrose% or g AA/kg/day with careful attention to optimize energy, GIR and protein provision as much as possible.
- When adjusting AA; adjust cysteine accordingly (**40 mg/kg/day Cysteine per 1 g AA/kg/day**)

**EPIC shows mOsm/L on left hand summary screen when ordering Neonatal PN; alerts >900 mOsm/L*

CYSTEINE◊

g/kg/day AA	mg/kg/day Cysteine
2.5	100
3	120
3.5	140
4	160

MULTIVITAMIN

Wt	Dose
<2500g	2 mL/kg/day
≥2500g	5 mL/day

NEO. TRACE ELEMENTS (NTE)

Wt	Dose
<2500g	0.2 mL/kg/day
≥2500g	0.5 mL/day
Cholestasis *(D. Bili >2)*	0.1 mL/kg/day

HEPARIN

Central PN*:
0.5 units/mL
**Add to peripheral PN if attempt for central access*

SELENIUM

All infants:
2 mcg/kg/day*
**Consider removing or reducing in setting of renal failure*

ZINC

Add if NTE removed (i.e., cholestasis)

Preterm:	400 mcg/kg/day
Term:	250 mcg/kg/day

(Levo)CARNITINE

Add if on PN without EN for ≥14 days

10 mg/kg/day

CALCIUM AND PHOSPHATE GUIDELINES*

	Access	mEq Calcium per 100 mL	mmol Phos per 100 mL
Standard	Peripheral	1.5	0.75
Goal	Central	3	1.5

**Nutrition and/or Pharmacy approval required for any variance to these guideline*

MAGNESIUM

Elevated serum Mg:
0.1 mEq/kg/day
Standard:
0.3 mEq/kg/day

SUGGESTED LABORATORY MONITORING

Electrolytes, BUN, Creatinine	PRN in setting of clinical status. Note: BUN level up to 50 mg/dL reflects utilization of amino acids for energy and, in the absence of other clinical concerns, does not reflect toxicity or renal dysfunction.
Glucose	Daily checks until clinically stable and labs stable on goal GIR; BID when weaning PN and advancing feeds.
Triglycerides	**Check once receiving goal lipids of 3 g/kg/day.** Also consider checking during initial advancement if clinical concern, e.g. hyperglycemia (>180 mg/dL) or ELBW infant <1000g.
	For confirmed TG >250 mg/dL (i.e., not drawn off line infusing lipid): decrease lipids to 1 g/kg/day, follow daily labs and resume 1 g/kg/day advances to goal once <200 mg/dL. Avoid doses <1 g/kg/day if possible.
Calcium, Magnesium, Phosphorus	Once on ≥3 mEq Ca per 100 mL and ≥1.5mmol Phos per 100 mL, then weekly PRN.
Total/Direct Bilirubin; Alkaline Phosphatase	If on PN >2 weeks, follow every other week while on PN/lipids.

**Guidelines represent the minimum recommended frequency of monitoring for stable infants. Frequency of laboratory monitoring should primarily be decided by overall clinical status.*

PARENTERAL NUTRITION WEANING GUIDELINES

Macronutrients					Additives			
Feeding Volume mL/kg/day	40	60	80	100	(Once feeds are fortified)			
Lipids g/kg/day	1-2	**Central:** 0-1 **Peripheral:** 0.5-1		Discontinue PN and IL	**Multivitamin**	1 mL/kg/day	**Calcium**	1.5 mEq/100 mL
Dextrose %	*Maintain %Dextrose in setting of euglycemia;* Ideally ≤ 15%				**Neo. Trace Elements**	0.1 mL/kg/day	**NaPhos**	0.75 mmol/100 mL
Trophamine (AA) g/kg/day:	Fortified Feeds: 1.5-2 Unfortified Feeds: 3-4				**Selenium**	1 mcg/kg/day	**Magnesium**	0.1 mEq/kg/day

Revised February 27, 2017

PACT CODE CARD

What is Pediatric Palliative Care (PPC)?

PPC provides physical, psychological, spiritual, and psychosocial support to children with life-threatening illness and their families, despite prognostic uncertainty. PPC focuses on comfort and quality of life, *without precluding continuation of disease-directed treatment.*

Core PACT Team Members:

- Joanne Wolfe, MD, MPH (PACT Medical Director)
- Tamara Vesel, MD (Fellowship Director)
- Rick Goldstein, MD (PACT Physician)
- Christina Ullrich, MD, MPH (BCRP Rotation Director)
- Janet Duncan, CPNP (Nursing Director)
- Marsha Joselow, LiCSW (Social Work Director)
- Rita Fountain (PACT Coordinator)

Requesting a PACT Consultation:

- Introduce the concept of PACT to the child and family. If you are not sure how to do this, PACT can help you.
- Page the PACT clinician on call via the CHB paging system, and provide the following information: ***reason for*** and ***urgency*** of the referral, and the requesting ***attending physician***.

Introducing PACT: Example Conversation:

"To best meet these goals that we have been discussing, we believe it would be helpful to have the PACT team visit with your family. They are a team that works with us, and they specialize in optimizing your child's quality of life by helping to manage symptoms and provide support to your child and your family. They can also help you clarify your goals of care, and help think through any decisions as they might arise. Our goal is for all of the teams to work together to provide your child with the best care possible."

Enhancement of Quality of Life (QOL):

- Integrated Therapies Team (617-355-7684): Offers Massage Therapy, Guided Imagery, Reiki, Yoga, Meditation
- Expressive Art Therapy: Child Life (617-355-6551)
- Pet Therapy: Center for Families (617-355-6279)
- Acupuncture: For inpatient consultations, call 617-355-4158. For outpatient appointments, call 781-216-3700.
- Make-A-Wish Foundation: (800) 722-WISH

Non-Pharmacologic Symptom Management:

- Limit non-essential painful procedures
- Address coincident depression and anxiety
- Consider alternative therapies: relaxation, meditation, breathing exercises, hypnosis, guided imagery, Reiki, biofeedback, yoga, massage, acupuncture/acupressure, or art/pet/play/music therapy
- For fatigue: consider contributing factors (anemia, depression, drug effects), address sleep hygiene, encourage gentle exercise

More Non-Pharmacologic Symptom Management:

- For dyspnea: consider suctioning, repositioning, comfortable loose clothing, a fan to blow cool air towards the face, limitation of IV fluids, breathing and relaxation exercises
- For nausea/vomiting: dietary modifications (bland/soft, adjust timing/volume of feeds), aromatherapy (peppermint, lavender), acupuncture/acupressure

WHO Pain Ladder:

Pain Level	Drug Class	Specific Agent
Step 1: Mild-Mod Pain	Non-opioid ± Adjuvant	Acetaminophen or NSAID
Step 2: Mod Pain, or Pain Uncontrolled after Step 1	Non-opioid around the clock (ATC) + Short-acting PRN opioid ± Adjuvant	Acetaminophen or NSAID, + PRN morphine, oxycodone, or hydromorphone
Step 3: Mod to Severe Pain, or Pain Uncontrolled after Step 2	Sustained-release (SR) opioid ATC or continuous infusion, + PRN short-acting opioid ± non-opioid ± adjuvant	SR oxycodone, morphine, or transdermal fentanyl

KEY TIPS for Dosing/Escalating Opioids:

- Any patient on opioids must be on a bowel regimen that consists of more than just a stool softener!
- When speaking with patients and families, use the term "opioid" rather than "narcotic."
- Reassure families that their child will not become a "drug addict" on the appropriate opioid regimen.
- Increase the dose of opioid based on clinical response; the "right opioid dose" is the dose that best controls the child's pain with the fewest side effects.
- Dose increases are based on a percentage of the current dose:
  - → 30% increase for mild pain
  - → 50% increase for moderate pain,
  - → 100% increase for severe pain.

Key Tips for Managing Breakthrough Pain:

- Breakthrough pain (BTP) is a transitory flare of moderate to severe pain that occurs on a background of otherwise adequately controlled pain.
- Remember that BTP is different from end-of-dose failure (EDF). EDF refers to pain at the end of a dosing interval of around-the-clock (ATC) opioid medication.
- Increase the daily dose of sustained-release (SR) opioid by an amount equal to 50-100% of the total amount of breakthrough medication that the child required during the past 24 hours.
- Each subsequent dose of the breakthrough opioid should equal 10-15% of the total daily requirement of SR opioid.

Performing Equianalgesic Conversions:

Opioid Agent	PO/PR (mg)	IV/SQ (mg)
Morphine	30	10
Oxycodone	20	n/a
Hydromorphone	7.5	1.5
Fentanyl	n/a	0.1 (100 mcg)

Keeping the Same Opioid, but Changing the Route:

Ex: 90 mg q12 SR morphine PO → morphine IV infusion

- Calculate 24 hr dose: 90 mg q12 * 2 = 180 mg PO/24 hrs
- Use PO to IV equianalgesic ratio: 30 mg PO = 10 mg IV
- Use ratios to calculate new dose: 180/x = 30/10; x= (180*10)/30 = 60 mg IV/24hr = 2.5 mg IV/hr infusion

Changing the Opioid, but Keeping the Same Route:

Ex: 90 mg q12 SR morphine PO → hydromorphone PO

- Calculate 24 hr dose: 90 mg q12 * 2 = 180 mg PO/24 hrs
- Use equianalgesic ratio: 30 mg morphine PO = 7.5 mg hydromorphone PO
- Use ratios to calculate new dose: 180/x = 30/7.5; x = (180*7.5)/30 = 45 mg hydromorphone PO/24 hr
- Reduce dose by 25-50% to account for cross-tolerance: 45 * 0.5 = 22 mg/24 hr (or 4 mg q4h)

Appropriate Use of Naloxone (Narcan):

- Opioid antagonists can reverse opioid-induced respiratory depression, but they also may reverse analgesic effects.
- Naloxone should *NOT* be administered for a depressed respiratory rate with normal O2 saturation, or for a patient who is arousable.
- In this case, simply reduce the opioid dose, provide physical stimulation, and continue to monitor the patient closely.
- If naloxone is needed: dilute 0.4 mg (1 ml) in 9 ml of NS, and administer IV in 1-2 ml increments at 2-3 min intervals until response.

Adjuvant Agents: The primary purpose of these medications is not analgesic, however they may be used to relieve pain in conjunction with other analgesics.

Adjuvants	Comments
Tricyclics: *Nortriptyline*	May cause constipation, dry mouth, postural hypotension, prolonged QT
Anticonvulsants: *Gabapentin* *Pregabalin*	Titrate up gradually to prevent dizziness or drowsiness
Sedatives: *Diazepam* *Clonidine*	Synergistic sedative and respiratory effects with opioids; clonidine acts as an opioid sensitizer
Antispasmodics: *Baclofen*	May cause anticholinergic symptoms; lowers seizure threshold
Salicylates: *Trilisate*	Trilisate has decreased risk for bleeding as compared to other salicylates

Tips for Improving Communication Skills:

Instead of Saying:	*Try Saying:*
Our hypoplast	The child with hypoplastic left heart disease
Your child failed induction (or other treatment plan)	Our treatments were not successful in curing your child
I know how you feel, or I know how difficult this situation is for you	I can only imagine how difficult this situation is for you
Do you want us to do everything to keep your child alive?	What is your understanding of the decision to attempt life-sustaining interventions?
Are you ready to sign the "Do Not Resuscitate" (DNR) orders?	Do you agree with the medical recommendation for "Do Not Attempt Resuscitation" (DNAR)?
We are going to withdraw support now, or We will be pulling the ventilator at this time	We will stop mechanical ventilation as it is no longer clinically indicated, but we will continue to provide maximal supportive care

Clarifying Goals of Care:

- Goals of care are different for everyone. The only way to truly identify and understand your patient's goals of care is to ***ASK***.
- Some examples of goals of care might include: physical and psychological comfort, attending prom or other important events, speaking, eating favorite foods, sleeping in own bed at home.
- **Important questions to ask:** *What do you expect in the future? What are the most important things that you are hoping for your child right now? What are you most worried about?*

Sharing Bad News:

- Acknowledge the difficulty inherent in this discussion.
- Establish a shared agenda before the meeting begins.
- Ask the patient/family to explain their hopes and goals.
- Restate these hopes and goals to ensure that all heath care providers fully understand the wishes of the patient and family.
- Explain the role and impact of life-sustaining therapies
- Forecast the medical possibilities and offer a medical opinion.
- Offer resources to help the family think about difficult decisions (social worker, chaplain, families who faced similar decisions).
- Plan a time to meet again.
- Document the discussion.

Tips for Discussing Life-Sustaining Therapies (LST):

- Avoid mechanical descriptions of CPR ("starting the heart" or "putting on a breathing machine").
- Use neutral, non-judgmental language to describe options. If you are describing cardiac resuscitation in terms of broken ribs and painful electroshock, you may want to reflect on your word choice; consider sharing your reflections with the family.
- Using the word "die" often helps to clarify the fact that CPR is a treatment that attempts to reverse death.

Example Conversation about LST:

We all share the hope that your child will live as long as possible. But that is usually not the only goal. We also want your child to live as well as he possibly can, and some of the treatments that we use to extend life may alter his quality of life in ways that may not be what you want for him. If the time comes when critical decisions need to be made, you will have more control over the situation if we all understand and agree about what is most important for you and your child. Talking about these possibilities does not mean that we are giving up – we think of this strategy as hoping for the best, but planning for the worst. In case your child does not get better, what are you hoping for?

Tasks to Complete BEFORE the Death of a Child:

☐ If there is a possibility that a child may die during your shift, introduce yourself to the child and family as soon as you arrive.
☐ Familiarize yourself with the child's story by speaking with the child's nurse and/or other caregivers.
☐ Involve chaplaincy, child life, and other supportive services.
☐ Determine whether autopsy or organ donation have been discussed with the family. If not, address these issues with the family. If they agree, obtain informed consent.

KEY TIPS About Organ Donation:

- In most cases, the donor must be >36 weeks gestation; HIV, HepB, and HepC negative; no IV drug use in past 5 yrs, no history of lymphoma or leukemia.
- Donation is not limited to whole organs; families may choose to donate tissues such as corneas, heart valves, aortoiliac grafts, pericardium, bone, saphenous and femoral veins, or skin.
- Call the New England Organ Bank (NEOB) at 1-800-446-6362 in order to speak with a representative who can help you determine eligibility and arrange the logistics of procurement.

