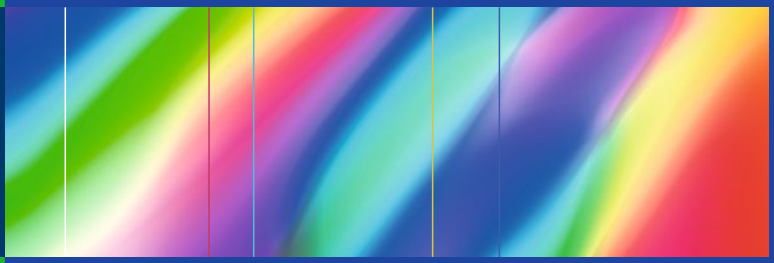
Cristina M. Zeretzke-Bien
Tricia B. Swan
Brandon R. Allen *Editors*



Quick Hits for Pediatric Emergency Medicine

Springer

Quick Hits for Pediatric Emergency Medicine

Cristina M. Zeretzke-Bien
Tricia B. Swan • Brandon R. Allen
Editors

Quick Hits for Pediatric Emergency Medicine

Springer

Editors
Cristina M. Zeretzke-Bien
Division of Pediatric Emergency Medicine
University of Florida
Department of Emergency Medicine
Gainesville
FL, USA

Tricia B. Swan
Division of Pediatric Emergency Medicine
University of Florida
Department of Emergency Medicine
Gainesville
FL, USA

Brandon R. Allen
University of Florida
Department of Emergency Medicine
Gainesville
FL, USA

ISBN 978-3-319-93829-5
ISBN 978-3-319-93830-1 (eBook)
https://doi.org/10.1007/978-3-319-93830-1

Library of Congress Control Number: 2018958166

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Special thanks to my husband, Chris, and my children, Jackson and Preston, for all of your support and love. Thank you to our patients for the privilege to care for them.
—Cristina M. Zeretzke-Bien MD, FAAP, FACEP

Much love and thanks to my husband, Jeff, for making all things possible. To my children, Andrew and Abigail, who fill my days with love, snuggles, giggles, and kisses and have made me a better pediatric emergency medicine physician.
—Tricia Swan, MD, FAAP, FACEP

A special thanks to my children, Nila and Owen. You're the source of my inspiration.
—Brandon R. Allen, MD, FACEP

Foreword

I recall some 45 years ago as a senior PICU fellow being told, "We don't really see the value of having a fellowship trained attending" during a faculty position interview. Now in 2018, that comment seems absurd. Formal recognition of pediatric emergency medicine is now acknowledged as a distinct pediatric subspecialty. Pediatric emergency medicine has its own distinct and unique body of information and requires specialized skills to care for this targeted population.

We are continually challenged by the undifferentiated patient. We embrace these challenges and are rewarded daily by improving the outcomes of the acutely ill child. We recognize that children truly are not "little adults" and have championed the unique requirements that encompass their care. In this book, you will find some tips and tricks that will allow you to safely and compassionately care for this vulnerable population.

Jennifer Light, MD FAAP
Medical Director, Pediatric ED
Chief, Division of Pediatric EM
Department of Emergency Medicine
University of Florida, College of Medicine

Contents

Contributors

Brandon R. Allen University of Florida, Department of Emergency Medicine, Gainesville, FL, USA

Lui Caleon Emergency Medicine/Pediatric Combined Residency Program, Pediatrics and Emergency Medicine, Louisiana State University Health Science Center, New Orleans, LA, USA

Cullen Clark Emergency Medicine/Pediatric Combined Residency Program, Pediatrics and Emergency Medicine, Louisiana State University Health Science Center, New Orleans, LA, USA

Sadiqa A. I. Kendi Pediatric Emergency Medicine, Children's National Health System, Washington, DC, USA

Judith K. Lucas Department of Emergency Medicine, Division of Pediatric Emergency Medicine, University of Florida Health-Shands Hospital, Gainesville, FL, USA

Anna McFarlin Emergency Medicine/Pediatric Combined Residency Program, Pediatrics and Emergency Medicine, Louisiana State University Health Science Center, New Orleans, LA, USA

Andrej Porgribny Emergency Medicine/Pediatric Combined Residency Program, Pediatrics and Emergency Medicine, Louisina State University Health Science Center, New Orleans, LA, USA

Tricia B. Swan Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA

Cristina M. Zeretzke-Bien Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA

Chapter 1
Airway: Pediatric Anatomy, Infants and Children

Cristina M. Zeretzke-Bien

Abstract Kids are not small adults, and their airways are different. Here we have an excellent image of the differences with pediatric airway anatomy and the classic seven Ps for intubation. This is a must-have quick reference for the pediatric airway.

Before You Intubate: What You Need to Know

Kids are not small adults, and their airways are different.

1. Pediatric airway anatomy: *see* Fig.1.1.
2. Obligate nasal breathers.
3. Adenoidal hypertrophy.
4. Large tongue.
5. Large occiput.
6. Larynx and trachea are funnel shaped.
7. Vocal cords slant anteriorly.

C. M. Zeretzke-Bien
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: Zeretzke@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_1

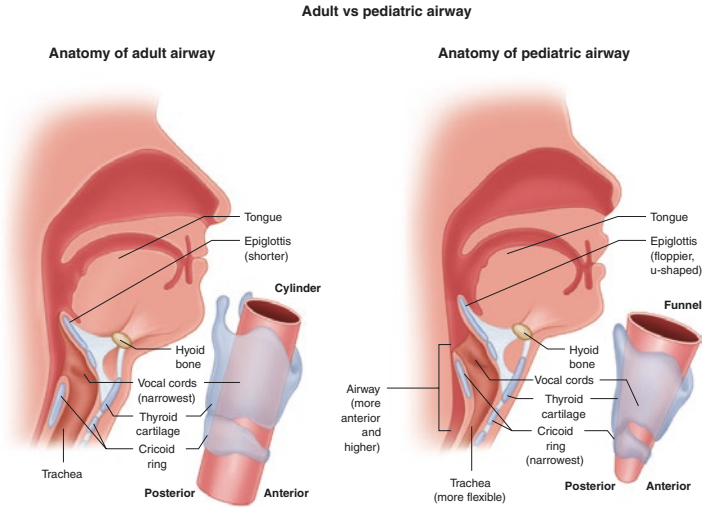


FIGURE 1.1 Pediatric airway differences- adults and pediatric

8. Larynx located higher in the neck (at C4 vs. C6 in adults).
9. Narrowest part of the pediatric airway is at cricoid cartilage (until age 5). In adults, the narrowest part is at the glottis opening.
10. Glottis different locations:

    Premature babies at C3
    Newborns C3–C4
    Adults C5

Lung Physiology

- Fewer and smaller alveoli (surface area reaches an adult around age 8).
- Channels for collateral ventilation: Pores of Kuhn and channels of Lambert.
  - Important with atelectasis and alveolar hypoventilation.

Lung Mechanics

- Ribs are more horizontal (hard to recruit accessory muscles).
- Thoracic skeleton is cartilaginous and very compliant (important with tidal volume).
- Accessory respiratory muscles: (muscle fibers are slow twitch) more susceptible to fatigue.
- Reduced FRC (functional residual capacity).
- Poiseuille's law: Airway resistance is inversely proportional to the fourth power of the radius of the airway (edema, obstruction, secretions).
- Cellular oxygenation: Resting oxygen consumption in the newborn twice in an adult.
  - (6 ml/kg/min vs. 3 ml/kg/min)

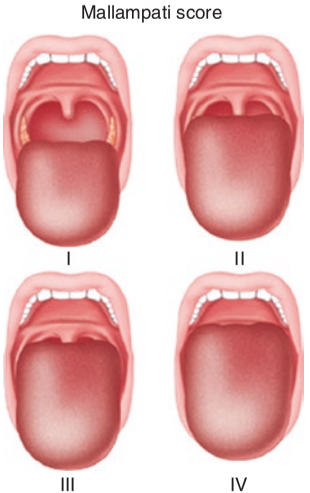
Tips for Intubation

Seven Ps

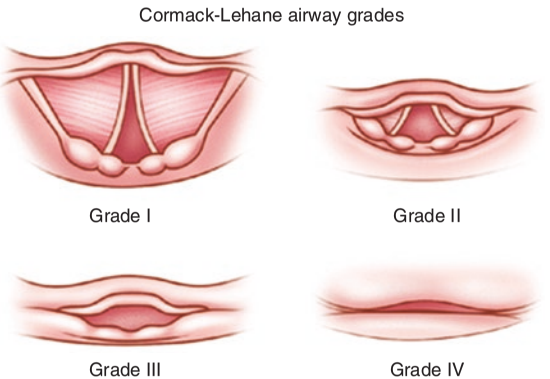
7 P's

- **P**repare = equipment
- **P**retreat = drugs
- **P**osition = sniffing position (if possible)
- **P**reoxygenate= 100 % pulse ox (consider apneic oxygenation during direct laryngoscopy) [1]
- **P**aralyze = drugs
- **P**lacement = tube through cords
- **P**osition = confirm with ETC02 then CXR

1.Weingart, S and Levitan, R. Preoxygenationand prevention of desaturation during emergency airway management. Ann Emerg Med. 2012 Mar; 59(3):165–175



Adapted from: Mallampati SR, Gatt SP, Gugino LD, et al. A clinical sign to predict dif fi cult tracheal intubation: a prospective study. Can Anaesth Soc J 1985;32:429–34



Adapted from: Cormack RS, Lehane J. Dif fi cult tracheal intubation in obstetrics. Cormack-Lehane Airway Grades Anaesthesia 1984; 39: 1105–11

Ventilation Equipment

Bag valve mask devices (anesthesia bag vs. self-inflating bag)
Suctioning

Laryngoscope

1. Miller: Straight (<1 year of age)
2. MacIntosh: Curved

Endotracheal Tubes

- (age in years/4) + 4 = ETT size
- Cuffed tubes may be used on all ages

Chapter 2
Respiratory Review: A, B, C, and P of Kids (Asthma, Bronchiolitis, Croup, and Pneumonia)

Cristina M. Zeretzke-Bien

Abstract Asthma, bronchiolitis, and croup are the ABC diagnoses of the pediatric patient presenting with a respiratory complaint. This chapter highlights the evidence-based care for these specific entities, with associated helpful clinical decision scores to guide care and resource utilization. It also includes the clinical manifestations of pneumonia with age-based antibiotic therapy.

Respiratory Overview

- Children have unique airway anatomy.
- Airway assessment begins with a good history.

First impressions give *a lot* of information.

C. M. Zeretzke-Bien
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: Zeretzke@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_2

Signs of Respiratory Distress

1. Increased work of breathing
2. Altered mental status
3. Color
4. Position
5. Auscultation findings

Asthma

Asthma is a lower airway disease, which may be chronic or recurrent, with:

- Bronchospasm.
- Airway inflammation.
- Ventilation problem with air trapping.

Clinical Presentation

- Dyspnea.
- Retractions.
- Tachypnea.
- Nasal flaring.
- Inability to speak.
- Wheezing.
- Prolonged expiratory phase.
- Beware of the quiet chest!

Treatment

- ABCs.
- Give oxygen.
- Nebulized or MDI beta-agonists (albuterol).
- Ipratropium bromide (Atrovent).
- Steroids.
- Upright position.

- Severe exacerbation.
  - Continuous nebulized therapy.
  - Epinephrine (IM or IV).
  - Magnesium sulfate (50 mg/kg, max dose = 2 g).

Considerations for Severe Asthma

- Bolus of fluid.
- Baseline BMP to determine K+ as multiple neb treatments can drive K+ into the cell.
- X-ray if other etiology is of concerns (not all that wheezes is asthma).
- Noninvasive positive pressure.
- Heliox.

Asthma Pearls

- Many patients/parents do not take this disease seriously.
- Parents may not have an asthma action plan.
- Albuterol is short-acting drug.
- If a patient is requiring multiple albuterol treatments at home, they need immediate evaluation.

Pediatric Asthma Score

Characteristic	**0**	**1**	**2**
Respiratory rate			
2–3 years	<34	35–59	>40
4–5 years	<30	31–35	>36
6–12 years	<26	27–30	>31
>12 years	<23	24–27	>28
Oxygen requirement	<93%	89–92%	<89%

Characteristic	0	1	2
Auscultation	Clear breath sounds	Expiratory wheezes	Inspiratory and expiratory wheezes
Work of breathing	<1 accessory muscle	2 accessory muscles	>3 accessory muscles
Dyspnea	Speaks full sentences, Playful, and takes PO well	Speaks partial sentences, short cry, or poor PO	Speaks short phrases, Grunting, or unable to PO

Score: 0–3 mild exacerbation, 4–7 moderate exacerbation, 8–10 severe exacerbation

Bronchiolitis

- Lower airway disease.
- Airway urgency.
- 2 months–2 years.
- Chronically ill children are at higher risk:
  - Premature.
  - Children with congenital heart disease.
  - Less than 1 month of age.
- Inflammation, edema, and mucous in the lower airways.
- Viral etiology.

Clinical Presentation

- Dyspnea.
- Tachypnea.
- Retractions.
- Nasal flaring.
- Wheezing.
- Long expiratory phase.
- Rales.
- Rhonchi.
- Decreased air movement.

Treatment

Supportive

- Oxygen.
- Suctioning.
- Upright positioning.
- High-flow oxygen therapy.
- If clinical bronchiolitis, recommendations do not support using albuterol, steroids, chest X-rays, or obtaining other labs.

Bronchiolitis Score

Score	Breath Rate	Retractions	Nasal flaring	Wheezing	General status
0	<30	No	No	No	Normal
1	30–45	Only intercostal	Mild and rarely	Heard only with stethoscope	Moderately uneasy and occasionally crying
2	45–60	Intercostal, Subcostal, and supraclavicular	Moderately severe and intermittently	Heard in both expiration and inspiration with stethoscope	Very uneasy, crying continuously
3	<60	Abdominal Respiration accompanying Crying	Severe and continuously	Heard in both expiration and inspiration without stethoscope	Lethargic

Croup (Laryngotracheobronchitis)

- Upper airway disease.
- You will hear *stridor*: *inspiratory*.

- Viral infection of the larynx, trachea, and bronchi.
  - Parainfluenza.
  - Influenza.
  - RSV.
  - Adenovirus.
- Age 6 mos–3 years.
- Male > female.
- Winter months.

Clinical Presentation

- Fever.
- Rhinorrhea.
- Barking cough.
- Inspiratory stridor.
- Respiratory distress.
- Worse at night.

Clinical Presentation with the Following

- Gradual onset of URI symptoms.
- Mild fever, hoarseness, barking cough.
- Sudden stridor and retractions.
- Dyspnea and tachypnea.

Treatment

- Labs and X-rays are unnecessary.
- Mist therapy.
- Racemic epinephrine.
- Dexamethasone 0.6 mg/kg (maximum dose 16 mg).

Westley Score

	0	1	2	3
Stridor	None	Only with agitation	Mild at rest	Severe at rest
Retraction	None	Mild	Moderate	Severe
Air entry	Normal	Moderate Decrease	Moderate decrease	Marked decrease
Color	Normal	N/A	N/A	Cyanotic
Level of consciousness	Normal	Restless when disturbed	Restless when undisturbed	Lethargic

Score: ≤ 2 mild croup, 3–5 moderate croup, 6–11 severe croup (consider impending respiratory failure ≥ 12)

Pneumonia

- Lower airway disease.
- Airway urgency.
- All ages.
- Younger patients can be very ill.
- Chronically ill at higher risk.
- Bacterial or viral etiology.

Clinical Presentation

- Rales (may be localized).
- Rhonchi.
- Tachypnea.
- Variable fever.
- +/− respiratory distress
- Hypoxemia.

Treatment

- Oxygen.
- Fluids.
- Upright position.
- Antibiotic therapy.

Pediatric Pneumonia

Age	**Bugs**	**Drugs**
Age < 5 years	*S. pneumoniae*, *H. influenzae*, *Mycoplasma,* group A streptococcus, *C. pneumoniae*, *S. aureus*, viral, influenza	*PO*: High-dose amoxicillin +/− azithromycin (atypical coverage) Alt: Clindamycin, amoxicillin/clavulanate, cefdinir *IV*: Ampicillin +/− azithromycin Alt: Ceftriaxone +/− azithromycin Add vancomycin or clindamycin if severe illness or features suggestive of *S. aureus* (cavitation, pleural effusion) *Treatment, 10 days Atypical organisms (*Mycoplasma, Chlamydia)* are more common in children >5 years old
Age > 5 years and immunized	*S. pneumoniae*, *Mycoplasma*, group A streptococcus, *C. pneumoniae*, *S. aureus*, viral, influenza	*PO*: High-dose amoxicillin + azithromycin (atypical coverage) Alt: Clindamycin + azithromycin *IV*: Ampicillin + azithromycin Alt: Ceftriaxone or cefotaxime + azithromycin Add vancomycin or clindamycin if severe illness or features suggestive of *S. aureus* (cavitation, pleural effusion) *Treatment, 7–10 days

Age	Bugs	Drugs
Age >5 years and unimmunized for *H. influenzae or S. pneumoniae*	*S. pneumoniae*, *Mycoplasma*, group A streptococcus, *C. pneumoniae*, *S. aureus*, viral, influenza	Ceftriaxone or cefotaxime +/– azithromycin Add vancomycin or clindamycin if severe illness or features suggestive of *S. aureus* (cavitation, pleural effusion)

Chapter 3
Resuscitation: Pediatric Algorithms

Cristina M. Zeretzke-Bien

Abstract This chapter provides "Quick Hit" algorithms to manage critically ill or coding pediatric patients and easy-to-follow, step-by-step references to manage the most acutely ill children. Seconds count in recognition, identification of causes, initiation of high-quality CPR, and administration of resuscitation medications and fluids. This chapter will give you the high-yield essential information you need to manage a pediatric code. The algorithms are easy to follow, with helpful tips and medication doses to providing rapid, high-quality care to the most critical pediatric patients.

Resuscitation: Pediatric Algorithms (Figs. 3.1, 3.2, 3.3, and 3.4)

C. M. Zeretzke-Bien
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: Zeretzke@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_3

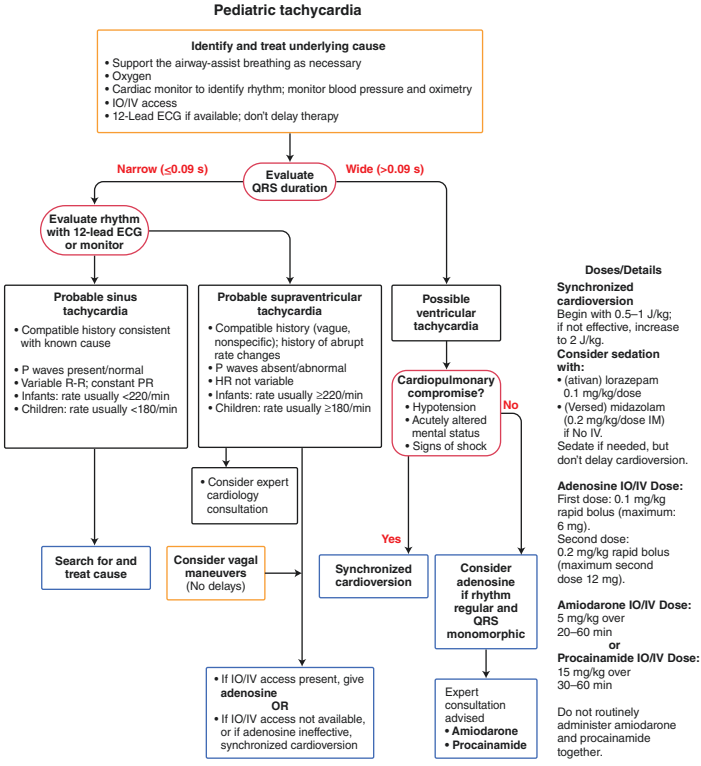


FIGURE 3.1 Pediatric tachycardia pathway

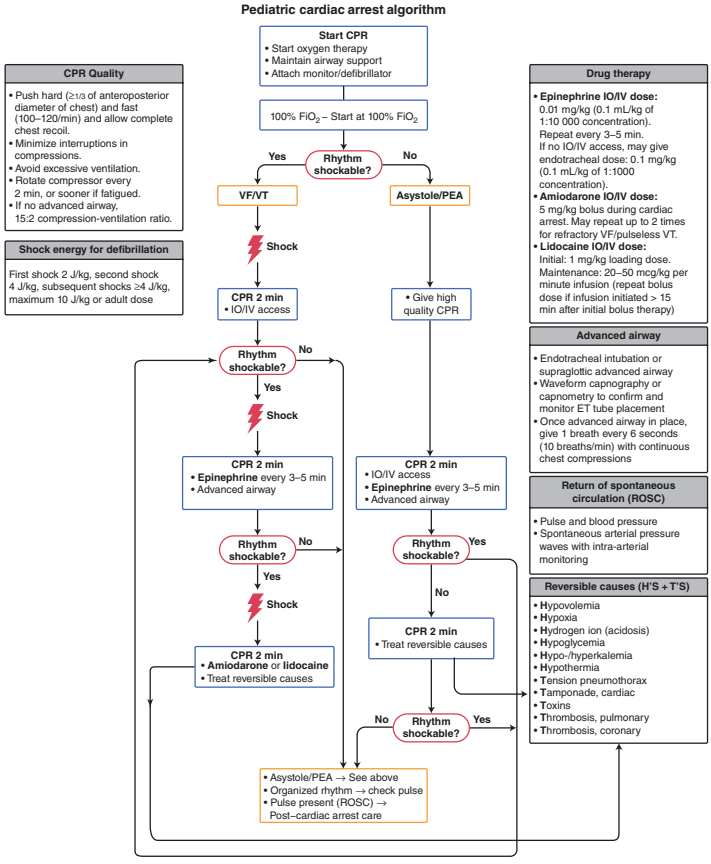


FIGURE 3.2 Pediatric cardiac arrest pathway

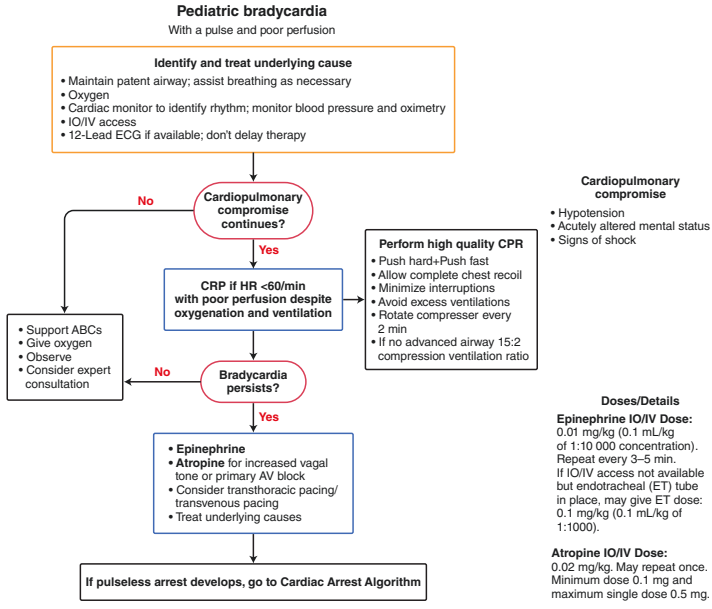


FIGURE 3.3 Pediatric bradycardia pathway

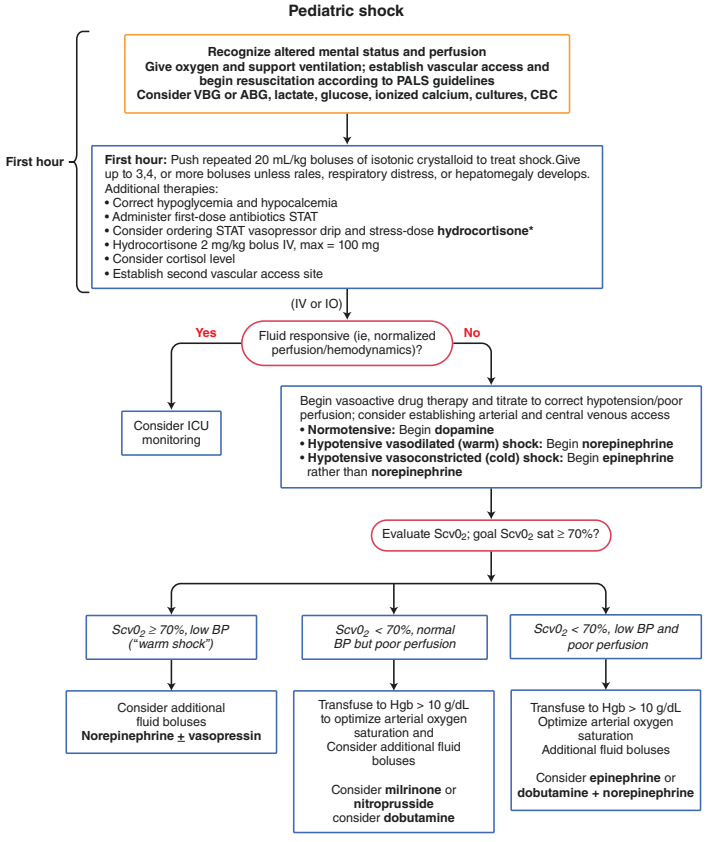


FIGURE 3.4 Pediatric shock pathway

Chapter 4
Pediatric Pearls: Management of Shock in Children

Cristina M. Zeretzke-Bien

Abstract The chapters on resuscitation and shock are incredibly valuable in the undifferentiated shock patient. It will set you up for success with initial stabilization while performing evidence-based care. The assistance with dosing for the common "code drugs" is a very valuable reference in a high-anxiety situation like the crashing pediatric patient.