Tasks to Complete AT the Time of Death:

☐ Familiarize yourself with the child's history before entering the child's room.
☐ Consider asking the child's nurse or chaplain to come with you to introduce you to the family and provide additional support.

In the Room:

☐ Introduce yourself to the family, including your role and your relationship to the deceased child.
☐ Express your sympathy and allow the family to express their emotions before beginning.
☐ Explain that you are going to examine their child. Reassure the family that they may stay if they wish.

Pronouncement of Death:

☐ Identify the patient by his or her hospital ID tag.
☐ Ensure that the patient does not rouse to verbal or tactile stimuli. *Avoid painful and unnecessary stimuli.*
☐ Listen/feel for the absence of heart sounds and of pulse.
☐ Look/listen for the absence of spontaneous respirations.
☐ Note the position of the pupils and the absence of pupillary light reflex.

Chart Documentation of the Death of a Child:

☐ Document all findings in the medical record, including: *Date/time of death; Presence of family at time of death; Physical examination findings; Date/time of physical assessment of patient; Family and attending physician notified; Family accepts/declines autopsy and/or organ donation; New England Organ Bank notified; Medical Examiner notified.*
☐ Notify the attending physician regarding the child's death.

Tasks to Complete AFTER the Death of a Child:

☐ **Autopsy and Organ Donation Conversation/Consent** (If not discussed prior to the child's death)
☐ **Notify the New England Organ Bank (NEOB):** MA mandates that the NEOB be notified for all hospital deaths. Call **1-800-446-6362** within 1 hour of death to inform the NEOB of the family's wishes regarding donation.
☐ **Notify the Massachusetts Medical Examiner (ME):** Call the ME at **1-617-267-6767.** This call is legally mandated for all deaths of children <18 years, including planned home deaths and deaths that occur +/- hospice.
☐ **Note in Chart:** See prior section for details.
☐ **Report of Death:** The physician who pronounced the patient must complete the "Report of Death" form and bring it to the Admitting Department (or the Emergency Dept during off-hours).
☐ **Sign the Typed Certificate:** Provide your pager number, so that you may be reached later to sign the typed Death Certificate.

Writing a Condolence Letter:

- Name the deceased and acknowledge the loss.
- Express your sympathy, using words that remind the bereaved that they are not alone in their feelings of sadness and loss.
- Avoid statements such as *I know how you feel*, unless you truly empathize from prior personal experience.
- Note those special qualities or characteristics that you most cherished or appreciated about the deceased person.
- Recall a memory about the deceased, and try to capture what it was about the person in the story that you admired. You may use humor – funny stories are often very appreciated by the bereaved.
- Remind the bereaved of their personal strengths (patience, optimism, religious belief, resilience) that will help them to cope.
- Offer help during this difficult time, and be specific about your offer. *Never* make an offer that you cannot fulfill.
- End your letter with a phrase of sympathy: "You are in my thoughts" or "My fond respects to you and yours."

Online Resources for Pediatric Palliative Care:

- End of Life/Palliative Care Education Resource Center (EPERC): http://www.eperc.mcw.edu/
- Fast Facts: http://www.eperc.mcw.edu/EPERC/FastFactsIndex
- Children's Project on Palliative/Hospice Services (ChiPPS): www.hhpco.org/pediatrics.
- The Initiative for Pediatric Palliative Care: www.ippcweb.org
- Children's Hospice International: http://www.chionline.org/
- AAP Section on Hospice and Palliative Medicine: http://www.aap.org/sections/palliative/

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Developmental Milestones

	Gross Motor	Fine Motor	Speech/Language	Cognitive	Social
Newborn	• Reflexes (Moro, Babinski) • Flexor posture	Reflexes (Grasp)	• Reflexes (root, suck) • Startles to sound	Soothes to voice	Bonding (parent → child)
2m	**Head up 45° prone**	Hands open ½ the time	Cooing	**Follows past midline**	**Social smile**
4m	• **Sits w/ support** • **Rolls front → back**	• Palmar grasp • Brings objects midline	Laughs, "ga"	Sensory exploration of objects	**"Turn-taking" conversations**
6m	Rolls both ways	• Raking grasp • Transfers objects hand-to-hand	Babble	**Stranger anxiety** Looks for dropped object	Expresses emotions (happy, sad, mad)
9m	• **Sits w/ hands free** • **Pulls to stand**	Radial digital grasp	• "Mama," "dada" (specific) • Gestures bye	**Object permanence**	**Separation anxiety**
12m	**Walks w/wide-based gait**	Fine pincer grasp Feeds self cheerios	**1 word w/meaning** (besides mama/dada)	Imitates gestures/ sounds	• **Explore from secure base** • **Points at wanted objects**
15m	**Walks well**	**Uses spoon**	Follows 1-step command	Looks for hidden object	• **Shared attention: points at interesting items** • **Parallel play**
18m	• **Runs well** • **Throws ball while standing**	• **4 cube tower** • Imitates vertical stroke • Removes garment	• **Point to/name: 3 body parts, self, 2-3 objects** • **10-25 words**	• Matches pairs • Passes M-CHAT	• Pretend play • Begins to show shame and possessiveness
2y	**Jumps on 2 feet**	Tower of 6 blocks	**50+ words, 50% intelligible, 2 word phrases**	Problem solves	• **Testing limits, tantrums** • **Negativism ("no!")** • **Posessiveism ("mine!)**
3y	• **Rides trike** • **Walks up stairs alternating feet**	• **Toilet trained** • **Draws circle**	• **200+ words, 75% intelligible, 3-4 word phrases** • **States name, age, gender**	Knows shapes Counts to 3	**Pretending, cooperative play**
4y	**Hops on 1 foot**	Draws square	• **Sentences, 100% intelligible** • **Past tense**	Counts to 4	Has preferred friend
5y	• **Balance on one foot** • **Skips**	• Copies letters • Draw person	• 5000 words • Future tense	Counts to 10	**Has group of friends**

Early Intervention is responsible for assessing developmental delays and providing appropriate support in children birth through 2 years and 9 months. Services are free. Refer in EPIC.
The Public School System is responsible for assessing deficits and providing appropriate support after 2.9 years. Their initial assessment is called a "TEAM evaluation". An IEP is developed after the TEAM evaluation.

RED FLAGS

- **REGRESSION** (loss of skills) & **PARENTAL CONCERN** are red flags at any age
- Persistent primitive reflexes
- Abnormal tone or movement patterns at any age, spasticity, hypottonia, absent DTRs
- Asymmetry
- Poor head control at 5 mos
- Not sitting independently w/ hands-free at 8 mos
- Not rolling back-front, not taking weight well through the legs when held at 9 mos
- Not walking by 18 mos
- Lack of transfer at 7 mos
- Using one hand exclusively at any age
- Delayed self care (ADLs) at 4 yrs
- Delayed printing at school entry
- Problems w/ feeding and/or swallowing
- Parent suspect hearing loss, babbling stops at >6 mos, lack of response to sound (check hearing!)
- No single words by 15 mos
- No combos by 24 mos
- Stutter past 3 ½ yrs (or earlier if anxiety/mannerisms)
- Idiosyncratic speech, disordered sequence of development
- Poor intelligibility for age
- Lack of developmentally appropriate response to visual stimuli
- Immature play (like younger child)
- Stereotypic play; lack of pretend
- School failure (either for specific subjects like reading or math, or generalized)
- Always check **vision** and **hearing** if any concerns – can be assessed as young as newborn
- Emotional dysregulation
- Abnormal attachment patterns (over-clingy, indiscriminate)
- Limited social smiling and shared enjoyment by 6 mos
- Limited gestures like pointing response to name, joint attention by 12 mos
- Limited social imitative play by 18 mos (e.g. imitating housework)
- Limited pretend play (e.g. feeding doll) by 24 mos
- No friends at school age

Commonly Used EBGs

- AOM
- ADHD, adolescents
- ADHD, preschool and school age
- Bronchiolitis
- Emergency contraception
- Headache
- HTN
- IDA
- Lead
- PrEP
- Pregnancy
- Minor head trauma
- Weight management 12-25
- Weight management 2-11

Newborn Visit

HPI

BIRTH/PREGNANCY HISTORY
- G/Ps, infectious work up
- Gestational age, birth method, sepsis rule-out?

IN/OUTs
- Feeding (8-12/24 hrs): breastfed vs. formula vs. mixed
- No more than 3-4 hours w/o feeding.
- Stool: transitioning from meconium (black, sticky) -> green -> yellow and seedy
- Urine: multiple times per day (# of voids = days of life up until DOL 6, then >6/day)

SLEEP
- Supine, in crib w/o pillows, blankets, or stuffed animals.
- Discuss dangers of co-sleeping

DEVELOPMENT
- Periods of wakefulness, watches faces intently, responds to sounds, fisted hands, can raise head momentarily from prone

Newborn Visit continued on next page →

Newborn Visit	
HPI cont.	**SOCIAL**: who lives at home, who is involved w/ care • Mother's mood: screen for postpartum depression/baby blues • Plan for child care: get process started early (long wait for daycares!)
Exam	• Full exam including red reflex, Ortolani and Barlow maneuvers • Weight check: % of birth weight (should regain BW by 10-14 days), umbilicus and jaundice
A/P	• Has child received Hep B in nursery? If no, give today. • Poly-Vi-Sol (Vitamin D) if exclusively breastfeeding or taking <32 oz of formula • Follow up: ▪ Does infant need weight check? ▪ Maximum allotted time would be to wait until 2 month visit • Anticipatory guidance: ▪ When to call: jaundice, temperature, decreased feeding ▪ Impossible to spoil infants ▪ Limit day time sleep to 4 hours ▪ Back to sleep ▪ Umbilical stump care

2 Month WCC	
HPI	**IN/OUTs** • Feeding (8-12/24 hrs): breastfed vs. formula vs. mixed • No more than 4 hours w/o feeding. • Stool: yellow and seedy • Urine: multiple times per day **SLEEP** • Supine, in crib w/o pillows, blankets, or stuffed animals. • Discuss co-sleeping **DEVELOPMENT** • Social smiles, coos and vocalizes reciprocally, will grasp object placed in hand, lifts head and chest when on stomach . **SOCIAL**: Mother's mood: screen for postpartum depression/baby blues, plan for childcare
Exam	• Full exam including red reflex, Ortolani and Barlow maneuvers • Weight, length, height: head circumference, growing along curve
A/P	• Vaccines: Hep B #2, Hib #1, DTaP #1, IPV #1 , PCV #1, Rotavirus #1 (NOTE: CHPCC gives HepB # 2 @ 1 month) • Poly-Vi-Sol (Vitamin D) if exclusively breastfeeding (should start at newborn visit) • Anticipatory Guidance: ▪ When to call: temperature, decreased feeding, decreased wakefulness ▪ Avoid putting to bed w/ bottle ▪ Rear facing car seat ▪ Place in crib before completely asleep, Back to sleep ▪ Risk of falling once learns to roll ▪ Wait to introduce solids until 4-6 months ▪ Family planning • Follow up: 4 month CPE

4 Month WCC	
HPI	**IN/OUTs** • Feeding Q4-5 hours. breastfed vs. formula vs. mixed • Assess if started any purees/table foods • Stool: yellow and seedy • Urine: multiple times per day **SLEEP** • Supine, in crib w/o pillows, blankets, or stuffed animals. **DEVELOPMENT** • Smiles spontaneously, laughs, babbles expressively, pushes chest to elbows, rolls from stomach to back, reaching for objects. **SOCIAL**: Who lives at home; Mother's mood: screen for postpartum depression/baby blues, childcare plans
Exam	• Full exam including red reflex, Ortolani and Barlow maneuvers • Weight, length, height: head circumference, growing along curve
A/P	• Vaccines: Hib #2, DTaP #2, IPV #2, PCV #2, Rotavirus #2 • Poly-Vi-Sol + IRON if > 50% breastfed or taking <32 oz formula per day • Anticipatory Guidance: ▪ When to call: temperature, decreased feeding, decreased wakefulness ▪ Avoid putting to bed w/ bottle ▪ Rear facing car seat ▪ Place in crib before completely asleep, back to sleep ▪ Keep one hand on baby ▪ Keep small objects away from baby ▪ Start babyproofing ▪ Introduce solids (1 at a time): our families start w/ traditional foods from their countries • Follow up: 6 month CPE

6 Month WCC	
HPI	**IN/OUTs** • Feeding Q4-5 hours. breastfed vs. formula vs. mixed • Ask if started solids (if so, stool might be less frequent, firm/hard, constipation) • Stool: yellow and seedy • Urine: multiple times per day **SLEEP** • Supine, in crib w/o pillows, blankets, or stuffed animals. **DEVELOPMENT** • Babbles, turns to voice, beginning to sit on own, rolls from back to stomach, will transfer across midline **SOCIAL**: Who lives at home; Mother's mood: screen for postpartum depression/baby blues, childcare plans
Exam	• Full exam including red reflex, Ortolani and Barlow maneuvers • Teeth? • Weight, length, height: growing along curve

6 Month WCC continued on next page →

6 Month WCC	
A/P	• Vaccines: Hep B #3, Hib #3, DTaP #3, IPV #3 , PCV #3, Rotavirus #3 Eligible for flu vaccine (will need 2 to complete series, separated by 1 month) • Poly-Vi-Sol + IRON if more than 50% breastfeeding • Anticipatory Guidance: ▪ When to call: temperature, decreased feeding, decreased wakefulness ▪ Solids: one at a time ▪ High chair for feeding so baby can see you ▪ No cow's milk until 1 year old ▪ Brushing teeth ▪ Rear facing car seat ▪ Keep small objects away • Follow up: 9 month CPE

9 Month WCC	
HPI	**IN/OUTs** • Feeding Q4-5 hours. breastfed vs. formula vs. mixed • Solids, no overnight feeds • Stool: *might be less frequent since starting solids, ask if stool if firm/hard and if pt having abdominal distention (these are signs of constipation) • Urine: multiple times per day **DEVELOPMENT** • Uses basic gestures (wave goodbye), seeks out parents, uses repetitive vowel and consonant sounds, turns when name is called, sits on own, pulls to stand, crawls on hands and knees, lets go of objects intentionally, bangs things together
Exam	• Full exam • Weight, length, height: growing along curve (head circum)
A/P	• Vaccines: check that have received 3 of: Hep B, Hib, DTaP, IPV, PCV, Rotavirus ▪ Eligible for flu vaccine (will need 2 to complete series) • CBC and lead • Poly-Vi-Sol + IRON if more than 50% breastfeeding • Anticipatory Guidance: ▪ When to call: temperature, decreased feeding, decreased wakefulness ▪ Increase table foods: 3 meals and 2-3 snacks ▪ Read together ▪ No cow's milk until 1 year old ▪ Brushing teeth ▪ Rear facing car seat until until age 2 ▪ Keep small objects away (babyproofing) • Follow up: 12 month CPE (warn will need blood work at next visit), 1st dental visit at 1 year old or w/i 6 months of 1st tooth eruption

12 Month WCC	
HPI	**IN/OUTs** • Eat w/ family, 3 meals and 2-3 snacks spaced evenly. • Transition from formula to whole milk • Solids, no overnight feeds • Stool: *might be less frequent since starting solids, ask if stool if firm/hard and if pt having abdominal distention (these are signs of constipation) • Urine: multiple times per day **DEVELOPMENT** • Stranger anxiety, shows book if wants to read, responds to simple commands, uses gestures like shaking head no or waving, says mama and dada, tries to copy words, drinks from cup, pulls up to stand, cruising, may take a few steps alone, points
Exam	• Full exam • Weight, length, height: growing along curve (head circum)
A/P	• Vaccines: PCV#4, MMR#1, VZV#1 ▪ Eligible for flu vaccine (will need 2 to complete series) • Anticipatory Guidance: ▪ When to call: temperature, decreased feeding, decreased wakefulness ▪ Falls, drowning prevention and water safety ▪ Poison control 1-800-222-1222 ▪ Read together ▪ Limit screen time ▪ Establish routine ▪ Rear facing car seat until until age 2 ▪ Keep small objects away (babyproofing) • Follow up: 15 month CPE, 1st dental visit at 1 year old or w/i 6 months of 1st tooth eruption

15 Month WCC	
HPI	**IN/OUTs** • Eat w/ family, 3 meals and 2-3 snacks spaced evenly. • Drinks whole milk • Solids, no overnight feeds • Stool: *might be less frequent since starting solids, ask if stool if firm/hard and if pt having abdominal distention (these are signs of constipation) • Urine: multiple times per day **DEVELOPMENT** • 3-5 words, points to body parts, steps w/o support, drinks from cup, scribbles w/ crayon, shows preference for certain activities, begins to have strong dislikes, shows affection to caregivers, follows simple commands
Exam	• Full exam • Weight, length, height: growing along curve (head circum)

15 Month WCC continued on next page →

15 Month WCC	
A/P	• Vaccines: HepA#1, DTap#4, Hib#4, flu if hasn't had • Anticipatory Guidance: ▪ When to call: temperature, decreased feeding, decreased wakefulness ▪ Falls, drowning prevention and water safety ▪ Poison control 1-800-222-1222 ▪ Read together ▪ Limit screen time ▪ Establish routine ▪ Rear facing car seat until until age 2 ▪ Keep small objects away (babyproofing) Follow up: 18 month CPE, 1st dental visit at 1 year old or w/i 6 months of 1st tooth eruption

18 Month WCC	
HPI	**IN/OUTs** • Eat w/ family, 3 meals and 2-3 snacks spaced evenly. Drinks whole milk • Starts developing preferences, important to introduce healthy foods multiple times • Stool: *might be less frequent since starting solids, ask if stool if firm/hard and if pt having abdominal distention (these are signs of constipation) • Urine: multiple times per day **DEVELOPMENT** • Plays simple pretend, points to show interesting things, clings to caregivers in new situations, several single words, points to show wants something, knows names of household objects, follows 1 step commands, walks alone, may do steps, can undress self, eats w/ spoon
Exam	• Full exam • Weight, length, height: growing along curve (head circum)
A/P	• Vaccines: Catchup and flu • Anticipatory Guidance: ▪ When to call: temperature, decreased feeding, decreased wakefulness ▪ Falls, drowning prevention and water safety. Firearm and fire safety. ▪ Poison control 1-800-222-1222 ▪ Limit screen time ▪ Establish routine ▪ Consistent limit setting ▪ Rear facing car seat until until age 2 ▪ Keep small objects away and watch for dangerous spots in house now that walking • Follow up: 2 year CPE, 1st dental visit at 1 year old or w/i 6 months of 1st tooth eruption

2 Year Old WCC	
HPI	**IN/OUTs** • Eat w/ family, 3 meals and 2-3 snacks spaced evenly. Transition to 1-2% milk. • Starts developing preferences, important to introduce healthy foods multiple times • Beginning of awareness of urges to urinate and stool, discomfort in diaper, interested in toileting **DEVELOPMENT** • Copies others, plays beside other children, more defiant, knows names of familiar people, 2-4 word sentences, repeats words, points to things in book, builds towers, shows hand preference, follows two-step instructions, stands on tiptoe, runs, throws ball, walks stairs, copies lines and circles

2 Year Old WCC	
Exam	• Full exam • Weight, height: growing along curve (head circum)
A/P	• Vaccines: HepA#2 and flu • CBC and lead • Anticipatory Guidance: ▪ When to call: temperature, decreased feeding, decreased wakefulness ▪ Drowning prevention and water safety. Firearm and fire safety. ▪ Poison control 1-800-222-1222 ▪ Limit screen time 1-2h/day ▪ Establish routine and stick to it! ▪ Consistent limit setting and encourage positive behaviors. ▪ Help child express and name feelings. Give choices between good options. ▪ If outgrown weight/height limit of rear facing car seat, switch to forward facing ▪ Wear helmet on bikes and trikes ▪ Think about pre-school/school enrollment at 2.5yo • Follow up: 2.5-3 year CPE, 1st dental visit at 1 year old or w/i 6 months of 1st tooth eruption

3 Year Old WCC	
HPI	**IN/OUTs** • Eat w/ family, 3 meals and 2-3 snacks spaced evenly. 1-2% milk. • Starts developing preferences, important to introduce healthy foods multiple times • Beginning of awareness of urges to urinate and stool, discomfort in diaper, interested in toileting **DEVELOPMENT** • Takes turns, shows wide range of emotion and recognizes emotion in others, dresses and undresses self, knows age, name and sex, 2-3 sentence conversation, problem solving puzzles and toys, turns pages of book, turns door handles, climbs well, pedals tricycle, walks stairs one foot on each step
Exam	• Full exam • Weight, height: growing along curve
A/P	• Vaccines: MMRV and flu • CBC and lead • Begin BP screening • Anticipatory Guidance: ▪ When to call: temperature, decreased feeding, decreased wakefulness ▪ Drowning prevention and water safety. Firearm and fire safety. ▪ Poison control 1-800-222-1222 ▪ Limit screen time 1-2h/day ▪ Establish routine and stick to it! ▪ Consistent limit setting and encourage positive behaviors. ▪ Help child express and name feelings. Give choices between good options. ▪ If outgrown weight/height limit of rear facing car seat, switch to forward facing ▪ Wear helmet on bikes and trikes ▪ Address SDH and protective factors of family/child resilience • Follow up: yearly CPE, yearly dental visit

School Age (~4-10)	
HPI	**IN/OUTs** • Emphasize healthy eating and continue to introduce healthy foods even if child does not like. Limit calorie containing beverages. • Typically toilet training; screen for enuresis/encopresis **DEVELOPMENT** • Assess school readiness (language understanding and fluency, communication of feelings). Provide opportunities for socialization and structured learning experiences like early childhood programs or pre-school.
Exam	• Full exam • Weight, height: growing along curve
A/P	• 4y Vaccines: DTaP, IPV and flu • 9y Vaccines: HPV and flu (second HPV in 6mo or at next WCC visit) • CBC and lead at age 4 and then as needed • BP screening • Obesity screening • Anticipatory Guidance: ▪ Emphasize safety and accident prevention ▪ Drowning prevention and water safety. Firearm and fire safety. ▪ Poison control 1-800-222-1222 ▪ Limit screen time 1-2h/day and encourage fun physical activity ▪ Establish routine and stick to it! ▪ Consistent limit setting and encourage positive behaviors. ▪ Teach child about how to be safe w/ other adults (safe touching, no secrets) ▪ Always wear seatbelt ▪ Wear helmet on bikes and trikes ▪ Address SDH and protective factors of family/child resilience • Follow up: Yearly CPE, yearly dental visit

Middle School (~11-13)	
HPI	**IN/OUTs** • Emphasize healthy eating and continue to introduce healthy foods even if child does not like. Limit calorie containing beverages. Allow child to choose between healthy options and be involved in food preparation. **DEVELOPMENT** • Evaluate for school challenges. Discuss bullying, peer group, after school activities.
Exam	• Full exam • Weight, height: growing along curve
A/P	• 11y Vaccines: TDap#1, MCV#1 and flu • BP screening • Obesity screening • Anticipatory Guidance: ▪ Discuss puberty and sexuality and gender identity. ▪ Discuss drugs, tobacco products, and alcohol ▪ Discuss mental health, mood, and how to seek help ▪ Talk to child alone or discuss that this will happen at next visit. ▪ Firearm and fire safety.

Middle School (~11-13)	
A/P cont.	• Anticipatory Guidance: ▪ Limit screen time 1-2h/day and encourage fun physical activity ▪ Consistent limit setting and encourage positive behaviors. ▪ Always wear seatbelt and helmet ▪ Address SDH and protective factors of family/child resilience • Follow up: Yearly CPE, Yearly dental visit

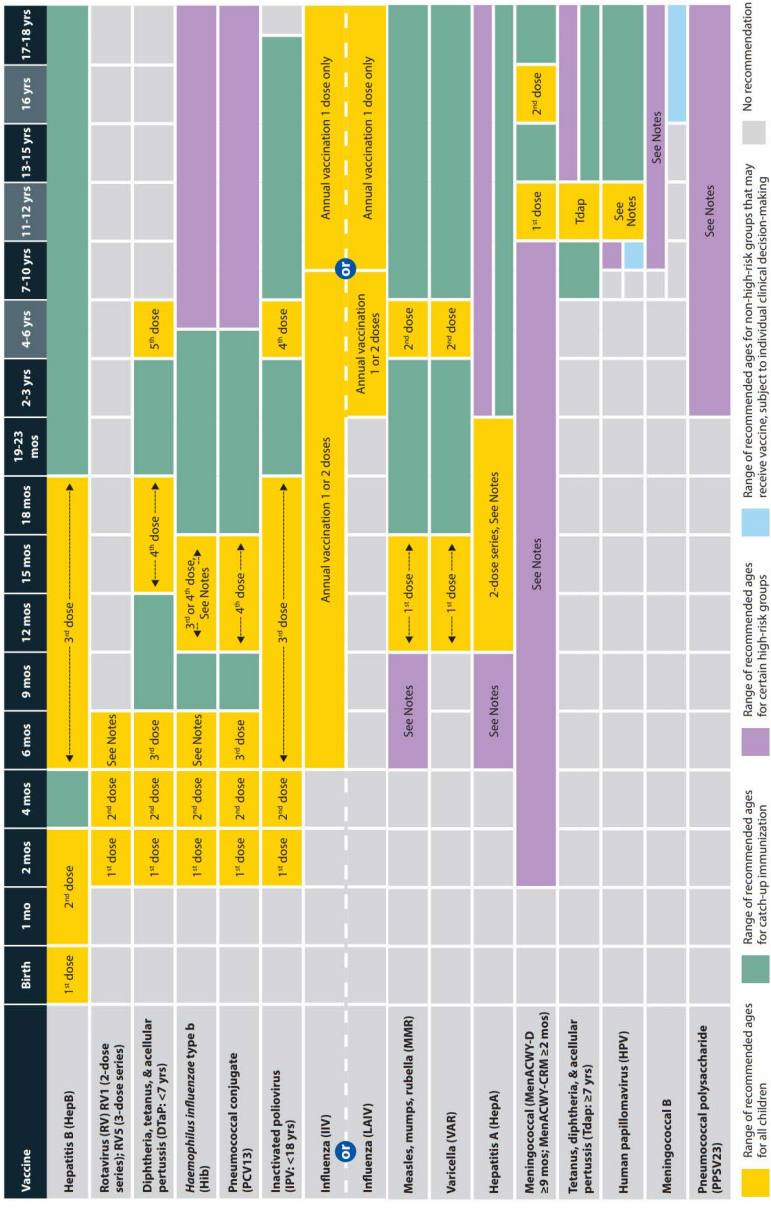
Adolescence (~13-18)	
HPI	**IN/OUTs** • Emphasize healthy eating and healthy choices. Discuss what child purchases and chooses for his or herself. **DEVELOPMENT** • Evaluate for school challenges. Discuss bullying, peer group, after school activities. Discuss college preparation and resources for college assistance.
Exam	• Full exam • Weight, height: growing along curve
A/P	• 16y Vaccines: MCV#2 and flu • BP screening • Obesity screening • Anticipatory Guidance: ▪ Continue to discuss sexuality and gender identity. Discuss safe sexual practices. ▪ Discuss drugs, tobacco products, and alcohol. ▪ Discuss mental health, mood, and how to seek help. Assess for suicide risk. ▪ Firearm safety ▪ Talk to child alone ▪ Limit screen time 1-2h/day and encourage fun physical activity ▪ Consistent limit setting and encourage positive behaviors. ▪ Always wear seatbelt and helmet ▪ Address SDH and protective factors of family/child resilience • Follow up: Yearly CPE, Yearly dental visit

PEDS Scoring

Child's Age: 4 mos -- 17mos	Child's Age: 18mos to 2 yrs	Child's Age: 3 to 4yrs	Child's Age: 5 yrs
PREDICTIVE CONCERNS: *Expressive language* (K6Q02) *Socio-emotional* (K6Q07)	**PREDICTIVE CONCERNS:** *Expressive language* (K6Q02) *Receptive language* (K6Q03)	**PREDICTIVE CONCERNS:** *Expressive language* (K6Q02) *Receptive language* (K6Q03) *Gross motor* (K6Q05)	**PREDICTIVE CONCERNS:** *Expressive language* (K6Q02) *Receptive l language* (K6Q03) *Gross motor* (K6Q05) *Fine motor* (K6Q04) *Preschool/school skills* (K6Q09)
Non-PREDICTIVE CONCERNS: *Global concerns (K6Q01)* *Receptive lang* (K6Q03) *Fine motor* (K6Q04) *Gross motor* (K6Q05) *Behavior* (K6Q06) IF 10-18mos: *Self-help* (K6Q08)	**Non-PREDICTIVE CONCERNS:** *Global concerns (K6Q01)* *Fine motor* (K6Q04) *Gross motor* (K6Q05) *Behavior* (K6Q06) *Self-help* (K6Q08) *Socio-emotional* (K6Q07) *Preschool/schl skills* (K6Q09)	**Non-PREDICTIVE CONCERNS:** *Global concerns (K6Q01)* *Fine motor* (K6Q04) *Behavior* (K6Q06) *Self-help* (K6Q08) *Socio-emotional* (K6Q07) *Preschool/school skills* (K6Q09)	**Non-PREDICTIVE CONCERNS:** *Global concerns (K6Q01)* *Behavior* (K6Q06) *Self-help* (K6Q08) *Socio-emotional* (K6Q07)