Shock

Defined as abnormal physiologic state in which there is an inability to deliver adequate oxygen to meet the metabolic needs of the body.

Types of shock
Hypovolemic
Cardiogenic
Distributive
Obstructive

C. M. Zeretzke-Bien
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: Zeretzke@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_4

- Vitals are extremely variable in pediatric shock. Evaluate the patient.
- Tachycardia is an early finding, while bradycardia is a late finding.
- Tachypnea is an early finding. Widened pulse pressure may be an early subtle finding.
- Prompt recognition of shock is important for aggressive treatment.

Cardiac Output (CO) = Heart Rate (HR) × Stoke Volume (SV)

Quick Hit Cardiac Pearls

Cardiac output (CO) is the amount of blood the heart pumps through the circulatory system in a minute.

Children compensate for cardiac output with increased heart rates.

Children tolerate high heart rates.

Hypovolemic shock requires aggressive fluid management!

- Most common cause of shock around the world.
- Treatment is normal saline (20 ml/kg) up to 60–80 ml/kg with two large-bore IVs.

Cardiac shock: Use 10 ml/kg saline bolus.

Septic Shock: The Golden Hour

- Maintain perfusion, oxygenation, and ventilation.

Inadequate early fluid resuscitation is associated with increased mortality.

Definition of Hypotension by Systolic Blood Pressure and Age

Age	Systolic BP (mm hg)
Term neonates (0–28 days)	<60
Infants (1–12 m)	<70
Children 1–10 years (fifth percentile)	<70 + (age in years × 2)
Children >10	<90

Heart Rate and Perfusion Pressure for Age

Current age	Heart rate	MAP-CVP
Term neonate	120–180	55
<1	120–180	60
<2	120–160	65
<7	100–140	65
<15	90–140	65

Adapted from Carcillo JA, Fields AI, American College of Critical Care Medicine Task Force Committee Members: Clinical practice parameters for hemodynamic support of pediatric and neonatal patients in septic shock. *Crit Care Med*. 2002;30:1371

Pediatric CPR

- Emphasis on effective CPR – Most important: *compressions*.
- CPR sequence: Chest compressions, airway, breathing.
- Depress 1/3 of the anterior-posterior diameter of the chest. Allow full recoil!
  - Approximately 1 ½ inches in infant.
  - Approximately 2 inches in children.

- "Push hard, push fast."
- Rate: 100 compressions/minute.
- Single rescuer: 30:2 (compressions: ventilations).
- Two rescuers trained in CPR: 15:2 (compressions: ventilations).
- NEW 2015 PALS guideline change! Once intubated, six breaths per minute without interrupting CPR.

Pediatric Pearls

Do not hyperventilate!

Excessive ventilation increases intrathoracic pressure:

=> Decreased cardiac output, cerebral flow, and coronary flow.
=> Air trapping.
=> Risk of stomach inflation and aspiration.

If patient has perfusion and return of spontaneous circulation (ROSC), but still not breathing or intubated, then ventilation should be 12–20 breaths per minute.

SIRS Criteria

In children, the SIRS criteria are modified and must include at least two of the following:

1. **Heart rate** > 2 standard deviations above normal for age in the absence of stimuli such as pain and drug administration or unexplained persistent elevation for greater than 30 min. In infants, it also includes heart rate < 10th percentile for age in the absence of vagal stimuli, beta-blockers, or congenital heart disease or unexplained persistent depression for greater than 30 min.
2. **Body temperature** obtained orally, rectally, from Foley catheter probe, or from central venous catheter probe <36 °C or > 38.5 °C. *Temperature must be abnormal to qualify as SIRS in pediatric patients.*

3. **Respiratory rate** > 2 standard deviations above normal for age or the requirement for mechanical ventilation not related to neuromuscular disease *or* the administration of anesthesia.
4. **White blood cell** count elevated or depressed for age not related to chemotherapy or greater than 10% bands.

Common Pediatric Medications for Resuscitation and Cardiac Arrest

Epinephrine

- 0.01 mg/kg of 1:10,000 IV/IO or 0.1 mg/kg of 1:1000 endotracheal (ET). (IV or IO route is preferred.)

Atropine

- 0.02 mg/kg IV/IO or 0.04–0.06 mg/kg ET
- *New 2015 update! No minimum.*
- Maximum 0.5 mg.
- Can repeat once if needed.
- Not used routinely for pretreatment or sedation.

Adenosine

- 0.1 mg/kg IV/IO, followed by 0.2 mg/kg
- Maximum dose 6 mg first dose, 12 mg second dose.

Amiodarone

- 5 mg/kg IV/IO, may repeat twice up to 15 mg/kg
- Maximum dose 300 mg.

Lidocaine

- 1 mg/kg

Procainamide

- 15 mg/kg IV/IO over 30–60 min

Magnesium Sulfate (for torsades)

- 25–50 mg/kg IV/IO over several minutes
- Maximum 2 grams.

Chapter 5
Pediatric Ventilator Management

Tricia B. Swan

Abstract This is the go-to guide for invasive and noninvasive ventilation for the non-intensivist. From the crashing asthmatic to the patient requiring titration of their ventilator, this chapter sets you up for success in the pre- and post-intubation period for the pediatric respiratory failure patient. The DOPES mnemonic is a quick hit that everyone must know when your ventilated patient acutely deteriorates in order to troubleshoot and quickly correct their decompensation.

T. B. Swan
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: tfalgiani@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_5

Noninvasive Modes of Ventilation

Benefits	Indications	Contraindications
• Reduce work of breathing (Reduce oxygen consumption) • Reverse hypoventilation (Increase tidal volume) • Increase FRC-improve oxygenation, lung compliance • Maintain and splint collapsed airways • Preserved defense mechanisms • Improve diaphragmatic activity • Less sedation	• Respiratory insufficiency • Aspiration • Chronic lung disease • Pulmonary edema • Bronchiolitis • Pneumonia • Status asthmaticus • Obstructive sleep apnea • Neuromuscular diseases (weakness) • Post-extubation respiratory insufficiency	• Severely impaired consciousness • Inability to protect airway • Inability to clear secretions • Craniofacial deformities or injuries • Pneumothorax • Shock • Cardiopulmonary arrest

High-Flow Nasal Cannula	CPAP	BiPAP

• Heated, humidified, high flow oxygen
• Up to 60L/min and 100% FiO_2
• Creates 2-3 cm H_2O of PEEP
• Increases alveolar O_2
• Decreased CO_2
• Reduces deadspace
• Initial setting
  • Infants: 4-6 LPM
  • Children: 10-12 LPM
	• Delivers a fixed positive pressure throughout the respiratory cycle
	• Pressure does not change with inspiration or expiration
	• Initial setting at 5 cm H_2O
	• May increase to 5-8 cm H_2O if poor lung compliance (stiff lungs)
		• Delivers different levels of pressure during inspiration (IPAP) and expiration (EPAP)
		• Increase the EPAP to improve work of breathing and oxygenation
		• Increase the Δ (IPAP-EPAP) to improve ventilation
		• Initial settings:
		  • Infants: 10/5
		  • Children: 12/8

CPAP = continuous positive airway pressure, BiPAP = bilevel positive airway pressure

Invasive Ventilation

Indications for invasive ventilation:

- Respiratory failure or insufficiency.
  - Hypoxia ($PaO_2 < 50$).
  - Hypercarbia ($PaCO_2 > 50$).

- Inability to protect airway.
- Airway obstruction.
- Severe respiratory distress.
- Increased ICP.
- Apnea.
- Excessive respiratory load (shock, uncompensated acidosivs).

Types of Ventilator Support

Pressure Control	Volume Control
• Gas flow is delivered until a preset pressure is reached and then held for the set I-time • Delivery of reliable set tidal volume difficult: volume of gas delivered is small in relation to volume in the ventilator circuit • Reduces risk of barotrauma • Useful for newborn and infant ventilatory support • Consider pressure control setting for large air leaks due to small ET tube size, poor lung compliance or poor ventilation due to adult size vent circuit on a small infant/child • As lung compliance increases, tidal volume increases • Set pressure control to give effective chest rise and adequate air entry (expect PIPs 18-22 in healthy lungs, 23-27 in moderate lung disease, 28-35 in severe lung disease)	• Preset tidal volume is delivered to patient, regardless of the pressure required • Increased risk for barotrauma • As lung compliance worsens, PIP will increase • Risk of barotrauma can be reduced by pressure alarms and pressure pop-off valves • Adult size ventilator circuits may require you to increase the tidal volume (circuit takes large volume amount itself)

PIP = Peak Inspiratory Pressure

Modes of Ventilation

Mode	Definition	Advantages	Disadvantages
Volume control (assist control or AC/VC)	Each breath is the same flow, volume and I-time regardless of mandatory or triggered breath	Full ventilator support Controlled minute ventilation Able to measure mechanics	Fixed flow rate and pattern increases risk for asynchrony on the ventilator

Mode	Definition	Advantages	Disadvantages
Synchronized intermittent mandatory ventilation (SIMV)	Volume or pressure controlled breaths are delivered at a set rate and synchronized with patient trigger Additional breaths are not controlled	Extra breaths are comfortable Allows the patient to finish expiration before cycling on	Can have rapid shallow breathing if pressure support is not adequate
Pressure support (PSV, CPAP)	Each breath is supported but patient determines the volume, rate, and inspiratory time	Increased patient comfort Patient determines their own minute ventilation	Minute ventilation completely dependent on patient effort Tidal volume can get too low or too high
Pressure control (AC/PC)	Every breath has the same I-time and peak inspiratory pressure regardless of triggered or mandatory breath	Variable flow rate and pattern increases patient comfort Able to limit PIP (important if airway surgery)	If poor patient effort or lung compliance, volume can get too low If increased patient effort or increased lung compliance, volume can get too high

Initial Ventilator Settings

	Infant	Child	Adolescent
Tidal volume	7–10 mL/kg	7–10 mL/kg	7–10 mL/kg
Respiratory rate	25–30 bpm	15–20 bpm	8–12 bpm
PEEP	5 cm H_2O	5 cm H_2O	5 cm H_2O
FiO_2	Start at 100% and wean to avoid oxygen toxicity Goal: Sats >90%	Start at 100% and wean to avoid oxygen toxicity Goal: Sats >90%	Start at 100% and wean to avoid oxygen toxicity Goal: Sats >90%
Inspiratory time (I-time)	0.5 s[a]	0.7–0.8 s[a]	0.8–1.0 s[a]
PIP	<30 cm H_2O, use minimal pressure needed to produce adequate chest wall movement (usually <25 cm H_2O if normal lungs)	<30 cm H_2O, use minimal pressure needed to produce adequate chest wall movement (usually <25 cm H_2O if normal lungs)	<30 cm H_2O, use minimal pressure needed to produce adequate chest wall movement (usually <25 cm H_2O if normal lungs)

[a]In asthma shorten the I-time to allow more time for expiration to overcome air trapping

DOPES

Troubleshooting a ventilated patient who acutely deteriorates (acute hypoxemia or cardiovascular collapse):

D: Displaced ETT – check for equal BS, $EtCO_2$, and CXR.
O: Obstructed airway – suction patient, mucous plug, and replace ETT.
P: Pneumothorax – check for equal BS, needle decompression, bedside ultrasound for pleural sliding, and CXR.
E: Equipment failure – disconnect from circuit, hand ventilate, ensure 100% FIO_2 is flowing.
S: Stacking/stretching (breath stacking in asthma, over-PEEP in non-recruitable lung segments) – disconnect from circuit, compress chest, allow full exhalation, decrease RR, decrease PEEP, and decrease tidal volume.

Chapter 6
Neonatal Delivery and the Acutely Ill Neonate

Tricia B. Swan

Abstract The sick or crashing neonate is a stressful patient for any emergency provider. THE MISFITS mnemonic is a must-know heuristic for the potential causes of severe illness in patient under 28 days of age. The steps for the precipitous delivery of the newborn are a quick-glance guide to review prior to that EMS arrival. The newborn resuscitation medication flowcharts and the umbilical vein catheter (UVC) placement procedure checklist are some of the top "Quick Hits" in this book.

Neonates (Age ≤ 28 Days)

Causes of Severe Illness in Neonates: THE MISFITS

T	Trauma/non-accidental trauma (abuse)
H	Heart disease (ductal-dependent congenital lesions)

(continued)

T. B. Swan
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: tfalgiani@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_6

E	Endocrine and electrolyte
M	Metabolic disorders (congenital adrenal hyperplasia, thyrotoxicosis)
I	Inborn errors of metabolism
S	Sepsis
F	Formula miscalculation (dilution or over concentration)
I	Intestinal catastrophes (volvulus, NEC, intussusception)
T	Toxins (home remedies)
S	Seizures

Immediate evaluation and treatment of the critically ill neonate includes:

1. ABCs.
2. IV fluids (20 cc/kg).
3. Bedside glucose.
   (a) Treat hypoglycemia 2–4 mL/kg of D10.
4. Initiation of antibiotic therapy to treat for presumed sepsis/meningitis.
   (a) Ampicillin + gentamicin IV.
   OR
   (b) Ampicillin + cefotaxime IV.
5. Head CT if seizures or suspect trauma (including abuse).
6. Prostaglandin for ductal-dependent congenital heart lesions.
   (a) Apnea is a side effect of prostaglandin – Be prepared to intubate.
   (b) Start infusion at 0.05 mcg/kg/min and may gradually increase to 0.2 mcg/kg/min if needed.
7. Steroids for congenital adrenal hyperplasia.
   (a) Give hydrocortisone 25 mg IV.
8. If seizures:
   (a) Correct hypoglycemia.
   (b) Phenobarbital 20 mg/kg IV loading dose.
   (c) Pyridoxine 100 mg IV.

9. Labs to obtain when possible (**not the primary goal; please give fluids, meds, and critical interventions first; may obtain labs and cultures at a later time): CBC, blood culture, UA, urine culture, CSF studies and CSF culture, CMP, lactate, ammonia, serum amino acids, urine organic acids.

Newborn Delivery and Resuscitation (Fig. 6.1)

Airway	Breathing	Circulation	Drugs
• Suction mouth then nose • Head placement in sniffing position	• HR <100, apnea or poor effort: give PPV at 40-60 BPM • Observe for rise in HR for 15 seconds of PPV • If no rise in HR or chest not moving: perform MR SOPA corrective steps until chest rise • Attach pulse ox and cardiac monitor • Intubate or LMA placement and give PPV for 30 seconds before starting compressions	• Compressions if HR < 60 BPM after 30 seconds of PPV with good chest movement • Check HR every 1 minute • 3 compressions: 1 breath • Use 100% oxygen • Use cardiac monitor to assess HR during CPR (not brachial or umbilical pulse)	• If HR < 60 BPM after 1 min of CPR: Give epinephrine • May give epinephrine via ETT, IV, IO, UVC • Repeat every 3-5 minutes if HR < 60 BPM with compressions

*PPV= positive pressure ventilation, HR=heart rate

MR SOPA Ventilation Correction Steps

M	Mask reposition
R	Reposition airway (sniffing position)
S	Suction mouth then nose
O	Open mouth and airway
P	Pressure increase (increase PEEP on BVM)
A	Artificial airway (ETT or LMA)

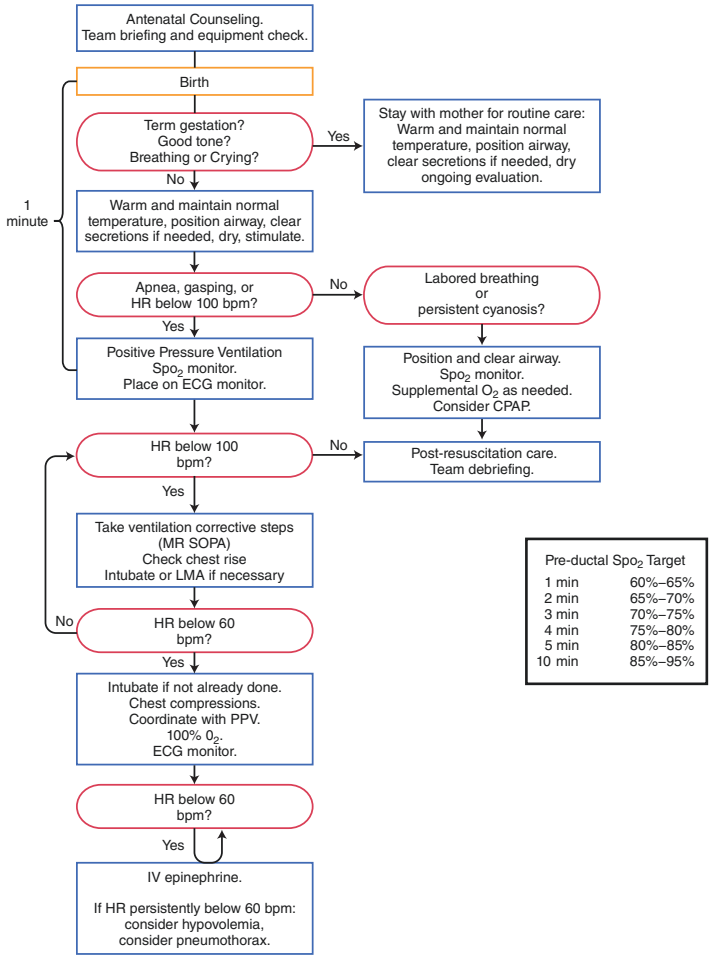
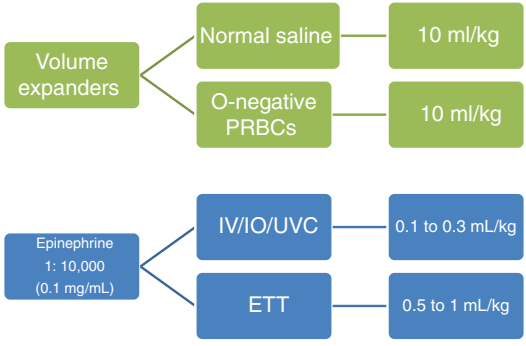


FIGURE 6.1 Neonatal resuscitation algorithm

Newborn Resuscitation Medications



Endotracheal Intubation Guide

Baby's weight	Gestational age	ET tube size
< 1 kg	< 28 weeks	2.5
1–2 kg	28–34 weeks	3.0
2–3 kg	34–38 weeks	3.5
>3 kg	>38 weeks	3.5–4.0

UVC Placement

Supplies Needed

1. Sterile gown, gloves, towels, and drapes.
2. Antiseptic solution.
3. 3.5 French umbilical catheter for infants <1500 g or 5 French umbilical catheter for infants >1500 g (may use 5 French feeding tube in place of umbilical catheter in emergent situation)
4. 10 mL syringe with heparinized saline flush and three-way stopcock
5. Umbilical tape (or suture material).
6. Non-toothed forceps, small hemostats, and #11 scalpel.

Procedure (Figs. 6.2 and 6.3)

1. Prepare and drape for sterile placement. Clean the skin and umbilical cord with antiseptic solution.
2. Loosely tie umbilical tape or suture at the base of the umbilical stump.
3. Using a scalpel, cut the umbilical cord horizontally approximately 2–3 cm from the skin.
4. Identify the two arteries and one vein. The two arteries are thick walled and smaller than the vein. The vein is thin walled with a larger lumen.
5. Place UVC catheter (5 French) into the umbilical vein, and advance the catheter approximately 2 cm beyond the point in which good blood flow is obtained. Emergency UVC access is 5 cm + length of umbilical stump.

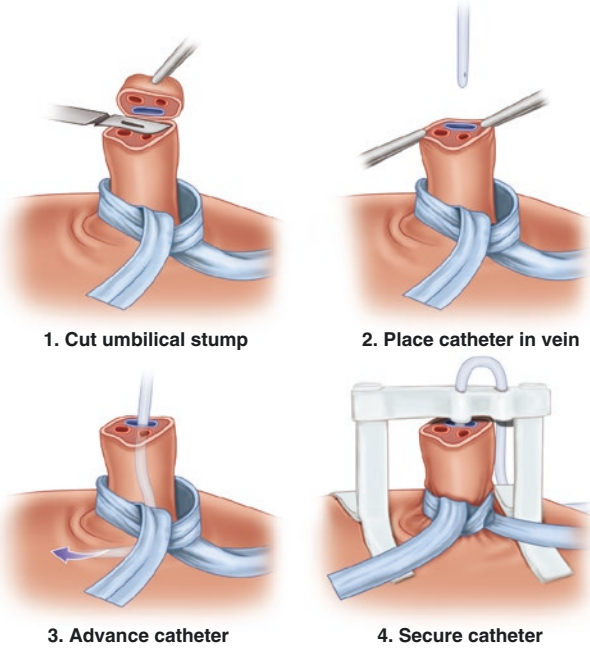


FIGURE 6.2 Umbilical venous catheter (UVC) placement

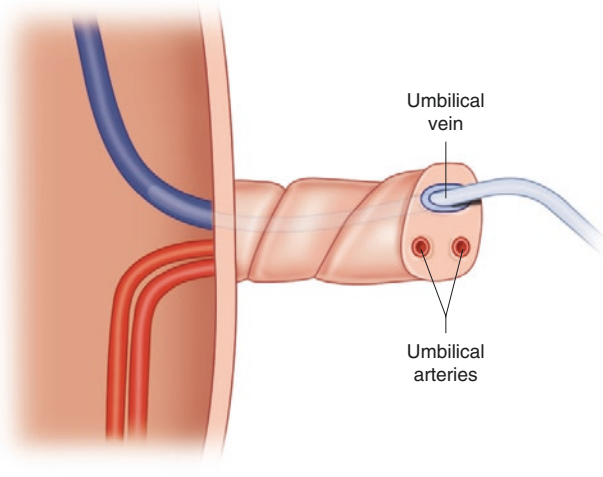


FIGURE 6.3 Umbilical cord

6. Loosen umbilical tape if resistance is met; otherwise, tighten tape after UVC is passed.
7. Secure catheter placement and obtain X-ray for placement confirmation.

APGAR Score

Sign		0 point	1 point	2 Points	1 min	5 min
A	**A**ctivity (muscle tone)	Absent, flaccid, or limp	Flexed arms and legs	Active movement		
P	**P**ulse	Absent	Below 100 bpm	Over 100 bpm		
G	**G**rimace (reflex irritability)	Floppy	Minimal response to stimulation	Strong response to stimulation		

(continued)

Sign		0 point	1 point	2 Points	1 min	5 min
A	**A**ppearance (color)	Blue or pale	Pink body, blue extremities	Pink		
R	**R**espiration	Absent	Slow or irregular	Vigorous cry		
Total score						

Severely depressed	0–3
Moderately depressed	4–6
Excellent condition	7–10

Chapter 7
Pediatric Abdominal Pain

Sadiqa A. I. Kendi

Abstract Abdominal emergencies differ by age in the pediatric population. This chapter is a wonderful way to frame the likelihood of a diagnosis in an easy-to-read table format packed with "Quick Hits." The pearls at the end of the chapter are a nice way to avoid some common pitfalls in the pediatric abdominal pain patient.