Vaccine Schedule

Table 1. Recommended Child and Adolescent Immunization Schedule for ages 18 years or younger



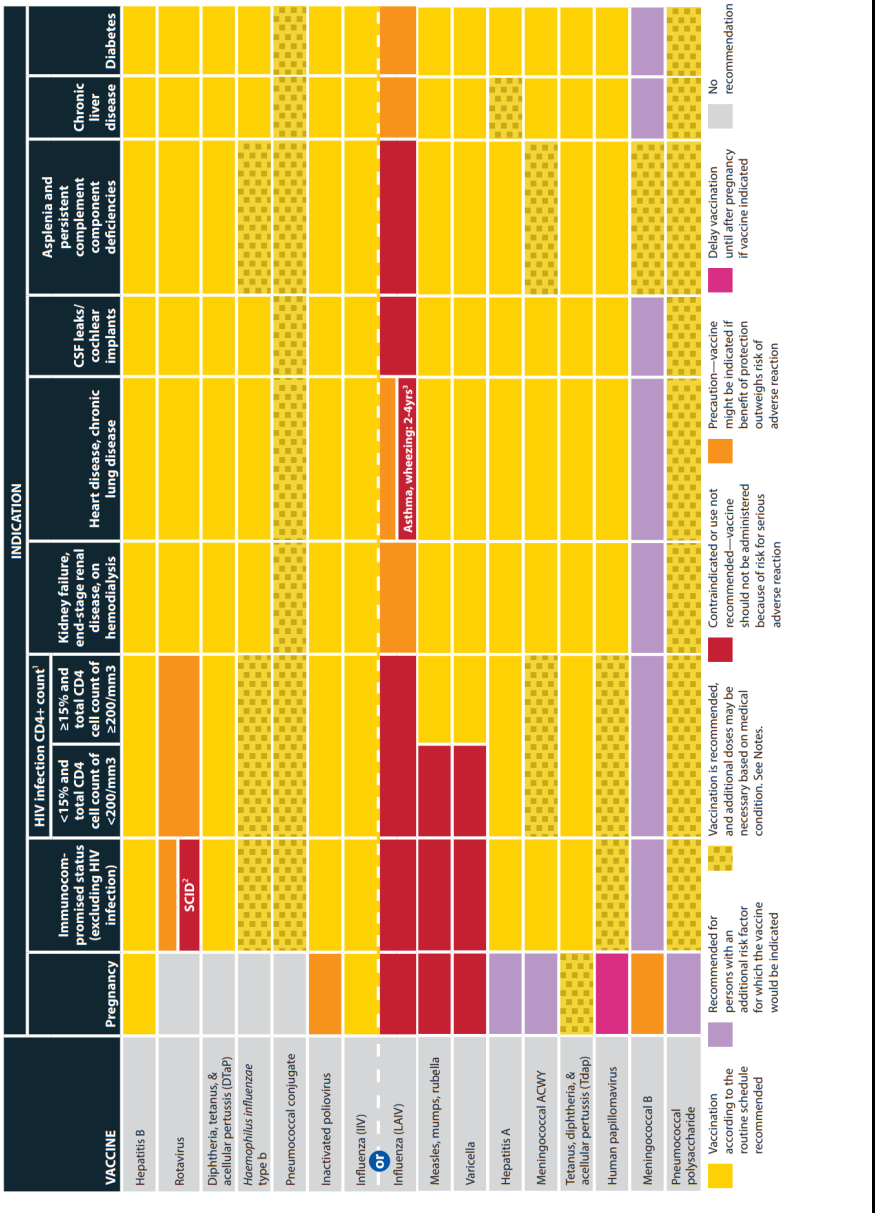
Vaccine Schedule

Table 2. Catch-up immunization schedule for persons aged 4 months—18 years who start late or who are more than 1 month behind

Vaccine	Minimum Age for Dose 1	Minimum Interval Between Doses			
		Dose 1 to Dose 2	Dose 2 to Dose 3	Dose 3 to Dose 4	Dose 4 to Dose 5
Children age 4 months through 6 years					
Hepatitis B	Birth	**4 weeks**	**8 weeks *and* at least 16 weeks after first dose.** Minimum age for the final dose is 24 weeks.		
Rotavirus	6 weeks Maximum age for first dose is 14 weeks, 6 days	**4 weeks**	**4 weeks** Maximum age for final dose is 8 months, 0 days.		
Diphtheria, tetanus, and acellular pertussis	6 weeks	**4 weeks**	**4 weeks**	**6 months**	**6 months**
Haemophilus influenzae type b	6 weeks	**No further doses needed** if first dose was administered at age 15 months or older. **4 weeks** if first dose was administered before the 1st birthday. **8 weeks (as final dose)** if first dose was administered at age 12 through 14 months.	**No further doses needed** if previous dose was administered at age 15 months or older. **4 weeks** if current age is younger than 12 months ***and*** first dose was administered at younger than age 7 months, ***and*** at least 1 previous dose was PRP-T (ActHib, Pentacel, Hiberix) or unknown. **8 weeks *and* age 12 through 59 months (as final dose)** if current age is younger than 12 months ***and*** first dose was administered at age 7 through 11 months; OR if current age is 12 through 59 months ***and*** first dose was administered before the 1st birthday, ***and*** second dose administered at younger than 15 months; OR if both doses were PRP-OMP (PedvaxHIB; Comvax) ***and*** were administered before the 1st birthday.	**8 weeks (as final dose)** This dose only necessary for children age 12 through 59 months who received 3 doses before the 1st birthday.	
Pneumococcal conjugate	6 weeks	**No further doses needed** for healthy children if first dose was administered at age 24 months or older. **4 weeks** if first dose administered before the 1st birthday. **8 weeks (as final dose for healthy children)** if first dose was administered at the 1st birthday or after.	**No further doses needed** for healthy children if previous dose administered at age 24 months or older. **4 weeks** if current age is younger than 12 months and previous dose given at <7 months old. **8 weeks (as final dose for healthy children)** if previous dose given between 7–11 months (wait until at least 12 months old); OR if current age is 12 months or older and at least 1 dose was given before age 12 months.	**8 weeks (as final dose)** This dose only necessary for children age 12 through 59 months who received 3 doses before age 12 months or for children at high risk who received 3 doses at any age.	
Inactivated poliovirus	6 weeks	**4 weeks**	4 weeks if current age is < 4 years. 6 months (as final dose) if current age is 4 years or older.	**6 months** (minimum age 4 years for final dose).	
Measles, mumps, rubella	12 months	**4 weeks**			
Varicella	12 months	**3 months**			
Hepatitis A	12 months	**6 months**			
Meningococcal	2 months MenACWY-CRM 9 months MenACWY-D	**8 weeks**	See Notes	See Notes	
Children and adolescents age 7 through 18 years					
Meningococcal	Not Applicable (N/A)	**8 weeks**			
Tetanus, diphtheria; tetanus, diphtheria, and acellular pertussis	7 years	**4 weeks**	**4 weeks** if first dose of DTaP/DT was administered before the 1st birthday. **6 months (as final dose)** if first dose of DTaP/DT or Tdap/Td was administered at or after the 1st birthday.	**6 months** if first dose of DTaP/DT was administered before the 1st birthday.	
Human papillomavirus	9 years	**Routine dosing intervals are recommended.**			
Hepatitis A	N/A	**6 months**			
Hepatitis B	N/A	**4 weeks**	**8 weeks *and*** at least 16 weeks after first dose.		
Inactivated poliovirus	N/A	**4 weeks**	**6 months** A fourth dose is not necessary if the third dose was administered at age 4 years or older and at least 6 months after the previous dose.	A fourth dose of IPV is indicated if all previous doses were administered at <4 years or if the third dose was administered <6 months after the second dose.	
Measles, mumps, rubella	N/A	**4 weeks**			
Varicella	N/A	**3 months** if younger than age 13 years. **4 weeks** if age 13 years or older.			

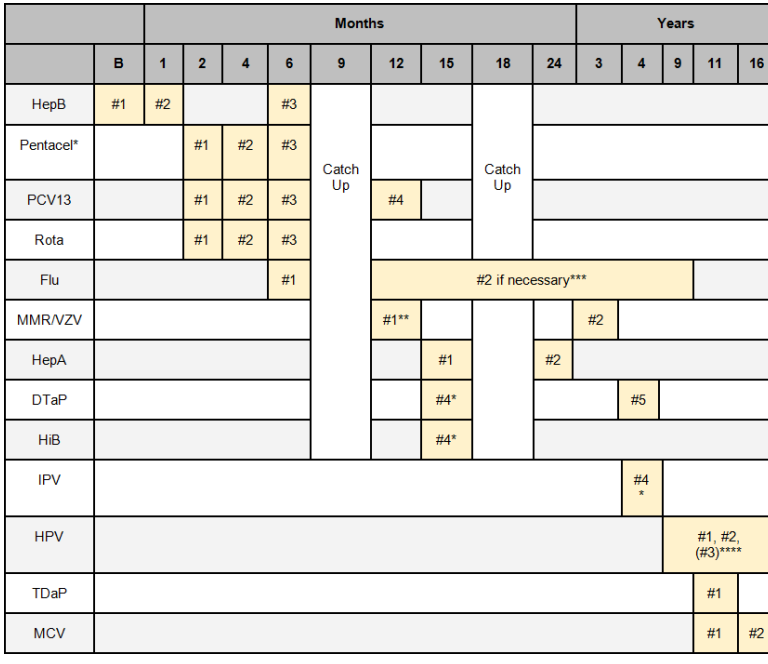
Vaccine Schedule

Table 3. Recommended Child and Adolescent Immunization Schedule by Medical Indication



https://www.cdc.gov/vaccines/schedules/downloads/child/0-18yrs-child-combined-schedule.pdf

CHPCC Vaccine Schedule



* **PENTACEL** = HiB + DTaP + IPV. **PEDIARIX** = HepB + DTap + IPV. KINRIX = DTaP + IPV
** **MMR + VZV (separate)** given @ 12m, combined MMRV @ 3 y/o
***Children 6m - 9y who have never had flu vaccine require 2 doses, 4 weeks apart.
****If HPV course started before 15th birthday, only need two doses. Each dose should be 6-12m apart.

CHPCC Screening Schedule

	6m	9m	18m	1y	2y	3y	4y	5y	9-11	17-21
CBC & Lead		X		X	X	X	X			CBC 1x in post-menarch. girls
GC/CT										annually in sexually active pts
Hearing, Vision							X	X		
PEDS*	X	X	X	X	X	X	X	X		
MCHAT**			X		X					
Oral Risk Assessment		X	X							

CHPCC Screening Schedule continued on next page →

CHPCC Screening Schedule										
	6m	9m	18m	1y	2y	3y	4y	5y	9-11	17-21
Fluoride Varnish		X								
Non-Fasting LDL + HDL									X	X

BMC Clinic Screening Questionnaire Schedule

Visits: / Tools:	All new patients	1m	2m	4m	6m	9m	12m	15m	18m	24m	2.5y	3y	4y	5y	6y	7y	8y	9y	10y	11y	12y	13+: yearly
PEDS																						
THRIVE																						
M-CHAT-R																						
PSC-17																						
PHQ-2/9																						
EPDS																						

Autism Management in Primary Care Clinic*
(CHOP EBG)

Who to Screen	Children ages 12 months or older (AAP recommends screening at 18 mo and 24mo or 30mo) ▪ Risk factors for ASD: sibling w/ ASD, unusual social responses, genetic disorder
How to Screen	PEDS questionnaire @ every visit: "Do you have any concerns about your child's development or behavior?" MCHAT-R or MCHAT-R/F (modified checklist for autism in toddlers) @ 18mo, 24mo
Developmental Red Flags	• Diminished, atypical, or no babbling by 12 months • Diminished, atypical, or no gesturing (e.g., pointing, waving bye-bye) by 12 months • Lack of response to name by 12 months • No single words by 16 months • Diminished, atypical, or no two-word spontaneous phrases (excluding echolalia or repetitive speech) by 24 months • Loss of any language or social skill at any age • Lack of joint attention
Positive Screening – What Now?	• Formal audiology testing • EI referral (<5 years old)(EI services end at 2 years and 9 months • DBP clinic referral for all • Other specialty referrals as needed
Follow Up	• 1 month after positive screening w/ primary provider for continuity • Ensure EI referral was placed, answer family questions, make sure school is involved for children > 2.9 years

ADHD*	
EBGs	ADHD, adolescents; ADHD, pre-school and school-age
ADHD Definition	Persistent and pervasive inattention, hyperactivity, and/or impulsivity affecting cognitive, academic, behavioral, emotional, and social functioning **in more than one setting.**
How to Screen	Age >/= 4 years: Vanderbilt Assessment Scales (**Diagnostic)** (print from internet) ▪ To be filled out by parent and teacher ▪ Obtain detailed information from teacher, including report cards, review of IEP
Common Coexisting Disorders	• Learning disabilities • Tic disorders • Anxiety • Depression • OCD • ODD • Substance abuse
Additional Evaluation PRN	Consider speech/language eval as appropriate ▪ OT/PT referral if motor deficits ▪ Mental health referral ▪ Labs/imaging if risk factors for alternate organic diagnosis: • Blood lead levels, TSH, neuroimaging, EEG