Common Diagnoses with Work–Up and Management

Symptoms	Diagnosis to consider	Work-Up	Management
Right lower quadrant pain, fever, vomiting	Appendicitis	Ultrasound first if available (reserve CT if unable to visualize), complete blood count (CBC), C-reactive protein (CRP)	Appendectomy

(continued)

S. A. I. Kendi
Pediatric Emergency Medicine, Children's National Health System, Washington, DC, USA
e-mail: skendi@cnmc.org

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_7

Symptoms	Diagnosis to consider	Work-Up	Management
Bilious vomiting in an infant	Malrotation with volvulus	Abdominal X-ray "double bubble sign," upper GI series	NG placement, IV fluid resuscitation, and operative management (Ladd procedure)
Vomiting and intermittent abdominal pain in infant (bloody stool is a late sign)	Intussusception	Ultrasound	IV fluids, air enema (diagnostic and curative)
Right upper quadrant pain which is colicky	Cholelithiasis	Ultrasound	Pain management, delayed operative management
Right upper quadrant pain which is colicky with fever	Cholecystitis	Ultrasound	Antibiotics
Epigastric pain radiating to back, vomiting	Pancreatitis	Labs (lipase, amylase)	Bowel rest, fluids
Painless rectal bleeding	Meckel's diverticulum	Meckel's scan	Operative management (surgical resection)

Symptoms	Diagnosis to consider	Work-Up	Management
Lower quadrant abdominal pain with vaginal bleeding	Ectopic pregnancy	Quantitative HCG, pelvic US, type and screen	Surgical resection or methotrexate (medical therapy)
Vaginal discharge, lower abdominal pain	Pelvic inflammatory disease	Bimanual exam, sed rate (ESR), C-reactive protein (CRP), US if concerned about Fitz-Hugh-Curtis	Antibiotics
Lower quadrant abdominal pain, colicky	Ovarian torsion	Pelvic US	Operative management (detorsion or oophorectomy)
Nonbilious projectile emesis in infant <2 months old	Pyloric stenosis	Abdominal US, electrolytes	IV fluids, correct electrolytes, operative management (pyloromyotomy)
Generalized crampy abdominal pain	Constipation	KUB	Laxatives, fiber, water
Flank pain, colicky	Renal stones	Renal US to evaluate for hydronephrosis, CT without contrast to further evaluate	Fluids, pain control, operative management with urology for obstructive stone

Differential Diagnosis for Abdominal Pain Stratified by Age

*Easy-to-miss diagnoses in bold

Infant	Toddler	Child	Adolescent
Pyloric stenosis	**Malrotation with volvulus**	Appendicitis	Testicular torsion
Malrotation with volvulus	**Appendicitis**	Testicular torsion	Ovarian torsion
Gastroesophageal reflux disease	**Testicular torsion**	Pancreatitis	**Ectopic pregnancy**
Urinary tract infection	Meckel's diverticulum	Acute gastroenteritis	Pelvic inflammatory disease
Non-accidental trauma	**Non-accidental trauma**	**Diabetic ketoacidosis**	Pancreatitis
Acute gastroenteritis	Acute gastroenteritis	Constipation	Cholelithiasis
Necrotizing enterocolitis	Constipation	**Pneumonia**	Cholecystitis
Hirschprung's disease	Intussusception	Hemolytic uremic syndrome	Peptic ulcer disease
Incarcerated hernia	**Increased intracranial pressure**	Porphyria	Appendicitis
Increased intracranial pressure	**Pneumonia**		Gastroenteritis
			Diabetic ketoacidosis
			Inflammatory bowel disease (IBD)
			Irritable bowel syndrome (IBS)

Quick Hits Abdominal Pain Pearls

- Abdominal pain and vomiting isn't always from an abdominal process in kids. Always do a complete physical exam and consider lower lobe pneumonias, testicular torsion, and intracranial processes (atypical diagnoses that can present with vomiting and abdominal pain).
- Classic electrolyte abnormalities in pyloric stenosis are hypochloremia, hypokalemia, and metabolic alkalosis.

- Classic "currant jelly stools" are only seen in about 50% of intussusception cases.
- If intussusception is reduced by air enema, child requires observation for 24 h due to 3–5% recurrence rate after reduction (usually occurs within 24 h).

Chapter 8
Trauma Tidbits

Cristina M. Zeretzke-Bien

Abstract Pediatric trauma is the #1 etiology of morbidity and mortality in the US pediatric population. This chapter is a great assist with appropriate dosing, fluids, and the ABCDEs of resuscitation. The modified Glasgow Coma Scale (GCS) for age is always a challenge to remember but is right there as the first item of the chapter for easy reference.

C. M. Zeretzke-Bien
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: Zeretzke@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_8

Glasgow Coma Scale

Trauma score	Motor activity	Verbal activity	Eye opening
1	None	None	None
2	Extension to pain	Incomprehensible	To pain
3	Flexion to pain	Inappropriate	To command
4	Withdraws to pain	Confused	Spontaneous
5	Localizes pain	Oriented	–
6	Obeys commands		–

Modified GCS for Age < 1

Score	Motor activity	Verbal activity	Eye opening
1	None	None	None
2	Abnormal extension	Grunts or moans	To pain
3	Abnormal flexion	Cries to pain	To shout
4	Withdraws	Irritable cry	Spontaneous
5	Localizes pain	Coos and babbles	–
6	Spontaneous movement	–	–

Consider Intubation for GCS < 8

Fluid Resuscitation Guidelines

- Bolus one: 20 ml/kg normal saline (NS) (or Ringer's lactate, RL).
- Bolus two: 20 ml/kg NS or RL.
- Bolus three: 20 ml/kg NS or RL, consider starting PRBCs (uncrossmatched O-negative blood) if starting third fluid bolus in trauma patient (3:1 rule).

Fluid Maintenance Requirements

Weight (Kg) Requirements Per 24 hours:

0–10 kg	100 ml/kg
10–20 kg	1000 ml for 1st 10 kg + 50 ml for every kg over 10 and under 20 kg
More than 20 kg	1500 ml for 1st 20 kg +20 ml for every kg over 20 kg

4 ml/kg/h for 1st 10 kg
2 ml/kg/h for 2nd 10 kg + 40 ml
1 ml/kg/h for every kg >20 kg +60 ml

Fluid Replacement for Burns

Ringer's lactate: 4 ml/kg/%BSA for 2nd and 3rd degree burns.
Give ½ in first 8 h and ½ in next 16 h.
(Add maintenance fluids with 5% dextrose in children <5 years old.)

Adequate Urine Output

Infant: 1–2 ml/kg/h.
Adolescent: 0.5–1 ml/kg/h.

Estimated Normal Blood Volume by age:
Full term = 90 ml/kg.
3–12 months = 80 ml/kg.
>1 year = 70 ml/kg.

Blood Replacement Guidelines

PRBCs: 10 ml/kg (hemoglobin rises 2–2.5 g/dL for each 10 ml/kg of RBCs transfused).
Platelets: 5–10 ml/kg should raise count by 50,000.

Fresh frozen plasma: (FFP) 10–20 ml/kg for coagulation factor replacement – raise 20%.
Factor VIII: 1 U/kg increase factor VIII plasma levels by 2%.
Factor IX: 1 U/kg increases factor IX plasma levels by 1%.

Tube Sizes (French)

	Neonate	**6 months**	**1–2 years**	**5 years**	**8–10 years**
Chest tube	10–12 F	10–12 F	16–20 F	20–28 F	28–32 F
NG tube	5–8 F	5–8 F	8–10 F	10–14 F	14–18 F
Urinary catheter	5–8 F (feeding)	8 F	8–10 F	10–12 F	12 F

General Considerations for Pediatric Trauma Patients

Size and Shape

- Greater amount of force per unit body area because of smaller body mass.
- Child's body has less fat, less elastic connective tissue, and close proximity of multiple organs, which results in high frequency of multiple organ injuries.
- Larger surface area relative to volume predisposes to thermal evaporative loss.
- Hypothermia may develop quickly and complicate hypotension.

Skeleton

- More pliable skeleton due to incomplete calcification which results in serious organ injury without overlying skeletal fracture; if rib fractures are identified, anticipate serious organ injury.

- Multiple active growth centers with unique fractures with potential growth arrest or growth abnormality.

Surface Area

- Disproportionate ratio of body surface area (highest at birth).
- Thermal energy loss is a significant stress factor in the injured child.

ABCDE of Pediatric Trauma Management

Airway and Cervical Spine Stabilization

- Establish a patent airway to provide tissue oxygenation.
- Hold cervical spine stabilization while obtaining an airway.
  - Cervical spine fractures are uncommon – more likely ligamentous injury.
  - Cervical spine fractures and injury occur higher in the C-spine due to weight of the head.
  - Flexible ligaments may allow vertebral shift and cord injury without fracture (SCIWORA).

Breathing and Ventilation

- Pediatric bag mask for children <30 kg.
- Tidal volumes 4–6 ml/kg (infants and children).
- Hypoxia is the most common reason for arrest.
- With adequate perfusion and ventilation, a child should maintain a normal pH.

Circulation and Hemorrhage Control

- A child's increased physiologic reserve results in normal systolic blood pressure even in the presence of shock.

- Up to 30% of blood volume may be lost before a change in systolic blood pressure.
- Tachycardia and poor skin perfusion (cap refill) are the keys to early recognition of hypovolemia.

Disability

- Modified GCS for infants and children (see above).
- Pupil size and reactivity.
- Extremity movement and tone.
- Posturing.
- Reflexes.

Exposure

- The young child is unable to shiver.
- Thin skin and lack of subcutaneous fat.
- Larger surface area with an increased evaporative heat loss.
- Less energy reserve.
- Increased caloric expenditure.

Quick Hits Pediatric Trauma Pearls

- Trauma is the most common cause of mortality and morbidity in the US pediatric population.
- Accounts for >50% of all pediatric deaths.
- Twenty thousand children die each year from injury.
- Head injury is the leading cause of death, followed by chest and abdominal trauma.
- Eighty-seven percent of injuries are from blunt trauma.

Chapter 9
Pediatric Head Injury Guidelines

Andrej Porgribny, Anna McFarlin, and Cristina M. Zeretzke-Bien

Abstract The Pediatric Head Injury chapter is a poignant depiction of the widely accepted and utilized PECARN clinical decision rules for the patient in two specific age cohorts. Applying these rules can decrease the need for head CT and unnecessary radiation exposure.

A. Porgribny
Emergency Medicine/Pediatric Combined Residency Program, Pediatrics and Emergency Medicine, Louisina State University Health Science Center, New Orleans, LA, USA

A. McFarlin (✉)
Emergency Medicine/Pediatric Combined Residency Program, Pediatrics and Emergency Medicine, Louisiana State University Health Science Center, New Orleans, LA, USA

C. M. Zeretzke-Bien
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: Zeretzke@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_9

Pediatric Head Injury Guidelines

Pediatric Blunt Head Injury, Less Than 2 Years Old (Fig. 9.1)

- Clinical decision rules (CDRs) have been constructed to balance minimizing unnecessary CT exposure and cost while also detecting clinically significant TBIs (ciTBIs).
- PECARN (pediatric emergency care applied research network) has the highest sensitivity of detecting ciTBIs, has been validated, and demonstrates reduction in both cost and utilization of head CTs.

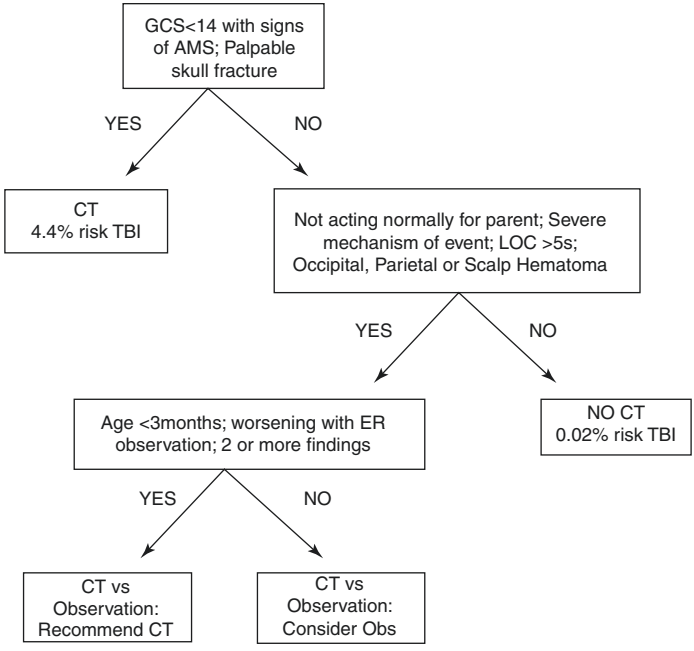


Figure 9.1 Pediatric blunt head injury less than age 2 years old

Pediatric Blunt Head Injury, 2 Years Old and Older (Fig. 9.2)

- Severe mechanism of action: Motor vehicle crash with ejection, death of a passenger, rollover, pedestrian or bicyclist struck by motor vehicle, fall from >3 ft. (<2 years old) or > 5 feet (>2 years old), impact by fast-moving object.
- Altered mental status: Somnolence, agitation, slow response to external stimuli.

Reprinted with permission from Kuppermann et al. Identification of children at very low risk of clinically important brain injuries after head trauma: a prospective cohort study. *Lancet*. 2009; 374:1160–70.

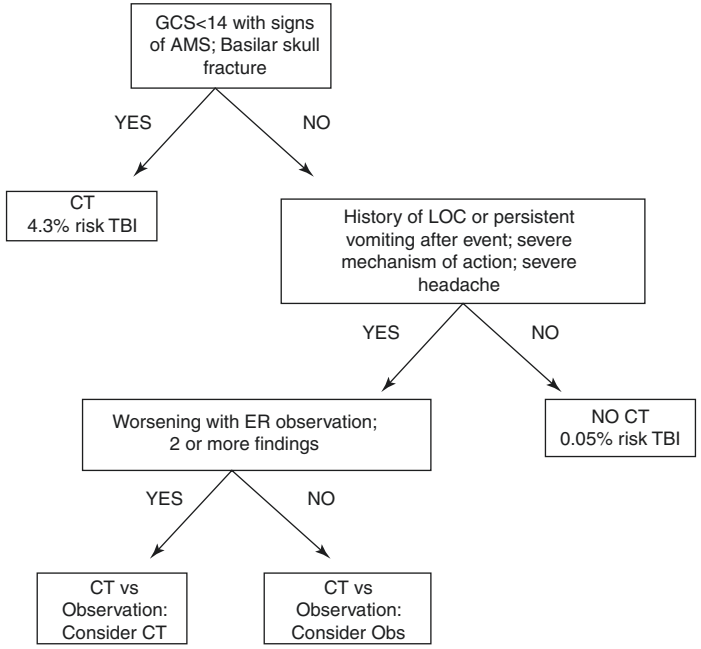


FIGURE 9.2 Pediatric blunt head injury greater than age 2 years old

Chapter 10
Pediatric Burns

Sadiqa A. I. Kendi

Abstract Identification and classification of a burn in a pediatric patient has significant implications for care and possible transfer to a burn center. This chapter discusses characteristics of different burn classifications as well the evidence-based management required to decrease the risk of disability. A must-know list of indications for admission versus transfer to a burn center are included.

Etiology

- Often accidental but must consider abuse.
- Ensure stated mechanism matches pattern of burn.

Work-Up

- Ensure ABCs are intact.
- Primary and secondary survey.

S. A. I. Kendi
Pediatric Emergency Medicine, Children's National Health System, Washington, DC, USA
e-mail: skendi@cnmc.org

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_10

Classification of Burns

- Superficial.
  - Sunburn
  - Mild erythema
  - Involves epidermis only
- Partial thickness.
  - Blisters
  - Erythematous, painful
  - Involves epidermis and dermis
- Full thickness.
  - Waxy appearing
  - Usually insensate
  - Extending through the dermis
- Calculate body surface area (as described below) to further classify burn.

Management

- Consider airway protection if soot in is present in the nose or mouth or significant burns over the face.
- Fluids.
  - Parkland formula (4 mL/kg/%BSA of crystalloid × 24 h, half in the first 8 h and half in the next 16 h)
- Pain control.
  - Opioids usually first line (can consider intranasal until IV established)

- Debridement.
  - Required for partial- or full-thickness burns
  - Must reevaluate classification of burn after debridement
- Antibiotics *not* indicated for prophylaxis.

Disposition

- Indications for transfer to burn center and/or admission:
  - Partial thickness burns >10% BSA
  - Full-thickness burns of any size
  - Circumferential burn
  - Involving the face, genitals, hand, or feet
  - Electrical or chemical burns
  - Associated with inhalation injury
  - Burn crosses joints
  - Inability to provide adequate care for children

Estimating Body Surface Area for Burns (Fig. 10.1)

Quick Hits: Pediatric Burn Pearls

- Always consider abuse when evaluating a burn.
- Consider transfer to a burn center early in the evaluation.
- Ensure fluid management and pain control.

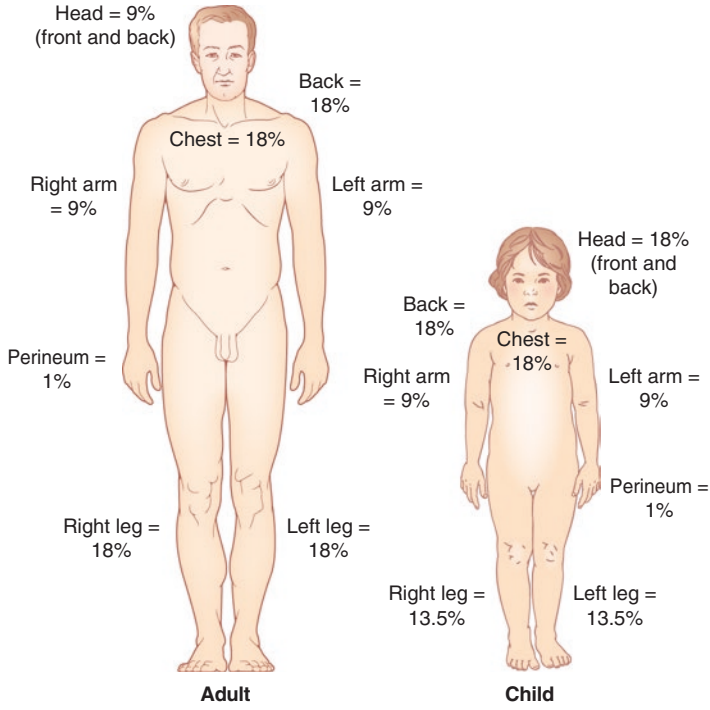


FIGURE 10.1 Percentage of total body surface area burn

Chapter 11
Procedure Pearls

Lui Caleon, Anna McFarlin, and Cristina M. Zeretzke-Bien

Abstract This chapter is a "Quick Hit" for every common procedure that an ED provider will perform on a pediatric patient. Whether it's in an acute resuscitation needing to intubate and achieve intraosseous (IO) access or perform a laceration repair to the forearm, this chapter has you covered.

L. Caleon · A. McFarlin (✉)
Emergency Medicine/Pediatric Combined Residency Program, Pediatrics and Emergency Medicine, Louisiana State University Health Science Center, New Orleans, LA, USA
e-mail: lcale1@lsuhsc.edu

C. M. Zeretzke-Bien
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: Zeretzke@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_11

Indications for Advanced Airway

Inability to protect airway	**Impaired ventilation/ oxygenation**
Decreased consciousness (GCS < 8)	Respiratory arrest (apnea, seizure)
Airway obstruction (stridor, peritonsillar abscess, hematoma, smoke inhalation)	Respiratory failure Hypercarbia ($paCO_2$>55 mmHg) Hypoxemia despite O_2 (paO_2<55 RA or <70 on 100% O_2)
Polytrauma	
Head injury with worsening mental status	

Airway Adjuncts

Nasopharyngeal Airway "Nasal Trumpet" (Fig. 11.1)

- *Sizing*: Measure from patient's nare to their earlobe/jaw.
- *Insertion*: Lubricate device and insert with bevel facing out from nasal septum. The tip should be visible posterior to uvula.

Oropharyngeal Airway (Fig. 11.2)

- Indicated in unconscious patients to prevent airway occlusion from a collapsing tongue.
- *Sizing*: Measure from incisors to angle of mandible.
- *Insertion*: Use tongue blade to pass over the tongue.

FIGURE 11.1 Nasopharyngeal airway "nasal trumpet"

FIGURE 11.2 Oropharyngeal airway

Laryngoscope Blades

Miller blades		**Macintosh blades**	
00	Small	1	Term infant
0	premature	2	Child
1	Premature	3	(2–9 yearr)
2	Term infant	4	Medium
3	Child		adult
4	(2–9 year)		Large adult
	Medium adult		
	Large adult		
Pros: Takes up less space in the mouth, designed to be passed past the epiglottis		*Pros*: Designed to sweep and contain the tongue	

Endotracheal Tubes (Fig. 11.3)

Sizing

- Equation: $\frac{\text{Age} + 4}{4}$
- Use ½ size smaller for cuffed tube.

Depth

- Equation: 3 × ETT size.
- Measure at the teeth since the lips can swell.

Figure 11.3 Endotracheal tubes

Confirmation

- CXR: Between clavicles and carina, by 1st/2nd ribs
- Continuous end-tidal CO_2 or colorimetry
- US: At sternal notch
- Misting in the endotracheal tube
- Auscultation
- Direct visualization

Laryngeal Mask Airways

Weight (kg)	Mask size	Max cuff volume (mL)
<5	1	4
5–10	1.5	7
10–20	2	10
20–30	2.5	14
30–50	3	20

Weight (kg)	Mask size	Max cuff volume (mL)
50–70	4	30
70–100	5	40
100+	6	50

Intraosseous Access

Indications

- Failure to gain peripheral venous access after approximately ninety seconds or two peripheral IV attempts in a critcally ill patient
- Manual or battery-operated drill style insertion options (Fig. 11.4)

Contraindications

- Overlying skin/tissue infection
- Fracture elsewhere in the same extremity

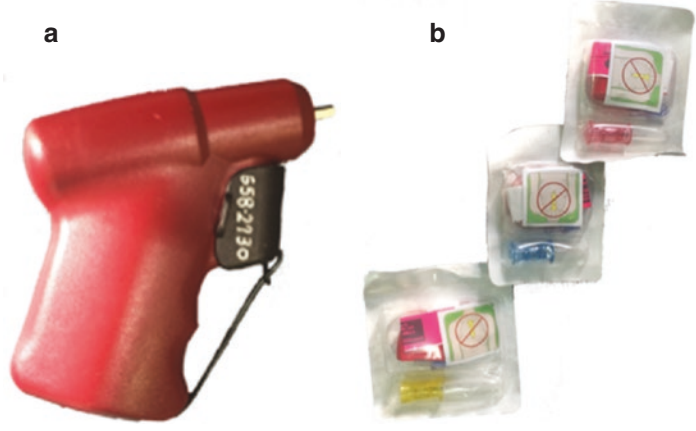


FIGURE 11.4 Drill and drill bits for intraosseous access

- Prior attempt in same bone
- History of osteogenesis imperfecta or osteopetrosis

Most Common Pediatric Sites

- *Proximal tibia*: two finger breadths below the patella, 1–2 cm medial to the tibial tuberosity
- *Distal tibia*: 3 cm proximal to medial malleolus on the flat central aspect of tibia
- *Distal femur*: 3 cm proximal to lateral condyle on antero-lateral surface

IO Sizing

- 15mm RED (3–39kg)
- 25mm BLUE (40+kg)
- 45mm YELLOW (adult humerus, obese)

Quick Hits IO Access Pearls

- Aspirate bone marrow and flush with 20 mL to ensure placement and patency.
- Instill lidocaine (max 3 mg/kg) to minimize discomfort prior to using for conscious patients.

External Jugular Vein Cannulation

Contraindications

- Not recommended for use for high-pressure IV contrast agent

Procedure

- Place patient in Trendelenburg position with the head down.
- Turn patient head to the side, and ask the patient to bear down/Valsalva; have an assistant stabilize the head.
- Apply pressure just proximal to the clavicle to occlude and engorge external jugular vein to assist in location.
- Clean site.
- Use non-dominant hand to occlude and relocate the vein and apply traction.
- With dominant hand, insert the needle catheter with bevel facing up at a 10- to 30-degree angle.
- Once flash is obtained, decrease insertion angle and advance catheter.
- Verify ability to draw back and flush, and secure with tape/dressing.

Lumbar Puncture

Indications

- To obtain cerebrospinal fluid for analysis
- To determine opening pressure or therapeutically reduce intracranial pressure

Contraindications

- Overlying skin/tissue infection
- Risk of herniation (midline shift, posterior fossa mass, loss of cisterns)
- Coagulopathy
- Brain abscess

Procedure

- For accurate assessment of opening pressure, patient must be in lateral recumbent position.
- Have an assistant place patient with knees and hips flexed toward the chest to increase inter-disc spacing.
- Identify L3–L4 interspace by palpating the left and right superior iliac crests; make a superficial mark with marker or indentation with a pen cap or your fingernail.
- Sterile precautions, sucrose orally for infants, and local anesthesia (topical or injected).
- Direct needle toward patient's umbilicus.
- Withdraw stylet to assess for CSF flow; replace for any forward adjustments.
- Use fluid collected for opening pressure in manometer for tube #1 (normal pressure, 12–20).

Lab Orders

- *Tube 1*: gram stain, culture, and sensitivities.
- *Tube 2*: protein and glucose.
- *Tube 3*: cell count and differential.
- *Tube 4*: Hold and consider HSV studies (especially if CSF bloody).

Incision and Drainage

Indications

- Localized abscess/fluid collections

Procedure

- Ultrasound can be used to differentiate fluid collections from localized tissue inflammation. Look for hypoechoic areas suggestive of abscess versus diffuse "cobblestoning" seen with cellulitis.

- Analgesia.
  - ***TOPICAL***: EMLA for closed lesions, LET for open lesions
  - ***LOCAL***: Lidocaine intradermal
- Make sure to make an incision approximately 2/3 the size of the pocket to ensure adequate drainage and to prevent fluid accumulation.
- Pack with sterile iodoform gauze, or consider placing a sterile loop tie to keep wound open and to encourage continued drainage.
- Loop ties can be fashioned from Penrose drains or from the edge of a sterile glove.

Laceration Repair (Fig. 11.5)

Wound Approximation Options

- Steri-Strips
- Skin adhesives
- Sutures
- Staples: useful for high-tension areas (scalp)

Sutures

	Absorbable sutures	
Nonabsorbable sutures		**Tensile strength**
Silk	Fast absorbing plain gut	5–7 days
Nylon (Ethilon)	Cat/chromic gut	2–3 weeks
Polypropylene (Prolene)	Poliglecaprone (monocryl)	2 weeks
	Vicryl Rapide	2 weeks
	Polydioxanone (PDS)	50% at 4 weeks
	Polyglactin (Vicryl)	25% at 4 weeks
	Less strength but does not require removal	

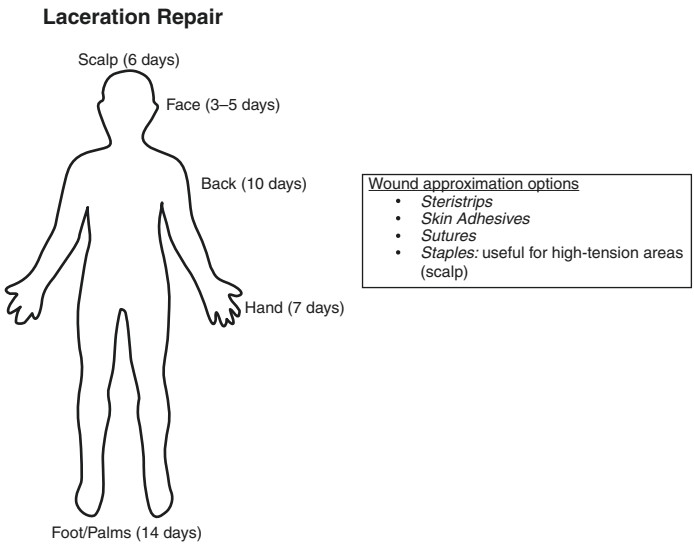


FIGURE 11.5 Approximate time ranges for wound healing

- Gauge increases resulting in a finer/thinner suture
- Gauge roughly estimates number of knot throws needed (Figs. 11.6 and 11.7)

Lacerations: Overview for Repair

- *Assess*
  - Size, if more complex, consider consultation.
  - Foreign body?
  - Neurovascularly intact?
  - Infection risk (tetanus, rabies).

Figure 11.6 Suture gauge 2.0

Figure 11.7 Suture gauge 6.0

- *Anesthesia*
  - Child life
  - Lorazepam 0.5–0.8 mg/kg PO or intranasal 0.4 mg/kg (max 10 ml to nare)
  - 1% lidocaine
    - w/epi (max = 0.7 cc/kg)
    - w/o (max = 0.4 cc/kg)

- *Topical*
  - LET (4% lidocaine, 1:2000 epi, 0.5% tetracaine)
  - Max = 7 mg lidocaine/kg (0.2 cc/kg).
  - Use for the face and scalp.
  - Contraindicated for end arteriolar.
  - Fill wound or soak gauze; leave for 20–30 min.
  - Onset, 5–10 min; duration, 20–30 min.
- *Irrigation:* sterilize NS or sterile water
- *Suturing*
  - Deep Sutures: absorbable monofilament (usually Vicryl®, PDS, chromic gut)
  - Superficial Sutures: non-absorbable monofilament (usually Prolene®, Ethilon®, others) *or* absorbable sutures such as fast absorbing plain gut
- *Dressing:* leave in place for 24 h, and then clean twice daily with clean water and mild soap.
  - Steri-Strips
  - Bacitracin
  - Sterile gauze
- *Suture Removal*
  - Face, 3–5 days
  - Joint, 10–14 days

Location	Anesthetic	Deep suture	Superficial suture	Dressing	Suture removal	Special
Scalp	1% lido w/ epi	3-0/4-0 Vicryl	5-0/4-0 Nonabsorbable suture, fast absorbing plain gut	Bacitracin, air	5–7 days	Pressure dressing if early hematoma
Pinna (ear)	1% lido	5-0 Vicryl in perichondrium	6-0 Nonabsorbable suture, fast absorbing plain gut	Bacitracin, light pressure dressing	5 days	
Eyelid/ eyebrow	1% lido	5-0 Vicryl	6-0/5-0 Nonabsorbable suture, fast absorbing plain gut	Bacitracin, air	4–5 days	Don't shave hair
Lip	1% lido w/ epi	5-0 Vicryl	6-0 Nonabsorbable suture (rapid)	Air		If through the vermillion border, consider plastics
Face Forehead	1% lido w/ epi	5-0 Vicryl	6-0 Nonabsorbable suture, fast absorbing plain gut	Bacitracin, air	4–6 days	Facial nerve – ensure it is in tact
Neck	1% lido w/ epi	4-0 Vicryl	5-0 Nonabsorbable suture		4–6 days	Thru platysma, needs consult

(continued)

Location	Anesthetic	Deep suture	Superficial suture	Dressing	Suture removal	Special
Trunk	1% lido w/ epi	4-0 Vicryl	5-0/4-0 Nonabsorbable suture	Bacitracin	7–10 days	r/o abd path, may need consult
Extremities/ buttocks	1% lido w/ epi	4-0 Vicryl 5-0 Vicryl	4-0 Nonabsorbable suture, 3-0 for over joints 5-0 Nonabsorbable suture (rapid)		7–10 days 10–14 days if over joint	Check if neurovascularly intact
Hands	1% lido	None	5-0/6-0 Nonabsorbable suture 5-0 rapid if <5 y.o.		7–10 days 10–14 days if over joint	
Nail beds	1% lido	None	6-0 Vicryl	Bacitracin/splint/ Xeroform gauze		If amputation, splint+ antibiotics
Feet/sole	1% lido	None	5-0/4-0/3-0 Nonabsorbable suture	Bacitracin, Xeroform	10–14 days	Kling wrap
Scrotum	1% lido	None	5-0/6-0 Vicryl or 5-0 Gut	Bacitracin, air, 4 × 4, fluff, scrotal support		Consider specialty consult
Penis	1% lido		5-0 Nonabsorbable suture		6–8 days	Consider specialty consult

Chapter 12
Pediatric Orthopedics

Tricia B. Swan

Abstract This chapter is packed with great "Quick Hits" about pediatric orthopedic injuries. It starts with the mnemonic for elbow ossification centers and continues through the suggested management of specific fractures. The pearls at the end of the chapter are a must-read.

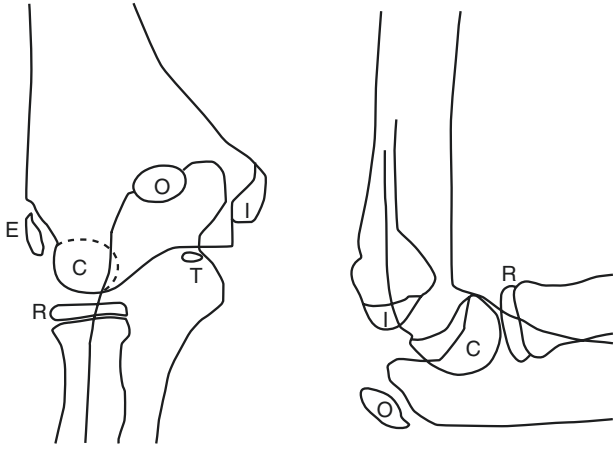
Pediatric Elbow Ossification Centers (CRITOE) (Fig. 12.1)

Supracondylar Fractures of the Humerus

- Fifty percent of all fractures of the elbow.
- Extension-type fracture.
  - Most common (95%).
  - Distal fragment displaced posteriorly.
  - Occurs from fall onto outstretched hand.

T. B. Swan
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: tfalgiani@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_12



C – capitellum	(1–2 years)	T – trochlear	(6–8 years)
R – radial head	(2–4 years)	O – olecronon	(8–10 years)
I – internal malleous	(4–6 years)	E – external malleolus	(10–12 years)

FIGURE 12.1 Pediatric elbow ossification centers

- Flexion-type fracture.
  - Rare.
  - Distal fragment displaced anteriorly.
  - Occurs from falling directly onto flexed elbow.
- Plain AP and lateral X-rays should be obtained.
- Posterior fat pad sign on lateral view is always pathologic and should raise suspicion of occult elbow fracture, even if not evident on plain film.
- Neurovascular status of the arm and hand must be assessed immediately.
- Appropriate and timely treatment of supracondylar fractures has two goals:
  - Avoid neurologic and vascular issues.
  - Prevent long-term angular and extension deformities.

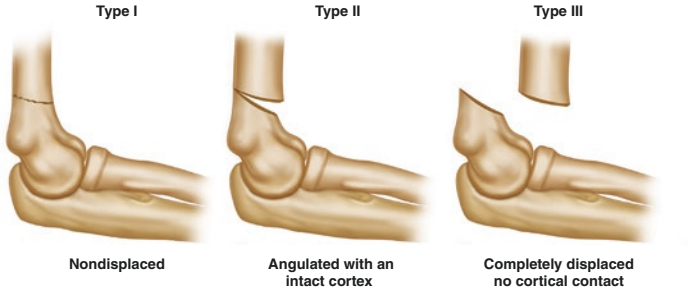


FIGURE 12.2 Gartland classification of supracondylar humerus fractures

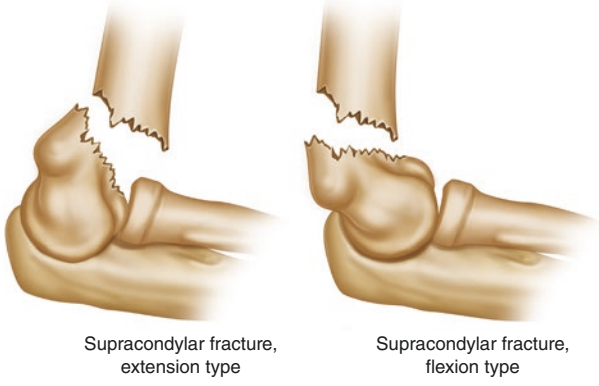


FIGURE 12.3 Flexion/extension injury in supracondylar humerus-fractures

Neurovascular Injuries in Supracondylar Fractures

Neurovascular structure	Finding
Anterior interosseous nerve	Most common nerve injury Unable to do OK sign with finger and thumb Unable to bend the tip of the index finger

(continued)

Neurovascular structure	Finding
Radial nerve	Second most common nerve injury Weakness or inability to extend wrist or fingers Unable to give "thumbs up" sign Loss of sensation in first web space
Ulnar nerve	Unable to abduct digits 3–5 (spread fingers) Loss of sensation in the pinky finger
Median nerve	Unable to flex digits 2–3 Unable to grasp object or finger Loss of sensation on volar aspect of index finger
Brachial artery	Absent radial pulse Cold, pale, pulseless hand

Salter–Harris Fracture Classification (SALTR) (Fig. 12.4)

Type I: Fracture through the physis without injury to epiphysis or metaphysis.
Type II: Fracture through the physis and extends through metaphysis (most common).
Type III: Fracture through the physis and extends through epiphysis.
Type IV: Fracture traverses through epiphysis, physis and metaphysis.
Type V: Crush injury of physis (very rare).

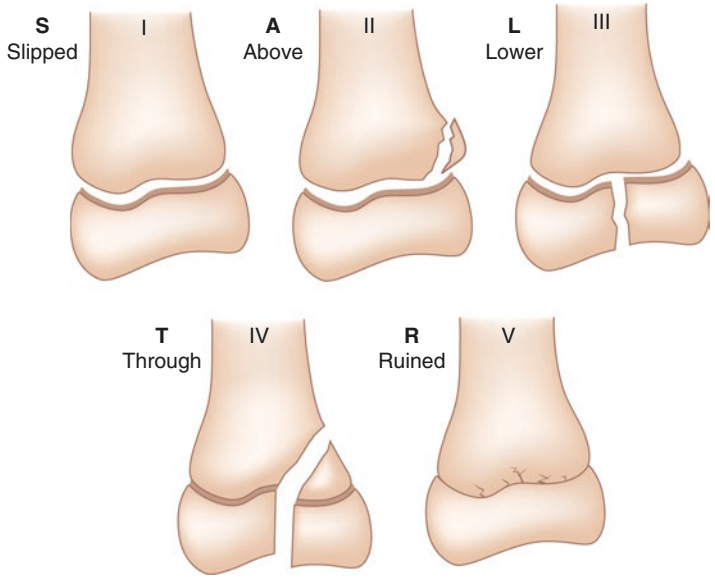


FIGURE 12.4 Salter Harris fractures

Common Pediatric Fractures and Management

Fracture	X-ray	ED management	Immobilization
Clavicle	AP, cranial/caudal tilt view	Outpatient follow-up unless fracture is open, neurovascular injury, significant degree of angulation or displacement >2 cm in an older child	Arm sling (recommended) or figure of 8 wrap (1–4 weeks) Orthopedic follow-up for children who participate in athletics

(continued)

Fracture	X-ray	ED management	Immobilization
Elbow supracondylar type I	AP in extension, lateral with 90° of flexion, oblique	Outpatient follow-up in 3–5 days	Posterior long arm splint with elbow in 90° of flexion with forearm in neutral position **Be sure not to flex arm more than 90° to avoid vascular compromise and compartment syndrome
Elbow supracondylar types II and III	AP in extension, lateral with 90° of flexion, oblique	Orthopedic consultation; closed or open reduction	Long arm immobilization while awaiting orthopedic consult
Elbow lateral condyle	AP in extension, lateral with 90° of flexion, oblique	Orthopedic consultation; surgical repair	Long arm immobilization while awaiting orthopedic consult

Fracture	X-ray	ED management	Immobilization
Distal radius/ulna fracture	Wrist AP, lateral (+/− forearm and elbow X-rays)	Outpatient follow-up unless fracture is open, neurovascular injury, significant displacement or degree of angulation >10° (>6 years of age) or > 15° (<6 years of age)	Volar splint with arm sling Orthopedic follow-up in 1–2 weeks
Nightstick (midshaft ulnar fracture)	Forearm AP, lateral (+/− elbow X-rays)	Outpatient follow-up unless fracture is open, neurovascular injury, significant displacement or degree of angulation >10° (>6 years of age) or > 15° (<6 years of age)	Posterior long arm splint Orthopedic follow-up in 1 week

(continued)

Fracture	X-ray	ED management	Immobilization
Monteggia (ulnar fracture with radial head dislocation)	Forearm AP, lateral Elbow AP, lateral	Orthopedics consult Closed or open reduction	Long arm immobilization while awaiting orthopedic consult
Galeazzi (radial shaft fracture with disruption of the radioulnar joint)	Forearm AP, lateral Elbow AP, lateral	Orthopedics consult Closed or open reduction	Long arm immobilization while awaiting orthopedic consult
Colles (distal radius fracture with dorsal displacement and volar angulation)	Forearm AP, lateral Elbow AP, lateral +/− wrist	Outpatient follow-up unless fracture is open, neurovascular injury, rotational deformity or degree of angulation >40°, or severe displacement; if not appropriate for outpatient follow-up, orthopedic consultation for closed or open reduction	Long arm posterior or sugar tong splint Orthopedic follow-up in 3–5 days If orthopedic consultation is required, long arm immobilization while awaiting orthopedic consult

Fracture	X-ray	ED management	Immobilization
Smith (distal radius fracture with volar displacement and dorsal angulation)	Forearm AP, lateral Elbow AP, lateral +/− wrist	Outpatient follow-up unless fracture is open, neurovascular injury, rotational deformity or degree of angulation >10°, or severe displacement; if not appropriate for outpatient follow-up, orthopedic consultation for closed or open reduction	Long arm posterior or sugar tong splint Orthopedic follow-up in 3–5 days If orthopedic consultation is required, long arm immobilization while awaiting orthopedic consult
Buckle (aka torus fracture)	Wrist AP, lateral, oblique Forearm AP, lateral	Outpatient follow-up unless fracture is open or neurovascular injury	Short arm cast or removable Velcro wrist splint Orthopedic follow-up in 1–2 weeks
Toddler fracture (spiral tibial shaft fracture)	Tibia and fibula AP, lateral, oblique	Outpatient follow-up unless fracture is open or neurovascular injury	Long leg posterior splint; orthopedic follow-up in 3–5 days

(continued)

Fracture	X-ray	ED management	Immobilization
Femoral shaft	Femur AP, lateral Pelvis X-ray Knee AP, lateral	Immediate orthopedic consultation	Immobilization while awaiting orthopedic consult Consider traction techniques
Ankle triplane (complex tibial physis fracture occurring in three planes)	Ankle AP, lateral, mortise CT scan of ankle	Immediate orthopedic consultation	Short or long leg immobilization while awaiting orthopedic consult
Tillaux ankle fracture (Salter-Harris type III fracture of the distal tibia)	Ankle AP, lateral, mortise CT scan of ankle	Immediate orthopedic consultation	Short or long leg immobilization while awaiting orthopedic consult

Common Splints and Indications

Splint	Indication
Thumb spica	Scaphoid fracture, thumb fracture, non-displaced first metacarpal fracture
Radial gutter	Non-rotated/non-displaced second and third metacarpal or proximal and middle phalangeal fractures
Ulnar gutter	Non-rotated/non-displaced fourth and fifth metacarpal or proximal and middle phalangeal fractures
Dorsal/volar	Carpal bone fractures (except for trapezium or scaphoid fractures), distal radius buckle fracture, soft tissue injury to hand and wrist

Splint	Indication
Sugar tong	Distal radius and ulna fractures
Long arm posterior	Proximal and midshaft radius and ulna fractures, non-buckle-type distal radius fractures, distal humerus fractures
Buddy taping	Non-angulated/non-displaced fractures of the phalanx
Aluminum U-shaped finger	Non-angulated/non-displaced fractures of the phalanx
Knee immobilizer	Knee soft tissue injuries, postreduction of patella dislocations
Long leg posterior	Proximal tibia and fibula fractures, knee soft tissue injuries and patellar fractures
Short leg posterior	Non-displaced malleolar fractures, midshaft and distal tibia and fibula fracture, severe ankle sprains, tarsal and metatarsal fractures (make sure to extend splint past toes)
Ankle stirrup	Non-displaced malleolar fractures, severe ankle sprains
High top walking boot	Distal tibia and fibula fractures, severe ankle sprains, tarsal and metatarsal fractures
Hard sole shoe	Non-displaced, non-angulated metatarsal fracture, phalanx fracture

Quick Hits Orthopedic Pearls

1. Any neurovascular injury/deficit, compartment syndrome, or open or multiple fractures should be evaluated by an orthopedic specialist in the emergency department.
2. If orthopedic consultation should be required or you are transferring the patient for further management, the patient should be made NPO.

3. Children with suspected fractures or obvious deformity should have expedited pain control.
4. Consider radiographic imaging of the joint above and the joint below the suspected fracture site.
5. Splinting of the joint above and joint below will provide optimal comfort while decreasing the likelihood of additional injury.
6. Splints are often the initial choice of management for fractures, to allow for swelling and decrease the risk of compartment syndrome.
7. Non-accidental trauma should be in your differential for all children with fractures. Highly suspicious fracture patterns for abuse include posterior rib fractures, metaphyseal bucket handle/corner fractures, fractures in non-ambulatory patients, bilateral long-bone fractures, complex skull fractures, and spinous process fractures.

Chapter 13
Pediatric Altered Mental Status

Tricia B. Swan

Abstract A quick chapter on the approach to pediatric altered mental status. The mnemonic AEIOU TIPS is a comprehensive heuristic to work through the possible etiology of the patient's altered state. This chapter also includes some empiric bedside therapies for potentially reversible causes, as well as some pearls to remember in all cases.

Signs of Altered Mental Status

- Poor responsiveness to environment or caregiver.
- Weak or absent cry.
- Eye deviation.
- Abnormal pupillary size or reaction.
- Abnormal respiratory patterns (tachypnea, apnea, Cheyne-stokes respirations).
- Abnormal motor movements.
- Lack of response to painful stimuli.

T. B. Swan
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: tfalgiani@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_13

Causes of Altered Mental Status in Children: AEIOU TIPS

A	Abuse Alcohol Arrythmia
E	Electrolyte abnormality Encephalopathy Endocrine crisis
I	Infection Intussusception
O	Overdose/ingestion Opiate ingestion Oxygen deprivation (hypoxia)
U	Uremia
T	Trauma Tumor Temperature (hyper or hypothermia)
I	Insulin-related issues (hyper/hypoglycemia, DKA) Inborn errors of metabolism
P	Psychosis Porphyria Psychogenic
S	Shock Seizures Stroke Shunt malfunction

Initial Laboratory and Imagining Evaluation

- Bedside glucose, VBG or ABG, bedside electrolytes, CBC, blood culture, UA and urine culture, CSF studies and culture (if clinically stable), ammonia, complete metabolic panel.

- If inborn error of metabolism is suspected, obtain serum amino acids, urine organic acids, and carnitine level.
- CT head if trauma is suspected or visible, status epilepticus, or severely obtunded.
- Consider toxicology screen.

General Treatment Guidelines

- ABCs—Intubation for comatose or severely obtunded patients or inability to maintain/protect airway.
- Fluid bolus—20 ml/kg if no cardiac etiology is suspected, otherwise 10 ml/kg.
- Address and correct temperature abnormalities.
- Administer dextrose if hypoglycemic.
- Address and correct any electrolyte abnormalities.
- Consider naloxone.
- Avoid hypotension.
- Avoid hyperventilation.
- Obtain ECG.
- Administer broad-spectrum antibiotics.
- Start specific therapy based on most likely diagnosis.

Pediatric Altered Mental Status Pearls

- Consider lead poisoning and Reye syndrome in addition to infectious cause as an etiology of encephalopathy.
- Consider EEG in the emergency department if patient remains in persistently altered state as some seizures may be undetectable by physical exam alone.
- Toxic ingestion is still possible even in toxicology screen is negative.
- Non-accidental trauma should be suspected as an etiology of altered mental status in all children.