ADHD Treatment (age 6+) in Primary Care Clinic (adapted from BCH EBG)	
Criteria for Initiation of Pharmacotherapy	Confirmation of diagnosis as above: ▪ Age >6 ▪ No allergy to medication ▪ Normal HR, BP ▪ No hx seizures, tourette syndrome, PDD, significant anxiety d/o
Medication Considerations and Recommendations	• Obtain hx of cardiovascular disease (no EKG needed if hx unremarkable) • Consider length of school day, homework, after school activities: ▪ Intermediate release 4-8 hours ▪ Extended release 10-12 hours
Recommended Starting Med (at lowest dose)	Metadate CD 10mg ▪ if cannot swallow pills, few after school demands (sprinkle on food) Metadate ER (Concerta) 18mg ▪ if can swallow pills, extended coverage for afterschool **Paper prescriptions will need to be written monthly
Side Effects	HA, insomnia, anorexia, tics, abdominal pain, HTN
When to Follow Up	Give family Vanderbilt forms to be filled out by teacher/parent, bring to f/u visit Schedule follow up visit for **2 weeks**
2 Week Follow Up Visit	**Improved, minimal side effects**: continue at current dose, return in 1 month **No improvement, minimal side effects:** increase dose on current med, f/u 1-2 weeks ▪ if time of day dependent, consider adding immediate release in late afternoon **Improvement/stable symptoms, significant side effects:** ▪ Severe side effects- change med to equiv dose (e.g.; MPH —> AMP) ▪ Mild side effects- continue current medication, return in 1 month ****Always evaluate for co-morbid dx:** depression, tics, ODD/CD, anxiety
Maintenance/ Other Considerations	• Follow up every 3-6 months when symptoms stable on medication w/ tolerable side effects • Consider starting immediate release for pts <6y OR to find optimal med prior to starting long acting version

Anxiety Management in Primary Care Clinic	
Types of Anxiety Disorders	Selective mutism, separation anxiety disorder, phobias, OCD, social anxiety disorder, generalized anxiety disorder, panic disorder
How to Screen	PSC-17 (Pediatric Symptom Checklist): **4 year olds +** ▪ Looks at psychosocial functioning, externalization and internalization SDQb (Strengths and Difficulties Questionnaire): **3 year olds +** ▪ Sensitivity: 63% to 94% for emotional symptoms ▪ Specificity: 88% to 98% conduct problems ▪ Separate scale assesses impact of symptoms on global functioning ASQ-SE (Ages and stages questionnaire—social emotional): **6-60 months** ▪ Screens for social-emotional communicative, motor, problem- problems ▪ Sensitivity: 71% to 85% ▪ Specificity: 90% to 98%
Positive Screening	• Obtain detailed hx re: symptoms, freq, duration, severity, degree of distress or interference • Consider SW involvement as needed • Behavioral Health/Psych referral
Initial Treatment (School Aged)	• CBT • **What if symptoms persist? (school age)**: SSRI treatment in consult w/ psych

BMC Primary Care Clinic Resources	
Asthma Education	**WHAT**: 5-10 minute check in w/ patients to review triggers, spacer teaching, med teaching, AAP, screening for in home asthma services such as Breathe Easy **WHEN**: Monday-Friday 9am-5pm. Appropriate for any patient w/ asthma here for WCE, urgent visit, etc. **HOW**: Reachable via pager 8818
Health Leads	**WHAT**: A team of college students (usually premed) who can help patients access community resources including housing, daycare, adult education, food pantries, etc. **WHEN**: Monday-Friday; 9am-12pm and 2pm-5pm **HOW**: Find them in the blue shirts in the hallway or page them at 8203
Reach out and Read (ROR)	**WHAT**: Program to promote early literacy **WHO**: Age child 6 months – 5 years **HOW**: Kids ages 6 months – 5 years receive a book at every well child visit. **WHERE**: The ROR books are located in the little office next to the nursing office in the main primary care clinic hallway – they are next to a bunch of stickers too!!
Lactation Resources	**WHAT**: We have lactation consults (both in the clinic and in the newborn nursery) who can often help mom's during the newborn visits. **WHO**: Any mom who is breastfeeding or attempting to breastfeed, especially those who have babies who aren't gaining good weight. Also appropriate to call them if moms have questions about pumping, latch, nipple pain, etc. **WHEN**: Anytime during PC clinic **HOW**: You can page the Child Life Specialist (Karlie Kennedy) who is usually in clinic and can come work w/ moms! You can also page a lactation consultant from the newborn nursery but it is very likely that they will be too busy to come during your visit.
Food Pantry	**WHAT**: Provides food resources (including fresh fruits and vegetables) to patients w/ food insecurity, chronic illness, etc. **WHO**: Anyone who gets a referral; immigration status DOES NOT matter and you don't need to document income when you refer, you just need to place the referral **WHEN**: Open Monday – Friday; 10:00 AM – 4:00 PM; pts can go 2x monthly **HOW**: Write a prescription for your patient in EPIC (they MUST have a Rx)

BMC Primary Care Clinic Resources	
Street Cred	**WHAT**: Organization started by BCRP alum Lucy Marcil to help families get the maximum amount on their tax returns **WHO**: For all pts w/ income <54,000 **HOW**: Refer patients to street cred (use .STREETCRED in the EMR) info@mystreetcred.org (617) 414-5946
Child Witness to Violence Project	**WHAT**: Provides social support and counseling for young (< 8y) children who have witnessed domestic violence. Run under the auspices of the DBP clinic. **WHERE**: Counseling happens at BMC but there is no documentation left in the chart. This can be tricky because you will not know if your patients are receiving services based on chart review alone. **HOW**: Call (617) 414-7425

BMC Pediatrics Specialty Outpatient Clinics	
CCP Clinic	**WHAT**: Primary care home for patients w/ complex medical problems including NICU grads, patients w/ complex genetic disorders, etc. **WHO**: All patients w/ multiple medical problems and/or exceptionally complex social situations AND their siblings **HOW**: Talk to Dr. Jack Maypole (BCRP alum!)
GROW Clinic	**WHAT**: BMC based clinic for kids w/ FTT, provides comprehensive wrap around services including social work and home visits performed by a dietician. Not a PCP **WHO**: For FTT kiddos (I think only less than age 5) **HOW**: Talk to the Grow clinic patient navigator (refer in EPIC)
Baby Steps Clinic	**WHAT**: Provides coordination of care for babies who are preterm or have had complicated newborn courses; NOT primary care. Comprehensive team including pediatrician, nutritionist, OT, dieticians and close communication w/ neuro and GI **WHO**: For any baby who had a tough newborn course, is having difficulty gaining weight or other challenges. (All preterm) **HOW**: This is usually done when the baby leaves the nursery but if you think a baby would benefit from this clinic as well you can place a referral in EPIC
SoFAR Clinic	**WHAT**: Primary Care Clinic for moms w/ a history of substance use and their babies (babies w/ a history of NAS) or exposure **WHO**: Babies born to moms who struggled w/ substance use during pregnancy and their siblings. Moms get care too--Dyadic approach! **HOW**: Usually referred to the clinic from the newborn nursery but this can this can also be done on the outpatient side. Reach out to SoFar clinic SW to schedule an intake for the family.
Teen and Tot Clinic	**WHAT**: Primary Care Clinic for teen moms and their babies – teen girls can get prenatal care in a centering group by midwife. Teen girls and children are seen together during primary care visits. The clinic also has a patient navigators and is run by Dr. Pierre-Joseph **WHO**: Teen moms and their babies/pregnant teens who have elected to become parents **HOW**: Page Adrian Stevenson (teen and tot patient navigator) or talk to Dr. Adolphe or Dr. Pierre-Joseph to transfer maternal/newborn care to teen and tot. Adrian will talk to the mom and do an intake
IEP Clinic	**WHAT**: Clinic that is run by BMC preceptor Dr. Adolphe that bridges primary care w/ DBP, Helps w/ ADHD, ASD, learning/intellectual disorders. Appropriate for kids w/ IEP who aren't making progress or accessing the curriculum well or if parents have questions about the IEP. **WHEN**: Usually takes patients ~ 1 month to get in (for now)… if you need help sooner or in the meantime, reach out to Dr. Adolphe directly. **HOW**: Place a referral in EPIC

Specialty Outpatient Clinics continued on next page →

BMC Pediatrics Specialty Outpatient Clinics

Family Planning Services	Birth control counseling, STD testing, options counseling, for patients of ANY AGE, same-day birth control available page Teakia Brown
Pain Clinic	For kids with chronic pain (including functional), MD, acupuncturist, psychologist, PT
CATALYST Clinic	Teens with substance use disorder
Menstrual Disorders Clinic	Joint Adolescent/Heme Clinic
Lead Clinic	Sean Palfrey, for kids with elevated lead
CATCH Clinic	For gender affirming care
Embedded Child Psychiatrist	Andrea Spencer available for “curbside consults” and “co-management of patients with behavioral health concerns”-- page directly or refer to Integrated Behavioral health

BMC Indications for Social Work Consult

- Child Abuse
- Neglect
- Domestic Violence
- Sexual assault
- Mental health (depression, anxiety, psychosis, PTSD, etc.)
- Thoughts of suicidal ideation/homicidal ideation
- Substance abuse
- Family bereavement
- Newly diagnosed chronic or fatal illness
- Witnessing/part of community violence
- Family distress or dysfunction
- Bullying

Liz Kerr #3433, 4-7756 **Jill Baker #2610, 4-7799**

BMC Clinic Tips

- Always review medications, allergies, etc by going to the A/P section of epic and clicking “mark all as reviewed”
- You can delete a note by clicking the “X” by the “sign note” or “pend note” drop down
- When ordering immunizations, use the order sets, which are present under “A/P” order section
  - Simply check off the box and sign the orders
- Huddle w/ your nurse and CA prior to clinic to discuss patients that may be late, clinic flow goals, complex patients, anticipated orders
- You know a patient is roomed when their vitals populate into your note
- To promote continuity, staple your card to the after visit summary
- Utilize case manager to make follow up appts for high risk patients

**** You must import the flowsheets for the developmental screens into your note & indicate positive or negative**
**** You must send your notes to your preceptor w/i 48 hours for signing and billing**

CHPCC Contacts

Fax: 617-730-0505
Charge RN: 84706
Front Desk: 58944
SW Pager: 0170
Child Life: 84708
Dental Clinic: 5654
Lactation: 56445
Newborn Pager (for scheduling visits): 5222
Navigator: 5931
YPP: 7718

CHPCC Primary Care Workflow

- Huddle with your nurse prior to clinic. During the session, you can stay in touch in person, or via ASCOM phone
- Patient checks in, which triggers a color change on PowerChart
- CA vitalizes patient and then places paperwork in the large conference room door after the patient is roomed
- Time permitting, your nurse will complete an intake medicine reconciliation and perform an initial assessment
- If age appropriate, take Reach out and Read book, toothbrush, and toothpaste with you
- Time permitting, to support workflow, nursing orders routine vaccines and sends them to you to be co-signed
- During the visit, don't hesitate to page any of the below numbers to help facilitate timely care for your families
- Consider using the clinic's "quick orders" tab to streamline your workflow
- Schedule a follow-up visit with your patient. It is good practice to even book the next annual visit in the computer
- Labs are drawn after the visit. Phlebotomy is located one floor above CHPCC. Instructions are printed on the "Patient passport" handouts available in all the rooms
- After the session, indicate if your patients' developmental screens were positive or negative on the paper billing pass, and give the pass to your preceptor

CHPCC Urgent Care

- Urgent care visits can be interspersed with primary care visits. You will also have dedicated urgent care sessions.
- Use the note's nurse triage assessment and the urgent care patient board to identify which nurse is caring for each patient. This nurse is your point person for additional interventions, such as a dose of ibuprofen or a nebulizer treatment.
- Be flexible -- you may be asked to see a sick walk-in patient, or assist another provider with a difficult case.
- Important contact information, such as the ED expect line (call this number before transferring a patient to the ED) and the x-ray reading room are posted in the urgent care workroom.

CHPCC Co-Located "Specialty" Clinics

Refer patients with a PowerChart order	
Asthma Clinic	In-depth education or intervisit care, including home visits, for asthma patients requiring more frequent visits and/or asthma patients with more severe disease
Advocating Success for Kids (ASK)	A multidisciplinary team (developmental medicine, educational specialist, social worker, and primary care) assists children who are having academic difficulties, such as from ADHD or a learning disability, who are not making adequate progress despite having an IEP, and also conducts evaluations for autism spectrum disorder and other developmental delays
Rainbow	A multidisciplinary team to coordinate care for our clinic's medically complex children. Owing to their medical complexity, patients with a "Rainbow" distinction get longer patient visits, intervisit monitoring, and additional nursing, social work, and case management support.
RASH	Have your patients' skin concerns addressed quickly, in a primary care setting, by pediatricians. This is generally far faster than a referral to dermatology.
Young Parents Program (YPP)	A teen-tot clinic that provides primary care for adolescent parents and their children. Dedicated YPP staff provide longitudinal support.

DECISION SUPPORT ALGORITHM FOR ADOLESCENT SCOLIOSIS
Ages 10 to 18 Years

INSPECT

From the back
Is pelvis level?
Is waist symmetrical?
Are shoulders leveled?
Adam forward bending test

From the side
Excessive lordosis?
Excessive kyphosis?