Chapter 14
Pediatric Fever Protocols

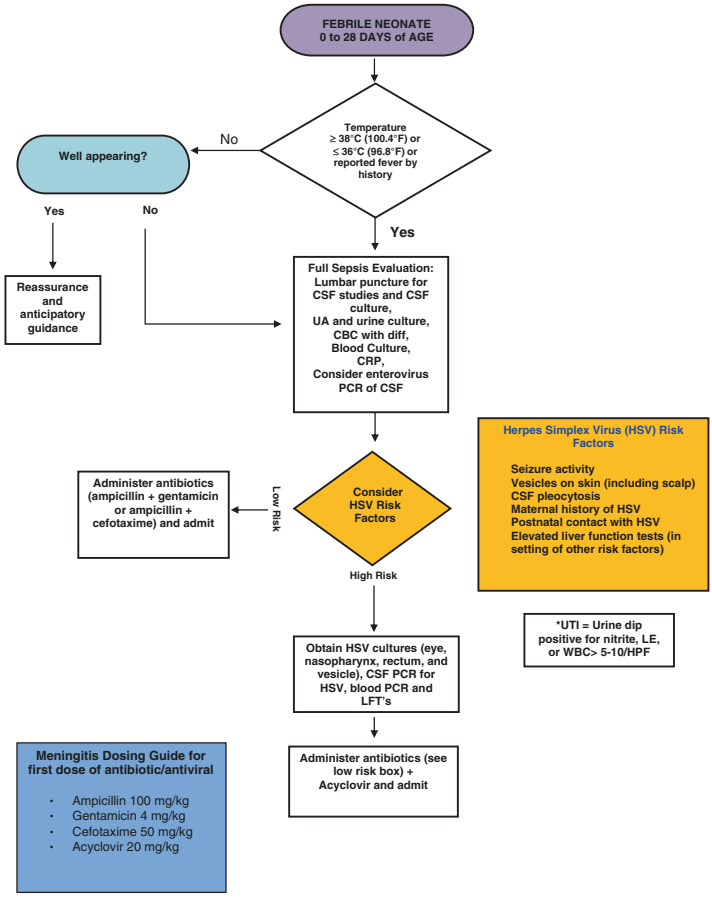
Tricia B. Swan and Sadiqa A. I. Kendi

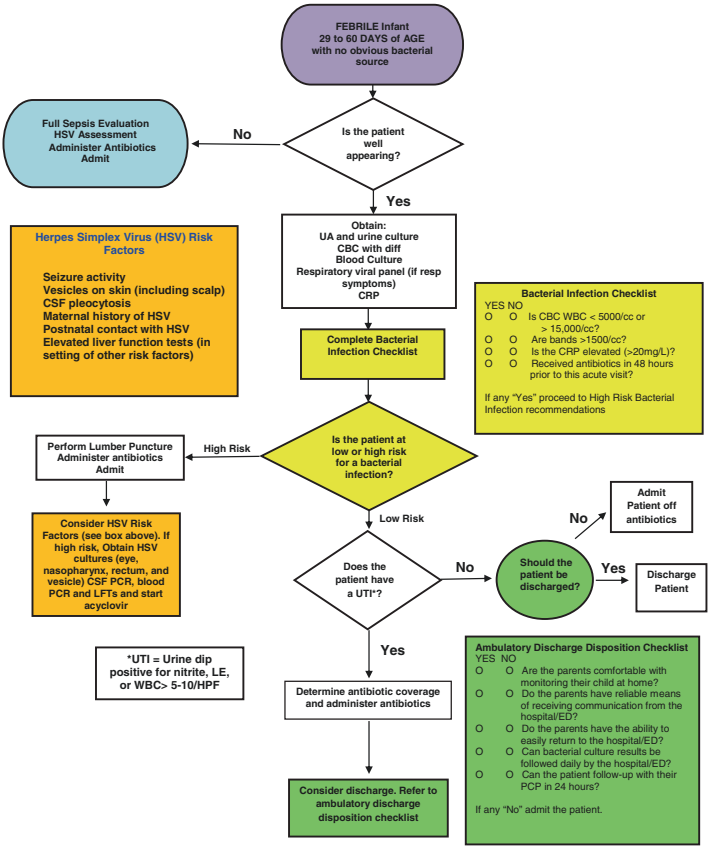
Abstract A descriptive algorithm for the evaluation and management of the febrile neonate, infant, and child. The bacterial infection and ambulatory discharge disposition checklists are true "Quick Hits." Further risk stratification in the febrile child for a serious bacterial infection will improve resource utilization and breed antibiotic stewardship.

T. B. Swan (✉)
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: tfalgiani@ufl.edu

S. A. I. Kendi
Pediatric Emergency Medicine, Children's National Health System, Washington, DC, USA
e-mail: skendi@cnmc.org

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_14


FEBRILE NEONATE
0 to 28 DAYS of AGE
Temperature
≥ 38°C (100.4°F) or
≤ 36°C (96.8°F) or
reported fever by
history
No
Well appearing?
Yes
No
Yes
Reassurance
and
anticipatory
guidance
Full Sepsis Evaluation:
Lumbar puncture for
CSF studies and CSF
culture,
UA and urine culture,
CBC with diff,
Blood Culture,
CRP,
Consider enterovirus
PCR of CSF
Herpes Simplex Virus (HSV) Risk
Factors
Seizure activity
Vesicles on skin (including scalp)
CSF pleocytosis
Maternal history of HSV
Postnatal contact with HSV
Elevated liver function tests (in
setting of other risk factors)
Consider
HSV Risk
Factors
Low Risk
Administer antibiotics
(ampicillin + gentamicin
or ampicillin +
cefotaxime) and admit
High Risk
*UTI = Urine dip
positive for nitrite, LE,
or WBC> 5-10/HPF
Obtain HSV cultures (eye,
nasopharynx, rectum, and
vesicle), CSF PCR for
HSV, blood PCR and
LFT's
Administer antibiotics (see
low risk box) +
Acyclovir and admit
Meningitis Dosing Guide for
first dose of antibiotic/antiviral
Ampicillin 100 mg/kg
Gentamicin 4 mg/kg
Cefotaxime 50 mg/kg
Acyclovir 20 mg/kg



**Full Sepsis evaluation includes CSF fluid analysis and CSF culture, CBC with differential, Blood culture, Urinalysis and Urine culture from a catheterized specimen, CRP and consideration of viral CSF studies including HSV and enterovirus


FEBRILE Child
3-36 months of AGE
(Temp ≥ 38°C)
Is the patient well appearing?
No
Full Sepsis Evaluation
Administer Antibiotics
Admit
Yes
Perform complete history and physical exam
Fever source identified
Treat as indicated
No source identified
Risk stratification for serious bacterial illness
Temp ≥ 39°C?
No
No diagnostic testing or antibiotics
Antipyretic medications
Return follow up in 24-48 hours if fever persists or clinical condition worsens
Yes
Urinary Tract Infection Risk Factors
Female
Male
Fever > 48 hrs
Fever > 24 hrs
White race
Non-black race
No other source
No other source
Age < 12 mo
Perform UA and urine culture if:
Female with ≥ 2 risk factors
Uncircumcised male with any risk factor
Circumcised male with ≥ 3 risk factors
Bacteremia Risk Factors
< 2 PCV/Hib Vaccinations
Petechial rash
Ill appearance with diarrhea or UTI
If risk factors are present:
Perform CBC with differential, blood culture, and CRP
Pneumonia Risk Factors
Acute Pneumonia
Occult Pneumonia
< 2 PCV/Hib Vaccinations
Fever > 39°C for > 5 days
Focal lung findings (crackles)
Cough
Cough, retractions
WBC > 20,000
O2 sats < 92%
If risk factors and clinical concern, consider chest x-ray
UA concerning for UTI?
= Urine dip positive for nitrite, LE, or WBC> 5-10/HPF
Yes
No
Treat with appropriate oral antibiotics
Admit if vomiting/unable to tolerate PO fluids
Follow up in 24 hours
WBC > 15,000/cc
Bands > 1,500/cc
CRP > 20 mg/L
WBC < 15,000/cc
Bands < 1,500/cc
CRP < 20 mg/L
Yes
Treat with empiric ceftriaxone and follow up in 24 hours
Yes
Chest x-ray positive for pneumonia or high clinical suspicion?
No
Yes
Treat with appropriate antibiotic
Follow up in 24 hours
Evaluated for other sources of SBI: If patient is low risk for all SBI and appears well:
Discharge home
No antibiotics
Antipyretics as needs and encourage oral hydration
Follow up in 24 hours or if fever persists > 48 hours or clinical condition worsens

Chapter 15
Pediatric Electrocardiography

Tricia B. Swan

Abstract This is what providers need to set them up for success interpreting a pediatric ECG, starting with special consideration and finishing with some pearls based on variation in age. The tables are full of Quick Hits based on ECG morphology and potential diagnosis that are crucial to the management of arrhythmias.

Special Considerations in Pediatric ECGs

- ECG normal values vary with age, reflecting the changing anatomy of the growing heart.
- At birth the right ventricle is larger and thicker than the left ventricle, which results in right axis deviation, T wave inversion in V_1–V_3, and prominent R wave in V_1.
- Normal heart rate values are dependent on age.

T. B. Swan
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: tfalgiani@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_15

- Conduction intervals are shorter (QRS duration, PR interval).
- To interpret pediatric ECGs accurately, it is important to have normal age-related value tables readily available.
- T wave inversion in V_1–V_3 may be a normal finding (juvenile T wave pattern).

Stepwise Approach to Interpretation of ECG: Rate, Rhythm, Axis, Intervals, and Voltages

- Typical paper speed is 25 mm/s.
- 1 mm = 1 small box = 0.04 s.
- 5 mm = 1 large box = 0.2 s.

Rate

To calculate rate: 300 ÷ number of large squares between consecutive R waves.

Quick calculation: HR 300 = 1 large box, 150 = 2 large boxes, 100 = 3 large boxes, 75 = 4 large boxes, 60 = 5 large boxes.

Normal Heart Rate by Age

Age	Heart rate
Premature	120–170
0–3 months	110–160
3–6 months	100–150
6–12 months	90–130
1–3 years	80–125
4–6 years	70–115
6 years to adult	60–100

Rhythm

- Sinus rhythm criteria:
  - Normal P wave (upright in I and aVF, inverted in aVR).
  - P wave before every QRS complex.
  - QRS after every P wave.
  - Constant PR interval.
- Inversion of P wave in II or aVF indicates a low atrial rhythm (not sinus) or limb lead reversal.

Axis

- The right ventricle is the dominant ventricle in the newborn and shifts the axis to the right (>90°).
- At 3–5 years of age, the left ventricle catches up and then is the dominant ventricle and shifts the axis to the left (<90°).
- An abnormal axis can be one of the first clues for the diagnosis of congenital heart disease.
- Determine both P wave and QRS axis. Net summation of positive and negative deflections is used. Look for two perpendicular leads (usually lead I and AVF).
  - If QRS is positive in both lead I and AVF, the axis is in the left lower quadrant.
  - (0 – +90°).
  - If QRS is negative in lead I and positive in AVF, the axis is in the right lower quadrant (90–180°).

Normal QRS Axis by Age

Age	QRS axis
Birth–1 month	+30 to 180°
1 month–3 years	+10 to 125°
4–5 years	0 to +110°
6–17 years	–15 to +110°
Adult	–30 to +105°

Adapted from Sharieff GQ, Rao SO. The Pediatric ECG. *Emerg Med Clin North Am*. 2006; 24: 195–208

Intervals

PR Interval

Measured from the beginning of the P wave to the beginning of the first deflection of the QRS complex:

- The PR interval is much shorter in neonates than in adults.

Normal PR Interval by Age

Age	PR interval (seconds)
Birth–5 months	0.08–0.15
6 months–1 year	0.8–0.16
1–2 years	0.08–0.16
3–11 years	0.09–0.17
12–16 years	0.09–0.18
>16 years	0.12–0.20

Adapted from Sharieff GQ, Rao SO. The Pediatric ECG. *Emerg Med Clin North Am*. 2006; 24: 195–208

Causes of Abnormalities of PR Interval

Prolonged PR interval	Shortened PR interval	Variable PR interval
Hyperkalemia	Preexcitation pattern (WPW)	Wenckebach (Mobitz type 1)
Myocarditis	Glycogen storage disease	
Digitalis toxicity		
Certain congenital heart diseases (ASD, Ebsteins anomaly)		

QRS Interval

- QRS interval lengthens as age increases.
- Abnormalities in the QRS morphology can detect ventricular hypertrophy which may reflect congenital heart disease.
- Right and left bundle branch patterns look similar to adult manifestations; however the normal duration of the QRS interval is age related.
- In the presence of bundle branch block, determination of ventricular hypertrophy is difficult, and an echocardiogram is indicated.
- Causes of prolonged QRS include bundle branch blocks, intraventricular block, ventricular arrhythmias, and preexcitation syndromes (Wolff-Parkinson-White syndrome).

Normal QRS Interval by Age

Age	QRS interval (seconds)
Birth–3 years	0.03–0.07
3–7 years	0.04–0.08
8–15 years	0.04–0.09
>16 years	0.05–0.10

Adapted from Sharieff GQ, Rao SO. The Pediatric ECG. *Emerg Med Clin North Am*. 2006; 24: 195–208

QTc Interval

- Diagnosis of prolonged QT is critical especially in the setting of seizures, syncope, or ALTE/BRUE events.
- Use the Bazett formula to correct the QT interval for heart rate:
  - Measured QT interval ÷ square root of the R-R interval.

Normal QTc Interval by Age

Age	QTc interval (seconds)
Birth–1 week	0.47
1 week–6 months	0.45
> 6 months	0.44

Causes of Abnormalities of QTc

Prolonged QTc	Shortened QTc
Myocarditis	Congenital short QT syndrome
Ingestions/drugs	Digitalis effect
Hypocalcemia	Hypercalcemia
Head injury	
Long QT syndromes (Romano-Ward)	

Voltages (and Wave Morphology)

P Waves

- Should be upright in II and aVF and inverted in aVR.
- Normal P waves <3 mm tall.
  - Tall P wave = right atrial enlargement.
- Normal P wave duration.
  - <0.07 s in infants
  - <0.09 s in children
  - Wide P wave = left atrial enlargement.
- Tall and wide P wave = combined atrial hypertrophy.

QRS Waves

Low QRS amplitude	High QRS amplitude
Pericarditis	Ventricular hypertrophy
Myocarditis	Ventricular conduction disturbances (WPW, bundle branch blocks)
Hypothyroidism	
Normal newborns	

- Age-related normal value tables are available for Q, R, and S waves.
- Recognition of ventricular hypertrophy:
  - Ventricular hypertrophy may be reflected by abnormalities in the QRS axis, QRS voltages, the R/S ratio, or T axis.
  - Evaluate QRS complex in V_1 and V_6. V_1 overlies the right ventricle and V_6 overlies the left ventricle; a tall R wave in these leads may mean hypertrophy.

Finding suggestive of RVH	Findings suggestive of LVH
Tall R wave in V_1 or V_2	Tall R wave in V_5 or V_6
Tall R wave in III and aVR	Tall R wave in I, II, aVL, aVR
Deep S wave in V_5/V_6	Deep S wave in V_1/V_2 or V_4R
R/S ratio > upper limit of normal in V_1	R/S ratio > upper limit of normal in V_6
R/S ratio < lower limit of normal in V_6	R/S ratio < lower limit of normal in V_1
qR pattern in V_1 (small Q wave, tall R wave)	Deep Q (>4 mm) in V_5/V_6
Upright T wave in V_1 or V_4R in children >3 days to 6 years (when T waves are normal otherwise)	Inverted T wave in V_6, I and aVL
Right axis deviation for age	Left axis deviation for age

Q Waves

- Normal Q wave.
  - Narrow (<0.03 s).
  - Less than 5 mm deep in aVF and left precordial leads.
  - May be up to 8 mm deep in III in child <3 years old.
- Abnormal Q wave.
  - Present in right precordial leads (i.e., V_1).
  - Absent in the left precordial leads.
  - Abnormally deep and/or wide (ventricular hypertrophy, MI, fibrosis).

ST Segment

- The normal ST segment is isoelectric.
- ST segment and T wave abnormalities signal similar pathology as in the adult ECG.
- J point (junction between QRS and ST segment) elevation and ST segment depression (2 mm in precordial leads/1 mm in limb leads) may be normal.
- Early repolarization (elevated ST segment and concave in leads with upright T wave) in adolescents is a normal variant.
- Ischemia, pericarditis, myocarditis, electrolyte disturbances, severe ventricular hypertrophy, and digitalis effect may produce abnormalities.
- Pathologic ST changes:
  - Downward slope of ST segment followed by a biphasic inverted T wave.
  - Sustained horizontal ST segment depression ≥0.08 s.

T Waves

- T wave morphology changes with age.
  - From birth to 1 week old, T waves are upright in the precordial leads.
  - After 1 week old, T waves typically inverted in V_1–V_3 (juvenile T wave pattern).
  - After 8 years old, T waves become upright in V_1–V_3; however juvenile T wave pattern may persist into early adulthood and can be a normal variant.

Causes of Abnormalities of T Waves

Peaked T waves	Flat T waves	Inverted T waves
Hyperkalemia	Hypokalemia	Increased intracranial pressure
Early repolarization	Hypothyroidism	
LVH with volume overload	Pericarditis/ myocarditis	
	Myocardial ischemia	
	Normal newborns	

Common ECG Findings Associated with Specific Diseases

Disease	ECG Findings
Hypocalcemia	ST segment prolongation, prolonged QTc
Hypercalcemia	Shorted ST segment, shortened QTc
Hypokalemia	Prominent U waves, ST depression, biphasic or flat T waves, PR interval prolongation, SA block
Hyperkalemia	Peaked T waves, prolonged QRS, prolonged PR interval, absence of p waves, sine waves (wide, bizarre, biphasic QRS complex)
Myocardial infarction/ischemia	ST elevation in contiguous leads with reciprocal ST depression, horizontal ST depression (ischemia)
Myocarditis	Low QRS voltage ($\leq$ 5 mm in limb leads), decreased T wave amplitude, QT prolongation, AV conduction disturbance (from PR prolongation to complete AV dissociation), deep Q waves and poor R wave progression in precordial leads, tachyarrhythmias

(continued)

Disease	ECG Findings
Pericarditis	QRS voltage <5 mm in limb leads, time-dependent changes: PR segment depression and concave ST segment elevation→ST segment normalizes and flattened T waves→T wave inversion

Types of Arrhythmias

Arrhythmia	ECG findings and characteristics
Supraventricular tachycardia (SVT)	Rapid, regular, narrow (<80 ms) complex tachycardia (220–320 bpm in infants; 150–250 bpm in older children) P wave typically invisible; if visible will be abnormal in axis P wave may be retrograde (follow QRS complex) 90% of pediatric dysrhythmias are SVT and 90% of SVT are re-entrant type ½ of children with SVT have no underlying heart disease ¼ of children will have congenital heart disease ¼ of children will have WPW Consider drug exposure or fever as cause 2 types of SVT: Reentrant and automatic Do not use verapamil or beta blockers in infants or children with SVT; may cause profound AV block, negative inotropy or sudden death

Arrhythmia	ECG findings and characteristics
Reentrant SVT	90% of SVT HR does not vary substantially Begins and ends suddenly Requires a bypass pathway (anatomic or functional) between atria and ventricles in addition to the AV node (e.G., WPW syndrome, AV nodal re-entrant tachycardia)
Automatic SVT	Abnormal or accelerated normal automaticity Can be due to medications/drugs (e.G., sympathomimetics) Begins and ends gradually Includes: Sinus tachycardia Atrial tachycardia Junctional ectopic tachycardia (usually post atrial surgery)
Wolf-Parkinson-white syndrome	Occurrence of SVT+ Short PR interval Widened QS with slurred upstroke(delta wave) Can cause wide complex tachycardia which may be mistaken for v tach (but is actually SVT with aberrancy)
Ventricular tachycardia (V tach)	Regular, fast heart rate Widened QRS Can be monomorphic or polymorphic May be caused by prolonged QT Extremely rare in children Usually have history of congenital heart disease

(continued)

Arrhythmia	ECG findings and characteristics
Ventricular fibrillation (V fib)	Chaotic irregular deflections of varying amplitude No identifiable P waves, QRS complexes, or T waves Rate 150 to 500 per minute Amplitude decreases with duration (coarse VF ⇒ fine VF) Extremely rare in children Usually have a history of congenital heart disease Can be caused by prolonged QT, intracranial hemorrhage, medications

Quick Hits Pediatric ECG Pearls

- Interpretation of the pediatric ECG is challenging due to large variations in age-related normal values.
- Use a stepwise approach to evaluate pediatric ECGs: Rate, rhythm, axis, intervals, and voltages (or wave morphology).
- Use reference tables to determine normal values for each age.
- SVT is the most common arrhythmia in children.
- 95% of wide complex tachycardias in children are *not* V tach, but SVT with aberrancy or SVT with bundle branch block or accessory pathway re-entrant SVT.

Chapter 16
Pediatric Seizure

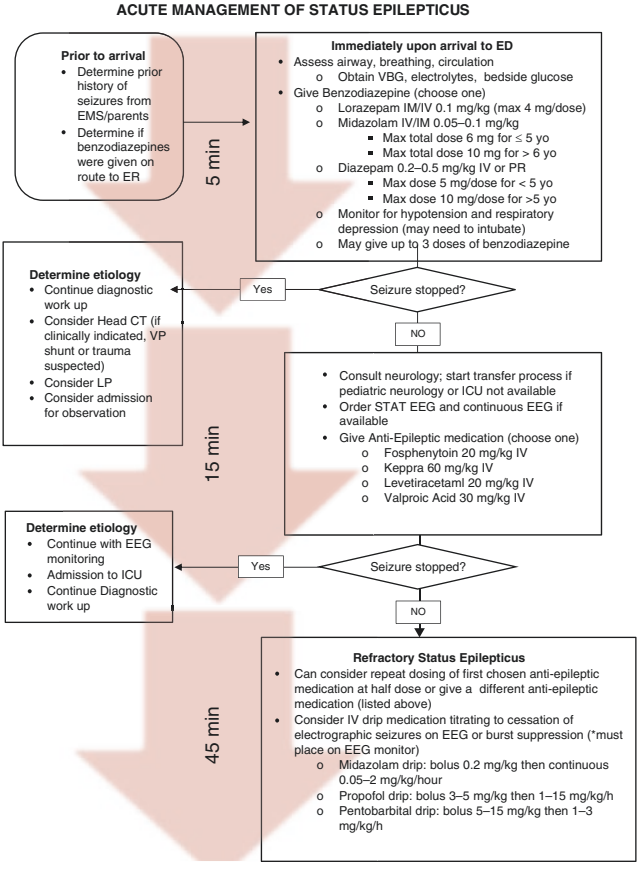
Tricia B. Swan

Abstract This chapter brings you a step-by-step guide on how to approach the actively seizing patient in status epilepticus. The differentiation of the simple versus complex febrile seizure is a must-know for all providers caring for the seizing pediatric patient. The differential diagnosis table of nonfebrile seizures is a "Quick Hit" that can easily be accessed while difficult to remember.

T. B. Swan
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: tfalgiani@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_16

Acute Management of Status Epilepticus



Defining Status Epilepticus

- Seizure lasting >30 min or > 30 min of intermittent seizure activity without return to baseline.
  - Early/impending: 5 min.
  - Early stage: 5–30 min.
  - Late/established: 30–60 min.
  - Refractory status: Failure to respond to two doses of different AEDs or duration >60 min.

Treatment Goals for Status Epilepticus

1. Abort seizure.
2. Maintain homeostasis and prevent cardiovascular collapse and brain injury.
3. Identify and treat underlying disorders.

Consideration of Underlying Disorders in Status Epilepticus

- Consider electrolyte disturbance:
  - Hypoglycemia: give glucose.
  - Hyponatremia: give 3% NaCl.
  - Hypomagnesemia: give magnesium sulfate.
  - Hypocalcemia: give calcium gluconate.
- Consider pyridoxine deficiency or INH toxicity:
  - Give pyridoxine.
- Consider other toxidromes.
- Consider pregnancy.
- Consider hypoxia.
- Consider infectious etiology:
  - Broad-spectrum antibiotics.
  - Acyclovir.

FEBRILE SEIZURE FUNDAMENTALS

Simple	Complex
• T ≥ 38 Celsius • Age 6 mos–5 years • < 15 min duration • Generalized • No recurrence	• T ≥ 38 Celsius • Age < 6 mo or > 5 years • 15+ minute duration • Focal • Multiple in 24 h • 20–30% of all febrile seizures

Simple Febrile Seizure Management

- Very low risk of meningitis.
- Not the SOLE indication of meningitis.
- No difference in risk of serious bacterial illness compared with febrile kids who don't seize.
- Neuroimaging/EEG not indicated.
- Labs only as indicated for evaluation of fever cause.
- LP is an OPTION: 6 months–12 months if unimmunized, underimmunized or unclear immunization status or pre-treatment with systemic antibiotics or does not return to neurologic baseline.

Complex Febrile Seizure Management

- Even in complex febrile seizures, rate of acute bacterial meningitis is LOW.
- Rarely the SOLE indicator of meningitis.
- LP or no LP?
  - Threshold to perform LP should be lower.
  - LP for persistent altered mental status and focal neuro exam or clinical concern.
  - LP for unimmunized.
  - LP if patient has been treated/partially pretreated with antibiotics.
  - Strongly consider observation admission.