ASYMMETRY ON EXAM
MEASURE WITH SCOLIOMETER AT THE HORIZON

SCOLIOMETER <7°

Follow-Up
- in 6 - 12 months based on growth potential

SCOLIOMETER ≥7°

Evaluate Further
- Obtain standing PA scoliosis X-Ray From C7 to iliac crest
- Must request Cobb Angle in X-Ray order
- Follow-up based on Cobb Angle

GROWTH POTENTIAL	FOLLOW-UP BASED ON COBB ANGLE (assuming no red flags are present)				
	10 - 14°	15 - 19°	20 - 24°	25 - 29°	greater than 30°
Age 10 or older but **Pre-Pubertal**	1 year. Repeat Hx/algorithm	3-6 mos. Repeat Hx/algorithm Refer if Xray progression**	**REFER** or 3 mos. Repeat Xray/Cobb Refer if Xray progression**	**REFER** Visit in 1 month	**REFER** Visit in 1 Month
Pubertal Pre-Menarcheal girl or Boy age 12-14	1 year. Repeat Hx/algorithm	3 mos. Repeat Hx/algorithm Refer if Xray progression**	**REFER** or 3 mos. Repeat Xray/Cobb Refer if Xray progression**	**REFER** Visit in 1 month	**REFER** Visit in 1 month
Post-Menarcheal girl or Boy age 15-16	1 year. Repeat Hx/algorithm	6 mos. Repeat Hx/algorithm Refer if Xray progression**	6 mos. Repeat Xray/Cobb Refer if Xray progression**	6 mos. Repeat Xray/Cobb Refer if Xray progression**	**REFER** Visit in 1 Month if ≥45°
Skeletally Mature (2y post menarche or age 17-18)	No Treatment Reassure	No Treatment Reassure	5 Years. Repeat Xray/Cobb Refer if Xray progression**	5 Years. Repeat Xray/Cobb Refer if Xray progression**	**REFER** Visit in 1 Month if ≥45°

RED FLAGS
- Pain
- Double Curves
- Neurofibromatosis
- Connective Tissue Disorders
- Left Curvature
- Neurological Abnormalities
- Foot Deformity
- Leg Length Discrepancy

HIGHER RISK OF PROGRESSION
- Girls
- During growth spurt
- Thoracic curves
- Double curves
- More severe curves

Sign of near completion of growth = gained <1cm in height in 6 months
**Xray progression = increase in Cobb Angle of 5 degrees or more

April 2009

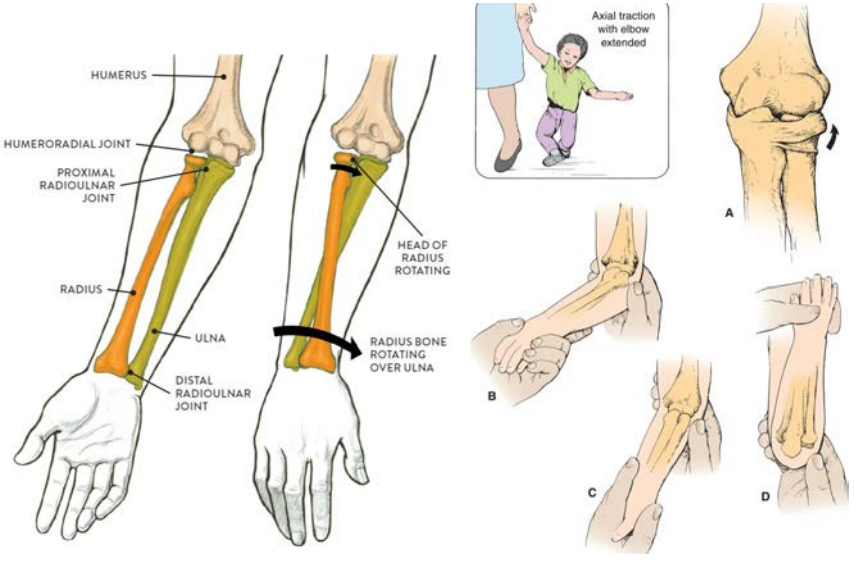
By Dr. M. Timothy Hresko, Department of Orthopaedic Surgery, Children's Hospital Boston and Dr. Wanessa Risko in collaboration with PPOC members

Pre-Participation Physical	
History	• Goal to elucidate conditions that might preclude or limit sports participation • Cardiac history • Dyspnea on exertion - consider exercise induced asthma • History of head trauma • History of "burners" or "stingers" (from transient brachial plexus compression/stretching) - if recurrent may need C-spine XR • Disordered eating (esp in sports w/ weight requirements) • Substance abuse • Family history: sudden death, congenital heart disease, arrhythmias, Marfan syndrome
PE	• Special attention to CV, respiratory, and MSK • MSK: assess ROM, symmetry, stability
Cardiac Testing	• e.g. EKG, echo, exercise testing • ONLY if clinically indicated
Clearance	• Increased risk of injury? • Would treatment make athlete safe to participate? • Can limited participation be allowed while treatment is undergone? • Limitations for some or all sports?

General Approach to the MSK Exam			
	Step	**Focus**	**Red Flags**
1	History	Mechanism, chronicity, exposures, associated symptoms	B symptoms Major trauma
2	Inspection (compare to contralateral side)	Make sure to EXPOSE for best exam Asymmetry, atrophy, deformity, ecchymosis, erythema, scars	Erythema - sign of infection Deformity concerning for major trauma
3	Palpation	Anatomic points of interest	Warmth - sign of infection Diminished sensation - sign of neurologic deficit
4	Range of Motion (active first, then passive)	Pain with motion, limited ROM (distinguish whether 2/2 pain, effusion, mechanical problem)	
5	Strength	5/5: full strength 4/5: movement against some resistance 3/5: movement against gravity 2/5: movement but not against gravity 1/5: muscle flicker 0/5: no contraction	Diminished strength (if not 2/2 pain) - sign of neurologic deficit
6	Special Testing	Joint specific - see relevant section	See relevant section

Upper Extremity – Elbow/Forearm/Wrist

Anatomy



Exam Pearls

Rapid Elbow/Forearm Neurovascular Exam

Brachial artery	Brachial + radial pulses, perfusion check
Median Nerve	Sensation over palmar side of digits 1-3
Anterior Interosseous Nerve ** Motor-only branch of median nerve	Test “OK” sign, grip strength
Radial Nerve	Wrist extension
Ulnar Nerve	Spread fingers against resistance

Common Diagnoses

Supracondylar Fracture

Description/ Mechanism	Usually FOOSH with elbow hyperextension
Diagnosis	• **Exam**: Gross deformity, limited active elbow motion • **Imaging**: Get AP and lateral XR. Findings may be subtle (posterior fat pad sign on lateral film)
Management	• Ortho consult • Usually surgical fixation for displaced fractures

Upper Extremity – Elbow/Forearm/Wrist

Common Diagnoses cont.

Nursemaid's Elbow (AKA subluxation of radial head)

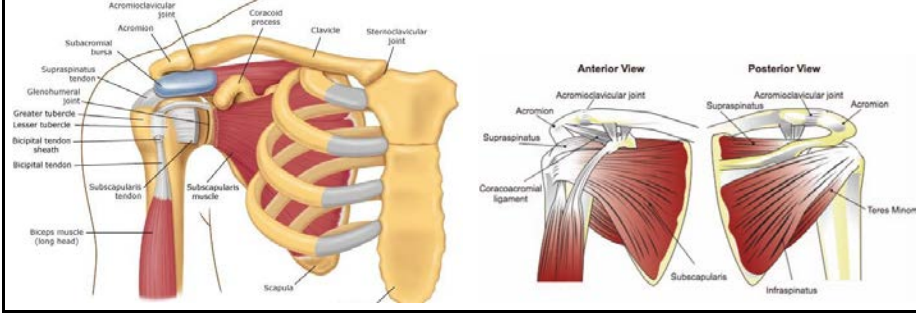
Description/ Mechanism	Traction on arm with extended elbow (e.g. swinging child through the air)
Diagnosis	• **Exam**: no deformity, elbow held in passive pronation with slight flexion, refusing to use arm • **Imaging**: Unnecessary unless suspect fracture based on H&P, or if reduction unsuccessful
Management	Stabilize elbow w/ one hand → supinate forearm and flex elbow (will usually feel/hear click)

Distal Radius Fracture

Description/ Mechanism	• Most common pediatric fracture • FOOSH
Diagnosis	• **Exam**: Pain, ecchymosis, swelling • **Imaging**: AP + lateral of wrist and forearm; consider AP+lateral of elbow if tender or if diaphyseal fractures present
Management	• Ortho consult • Depending on severity may require anything from immobilization to ORIF

Upper Extremity – Shoulder

Anatomy

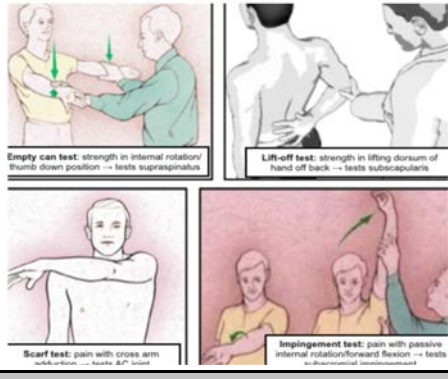


Shoulder continued on next page →

Upper Extremity – Shoulder

Exam Pearls

Rotator cuff muscles (mnemonic: SITS → AEEI)
- Supraspinatus → Abduction
- Infraspinatus and Teres Minor → External rotation
- Subscapularis → Internal rotation



Common Diagnoses

Proximal Humeral Fracture

Description/ Mechanism	• FOOSH • Direct blow to lateral shoulder
Signs/ Symptoms	History of trauma, severe shoulder pain, pain w/ arm movement
Diagnosis	• **Exam**: tenderness, swelling, shoulder asymmetry, arm shortened and held in extension • **Imaging**: AP and axillary XR views of humerus ▪ Get scapular "Y" view in addition if concerned for shoulder injury ▪ Suspect Salter-Harris I if negative XR + tenderness at physis
Management	• Immobilization • Likely ortho consult (esp if more severe - assoc. w/ shoulder dislocation, neurovascular compromise, etc.)

Dislocation

Description/ Mechanism	• Majority of dislocations are anterior • Blow to abducted/externally rotated/extended arm • Fall on outstretched arm • Forceful forward swinging of arm
Diagnosis	• **Exam**: arm abducted and externally rotated w/ resistance to all movement, loss of rounded appearance of shoulder ▪ Evaluate for sensory loss over lateral deltoid (2/2 axillary nerve dysfunction) • **Imaging**: AP + scapular "Y" + axillary XR to confirm dx and exclude fractures (can be repeated post-reduction if unsure of success)
Management	Reduction (variety of techniques exist) → immobilization and referral to sports med/ortho for prevention of recurrent dislocation

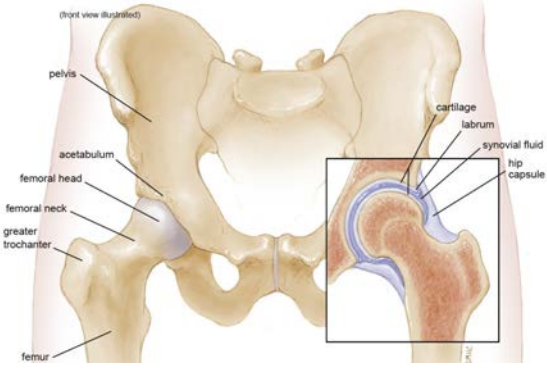
Rotator Cuff Injury

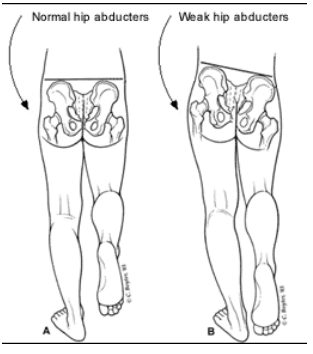
Description/ Mechanism	• Includes impingement (inflammation & pinching of rotator cuff tendons) and rotator cuff tears • Overuse or acute injury, usually involving throwing or overhead activities

Upper Extremity – Shoulder	
Common Diagnoses cont.	
Rotator Cuff Injury cont.	
Signs/ Symptoms	Pain in upper arm, worse w/ overhead activity or lying on affected side
Diagnosis	• **Exam**: pain/weakness with testing of rotator cuff muscles; positive empty can, lift off, and/or impingement tests (see above) • **Imaging**: XR only if bony pathology suspected; MRI best
Management	• Can start w/ conservative management (NSAIDs, PT) • Chronic, symptomatic tears → consider surgical intervention
Little League Shoulder (proximal humeral epiphysiolysis)	
Description/ Mechanism	• Overuse injury from throwing causing microfractures in humeral epiphysis • Most common in 11-16 yo athletes
Signs/ Symptoms	Progressive shoulder pain w/ throwing, localized to proximal humerus
Diagnosis	• **Exam**: TTP at proximal humerus • **Imaging**: AP XR of both arms in external and internal rotation; can get MRI if dx unclear
Management	• Rest x 3 mos (minimum) + PT, then gradual progression to throwing • Can still bat and play positions that do not require a lot of throwing
AC (acromioclavicular) Joint Injury	
Description/ Mechanism	• Ranges from sprain of AC ligaments to full ligamentous rupture w/ clavicular displacement • Usually fall onto or direct blow to shoulder
Diagnosis	• **Exam:** tenderness, swelling, asymmetry at AC joint, prominent distal clavicle; + scarf test • **Imaging:** XR (abnormal in more severe injury, may be normal if joint space not widened)
Management	• Less severe injury (no separation of joint capsule) → sling 1-2 weeks, ice, NSAIDs → early motion as able, including flexion/extension at elbow • More severe injury → likely surgical intervention
Clavicular Fracture	
Description/ Mechanism	Classified by location - most common is midshaft fracture > distal third > proximal third
Diagnosis	• **Exam**: arm held adducted close to body, often supported w/ opposite hand; point tenderness, crepitus ▪ Neurovascular and respiratory exam crucial due to risk of brachial plexus and lung injury • **Imaging**: XR
Management	• Most heal well w/ sling, but indications for surgery are controversial • Any sign of neurovascular compromise → acute reduction needed

Lower Extremity – Hip

Anatomy





Exam Pearls + Special Tests

- Hip pain can refer to groin, thigh, or knee - or present as a limp/refusal to walk w/o complaint of pain
  - Pain from intra-articular pathology often localizes to groin
- **Barlow/Ortolani**: remember to apply gentle anterior pressure to the trochanter during abduction (Ortolani test)
- **Trendelenburg test**: Positive when patient stands on one leg and the contralateral hip drops, indicative of gluteals/ hip abductor weakness
- **Log roll test**: patient on back w/ leg fully extended and relaxed, examiner passively rotates leg and hip internally and externally
  - Pain should yield high suspicion for intra-articular pathology

Common Diagnoses

Legg Calve Perthes

Description/ Mechanism	Avascular necrosis of the hip, most common age 5-7, M > F
Signs/ Symptoms	Activity-related hip pain and/or limp (acute or chronic)
Diagnosis	• **Exam**: Trendelenburg gait, decreased hip abduction and internal rotation • **Imaging**: XR often normal early in course, bone scan or MRI more suggestive of dx
Management	• Non-weight bearing and restoration of motion - crutches, NSAIDS, PT, aquatherapy • Severe cases may require spica casting or surgery

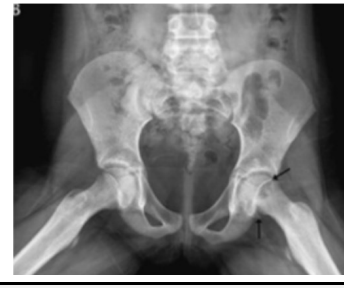
SCFE

Description/ Mechanism	Displacement of the capital femoral epiphysis from the femoral neck through the physeal plate; commonly ages 10-16, M > F
Signs/ Symptoms	Groin pain, knee pain, limp