Evaluation of First-Time Nonfebrile Seizure

- Most require ONLY a complete history and physical! Do only H&P for HEALTHY children back to baseline (no labs or imaging!).
- Younger children, not back to baseline or underlying diseases, may need more investigation.
- Utilize risk factors to guide when you should image (CT or MRI):
  - Abnormal or focal neurologic exam.

- Predisposing history (sickle cell disease, bleeding disorder, cerebral vascular disease, cancer, HIV, hemihypertrophy, hydrocephalus, closed head injury, VP shunt or recent shunt revision, travel to areas with endemic cysticercosis).
- Focal seizure or focal manifestations.
- Persistent altered mental status or status epilepticus.
- Age < 6 months.
- Uncertain follow-up.

Differential diagnosis of non-febrile seizures
Breath holding
Syncope
Non-accidental trauma
Encephalopathy
Parasomnia
TICs
Hypoglycemia
Complex migraine
Arrhythmia
Benign myoclonus of infancy
Gastroesophageal reflux (Sandifer Syndrome)
Chills

- Get labs for:
  - Kids under 6 months of age.
  - History of diabetes or other metabolic disorder.
  - Suggestive clinical history (vomiting, diarrhea).
  - Persistent altered mental status.
  - Status epilepticus.
- Lumbar puncture:
  - No evidence supporting routine performance of LP.
  - NOT for the well child back to baseline.

  - Only if clinically indicated.
  - LP should be done in ALL neonates (<28 days old).
- Should perform an EEG (can be done as outpatient at a follow-up neurology visit).
- Disposition:
  - Back to normal: Discharge home (arrange outpatient EEG).
  - Education for families – What to do if seizure occurs.
  - Outpatient follow-up with pediatric neurologist.
  - *Activity restrictions* (no swimming alone, no bathing alone, no driving, no mountain climbing, etc.)
  - Does not need antiepileptic medication.

Neonatal Seizures (⩽ 28 Days of Age)

- Full septic workup (CBC, blood culture, UA, urine culture, CSF studies, and CSF culture).
- HSV surface cultures.
- CSF HSV.
- Obtain electrolytes.
- Obtain imagining (CT or brain MRI).
- Give antibiotics and acyclovir (cover meningitis and HSV meningitis).
- Give pyridoxine if seizure is intractable.

Quick Hits: Pediatric Seizure Management Pearls

- *Simple febrile seizure: Bottom line*
  - Treat like any other kid with fever.
  - LP if appears meningitic.
  - LP is an OPTION if unimmunized or underimmunized or pretreatment with antibiotics.

- *Complex febrile seizures: Bottom line*
  - Lower threshold to perform LP.
  - Do NOT need to perform LP in the WELL appearing child who is back to baseline.
  - Strongly consider observation admission.
- *First nonfebrile seizure: MUST DO*
  - Clinical exam.
  - History.
  - Education/activity restrictions!
  - Everything else DEPENDS on clinical exam or concerning history findings.
  - Basic labs and imaging in <6 months of age or predisposing conditions.
  - Overall labs, LP, EEG, and imaging are NOT needed in the ED; will need outpatient EEG.

Chapter 17
Electrolyte Disturbances

Tricia B. Swan

Abstract This electrolyte disturbances chapter is full of important pearls to the identification and treatment of hyponatremia, hypernatremia, hypokalemia, hyperkalemia, hypokalemia, and hypoglycemia. The tables are a vital tool to help identify the etiology of the patient's electrolyte abnormality. Treatments are concise and bulleted for quick reference and action.

Hyponatremia (Na^+ <135 mEq/L)

Signs/Symptoms

- Altered mental status
- Lethargy
- Seizures

T. B. Swan
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: tfalgiani@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_17

- Coma
- Decreased tendon reflexes
- Hypothermia
- Respiratory distress or respiratory failure, Cheyne-stokes respirations
- Anorexia
- Nausea, vomiting
- Muscle cramps
- Weakness
- Agitation
- Headaches

Type	Etiology	Notable laboratory findings	Treatment
Pseudohyponatremia	Hyperlipidemia (Na^+ decreased by 0.002 × lipid mg/dL) Hyperproteinemia (Na^+ decreased by 0.25 × [protein g/dL-8])	Normal serum osmolality	Treat underlying cause
Pseudohyponatremia	Hyperglycemia (Na^+ decreased by 1.6 mEq/L for each 100 mg/dL rise in glucose over 100) Mannitol infusion	High serum osmolality	Treat underlying cause
Renal loss	Diuretics Adrenal insufficiency Na^+-losing nephropathy Obstructive uropathy Renal tubular acidosis Cerebral salt wasting	Decreased weight ↑ Urine volume ↑ Urine Na^+ ↓ Urine osmolality ↓ Urine specific gravity	Treat underlying cause Replace losses

Type	Etiology	Notable laboratory findings	Treatment
Extrarenal loss	GI losses (diarrhea, vomiting) Skin losses Cystic fibrosis Third spacing (ascites, burns, pancreatitis, etc.)	Decreased weight ↓ Urine volume ↓ Urine Na^+ ↑ Urine osmolality ↑ Urine specific gravity	Treat underlying cause Replace losses
Other	SIADH Congestive heart failure Nephrotic syndrome Acute or chronic renal failure Water intoxication Improper formula mixing Cirrhosis Hypothyroidism	Increased or normal weight ↓ Urine volume ↓ Urine Na^+ ↑ Urine osmolality ↑ Urine specific gravity	Treat underlying cause Restrict fluids/free water

Emergent Management for Hyponatremia

- Treat symptomatic hyponatremia (seizures, coma, etc.) with IV hypertonic saline:
  - Give 4–6 ml/kg of 3% NaCl.
  - Each ml/kg of 3% NaCl will increase the serum Na^+ by approximately 1 mEq/L.
  - Do not increase the serum Na^+ to more than 130 mEq/L acutely.
- Rapid correction of hyponatremia can cause central pontine myelinolysis:
  - Avoid increasing the serum Na^+ more than 12 mEq/L every 24 h.

- Treat asymptomatic hyponatremia with identification of underlying cause and then disease-specific treatment such as fluid and sodium replacement, water restriction, hormone replacement, or dialysis.

Hypernatremia (Na^+ >145 mEq/L)

Signs/Symptoms

- Altered mental status
- Lethargy
- Seizures
- Coma
- Decreased tendon reflexes
- Hyperthermia
- Respiratory distress or respiratory failure
- Nausea, vomiting
- Muscle cramps
- Weakness
- Irritability
- Headaches

Type	Etiology	Notable laboratory findings	Treatment
Renal loss	Diuretics Diabetes insipidus Nephropathy Post-obstructive diuresis Acute tubular necrosis (diuretic phase)	Decreased weight ↑ Urine volume ↑ Urine Na^+ ↓ Urine specific gravity	Treat underlying cause Replace free water loss
Extrarenal loss	GI losses (diarrhea, vomiting) Skin losses Respiratory loss of free water Insensible losses (premature infant, radiant warmers, phototherapy)	Decreased weight ↓ Urine volume ↓ Urine Na^+ ↑ Urine specific gravity	Treat underlying cause Replace free water loss

Type	Etiology	Notable laboratory findings	Treatment
Other	Mineralocorticoid excess Hyperaldosteronism Exogenous Na^+ intake Improper formula mixing Administration of sodium containing medications or fluids (sodium bicarbonate, hypertonic saline) Seawater ingestion Inadequate oral intake (ineffective breastfeeding, child abuse/neglect, etc.)	Increased weight ↓ Urine volume ↓ Urine Na^+ ↑ Urine osmolality ↑ Urine specific gravity	Treat underlying cause Replace free water loss Stop exogenous intake or administration of sodium containing medications or fluids

Emergent Management for Hypernatremia

- Identify and treat underlying cause.
- Stop exogenous administration of any sodium containing fluids/medications.
- For patients with shock or severe dehydration, volume expansion with isotonic saline is recommended regardless of serum Na^+.
- Hypernatremia should not be corrected rapidly:
  - Serum Na^+ should not be lowered more than 10–12 mEq/L per 24 h.

Hypokalemia (K <3.5 mEq/L)

Signs/Symptoms

- Muscle weakness
- Muscle cramps

- Paralysis
- Ileus/constipation
- Areflexia
- Arrhythmias
- Respiratory distress
- Urinary retention

ECG changes: flattened or absent T wave, ST segment depression, presence of a U wave between T wave and P wave, ventricular fibrillation, torsades de pointes.

Etiologies	
Decreased intake	Anorexia nervosa Poor diet (rare)
Transcellular shift	Alkalosis Insulin therapy Albuterol therapy Familiar hypokalemic periodic paralysis
Renal loss	Renal tubular acidosis Diuretics DKA Excessive mineralocorticoid effect (Bartter's syndrome, Cushing syndrome, licorice ingestion, hyperaldosteronism) Acute tubular necrosis Fanconi syndrome Antibiotics (high urine anions, especially penicillins)
Extrarenal loss	Vomiting/excessive NG suction Pyloric stenosis Cystic fibrosis Diarrhea Laxative abuse Ureterosigmoidostomy Excessive sweating
Spurious	Leukocytosis

Emergent Management for Hypokalemia

- Obtain ECG.
- Obtain creatine kinase (CK) (hypokalemia can cause rhabdomyolysis); glucose; ABG; urinalysis; urine K^+, Na^+, and Cl^-; and urine osmolality.
- If respiratory paralysis or cardiac arrhythmia is present, infuse 1 mEq/kg/h.
- If patient is not critical, calculate K^+ deficit, and replace with potassium acetate or potassium chloride. Oral replacement is safer when feasible.
- Correct underlying causes (DKA, alkalosis, etc.).
- If IV replacement is necessary, no more than 40 mEq/L via peripheral route or 80 mEq/L via central route should be used.

Hyperkalemia (K >5.5 mEq/L)

Signs/Symptoms

- Muscle weakness
- Paresthesias
- Paralysis
- Areflexia
- Arrhythmias
- Respiratory distress

ECG changes: ECG changes progress with increasing serum K^+ levels-peaked T waves, loss of P waves with widening QRS, ST segment depression with further widening of QRS, bradycardia, AV block, ventricular arrhythmias, torsades de pointes, cardiac arrest.

Etiologies	
Increased intake	IV or PO medications Exogenous K^+ intake (salt substitutes) Transfusions with aged blood
Transcellular shift	Acidosis Rhabdomyolysis Tumor lysis syndrome Large hematomas Succinylcholine Exercise Insulin deficiency Malignant hyperthermia Hyperkalemic periodic paralysis Crush injuries, trauma, burns.
Decreased renal excretion	Renal failure Congenital adrenal hyperplasia K^+-sparing diuretics Renal tubular diseases Urinary tract obstruction Aldosterone insensitivity Aldosterone deficiency Lupus nephritis Medications
Spurious	Hemolysis Thrombocytosis Leukocytosis Tight tourniquet during lab draw

Emergent Management for Hyperkalemia

- Obtain ECG.
- Continuous cardiac monitoring.
- Obtain repeat specimen; do not delay treatment waiting on repeat lab results!
- Stop all K^+ infusions or medications.
- If ECG changes are present:
  - IV administration of 10–20 mg/kg (max 500 mg) calcium chloride or 100 mg/kg/dose (max dose 3 g/dose) calcium gluconate over 5 min to stabilize cardiac membrane.

- **Patient must remain on cardiac monitor and infusion stopped if HR <60 bradycardia can be fatal.**
- Shift K^+ intracellularly:

Give IV sodium bicarbonate 1–2 mEq/kg over 5–10 min.
Give 5 mg nebulized albuterol.
Give IV insulin + glucose infusion (must give glucose with insulin therapy to prevent hypoglycemia).

- Initiate dialysis if renal failure.
- Kayexalate 1 g/kg PO or PR to bind K^+ (does not work immediately).
- Give mineralocorticoids if deficiency is suspected.
- Correct any co-existing magnesium deficiency.

Hypocalcemia (Ca^{++} <7 mg/dL in Preterm Infant, <8 mg/dL in Term Infant, or <9 mg/dL in Children)

Signs/Symptoms

- Muscular irritability
- Weakness
- Tetany
- Paresthesias
- Fatigue
- Muscle cramps
- Altered mental status
- Seizures
- Laryngospasm
- Cardiac arrhythmias
- Prolonged QT interval
- Trousseau sign (carpopedal spasm after arterial occlusion)
- Chvostek sign (perioral twitch with stimulus of the facial nerve)

Etiologies

Early Neonatal (1–3 days)	Late Neonatal (3 days–6 weeks)	Infants/Children
• Prematurity	• Hypoparathyroidism	• Hypoparathyroidsim
• Poor intake/delayed feeds	• Maternal hypercalcemia	• Autoimmune disease
• Increased calcitonin	• DiGeorge Syndrome	• Vitamin D deficiency
• Hypoxic encephalopathy	• Velo-cardio-facial Syndrome	• Wilson's disease
• Neonatal asphyxia	• Cow's milk tetany (high phosphate load with cow's milk)	• Hyperphospatemia from improper forumla mixing
• Intrauterin growth restriction	• Chronic diarrhea	• Excessive use of phosphorus containing enemas
• Exchange transfusion (citrate load)	• Malabsorption	• Total parental nutrition (TPN)
• Infant of a diabetic mother	• Alkaline treatements	• Blood transfusion
• Hypomagnesemia	• Hypomagnesemia	• Chelation therapy
• Hypoalbunemia	• Severe infantile osteopetrosis	• Acute severe illness
• Maternal hyperparathyroidism	• Renal disease	• Malabsorption
• Dietary phosphate loading		• Pancreatitis
		• Respiratory or metabolic alkalosis
		• Renal disease/renal failure
		• Hypomagnesemia
		• Medications

Emergent Management for Hypocalcemia

- Obtain ECG (causes arrhythmias/prolonged QT).
- Obtain total and ionized Ca^{++} levels, phosphate level, alkaline phosphatase, magnesium level, total protein, complete metabolic profile, 25-OH vitamin D, parathyroid hormone (PTH) level, albumin, ABG (acidosis increased ionized calcium), chest X-ray to visualize the thymus, ankle and wrist X-rays to assess for rickets, and urine studies for calcium, phosphate, and creatinine.
- Correct hypomagnesemia first if present (if mg^{++} <1.5 mg/dL) before calcium infusion.
- Stop any medication or infusions that may bind calcium (blood transfusions, TPN).
- Treatment for severe tetany, seizures, or cardiac arrhythmias:
  - 10% IV calcium gluconate 100 mg/kg given slowly over 10 min.
  - ***Patient must remain on cardiac monitor and infusion stopped if HR <60 (bradycardia can be fatal)***.
  - Never mix calcium with fluids containing phosphate or bicarbonate.
- If patient is stable, replacement therapy can be oral.
- Address and treat any underlying causes.

Hypercalcemia (Ca^{++} >11 mg/dL)

Signs/Symptoms

- Muscular irritability
- Weakness
- Lethargy
- Altered mental status/coma
- Seizures
- Abdominal cramping
- Cardiac arrhythmias
- Shortened QT interval

- Polyuria
- Polydipsia
- Pancreatitis
- Renal calculi
- Nausea, vomiting, anorexia

Etiologies
Hyperparathyroidism
Vitamin D intoxication
Excessive exogenous calcium administration
Malignancies
Prolonged immobilization
Thiazide diuretics
Granulomatous diseases (such as sarcoidosis)
Hyperthyroidism
Williams syndrome
Milk-alkali syndrome

Emergent Management for Hypercalcemia

- Obtain ECG (causes arrhythmias/shortened QT).
- Obtain total and ionized Ca^{++} levels; phosphate level; alkaline phosphatase; total protein; complete metabolic profile; 25-OH vitamin D; parathyroid hormone (PTH) level; albumin; urine studies for calcium, phosphate, and creatinine; abdominal X-ray; or renal ultrasound to assess for renal calculi.
- Address and treat any underlying causes.
- Hydration to increase urine output and Ca^{++} elimination, may give NS boluses for rapid hydration.
- Furosemide for diuresis.
- Severe or refractory hypercalcemia may require dialysis.

Hypoglycemia (Glucose <50 mg/dL)

Signs/Symptoms

- Diaphoresis
- Tachycardia
- Pallor
- Trembling/jitteriness
- Headache
- Confusion
- Altered mental status
- Lethargy
- Apnea
- Nausea, vomiting
- Difficulty speaking
- Weakness
- Seizures
- Ataxia
- Vision changes
- Poor feeding

Etiologies	
Glucose use increased	Hyperinsulinism – Insulin-producing tumor, ingestion of oral hypoglycemic agent, insulin therapy or overdose Large tumors (e.g., Wilms', neuroblastoma) Hyperthermia Growth hormone deficiency Polycythemia Infant of diabetic mothers
Glucose availability decreased	Decreased oral intake Fasting Malnutrition Diarrhea Vomiting Inborn errors of metabolism Inability to mobilize glucose Ineffective gluconeogenesis Inadequate glycogen reserve Ineffective glycogenolysis

(continued)

Etiologies	
Availability of alternative fuel decreased	Low/absent fat stores Enzyme deficiency in fatty acid oxidation
Others	Sepsis Shock Cardiogenic shock Burns Reye's syndrome Medications Salicylate ingestion Alcohol ingestion Other ingestions (esp. cardiac meds) Adrenal insufficiency Hypothyroidism Panhypopituitarism Hepatitis/liver failure

Emergent Management for Hypoglycemia

- *Immediate treatment of hypoglycemia – Rule of 50 (dextrose fluid x mL/kg = 50):*
  - *D50 = 1 mL/kg fluid bolus.*
  - *D25 = 2 mL/kg fluid bolus.*
  - *D10 = 5 mL/kg fluid bolus.*
  - *D5 = 10 mL/kg fluid bolus.*
- Once initial hypoglycemia has been corrected, begin infusion with D10-containing fluids at 1.5–2 X MIVF rate.
- Administer stress dose of glucocorticoid (2 mg/kg of hydrocortisone).
- Laboratory studies: CBC, blood culture, complete metabolic panel, ammonia, glucagon, c-peptide, lactate, pyruvate, carnitine level, ABG, acylcarnitine profile, cortisol level, growth hormone, plasma amino acids, urine organic acids, urinalysis, urine culture.

- Do not delay therapy with dextrose in order to obtain labs – Give glucose immediately!
- Inborn errors of metabolism/genetic disorders and ingestion should be high on your differential diagnosis in infants or children presenting with hypoglycemia.

Chapter 18
Pediatric Toxicology

Judith K. Lucas

Abstract One pill can kill in a pediatric ingestion. You must know the antidote and be able to identify a corresponding toxidrome to stabilize and manage a potentially lethal condition. This chapter leads you through the most common ingestions and antidotes in an easy-to-read table format. The commonly used acronyms are a "Quick Hit" that most providers struggle to remember. The button battery ingestion algorithm is extremely high yield and an excellent reference for management versus emergent transfer.

J. K. Lucas
Department of Emergency Medicine, Division of Pediatric Emergency Medicine, University of Florida Health-Shands Hospital, Gainesville, FL, USA
e-mail: judithklucas@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_18

Management of All Pediatric Poisonings Should Include Consultation with the Poison Control Center. Call 1-800-222-1222 (Nationwide)

Children <6 Years Old Make Up 48.6% of All Human Exposures

Top 10 *exposures* in children <6 years of age	**Top 10 *fatalities* in children <6 years of age**
Cosmetics	Fumes, gasses, vapors
Cleaning substances (household)	Analgesics (methadone, hydromorphone)
Analgesics	Household cleaners
Foreign bodies/toys/ miscellaneous	Alcohols
Topical preparations	Antihistamines
Vitamins	Cardiovascular medications
Antihistamines	Cosmetics/personal care products
Pesticides	Sedative/hypnotics
Gastrointestinal preparations	Miscellaneous
Plants	Button batteries

Toxidromes

Toxidrome	HR	RR	Sys BP	Temp	Mental status	Pupils	GI[a]	Skin
Sympathomimetic	↑	↑	↑	↑	Agitated	Dilated	↑	Diaphoretic
Anticholinergic	↑	↑	↑	↑	Agitated Seizures Impaired	Dilated	↓	Dry
Cholinergic	±	± *(bronchorrhea)*	±	–	Agitated Impaired	±	↑	Diaphoretic
Opioid	↓	↓	↓	↓	Impaired	Pinpoint	↓	–

[a]GI: Upward arrow indicates increased peristalsis, with associated increased bowel sounds; downward arrow indicates decreased peristalsis, to point of ileus, with associated decreased or absent bowel sounds

Small Doses, Big Problems

Several medications in small doses or single pill are toxic, or even lethal, in children.

***Suspected ingestion of any of these substances should include observation up to 24 h, even in asymptomatic pediatric population.

Drug	Toxicity	Management
Benzocaine/prilocaine (over the counter)	Local anesthetic (teething gels, EMLA) Ingestion, mucosal or dermal absorption Onset 30–60 min, up to 6 h Methemoglobinemia: Symptoms dependent on methemoglobin concentration Cyanosis without signs of symptoms (levels <30%) cardiovascular compromise as methemoglobin levels rise	*Antidote:* Methylene blue 1–2 mg/kg, with repeat dosing Q 1 h (max of 7 mg/kg)
Camphor (over the counter)	Found in topical ointments Symptom onset: 10–20 min post ingestion Neurotoxic-excitatory, Seizures with subsequent progression to coma and respiratory depression	A, B, Cs Decontaminate the skin Seizures – give benzodiazepines/ barbiturates

Drug	Toxicity	Management
Calcium channel blockers	***Bradycardia, hypotension, hyperglycemia – think of calcium channel blockers!* Worse with phenylalkylamines (verapamil) Cardiovascular disturbance Hypotension and bradycardia Second- and third-degree block Cardiogenic shock secondary to extreme negative inotropy Decreased mental status, seizures Hyperglycemia	A, B, Cs Volume Inotropes Ability to perform transcutaneous pacing *Consider* activated charcoal (1 g/kg, up to 50 g) if within 1 h and airway protected *Antidotes:* Glucagon, 50 mcg/kg initial bolus, double subsequent doses if no effect (max dose is 10 mg) Calcium chloride, 10 to 25 mg/kg of 10% CaCl IV q 10 to 20 min (max 1 g) Glucose + insulin
Clonidine (and the imidazolines)	Includes VISINE^{R} (tetrahydrozoline), Clear Eyes^{R} (naphazoline) (*over the counter*) Includes the clonidine patch, as well as oral formulations Opioid toxidrome: Bradycardia Respiratory depression Symptoms may be prolonged and recurrent for up to 24 h	A, B, Cs Volume Atropine, 0.02 mg/kg, Q 20 min for symptomatic bradycardia *Antidote:* Narcan, 0.1 mg/kg IV/ETT/SC/IN/IM/IO, given every 2 min up to a max or 2 mg *may* be helpful; higher doses than usual may be required

(continued)

Drug	Toxicity	Management
Cyclic antidepressants	All potent inhibitors of norepinephrine uptake; many inhibit serotonin uptake as well Classic EKG finding: QRS interval prolongation Tachydysrhythmias – V-tach Torsades Seizures Anticholinergic toxidrome	A, B, Cs Ability to perform transcutaneous pacing *Consider* activated charcoal (1 g/kg, up to 50 g) if presents within first hour, there are bowel sounds, and the airway is secure Benzodiazepines/ barbiturates for seizures *Antidote:* Sodium bicarbonate Initial bolus: 1–2 mEq/kg for QRS >100 ms Sodium bicarbonate infusion: goal to achieve a serum pH of 7.5

Drug	Toxicity	Management
Diphenoxylate hydrochloride/atropine sulfate	(Lomotil^{R}) – unique opiate/anticholinergic combination *No correlation between the dose ingested and the severity of toxicity* Symptoms may present in the first hour *or* be delayed by >12 h Toxicity may have components of both anticholinergic toxidrome and opioid toxidrome Symptoms may persist for up to 30 h, with *recurrence of respiratory and CNS depression*	A, B, Cs Volume Respiratory and ventilator support *Antidote:* Naloxone, 0.1 mg/kg IV/ETT/SC/IN/IM/IO, given every 2 min up to a max or 2 mg *may* be helpful; higher doses than usual may be required

(continued)

Drug	Toxicity	Management
Methyl salicylate (*over the counter*)	Severe, rapid-onset salicylate toxicity due to its high concentration; found in arthritis rubs and oil of wintergreen 1 ml oil of wintergreen = 1.4 g aspirin (5 ml = 7 g!) As little as 4 ml in a child can be fatal Symptom onset rapid, usually within 2 h post ingestion GI: nausea, vomiting, and abdominal pain, hematemesis Tinnitus Acid-base disturbances Hypoglycemia Hyperthermia Seizures, coma	Immediate ASA level (unlike with acetaminophen) Serial charcoal doses Alkalinization of the urine (goal of urine pH 7.5) with the use of bicarbonate infusion Hemodialysis for: Levels > 100 mg/dl Seizures Refractive metabolic derangements Severe electrolyte disturbances

Drug	Toxicity	Management
Sulfonylureas	Hypoglycemia, profound and persistent, depending on the formulation (sustained release) A single tablet of any of the sulfonylureas can result in significant toxicity Management Labs – even without symptoms, check glucose hourly Dextrose Volume: Do *not* use dextrose-containing fluids *unless* patient becomes hypoglycemic, due to masking onset of symptoms Hypoglycemia: 4 ml/kg D10 via peripheral IV (D25 too caustic for most peripheral lines) Dextrose-containing solutions, from D5 to D20 to keep serum glucose >100	*Antidote:* Octreotide (inhibits pancreatic insulin secretion) *compliments* dextrose infusion Dose: 4–5 mcg/kg SQ *divided* every 6 h until can maintain blood glucose without IV dextrose (max dose 50 mcg)

Antidotes

Indication	Antidote	*Initial* dose (peds dosing)
Acetaminophen	N-acetylcysteine	150 mg/kg IV over 1 h, then 50 mg/kg IV × 1 over 4 h, then 100 mg/kg IV × 1 over 16 h; requires special dilution in peds

(continued)

Indication	Antidote	*Initial* dose (peds dosing)
Iron	Deferoxamine	Start IV infusion at 5 mg/kg/h; titrate up to 15 mg/kg/h, up to total of 6–8 g/day
Digoxin	Dig-specific antibody	# vials IV = [dig level (ng/ml) × wt (kg)]/100
Methanol/ethylene glycol	Fomepizole	15 mg/kg, diluted in 100 ml over 30 min
Beta-blockers/Ca++ channel blockers	Glucagon	50 mcg/kg given over 1–2 min (max dose 10 mg)
Methemoglobinemia	Methylene blue	0.1–0.2 ml/kg IV over 5 min (max dose 7 mg/kg)
Opioid, clonidine, Lomotil	Naloxone	0.1 mg/kg
Sulfonylureas	Octreotide	1.25 mcg/kg SQ (max dose 50 mcg)
Carbamates/organophosphates	Atropine (carbamates only); pralidoxime + atropine (organophosphates)	Atropine: 20 mcg/kg Pralidoxime: 30 mg/kg infused over 15–30 min (pralidoxime) (max dose 2 g)
Isoniazid	Pyridoxine	70 mg/kg (max dose 5 g)

Toxicology Acronyms

ACRONYMS

Causes of elevated anion gap: MUDPILES

M	Methanol, metformin
U	Uremia
D	Diabetic ketoacidosis
P	Paraldehyde, phenformin, phenothiazines
I	INH, iron
L	Lactic acidosis
E	Ethylene glycol, ETOH
S	Salicylates

Symptoms of cholinergic crisis: SLUDGE

S	Salivation
L	Lacrimation
U	Urination
D	Diaphoresis
G	Gastric distress (vomiting, diarrhea, cramping, abdominal pain)
E	Edema (bronchorrhea)

Causes of bradycardia: PACED

P	Propranolol
A	Anticholinesterase intoxicants (organophosphates), antiarrhythmics (Ca++ channel blockers and beta blockers)
C	Clonidine
E	Ethanol/other alcohols
D	Digoxin

Radiopaque: COINS

C	Chloral hydrate, cocaine packets, calcium
O	Opium packets
I	Iron and other heavy metals (lead, arsenic, mercury
N	Neuroleptic agents
S	Sustained release or enteric coated tablets (tendency to form bezoars)

Dialyzable Toxins: I STUMBLE

I	Isopropyl
S	Salicylates
T	Theophylline
U	Uremia
M	Methanol
B	Barbituates
L	Lithium
E	Ethylene glycol, ETOH

Activated Charcoal

Activated charcoal has not been proven to change the clinical outcome of ingested poisonings, but can decrease serum drug levels if given within 1 hour of ingestion.

Single dose

- Give within 1st hour of ingestion
- 1 g/kg
- Max 50 g/dose

Multiple dose

- Massive ingestions of toxicants known to be absorbed by activated charcoal
- Suspected bezoar formation
- Enteric coated or prolonged release formulation
- Aspirin
- Phenobarbital
- Theophylline

Activated charcoal does NOT BIND:

- Corrosives (strong acids or bases)
- Lithium
- Arsenic
- Alcohols
- Inorganic minerals (sodium, iodine, fluorine)
- Iron
- Lead
- Cyanide

Ingestions with Delayed Presentation

- Acetaminophen – without symptoms for first 6–24 h (except in massive OD)
- Iron – initial symptoms of GI distress (due to localized toxic effects on GI tract) abate, and the second stage is "latent" or relatively asymptomatic
- Mushrooms:
  - *Amanita phalloides* (deadly nightshade) – 24 h (hepatic)
  - *Cortinarius* species – 24 h (renal)

Useful Formulas

Anion gap (nl <15): $Na^+ – (Cl^- + HCO_3^-)$

Osmolar gap (nl <10): measured serum osm – calculated osm

Calculated osm: (2 × Na) + (glucose/18) + (BUN/2.8)

Button Battery Ingestion

- The three Ns (the negative battery pole, identified by the narrowest side on the lateral X-ray, causes severe, necrotic injury):
  - Negative
  - Narrow
  - Necrotic
- 20 mm lithium cell battery is the most common cause of esophageal injuries.
- Hearing aid batteries are <12 mm.
- *Any* button battery can cause severe, life-threatening injury.
- Do not induce vomiting or give cathartics.
- Must perform X-rays of the neck, chest, and abdomen so that batteries are not missed.
- Must obtain AP and lateral X-rays to determine orientation of the negative pole.
- If button battery ingestion is suspected and no battery is seen on X-ray, check the ears and nose.

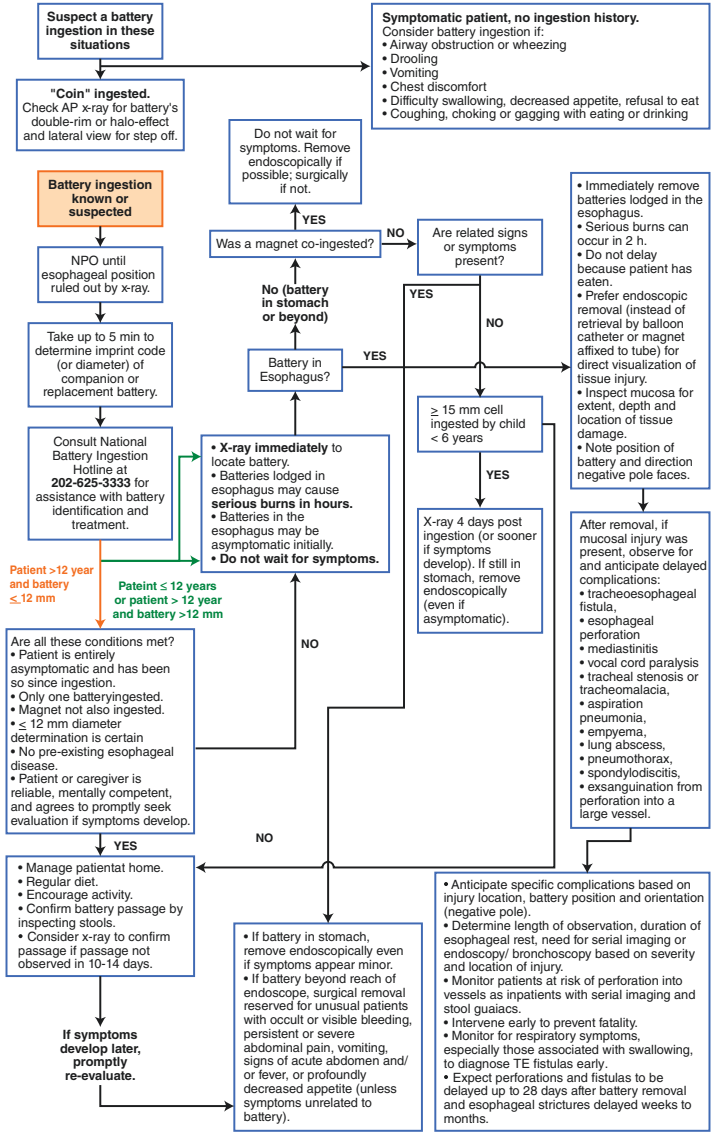


FIGURE 18.1 Button battery ingestion algorithm

Chapter 19
Pediatric Pain

Cristina M. Zeretzke-Bien

Abstract The inappropriate dosing and poor recognition of pain in the pediatric patient are a common pitfall for ED providers. This chapter focuses on both pharmaceutical and distraction/integrative therapy to help you achieve appropriate analgesia before performing that next laceration repair or lumbar puncture.

Pediatric Pain

- Pain is one of the top reasons patients present to the emergency department!
- Pain is a *unique* experience to each patient.
- It is varied and is a different experience based on developmental age, prior experience, culture, gender, ethnicity, as well as patient expectations.

C. M. Zeretzke-Bien
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: Zeretzke@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_19

- It is important to address a *patient's pain* as it relates to the developmental age; if pain and anxiety can be managed, the provider and patient will have a much better outcome.
- A pain memory starts as early as 6 months!

Avoid Medication Errors

- Include generic drug name, dose (stated as mg/kg = total dose mg) frequency, rate, and route.
- Spell out micrograms to avoid transcription error.
- Spell out morphine to avoid medication error when writing "ms."
- Avoid decimal errors: write "1" not "1.0" which can cause tenfold dosing errors.

WHO Principles of Pain Management

- Apply the WHO pain ladder: DO NOT undermedicate. Advance to opioids if pain control is suboptimal.
- Use around-the-clock pain medications if predictable PLUS additional pain medications for BREAKTHROUGH pain doses.
- Use the simplest and least invasive when possible (oral vs. intranasal vs. IV).
- Assess the pain regularly and change the plan accordingly.
- Use combinations of non-opioids and an opioid to enhance pain control.
- Always integrate NON-DRUG strategies in combination with medications to enhance pain control.

Infant FLACC Scale

Scoring

Category	0	1	2
Face	No particular expression or smile	Occasional Grimace or frown, withdrawn, disinterested	Frequent to constant quivering chin, clenched jaw
Legs	Normal position or relaxed	Uneasy, restless, tense	Kicking or legs Drawn up
Activity	Lying quietly, normal position or relaxed	Squirming, shifting back and forth, tense	Arched, Rigid, or Jerking
Cry	No cry (awake or asleep)	Moans or whimpers, Occasional complaint	Crying steadily, Screams, or sobs, frequent complaints
Consolability	Content, relaxed	Reassured by occasional touching, hugging, or being talked to, distracted	Difficult to console or comfort

Each of these 5 categories (F) face, (L) legs, (A) activity, (C) cry, (C) consolability is scored from 0–2, which results in a total score of 0–10.

Numeric Scale

FIGURE 19.1 Wong-Baker Faces Pain Scale

Use 0 (no pain) to 10 (worst pain you can imagine) scale for children older than 7 years of age.

Topical Local Anesthetics

Should always be offered!

- LMX (LMX 4% topical anesthetic cream contains 4% lidocaine and can be used to relieve pain) (at least 30 min).
- EMLA (a mixture of lidocaine 2.5% and prilocaine 2.5%) is indicated as a topical anesthetic for use on normal intact skin for local analgesia (60 min).
- J-tip (needleless lidocaine injector) consider with all IV starts.

Non-pharmaceutical Methods

Distraction and Integrative Therapies

Types of Distraction

1. Passive distraction: attention is redirected to a stimulus or an object.
   - Showing a toy, storytelling, singing songs, or playing with pinwheels
2. Active distraction: encourage participation in activities during procedures.
   - Blowing bubbles, playing a game, or interacting with an electronic device

Other Integrative Therapies

- Relaxation techniques (diaphragmatic breathing)
- Guided imagery
- Music therapy
- Ice pack or warm pack
- Hypnosis
- Tablet/smartphone

Sucrose (0–12 Months)

- Reduces cry and pain during painful procedures, such as venipuncture.
- Effective dose (24%) 0.05–0.5 ml (=0.012–0.12 g).
- Administer 2 min prior to mild/moderately painful procedures.
- Duration is approximately 4 min.

Pharmacological Treatment of Pain

Non-opioids Commonly Used for Mild to Moderate Pain

Drug	Route	Pediatric Dose	Maximal Dose	Dosing Interval
Ibuprofen	PO	5–10 mg/kg	400–600 mg	6–8 hours
Acetaminophen	PO, PR	10–15 mg/kg	60/mg/kg/day <2 years 90 mg/kg/day >2 years	4–6 hours
Acetaminophen	IV	<10 kg= 7.5 mg/kg 1-2yrs=15mg/kg >2yrs(<50kg)=15 mg/kg >13yrs(>50kg)=1000mg	30 mg/kg/day 60 mg/kg/day 75 mg/kg/day 4000mg/day	6 hours 6 hours 6 hours 6 hours
Ketorolac (Toradol)	IV	<2 years= 0.25 mg/kg >2 years= 0.5 mg/kg	30 mg	6–8 hours

Opioid Analgesics Used for Moderate to Severe Pain

Drugs	Dose	Dosing Interval
Oxycodone (1mg/1mL) (PO)	0.05–0.15 mg/kg/dose PO (up to 5 mg/dose)	4–6 hours
Fentanyl (intranasal)	1.5–2 mcg/kg nasal	1–2 hours
Tramadol (PO)	1–2 mg/kg PO (max=100 mg)	4–6 hours
Morphine (PO, SL, PR)	0.15–0.3 mg/kg (max=10–15mg)	2–4 hours

Opioid Analgesics Used for Moderate to Severe Pain (IV Form)

Drug	Route	Initial Pediatric Dose	Initial Adult Dose	Dosing Interval
Fentanyl	IV bolus IV continuous infusion	1–2 mcg/kg 1 mcg/kg/hr	25–75 mcg 50 mcg/hr	10 min–1 hr
Hydromorphone (Dilaudid)	IV bolus IV continuous infusion	15 mcg/kg 2–5 mcg/kg/hr	200–600 mcg 100–250 mcg/hr	2–4 hours
Morphine	IV bolus	0.05–0.1mg/kg	5–10 mg	2–4 hours

Opioid Antagonist

Drug	Route	Initial Pediatric Dose	Clinical Indication	Dosing interval
Naloxone	IV/SC	1–5 mcg/kg 10 mcg/kg	Reverse opioid induced depressed respiratory rate Reverse opioid induced apnea and coma	2–3 min

Sedation: Consider sedation when analgesia not feasible, minimal or moderate/deep sedation.

Procedural anxiety: Midazolam (Versed) (5 mg/ml), 0.3–0.4 mg/kg. Max dose, 10 mg or 1 ml per nostril (total 2 ml) (use with atomizer if possible); divide each dose between each nostril.

Quick Hits Painful Procedure Pearls

- Consider child life if available OR use parent/caregiver as "comfort coach."
- Comfort positioning: will increase sense of support and decrease resistance to the procedure.
- When feasible offer a parent's lap. Do not lay child supine unless necessary.

- Consider topical medications prior to procedure (with oral pain meds).
- Use a tiny needle (25 gauge) – Draw up medications with a separate needle (out of sight of child).
- Inject with the smallest needle. Slow and steady injection.
- At the time of injection, rub or stroke the skin near the injection site.
- Buffer lidocaine prior to injection.

Adapted from PAMI (Pain Assessment and Management Initiative) available at http://pami.emergency.med.jax.ufl.edu and from Pediatric Acute Pain Management Reference Card, Children's Hospitals and Clinic of Minnesota

Chapter 20
Pediatric Antibiotic Guide

Tricia B. Swan

Abstract This is a must-have guide to antibiotic therapy with both disease-specific suggested treatment and a quick guide to common pediatric antibiotics and their dosages. Truly a "Quick Hit" for antibiotics keeps you efficient while keeping your patient safe. The chapter even concludes with a table illustrating the bacterial coverage of the most commonly used antibiotics to ensure adequate antibacterial coverage as indicated.

T. B. Swan
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: tfalgiani@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_20

Antibiotic Therapies

Infection	Common Etiologies	Suggested Therapy	Special Considerations and Length of Treatment
Bites			
Human	*Streptococcus spp., Staphylococcus spp., Eikenella corrodens,* oral anaerobes, *Haemophilus spp.*	**PO:** amoxicillin/clavulanate Alt: clindamycin + (TMP/SMX or 3rd generation cephalosporin **IV:** ampicillin/sulbactam Alt: TMP/SMX + clindamycin	Treatment for 5-7 days Ensure cleaning, copious irrigation and debridement of wound Do not suture puncture wounds Assess Hep B and tetanus immunization status Evaluate HIV risk
Dog/Cat	*Streptococcus spp., Staphylococcus spp., Pasteurella multocida,* oral anaerobes	Same as above	Treatment for 7–10 days Ensure cleaning, copious irrigation and debridement of wound Do not suture puncture wounds Assess tetanus immunization status Assess rabies risk and provide rabies immunoglobulin (RIG) + rabies vaccine if indicated
Cellulitis/Skin Abscess	*S. aureus* (MSSA or MRSA), Group A *Streptococcus*	**PO:** Cephalexin or clindamycin if MRSA suspected **IV:** oxacillin; clindamycin or vancomycin if MRSA suspected TMP/SMX is not active against Group A *streptococcus*	Treatment for 5–7 days Incision and drainage should be performed if abscess is present Hospitalize for severe infections, immunocompromised state or limb threatening infections
Conjunctivitis (non-neonatal)	*S. Pnueumoniae, H. Influenza, Moraxella,* viral	Erythromycin ophthalmic ointment, bacitracin/polymyxin B or polymyxin B/TMP drops Levofloxacin solution for contact lens wearers	Treatment for 5 days Most conjunctivitis is viral but CDC recommends topical antibiotic treatment when purulent exudate is present

Conjunctivitis (neonatal)	*N. gonorrhoeae*	Ceftriaxone or cefotaxime	Onset 2–4 days of age Single dose IV/IM Admit for evaluation and treatment of possible disseminated disease (consider full septic work-up)
	C. Trachomatis	Azithromycin for 5 days or erythromycin for 14 days	Onset 3–10 days of age
Dacrocystitis	*S. pneumoniae, H. influenzae, S. aureus, S. pyogenes, Pseudomonas aeruginosa*	oxacillin or cephalexin	Treatment for 7–10 days Warm compresses
Dental abscess	Oral floral, anaerobes	Amoxicillin/ clavulanate or clindamycin	10 days Refer for dental evaluation and surgical drainage
Intra-abdominal Infection	*E. coli, Enterococcus, Bacteroides* spp., *Clostridium*spp., *P. aeruginosa, S. aureus,* other gram negative bacilli	Piperacillin-tazobactam, ticarcillin-clavulanate **Or** (Ceftriaxone or cefepime) plus metronidazole	Treatment 5–7 days Consider MRSA coverage in patients concerning for health care-associated infections
Lymphadenitis	Viruses, Group A *Strep., S. aureus, Actinomyces,* anaerobes, atypical mycobacteria, *Mycobacterium tuberculosis, Bartonella henselae* (cat scratch disease)	**PO:** Amoxicillin/clavulanate; clindamycin if MRSA suspected Azithromycin for cat scratch Alt: dicloxacillin or cephalexin **IV:** Oxacillin or cefazolin; clindamycin if MRSA suspected	Treatment for 10 days If PCN allergic may use cefdinir, cefuroxime or vancomycin
Mastoiditis	*S. pneumoniae, H. influenzae, S. aureus, S. pyogenes*	**PO:** Amoxicillin/clavulanate or third generation cephalosporin **IV:** Clindamycin or vancomycin plus (ceftriaxone or ampicillin/sulbactam or piperacillin/tazobactam	Patients with mild mastoiditis may be treated as outpatient with oral antibiotics Treatment up to 4 weeks May require surgical drainage
Meningitis (neonatal)	Group B streptococcus (GBS), *E. coli, Listeria monocytogenes*	**IV:** Ampicillin plus (cefotaxime or gentamicin)	Treatment for 14 days for GBS, 21 days for *Listeria* Gentamicin is less preferred due to poor CSF penetration

Meningitis (> 1 mo of age)	*S. pneumoniae, H. influenzae, N. meningitidis, E. coli*	**IV:** Ceftriaxone plus vancomycin	Duration of treatment depends on organism
Orbital Cellulitis (septal)	*S. pneumoniae, S. aureus, H. influenzae, M. catarrhalis,* Group A streptococcus, anaerobes	**IV:** Vancomycin or clindamycin plus (ampicillin/sulbactam or ceftriaxone or cefotaxime)	Treatment for 10 days Needs ophthalmology consult CT head to evaluate for intracranial extension
Osteomyelitis	*S. aureus, Streptococcus spp.,* Group A streptococcus, *Kingella kingae*(<4 years of age) Foot puncture: *P. aeruginosa* Sickle cell disease: *Salmonella spp.*	Oxacillin, nafcillin or clindamycin Alt: TMP-SMX **Foot puncture**: add ceftazidime or antipseudomonal penicillin **Sickle cell disease**: add ceftriaxone	Treatment for 4–6 weeks Clindamycin monotherapy not effective for *Kingella*
Otitis Media	*S. pneumoniae, S. aureus, H. influenzae, M. catarrhalis, S. aureus, S. pyogenes,* viral	High-dose amoxicillin If patient has been treated in the past 30 days with amoxicillin or has associated purulent conjunctivitis then amoxicillin/clavulanate should be used Alt: cefdinir, cefpodoxime, ceftriaxone **Treatment failure**: amoxicillin/clavulanate or ceftriaxone Alt for treatment failure: clindamycin + 3rd generation cephalosporin	Treatment for 10 days For treatment failure consider specialist consultation and tympanocentesis Clindamycin does not cover *H. influenzae or M. catarrhalis* Definition of treatment failure: Fever, bulging TM, no change in ear pain or otorrhea after 3 days of treatment
Otitis Externa	*Staphlococcus* spp., *P. aeruginosa, Bacteroides* spp.,	Otic solution: ciprofloxacin, ciprofloxacin/dexamethasone, ofloxacin or polymyxin B/neomycin/hydrocortisone	Treatment for 7–10 days Consider cerumen removal to expedite resolution

Parotitis	*S. aureus* most common, oral flora, gram negative rods, viral (mumps, HIV, EBV) and non-infectious causes	**PO:** Clindamycin or amoxicillin/clavulanate **IV:** Nafcillin/oxacillin, clindamycin, cefazolin	Treatment for 10–14 days Establish duct patency with warm compresses, sialogogues, gentle massage of gland and hydration Surgical drainage may be required
Periorbital Cellulitis (preseptal)	*S. pneumoniae, S. aureus, H. influenzae, M. catarrhalis*, Group A streptococcus, anaerobes	**PO:** amoxicillin/clavulanate or 3rd generation cephalosporin **IV:** ampicillin/sulbactam If concerned for MRSA add TMP/SMX, clindamycin or vancomycin	Treatment 10–14 days CT scan of orbits helps to differentiate from orbital cellulitis Indications for CT: proptosis, ophthalmoplegia, change in visual acuity, bilateral periorbital edema, inability to assess vision secondary to edema, no improvement after 24 hours of outpatient therapy
Pertussis	*Bordetella pertussis*	Azithromycin or erythromycin Use azithromycin in children < 1 mo of age	Treatment for 5 days with azithromycin or 10 days with erythromycin Chemoprophylaxis for close contacts
Pharyngitis	Group A, C and G streptococci, *Arcanobacterium haemolyticum*, Viral (EBV, coxsackievirus, others)	**PO:** PCN V or amoxicillin **IM:** Benzathine PCN G x 1 Alt: clindamycin, cephalexin or macrolide	Treatment must be full 10 days to prevent acute rheumatic fever in GAS infections Supportive treatment for viral pharyngitis
Pneumonia			
Age < 5 years	*S. pneumoniae, H. influenzae, Mycoplasma*, Group A streptococcus, *C. pneumoniae, S. aureus*, Viral, influenza	**PO:** high-dose amoxicillin +/- azithromycin (atypical coverage) Alt: clindamycin, amoxicillin/clavulanate, cefdinir **IV:** ampicillin +/- azithromycin Alt: ceftriaxone +/- azithromycin Add vancomycin or clindamycin if severe illness or features	Treatment for 10 days Atypical organisms (*Mycoplasma, Chlamydia*) are more common in children > 5 years old

		suggestive of *S. aureus* (cavitation, pleural effusion)	
Age > 5 years and immunized	*S. pneumoniae, Mycoplasma,* Group A streptococcus, *C. pneumoniae, S. aureus,* Viral, influenza	**PO:** high-dose amoxicillin + azithromycin (atypical coverage) Alt: clindamycin + azithromycin **IV:** ampicillin + azithromycin Alt: ceftriaxone or cefotaxime + azithromycin Add vancomycin or clindamycin if severe illness or features suggestive of *S. aureus* (cavitation, pleural effusion)	Treatment for 7–10 days
Age > 5 years and unimmunized for *H. influenzae or S. pneumoniae*	*S. pneumoniae, Mycoplasma,* Group A streptococcus, *C. pneumoniae, S. aureus,* Viral, influenza	Ceftriaxone or cefotaxime +/- azithromycin Add vancomycin or clindamycin if severe illness or features suggestive of *S. aureus* (cavitation, pleural effusion)	Treatment for 10 days
Septic Arthritis			
	S. aureus, Group A streptococcus, *S. pneumoniae, Kingella kingae*	Clindamycin or vancomycin plus (ceftriaxone or cefotaxime) Add amoxicillin for *Kingella*	Treatment for 3 weeks (IV) Aspiration of affected joint recommended Joint aspirate > 50,000 WBC with PMN predominance is associated with septic arthritis (although 33% will have less)
Age > 5 years	*S. aureus,* Group A streptococcus, *Streptococcus* spp.	Clindamycin or vancomycin plus (ceftriaxone or cefotaxime)	Treatment for 3 weeks (IV) Aspiration of affected joint recommended Joint aspirate > 50,000 WBC with PMN predominance is associated with septic arthritis (although 33% will have less)