Lower Extremity – Hip

Common Diagnoses

SCFE

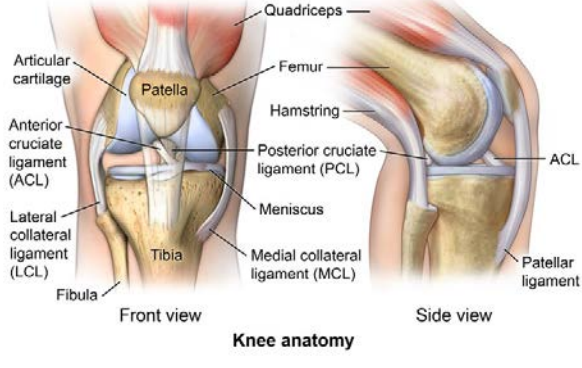
Diagnosis	• **Exam**: decreased hip ROM, hip externally rotated at rest, leg length discrepancy • **Imaging**: AP and frog leg lateral hip XR • Look for "ice cream scoop falling off the cone	

DDH

Description/ Mechanism	Abnormal development of shallow acetabulum causing hip joint instability; F > M
Diagnosis	• **Exam**: positive Barlow/Ortolani - only reliable in ages <3mo; limitation of hip abduction or positive Galeazzi (asymmetric knee heights when hips & knees flexed) in ages >3 mo • **Imaging**: US until age 4-6mos, AP XR pelvis w/ hip in 20-30 degree flexion after age 4-6mos
Management	• Ortho referral • Depending on age at diagnosis/referral and severity, may be treated w/ anything from observation to harness to operative management

Lower Extremity – Knee

Anatomy

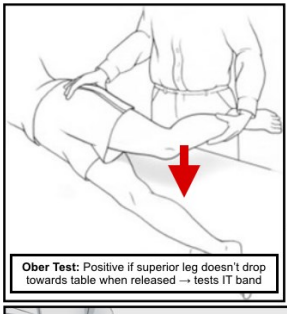


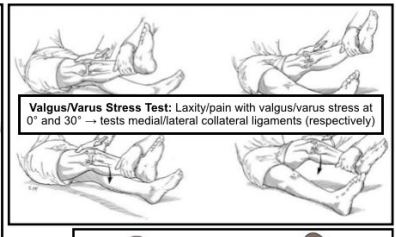
Knee anatomy

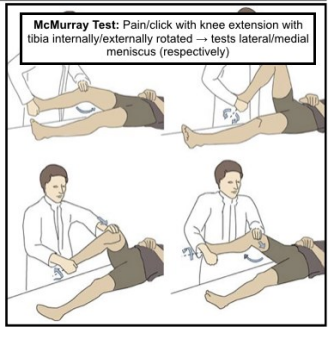
Knee continued on next page →

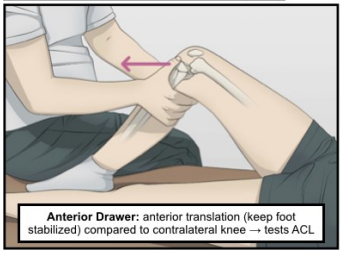
Lower Extremity – Knee

Exam Pearls + Special Tests









Common Diagnoses

Osgood Schlatter

Description/ Mechanism	• Traction apophysitis of tibial tubercle at patellar tendon insertion • Often children who play jumping sports and/or are undergoing rapid growth spurt • (Corollary process at inferior patellar pole = Sinding-Larsen-Johansson Syndrome)
Signs/ Symptoms	• Gradually worsening anterior knee pain, exacerbated by kneeling, jumping, stairs, walking uphill • Can be asymmetric or bilateral
Diagnosis	• **Exam**: prominence of and TTP at the tibial tubercle, pain w/ resisted knee extension or squatting • **Imaging**: not routinely indicated unless to rule out other dx
Management	• Usually conservative - pain management • PT for strengthening • Continuation of activity (as long as not prolonged squatting/kneeling - e.g. playing

Patellofemoral Pain Syndrome (PFPS)

Description/ Mechanism	Abnormal tracking of patella causes anterior knee pain w/o intraarticular pathology
Signs/ Symptoms	Anterior knee pain worsened w/ prolonged sitting (theater sign) or descending stairs

Lower Extremity – Knee	
Common Diagnoses	
Patellofemoral Pain Syndrome (PFPS)	
Diagnosis	• **Exam**: positive J-sign (lateral patellar tracking during terminal knee extension), positive patella mobility test (medial glide <¼ or >¾ patella width suggesting hypo- or hypermobility) • **Imaging**: not routinely indicated unless to exclude other dx
ACL Injuries	
Description/ Mechanism	• Cutting/pivoting motion causing valgus stress on knee, can be 2/2 direct blow causing hyperextension/valgus deformation • Medial meniscus and MCL often injured at same time (Unhappy Triad)
Signs/ Symptoms	"Pop" at time of injury, swelling, feeling of knee "giving out,"
Diagnosis	• **Exam**: Joint effusion, positive anterior drawer test • **Imaging**: MRI > XR, but can get XR to evaluate for associated injury/fracture
Management	• Ortho/Sports Medicine referral • Operative management in majority of cases, ideally w/ period of pre-operative rehabilitation to optimize outcomes
Meniscus Injuries	
Description/ Mechanism	• Direction change w/ knee rotation, planted foot, and flexed knee • Commonly in sports w/ lots of deceleration and direction change
Signs/ Symptoms	• Often insidious onset of pain/swelling in 24h after injury • Pain worse w/ twisting/pivoting • Can have locking/popping/catching sensation
Diagnosis	• **Exam:** joint line tenderness, inability to fully extend/squat/kneel, positive McMurray test • **Imaging:** MRI > XR (plain films often negative)
Management	• Ortho/Sports Medicine referral • Management varies from conservative to operative (usually arthroscopic)
IT Band Syndrome	
Description/ Mechanism	Tight IT band sliding over lateral femoral epicondyle
Signs/ Symptoms	Diffuse lateral knee pain, worsened w/ activity or w/ prolonged sitting w/ knee in flexed position
Diagnosis	• **Exam:** TTP in lateral knee, positive Ober test • **Imaging:** not routinely indicated
Management	• Activity modification • NSAIDs • Stretching/strengthening regimen

Knee continued on next page →

Lower Extremity – Knee	
Common Diagnoses cont.	
Osteochondritis Dissecans	
Description/ Mechanism	• Acquired subchondral bone lesion which can progress to involve cartilage causing separation from underlying bone; most common in knee • Can lead to osteoarthritis if not recognized/treated • Mechanism unknown. Proposed to 2/2 repetitive trauma vs. inflammation
Signs/ Symptoms	May be incidental finding on imaging vs. non-specific activity related knee pain, may have swelling or symptoms of catching/locking if lesions are unstable
Diagnosis	• **Exam**: no specific findings • **Imaging**: 4-view XR (AP, lateral, sunrise, tunnel) of knee, MRI to further delineate known OCD lesion and determine management (or if XR negative but high clinical suspicion)
Management	• Referral to ortho/sports med • May be treated conservatively (non-weight-bearing or activity limitation) vs. operatively if lesions are unstable or unresponsive to conservative Treatment

Lower Extremity – Ankle/Foot

Anatomy

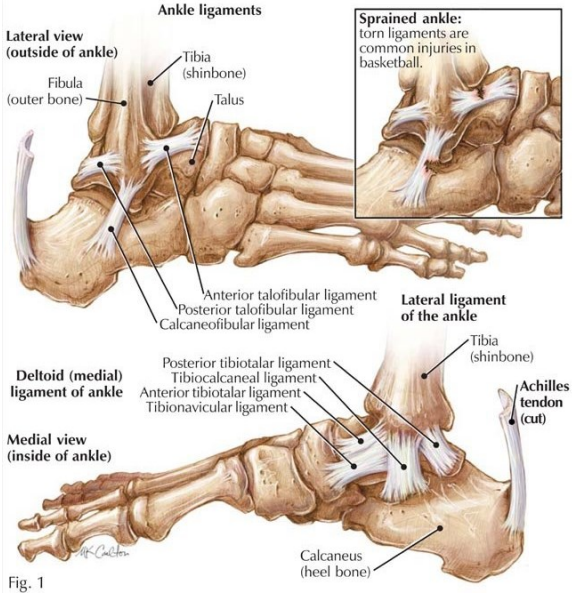
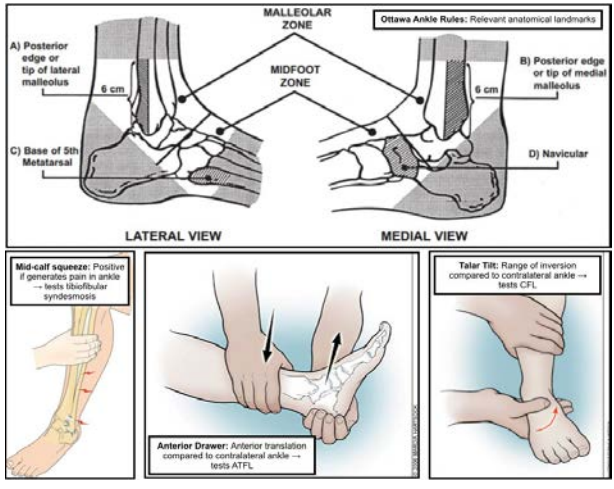


Fig. 1

Lower Extremity – Ankle/Foot

Exam Pearls + Special Tests



Ottawa ankle rules: when to get XR of the ankle/foot (validated age >18yo)

- Ankle: pain localized to malleolar zone and EITHER of:
  - Bony tenderness at post edge of lateral/medial malleolus
  - Inability to bear weight both immediately after injury and at time of exam
- Foot: pain in midfoot zone and EITHER of:
  - Bony tenderness at base of 5th met or navicular
  - Inability to bear weight both immediately after injury and at time of exam

Common Diagnoses

Ankle Sprain

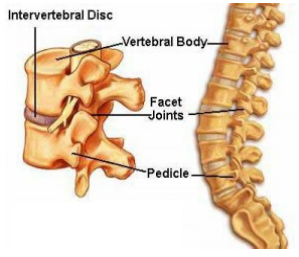
Description/ Mechanism	• Ligamentous stretching/tearing • Lateral: inversion of plantarflexed foot - injures ATFL most commonly • Medial: eversion or abduction/ external
Signs/ Symptoms	Pain, swelling (diffuse or localized), +/- inability to bear weight
Diagnosis	• **Exam**: swelling, TTP, positive anterior drawer/talar tilt (lateral sprain), positive mid-calf squeeze (high sprain) • **Imaging**: not routinely indicated unless concern for fracture (see Ottawa rules) or clinical uncertainty
Management	• Short period of complete immob. (longer depending on severity), supportive device (lace-up brace or elastic bandage) • ROM/strength exercises (can be w/ formal PT, esp in case of recurrent ankle sprains) critical to restoring function and proprioception • For HIGH ankle sprains, consult ortho/sports medicine (may need acute surgical stabilization if severe)

Ankle/Foot continued on next page →

Lower Extremity – Ankle/Foot	
Common Diagnoses cont.	
Sever's Disease	
Description/ Mechanism	• Traction apophysitis of calcaneal growth plate at site of Achilles insertion; often children who play sports w/ jumping/heel striking and/or are undergoing rapid growth spurt • Essentially Osgood Schlatter at the calcaneus
Signs/ Symptoms	Chronic heel pain w/ insidious onset, worse w/ activity or wearing non-supportive footwear
Diagnosis	• **Exam**: TTP at calcaneal apophysis or w/ "calcaneal compression test" • **Imaging**: not routinely indicated unless diagnosis unclear or to rule out fracture
Management	Painful activity → gradual return to play, use of heel cup for support, ice and stretching
Spiral/Oblique Fracture	
Description/ Mechanism	• "Toddler's fracture" in 9mo-3yr • Rotation around fixed foot → distal tibial fracture; often minimal trauma in toddlers, higher impact injury in older children • Approx 30% of tibial fractures have associated fibular fracture • Spiral fractures in NON ambulatory child → concern for NAT
Signs/ Symptoms	Limp, refusal to bear weight
Diagnosis	• **Exam**: point tenderness over distal ⅓ of tibia • **Imaging**: AP and lateral XR of the tibia and fibula; fractures may be occult (not seen on imaging)
Management	• Immobilization in long leg posterior splint/cast • Ortho referral
Congenital Clubfoot	
Description/ Mechanism	• Idiopathic vs 2/2 intrinsic (e.g. neurologic) or extrinsic (e.g. fibroids) factors • 1:1000 live births, M>F
Diagnosis	• **Exam**: fixed (e.g. not correctable) deformity of the foot w/ plantar flexion and inversion + rotation, calf atrophy • **Imaging**: usually dx on prenatal US, XR minimally useful initially
Management	Ortho referral (usually done in nursery prior to d/c), Serial casting → Achilles tenotomy → bracing

Spine

Anatomy



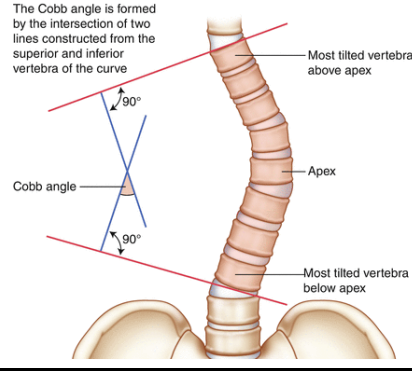
Exam Pearls + Special Tests

Straight leg raise: patient lying supine → flex at hip w/ knee straight (best if cervical spine flexed and ankle dorsiflexed) → assess for sciatic pain (sign of herniated disc)

Common Diagnoses

Scoliosis

Description/ Mechanism	• Lateral curvature of the spine ≥ 10 degrees • Causes: idiopathic (80%) vs congenital vs. neuromuscular
Diagnosis	• Adam's forward bend test + inclinometer • Shoulder/torso asymmetry, rib prominence, paraspinal muscle prominence • XR: Cobb Angle ≥ 10 degrees
Management	• <= 25 degrees → observation • 25-45 degrees + skeletal immaturity → bracing • >45 → consider surgical intervention



Spine continued on next page →

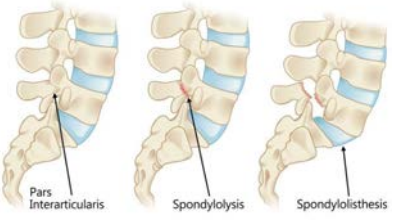
Spine

Common Diagnoses

Spondylolysis and Spondylolisthesis

Description/ Mechanism

- **Spondylolysis**: bony defect in pars interarticularis (usually L4 and L5)
- **Spondylolisthesis**: displacement of vertebral body relative to inferior vertebral body
- Cause: repetitive microtrauma
- Most common causes of back pain in children >10 years old; often in athletes engaged in sports w/ repetitive extension, flexion, and rotation



Signs/ Symptoms

- Low back pain that worsens w/ activity, improves w/ rest
- Spondylolisthesis: may have radicular or cauda equina symptoms

Diagnosis

- MRI is now study of choice
- XRays: poorly sensitive and do not assess acuity
  - Might be required prior to MRI
  - Standing AP, lateral, oblique views: visualize defect
  - Flexion and extension views: assess stability

Management

- Spondylolysis and low grade spondylolisthesis → conservative (rest from sports for ≥ 3 months, NSAIDs, PT, back bracing)
- Higher grade spondylolisthesis (or failure of conservative management) → consider surgical intervention

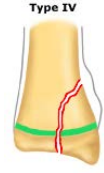
Spondyloarthropathies

Signs/ Symptoms

- Insidious onset
- Often misdiagnosed w/ recurrent strains/sprains
- Pain worse at night, improves w/ activity

Mild Traumatic Brain Injury (Concussion) & Graduated Return-to-Sport Program

Refer to ED Mild TBI section on page 257

Salter-Harris Classification (for physeal fractures)					
	 **S** Straight across	 **A** Above	 **L** Lower or BeLow	 **T** Two or Through	 **E R** ERasure of growth plate or CRush
Details	Only involves the growth plate	Growth plate + metaphysis *(Most common)*	Growth plate + epiphysis + joint space	Metaphysis + growth plate + epiphysis + joint space	Compression of growth plate
Implications	Good prognosis	Good prognosis	Threatens growth and articular integrity	Threatens growth and articular integrity	Very high risk for growth arrest
Diagnosis/ Mgmt	Usually clinical dx (XR negative unless displaced) Contralateral XR may be useful Immobilization (cast vs splint) for ≥ 3 wks	Immobilization (cast vs splint) for ≥ 3 wks	Immediate ortho consult Likely reduction (anatomic vs surgical)	Immediate ortho consult Likely reduction (anatomic vs surgical)	Immediate ortho consult Likely reduction (anatomic vs surgical)

Notes

Notes

Pre-rounding: Start notes with the following

- Listen to overnight events/copy signout into note
- Clear flags
- Numbers:
  - Vital Signs
  - I/O
- Labs (including micro)
  - Lab orders view (check outstanding labs sent)
- MAR Summary View (PRNs)
- Documents
  - Consults
  - Nursing notes
- Write down nursing numbers for your patients (posted after 7AM)
- Prep DSumms for AM discharges
  - Send meds for discharge

Rounds:

- Bring a COW
- 1 intern presents, 1 updates orders/notes/calls consults. OK to stay out of room if not your patient and not
  cross-covering in afternoon.

After Rounds:

- Consults
- Discharges
- Update families, RNs, etc. (Try to see patients in afternoon!)
- Finalize progress notes (edit exam)
- Update discharge summaries

New Admissions: SO MENDS

- **S**ign out (call back within 10 minutes, start note)
- **O**rders when pt hits floor (use relevant ordersets)
- **M**ed reconciliation (while in room, bring a COW)
- **E**xam/confirm history (ASAP when pt arrives, prioritize by illness severity and call RN if you will be delayed)
  - VTE questions: clotting hx? cancer? Autoimmune conditions?
- **N**ote
- **D**summ
- **S**ign out (update w/plan)

5-xxxx is 617-355-xxxx **4-yyyy is 617-919-yyyy** **8-zzz is 857-218-zzzz**

Labs		Tests		Ward	Front Desk	Conf Room	Fax 617-730-xxxx
Bacteriology	5-7485	CT	5-6308	6NE (Med/Heme)	5-8066	5-8070	0585
Blood Bank	5-6260	ECHO	5-8686	6N (Oncology)	5-8061	5-4154	0874
Blood Gas	5-7838	EEG	5-7970	6NE (All Units)	5-8066		
Chemistry	5-7122	EKG	5-5626	6W (BMT)	5-8069	5-4967	0878
Endocrine	5-7376	IR	5-6579	6 Mandell	5-8068		
Genetics	617-553-5880	MRI	5-6300	7N (NICU)	5-8076		
Hematology	5-6732	Nuclear Med	5-7010	7W (Medicine)	5-8079	5-8088	0909
Immunology	5-7620	PFTs	5-7510	7S (MSICU)	5-8077		0913
Lab Control	5-6351	Radiology	5-6286	8E (Cardiology)	5-8083	5-8060	1034
Pathology	5-7431	Sleep Study	5-7148	8S (Cardiac ICU)	5-8087		
Virology	5-7624	Sweat Test	5-7022	9E (Medicine)	5-8093	5-2988	0914
		Ultrasound	5-7840	9N (Neurology)	5-8096		
				9S (Medicine)	5-8097	5-9698 (GI)	0875
				10E (Infant Surgery)	5-8013	5-7443 (Pulm)	0883
				10NW (Ortho/Surg)	5-8016		0898
				10S (Transplant)	5-8017		0900
Miscellaneous		**Outside Hospitals**		11S (MICU)	5-8117		0813
Computer Help	5-HELP	**Dana Farber**	**617-632-xxxx**	11S (ICP)	5-8700		0883
COPP	5-0000	Operators	2-3000	Emergency Dept.	5-8811		**Batphones**
CPT	5-7979	Lab Control	2-3265	Communications	5-2170		*Interns*
CVS @ BCH	617-975-3500	Jimmy Fund	2-3270	Center (ED Expects)		6E-Subs Intern	8-3967
DCF (51A)	800-792-5200			**Offices**		Gen Peds C Intern	5-0016
Dictation	5-6600	**Brigham**	**617-732-xxxx**	Destiny Tolliver	5-3066	7W-Subs Intern	5-2643
Infection Control	5-6932	Operators	2-5500	Emily Cross	5-3248	Gen Peds A Intern	5-0014
Interpreters	5-7198	NICU	2-5420	Avital Ludomirsky	5-9182	Gen Peds B Intern	5-0022
Library	5-7232	NICU A	2-5739	Jess Angerman	5-3059	ICP Intern #1	5-0807
Medical Record	5-7546	NICU B	2-8319	Web Exchange	5-7241	ICP Intern #2	5-3637
NBS Office	617-983-6300 OR	NICU C	2-8351	Fred Lovejoy	5-6605	Pulmonary	5-0018
Desk	5-7731	NICU D	2-8341	Gary Fleisher	5-5022		*Juniors*
Pharmacy	5-6807	CWN 9	2-7595	Ted Sectish	5-8599	Cardiology	5-0640
Psych Consult	5-8606	CWN 10	2-6873	Tom Sandora	5-3858	GI	5-0017
Poison Ctr	800-222-1222	Page	2-5656	Ariel Winn	5-6296	CCS	5-0015
Security	5-6121	Lab Control	2-7415	Carolyn Marcus	4-1417	MSICU (7S)	5-1955
Social Services	5-7965	Help Desk	2-5927	Ron Samuels	5 -4507	Onc Heme Mag	5-0023
TPN Pharmacy	5-5523			House Staff Lounge	5-6032	Onc Solid Tumor	8-6047
					5-6033		*Seniors*
				Hailey Noble	5-1999	MICU (11S)	5-2559
Interpreter Services				Clare Blomberg	5-7260		*Supervisors*
		Beverly	978-922-3000	Anne Vaccaro*	5-5186	Gen Peds A Supervisor	5-0012
Main	5-7198	BI	617-632-6000	Elayne Fournier*	5-8241	Gen Peds B Supervisor	5-4617
Spanish	pg1313	Brockton	508-941-7000	Winnie Yu	5-7598	Gen Peds C Supervisor	5-0013
Arabic	pg3457	Cambridge	617-655-1000	*Notary Public by appointment.		7W-Subs Supervisor	5-2603 6E-Subs
All others	pg0120	MGH	617-726-2000			Supervisor	5-4616 ICP
Phone (24/7)	877-237-4933	South Shore	781-624-8000			Supervisor #1	5-0020
Weekend	8-5788	Winchester	781-729-9000			ICP Supervisor #2	5-0025
						Admit	5-6851

Clinics	
Adolescent	57181
Allergy/Immunology	56117
Audiology	56461
Cardiology	54278
CCS	56162
Child Protection Team	57979
CHPCC	57701/57702
Back Room	55157/53306
Charge RN	84706
Dental	56571
Dermatology	56117
Developmental Eval Center	57025
Endocrinology	57476
Environmental Health	58177
Feeding Team (Jennifer Perez)	57727
Genetics/Metabolism	56394
General Surgery	57800
GI	56058
Gynecology	57648
Hematology	58246
ID	56832
MEHC	617-971-2100
Nephrology	56129
Neurology	56388
Neurosurgery	56009
Nutrition	56058
Ophthalmology	56401
ORL	56462
Orthopedics	56021
Physical Therapy	57212
Plastic & Oral Surgery	57252
Pulmonary/CF	51900
Rheumatology	56117
Sports Medicine	56028

4-xxxx is 617-414-xxxx 8-yyyy is 617-638-yyyy

Operators	
Page Operator	8-7243
East Newton	8-8000
Pharmacy	
Main	4-7687
Pedi Satellite	4-5605
Main Outpt	4-4883
Pedi Outpt	4-7625
Services	
Admitting Office	4-4128
CIR Union	4-5301
Help Desk	4-4500
Housekeeping	#5183
Medical Records	4-4213
MLP	617-630-1700
Security	4-4444
Transport	4-5835
Interpreter Services	
Main	4-5549
Spanish	pg1313
Haitian	pg1288
French Creole	pg1288
Portuguese	pg1310
Cape Verdean	pg1310
Portuguese Creole	pg1310
Phone (24/7)	7-5757
	7-8787
Weekend	8-5788
Labs	
Blood Bank	4-4141
Blood Gas	4-4069
Chemistry	4-5136
Hematology	8-7805
Main	4-4060
Microbiology	8-7890
Tests	
Phlebotomy	#4671
EEG	8-7979
PFTs	8-6177
NBS Office	617-983-6300
Offices	
Daria Murosko	4-3931
Yuan He	4-7226
Bob Vinci	4-7424
Kate Michelson	4-3874
Christine Cheston	4-3571
Program Coordinator	4-6362
Missi Brennan	4-7424
Monique Bailey	4-3641

Radiology	
Radiology Main	4-3892
Main Scheduling	4-9729
Pedi Scheduling	4-4525
After Hour Sched	4-2779
XR Tech	4-7635
CT Tech	4-7631
MR Tech	4-6410
US Tech	4-2734
Pedi Read Room	4-4079
After Hours Read	4-2779
NM Scheduling	4-6440
NM Read	4-6451
IR Scheduling	4-3910
Sedation	4-4523
Consults	
Anesthesia	#0216
Audiology/BAER	#6690
BEST	4-4931
Cards (Pedi)	Website
Case Manager	#7788
Child Protection	#7336
Circumcision	#4242
Dermatology	#0378
Endo (Pedi)	#7202
ENT	#4433
Genetics	#3163
GI (Pedi)	Website
GYN	#3030
Heme (Pedi)	#5731
Heart Station	4-3450
ID (Pedi)	#9200
Neuro (Pedi)	#7666
Neurosurgery	#7000
Nutrition	#4580/#1999
Ophthalmology	#9495
OMFS	#7637
Orthopedics	#4200
OT	#9679
PICC Nurse	#7070
Psychiatry	8-8670
Pulm (Pedi)	Website
Renal	#0266
Respiratory	#1551/4-5775
Sedation RN	#2334
Social Work	#6733
After Hours SW	#3119
Surgery (Pedi)	#7337

Admitting Resident	#4958
PICU Resident	
Delivery Pager	
NICU Resident	
Nursery Resident	
Family Med Attending	
INPATIENT WARD (4E)	
Main	4-4511
Resident Back Room	4-8925/4-8924/4-8928
Fax	4-3171
Nurse Manager	#3814/4-4507
Ward Assistant	4-3621
EMERGENCY ROOM	
Main	4-4991
Fax	4-4999
PICU	
Main	4-4513
Fax	4-3951
Resident Back Room	4-3229
NICU	
Main	4-4359/4360
Resident Back Room	4-4369
Fax	4-4361
Attending Pager	#5000
Nurse Manager	4-4507
L&D	4-4364
NICU Social Work	#7416
NICU Case Manager	#0724
NURSERY	
Main	4-5840
Resident Desks	44358/5838
Fax	4-5807
Lactation	
#6455	
Circumcision Pager	#4242
ROOM CODES	
ED	5-3-4
Bathroom	
Resident Locker #23	35-5-15
Resident Locker #24	16-18-12
Third Floor	

BMC PEDIATRIC CLINICS	
#6789	Adolescent
#9977	Adult Surgery
#3445	Behavioral Health
#0202	Cardiology
#6094	CCP
	Dermatology
	Dental
	Development
	Endocrinology
	ENT
	Family Practice
	Grow Clinic
	Hematology
	Infectious Disease
	International Clinic
	Neurology
	NICU Follow-Up Clinic
	Ophthalmology
	Orthopedics
	Pediatric Surgery
	Primary Care (ACCS)
	Pulmonary (AIR)
	OB/GYN
COMMUNITY HEALTH CENTERS	
	Bowdoin St.
	Brookside
	Codman Square
	Dimock St.
	Dorchester House
	East Boston
	Geiger Gibson
	Harvard St.
	Hyde Park
	Longwood
	Martha Eliot
	Mattapan
	Neponset
	Roslindale
	South Boston
	South End
	Upham's Corner
	Whittier St.

	4-4086
	4-4861
	4-5245/4-4238
	4-4841
	4-4841 ext. 121
	8-7420
	4-4060
	4-4841
	4-4841
	4-4901
	4-2080
	4-5251
	4-4841
	4-4841
	4-4841
	4-4841
	4-4841
	4-4020
	8-5633
	4-5131
	4-5946
	4-4841
	4-2000
	617-754-0100
	617-522-4700
	617-825-9660 x8124
	617-442-8800
	617-288-3230
	617-568-4066
	On call pager 0990
	617-288-1140
	617-825-3400
	617-361-1470
	617-277-7320
	617-971-2100
	617-296-0061
	617-282-3200
	617-323-4440
	617-269-7500
	617-425-2000 x82248
	617-287-8000
	617-427-1000