Adolescent	Add *N. gonorrhoeae*	Add ceftriaxone	Treatment for 3 weeks (IV) Aspiration of affected joint recommended Consider gonococcal infection in polyarticular arthritis All patients with suspected gonococcal infection should also be treated with doxycycline or azithromycin to cover possible concurrent *C. trachomatis* infection
Sinusitis			
Acute	*S. pneumoniae, S.aureus, H. influenzae, M. catarrhalis,*	Amoxicillin/clavulanate Alt: cefixime or cefpodoxime If PCN allergy: levofloxacin	For acute uncomplicated bacterial sinusitis and reliable follow up consider watchful waiting and defer antibiotic therapy and treat with intra-nasal saline rinses and intra-nasal corticosteroids **Indication for antibiotic treatment:** no improvement in 10 days, fever >39°C and purulent nasal drainage, facial pain >3 days, worsening symptoms following viral URI for 6 days that was initially improving Treatment for 10–14 days If no improvement in 3–5 days, broaden coverage Severe symptoms or failure to respond: consider imaging and drainage **Warning:** The use of fluoroquinolones should be

			reserved for patients when there is no other therapeutic alternative
Chronic	Add *S. aureus,* anaerobes	Amoxicillin/clavulanate, cefpodoxime, cefuroxime or cefdinir Alt: fluoroquinolone	Treat for 7 additional days after resolution of symptoms *See above* **Warning:** The use of fluoroquinolones should be reserved for patients when there is no other therapeutic alternative
Seriously ill or immunocompromised	Add *Pseudomonas,* gram-negative bacilli, *Mucor, Rhizopus,* and *Aspergillus* coverage	Cefepime or piperacillin/tazobactam + amphotericin B	Surgical intervention needed *See above*
Tracheitis	*S. aureus, S. pneumoniae, M. catarrhalis, H. influenzae, Pseudomonas,* Group A streptococcus	Community acquired: ceftriaxone plus clindamycin Ventilator or tracheostomy dependent: Cefepime or piperacillin/tazobactam	Treatment for 7 days
UTI			
Cystitis	*E. coli, Proteus* Spp., Enterobacteriaceae, *Staphylococcus saprophyticus, Enterococcus* spp.	**PO:** cefixime, TMP/SMX, cephalexin **IV:** cefotaxime or ceftriaxone or ampicillin + gentamycin Alt: nitrofurantoin or ciprofloxacin	Treatment for 7–14 days **Warning:** The use of fluoroquinolones should be reserved for patients when there is no other therapeutic alternative
Pyelonephritis	*E. coli, Proteus* Spp., Enterobacteriaceae, *Enterococcus* spp.	Ceftriaxone or ampicillin + gentamycin Alt: cefixime or ciprofloxacin	Treatment 7–14 days **Warning:** The use of fluoroquinolones should be reserved for patients when there is no other therapeutic alternative
Abnormal host/urinary tract	Add *Pseudomonas,* resistant gram-negative organisms	Piperacillin/tazobactam or cefepime	Treatment for 7–14 days

Common Pediatric Antibiotic Drugs and Dosages

Drug	Dose	Coverage	Common Uses	Special Considerations
Amoxicillin	**Standard dose:** 40-50mg/kg/day ÷ Q 8–12 hrs PO **High dose**: 80-100mg/kg/day ÷ Q 8–12 hrs PO Max dose: 2–3 gram/day	*S. pneumoniae, H. influenzae, S. pyogenes, S. aureus, M. catarrhalis*	Acute otitis media, community acquired pneumonia, strep Pharyngitis	Adjust dose in renal failure High-dose regimen is increasingly useful and recommended in respiratory infection and acute otitis media GI side effects common
Amoxicillin/Clavulanate	80–100mg/kg/day ÷ Q 8–12 hrs PO	*S. pneumoniae, H. influenzae, S. pyogenes, S. aureus, M. catarrhalis, N. gonorrhoeae,* some *S. aureus*	Acute otitis media, community acquired pneumonia, sinusitis, animal and human bites	Adjust dose in renal failure GI side effects common
Ampicillin	**Group B streptococcal meningitis (GBS):** ≤ 7 days: 200–300 mg/kg/day ÷ Q 8 hrs IV ≥ 7 days: 300 mg/kg/day ÷ Q 6 hrs IV	*L. monocytogenes, S. pneumoniae, S. pyogenes*(GBS), some *S. aureus*, some *Enterococcus, N. meningitidis, H. influenzae*, some Enterobacteriaceae	Meningitis, pneumonia, otitis media, urinary tract infection, salmonellosis, endocarditis	Use higher dose with shorter dosing intervals in patients with CNS disease or severe infection Adjust dose in renal failure GI side effects

	Infant/Child: **Mild/moderate infections:** 100–200 mg/kg/day ÷ Q 6 hrs IV/IM 50–100 mg/kg/day ÷ Q 6 hrs PO **Severe infections:** 200–400 mg/kg/day ÷ Q 4–6 hrs IV/IM Max PO dose: 2-g/day Max IV/IM dose: 12 g/day			common
Azithromycin	**Child:** 10 mg/kg once daily on day 1 then 5 mg/kg once daily on days 2 through 5 **Adolescent/Adult:** 500 mg/day once daily on day 1 then 250mg/day once daily on days 2 through 5 **Pharyngitis**: 12mg/kg/day once daily for 5 days **Chlamydial cervicitis/urethritis:** 1 g PO x 1 **Gonococcal**	*H. influenzae, M. catarrhalis*, *S. pneumoniae*, *S. aureus*, *S. pyogenes*, *S. agalactiae, C. trachomatis* and *pneumoniae, N. gonorrhoeae, B. pertussis*, *Legionella pneumophila, M. pneumoniae*	Pneumonia, pertussis, pharyngitis, sinusitis, chlamydial/gonococcal cervicitis/urethritis/PID, atypical infections, otitis media (alternative therapy), uncomplicated skin infections, traveler's diarrhea	Absorbed best on an empty stomach Not typically used as monotherapy in treatment of gonorrhea due to resistance Use with caution in patients with arrhythmias or prolonged QT interval IV administration over 1–3 hours GI side effects common

	cervicitis/urethritis: 2 g PO x 1 **Acute PID:** 500 mg IV x 1 on day 1, then 250 mg once daily for 6 days Max dose 500mg/day (except in cervicitis/PID treatment)			
Cefazolin (1st generation)	50–100 mg/kg/day ÷ Q 6–8 hrs IV/IM (> 1 mo of age) Max dose 6 g/day	*S. aureus, S. epidermidis, S. pyogenes, S. agalactiae, S.pneumoniae, E.coli, Proteus mirabilis*	Cellulitis, UTI, endocarditis, biliary tract infections, surgical prophylaxis	Does not penetrate CSF Dosing adjustment required for children < 1 mo of age Adjust dose for renal failure
Cefdinir (3rd generation)	14 mg/kg/day ÷ Q 12–24 hrs PO Max dose 600 mg/day	*S. aureus, H. influenzae, S. pneumoniae, S.pyogenes, M. catarrhalis*	Otitis media, pharyngitis, sinusitis, skin infections, community acquired pneumonia, UTI	May cause red- or orange-colored stools BID dosing is recommended over once-daily dosing Adjust dose for renal failure
Cefepime (4th generation)	Children ≥ 2 mo: 100 mg/kg/day ÷ Q 12 hrs IV/IM Meningitis/fever with neutropenia/serious infection/cystic fibrosis: 150 mg/kg/day ÷ Q 8 hrs IV/IM	Broad spectrum against gram-positive and gram-negative organisms + *Pseudomonas aeruginosa*	Meningitis, fever in neutropenic patients, cystic fibrosis patients, tracheitis with pseudomonas infection, severe illness	Dosing adjustment required for children < 1 mo of age Adjust dose for renal failure

	Max dose: 6 g/day			
Cefotaxime (3rd generation)	**Neonate (IV/IM):** **≤7 days old:** < 2 kg: 100mg/kg/day ÷ Q 12hrs ≥2kg: 100–150 mg/kg/day ÷ Q 8 hrs **>7 days old:** < 1.2 kg: 100 mg/kg/day ÷ Q 12 hrs 1.2–2 kg: 150 mg/kg/day ÷ Q 8 hrs > 2kg: 150–200 mg/kg/day ÷ Q 6–8 hrs **Infant and children:** 100–200 mg/kg/day ÷ Q 6 hrs (use 200 mg/kg/day for meningitis dosing) Max dose: 12 g/day	*S. aureus, S. epidermidis, S. pyogenes, S.agalactiae, S.pneumoniae, S. epidermidis, E.coli, Proteus mirabilis, N. meningitidis, H. influenzae, Neisseria gonorrhoeae, Klebsiella* spp., *Burkholderia cepacia, Enterobacter* spp., *Bacteroides*spp., *Fusobacterium* spp.	Neonatal meningitis, meningitis, pneumonia, severe infections, skin infections, gonorrhea, PID	Adjust dose for renal failure
Cefotetan (2nd generation)	40–80 mg/kg/day ÷ Q 12 hrs IV/IM Adolescent/Adult: 2–4 g/day ÷ Q 12 hrs IV/IM Max dose 6 g/day	Some gram-positive coverage, good gram-negative coverage, *Bacteroides* spp., *Streptococcus* spp., and *Escherichia spp.,*	Uncomplicated skin infections, PID, UTI, pharyngitis, preoperative prophylaxis	Good anaerobic activity Poor CSF penetration Adjust dose for renal failure
Cefprozil (2nd generation)	30 mg/kg/day ÷ Q 12 hrs	Some gram-positive	Uncomplicated skin	Adjust dose for renal

	PO Pharyngitis: 15mg/kg/day ÷ Q 12 hrs PO Max dose 1 g/day	coverage, good gram-negative coverage, *Bacteroides* spp., *Streptococcus* spp., and *Escherichia spp.,*	infections, PID, UTI, sinusitis, otitis media, pharyngitis, preoperative prophylaxis	failure
Ceftazidime (3rd generation)	**Neonate (IV/IM):** **≤ 7 days old:** < 2 kg: 100mg/kg/day ÷ Q 12 hrs ≥ 2 kg: 100–150 mg/kg/day ÷ Q 8-12 hrs **>7 days old:** < 1.2 kg: 100 mg/kg/day ÷ Q 12 hrs > 1.2 kg: 150 mg/kg/day ÷ Q 8 hrs **Infant and children (IV/IM) :** 100–150 mg/kg/day ÷ Q 8 hrs Max dose: 6 g/day	*Enterobacter*, *E. coli*, *H. influenzae*, *Klebsiella*, *Proteus*, *Pseudomonas*, *N. meningitidis*, *Neisseria gonorrhoeae,* group B streptococci, *S. pneumoniae*, and *S. pyogenes*, *Bacteroides*	Meningitis, cystic fibrosis patients, pneumonia, sepsis, UTI, joint infections	Adjust dose for renal failure
Ceftriaxone (3rd generation)	**Gonococcal ophthalmia (IV/IM) :** 25–50 mg/kg/dose x 1 dose (max dose 125mg/dose) **Infants (>1mo) and**	*Staphylococcus* spp., *E. coli*, *H. influenzae*, *Klebsiella*, *Proteus* spp., *N. meningitidis*, group B streptococci, *S. pneumoniae*, and *S.*	Meningitis, pneumonia, otitis media, sinusitis, gonococcal opthalmia, gonorrhea, PID, UTI, bone and joint infections, intra-abdominal infections,	Unlike other cephalosporins, ceftriaxone is significantly cleared by the biliary route, therefore is contraindicated in

	children (IV/IM): Mild/moderate infection: 50–75 mg/kg/day ÷ Q 12–24 hrs Meningitis: 100 mg/kg/day ÷ Q 12 hrs Uncomplicated gonorrhea: 250 mg IM x 1 dose Max dose: 2 g/dose and 4 g/day	*pyogenes*, *Bacteroides*	uncomplicated skin infections, endocarditis, sepsis	neonates with hyperbilirubinemia, particularly those who are premature because ceftriaxone may displace bilirubin from albumin binding sites, causing bilirubin encephalopathy No activity against *Chlamydia trachomatis* **Concomitant use with intravenous calcium-containing solutions/products is contraindicated**
Cephalexin (1st generation)	25–100 mg/kg/day ÷ Q 6 hrs PO Otitis media: 75–100 mg/kg/day ÷ Q 6 hrs PO Streptococcal pharyngitis: 25–50 mg/kg/day ÷ Q 6–12 hrs PO Max dose 4 g/day	*S. aureus, S. pyogenes, S. pneumoniae, H.influenzae, E. coli, Proteus mirabilis, Klebsiella pneumoniae*	Uncomplicated skin infections, pharyngitis, UTI, bone and joint infections, otitis media	Less-frequent dosing (Q 8–12 hrs) may be used for uncomplicated infections
Clindamycin	**Neonate (IV/IM):** **< 7 days old:** < 2 kg: 5mg/kg/day ÷ Q 12	methicillin-resistant *Staphylococcus aureus*, *Staphylococcus* spp.,	Skin infections, skin abscess, MRSA infections, acne, otitis	Poor CSF penetration Oral liquid not

	hrs ≥ 2kg: 5 mg/kg/day ÷ Q 8 hrs **>7 days old:** < 1.2 kg: 5 mg/kg/day ÷ Q 12 hrs 1.2–2 kg: 5 mg/kg/day ÷ Q 8 hrs > 2kg: 5 mg/kg/day ÷ Q 6 hrs **Child:** **PO:** 10–30 mg/kg/day ÷ Q 6-8 hrs **IV/IM:** 25–40 mg/kg/day ÷ Q 6-8 hrs **Adult:** **PO:** 150-450 mg/dose Q 6-8 hrs **IV/IM:** 1200-1800 mg/day ÷ Q 6-12 hrs Max PO dose: 1.8 g/day Max IV/IM dose: 4.8 g/day	*Streptococcus* spp., *Bacteroides* spp., *Fusobacterium* spp., *Prevotella* spp.	media, pneumonia, empyema, bone and joint infections, pharyngitis, PID	palatable, consider oral capsules and sprinkle into pudding or applesauce Serious side effects include pseudomembranous colitis, Steven-Johnson syndrome, thrombocytopenia, granulocytopenia
Gentamicin	**Neonates/Infants**: 4 mg/kg/day ÷ Q 12–48 hrs (**Dosing intervals vary for neonates based on gestational age, please refer to trusted resource)**	Gram-negative bacteria including *Pseudomonas*, *Proteus* spp., *Escherichia coli*, *Klebsiella pneumoniae*, *Enterobacter aerogenes*, *Serratia* spp.,	Neonatal meningitis, neonatal sepsis, meningitis, bone infections, endocarditis, pneumonia, urinary tract infections, sepsis	May be ototoxic and nephrotoxic Adjust dose in renal failure

	Child: 7.5 mg/kg/day ÷ Q 8 hrs **Adult:** 3–6 mg/kg/day ÷ Q 8 hrs	and the Gram-positive *Staphylococcus*		
Piperacillin/tazobactam	**Neonate:** **< 1 kg**: 100 mg/kg/dose Q 12 hrs (0–14 days old) or Q 8 hrs (15–28 days old) **>1 kg**: 100 mg/kg/dose Q 12 hrs (0–7 days old) or Q 8 hrs (8–28 days old) **Severe infections:** **< 2 mo**: 300–400 mg/kg/day ÷ Q 6 hrs **2–9 mo:** 240 mg/kg/day ÷ Q 8 hrs **>9 mo:** 300 mg/kg/day ÷ Q 8 hrs Max dose 16 g/day	*S.aureus*, *E.coi*, *Haemophilus influenzae*, *B. fragilis, B. ovatus, B. thetaiotaomicron, B. vulgatus. Klebsiella pneumoniae,* and *Pseudomonas aeruginosa*	Intra-abdominal infections, skin infections, pneumonia, severe infections, peritonitis	Shortening dosing interval to Q 6 hours may enhance pharmacodynamics properties CSF penetration occurs only with inflamed meninges
Sulfamethozazole/Trimethoprim	**Dosed based on TMP component:** **Mild to Moderate infections (PO or IV):** < 40 kg: 8–12 mg/kg/day ÷ Q 12 hrs	methicillin-resistant *Staphylococcus aureus*, *Staphylococcus* spp., *Streptococcus* spp., *Bartonella henselae*, *Bordetella pertussis*, *Enterobacter* spp., *E. coli*,	UTI, skin infections, skin abscess, MRSA skin infections, traveler's diarrhea, cholera, pneumocystis pneumonia in immunosuppressed	Not recommended for use in infants < 2 mo of age Serious side effects include blood dyscrasias, renal or

	>40 kg: 160 mg/dose BID **Severe infections (PO or IV):** 20 g/kg/day ÷ Q 6–8 hr	*H. influenzae, Listeria monocytogenes*, *Moraxella catarrhalis*, *Mycobacterium tuberculosis*, *Neisseria gonorrhoeae*, *Neisseria meningitidis*, *Pneumocystis jirovecii*, *Proteus* spp., *Salmonella* spp., *Shigella* spp., *Vibrio cholerae*	patients	hepatic injury, Stevens-Johnson syndrome May cause hemolysis in patients with G6PD deficiency Adjust dose for renal impairment
Vancomycin	**Neonate(IV): (Dosing intervals vary for neonates based on gestational age; please refer to trusted resource)** Bacteremia: 10 mg/kg/dose Meningitis/pneumonia: 15 mg/kg/dose **Infant/child/adolescent (IV):** 15–20 mg/kg/day ÷ Q 6–8 hrs **Clostridium difficile colitis (PO):** Child: 40–50 mg/kg/day ÷ Q 6 hrs Adult: 125 mg/dose Q 6 hrs Max dose: 2g/day	methicillin-resistant *S. aureus* (MRSA), *C. difficile*, *Staphylococcus* spp., *Streptococcus* spp., some enteroccoci	Complicated skin infections, abscess, bacteremia, endocarditis, bone and joint infections, and meningitis caused by methicillin-resistant *S. aureus*, *Clostridium difficile* colitis	Ototoxicity and nephrotoxicity may occur Adjust dose in renal failure Red man syndrome may occur with rapid IV infusion

	Gram Positive	Gram Negative	Pseudomonas	MRSA	Anaerobe	Atypical bacteria
Penicillin	+	Limited	-	-	+/-	-
Oxacillin	+	-	-	-	-	-
Ampicillin	+	Limited	-	-	-	-
Amoxicillin	+	Limited	-	-	-	-
Amoxicillin/clavulanate (PO) Ampicillin/sulbactam (IV)	+	+	-	-	+	-
Piperacillin/tazobactam	+	+	+	-	+	-
Imipenem	+	+	+	+	-	-
Ciprofloxacin		+	+	-	-	+
Moxifloxacin	+	+	-	-	+	+
Levofloxacin	+	+	+			+
Cefazolin (1st gen)	Limited	+	-	-	-	-
Cephalexin (1st gen)	Limited	+	-	-	-	-
Cefoxitin (2nd gen)	Limited	+	-	-	+	-
Cefotetan (2nd gen)	Limited	+	-	-	+	-
Ceftriaxone (3rd gen)	+	+	-	-	-	-
Cefdinir (3rd gen)	+	+	-	-	-	-
Cefepime (4th gen)	+	+	+	-	-	-
Gentamicin		+	+	-	-	-
Clindamycin	+	Limited	-	+	+	-
Vancomycin	+	-	-	+	-	-
Trimethoprim/sulfa	+	+	-	+	-	-
Tetracyclines	+	+	-	+	Limited	+
Linezolid	+	-	-	+	-	-
Metronidazole	-	-	-	-	+	-
Azithromycin	Limited	-	-	-	-	+

Chapter 21
Pediatric Diabetic Ketoacidosis

Cullen Clark, Anna McFarlin, and Cristina M. Zeretzke-Bien

Abstract This chapter on evaluation and management of diabetic ketoacidosis (DKA) allows the provider to be confident in their assessment and resuscitation of this potentially critically ill patient. The total fluid deficit equation and recommendations on rehydration are Quick Hits that will save lives.

C. Clark · A. McFarlin (✉)
Emergency Medicine/Pediatric Combined Residency Program, Pediatrics and Emergency Medicine, Louisiana State University Health Science Center, New Orleans, LA, USA
e-mail: ccla11@lsuhsc.edu

C. M. Zeretzke-Bien
Division of Pediatric Emergency Medicine, University of Florida, Department of Emergency Medicine, Gainesville, FL, USA
e-mail: Zeretzke@ufl.edu

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_21

Pediatric Diabetic Ketoacidosis

Definition

- Hyperglycemia – glucose >200
- Metabolic acidosis pH <7.30 or HCO_3 <15
- Ketosis – ketones in blood or urine

Signs and Symptoms

- Dehydration
- Vomiting
- Abdominal pain
- Polyuria, polydipsia
- Breath has "fruity" odor
- Weight loss
- Tachypnea with deep, labored respirations (Kussmaul breathing)

Work-Up

Always assess and address ABCs prior to initiating treatment, especially in obtunded patients or clinically deteriorating patients.

- Labs
  - Fingerstick glucose
  - VGB or ABG
  - CMP
  - HbA1C
  - UA (assess for glucosuria and ketonuria)
  - CBC and work-up for the infection or any other contributing factor if suspected
- If new onset diabetes, add the following labs:
  - Islet cell antibodies
  - Insulin antibodies

- Anti-GAD antibodies
- Thyroid antibodies
- Thyroid function tests
- Celiac screen (tissue transglutaminase and total immunoglobulin)
- Zinc transporter 8 autoantibody
- Ia2 autoantibody

Initial Stabilization and Treatment

- NS or LR bolus (10–20 mL/kg over 1 h)
- Replete K+ if low prior to or during insulin administration
- Bicarbonate NOT indicated for treatment of acidosis in DKA unless:
  - Can be given with EXTREME CAUTION if pH <6.9 AND cardiac or respiratory decompensation (should be used only with consult from endocrine or intensive care)
- Volume replacement (always use isotonic fluids)
  - Total fluid deficit = [estimated % dehydration × weight (kg)] × 1000 mL
  - Rate of rehydration fluids over the next 48 h = (Total Fluid Deficit – Initial bolus)/48 h + hourly maintenance fluid requirement

Cerebral edema: Consider hypertonic saline or mannitol for concerns for cerebral edema (under guidance of endocrine and pediatric critical care specialists).

Triple Bag Therapy for Severe DKA

- Insulin 0.1 units/kg/h
- 0.9% NaCl + 20 mEq K acetate + 20 mEq KPhos
- D10 0.9% NaCl + 20 mEq K acetate + 20 mEq KPhos

Fluid therapy should run at a constant rate during treatment. Percentage of total fluid rate for each fluid combination determined by hourly blood glucose:

	Composition of rehydration fluids	
Blood glucose	NS +20KPhos +20 KAc	D10 NS +20KPhos +20 KAc
>350 mg/dL	100%	0%
250–350 mg/dL	50%	50%
<250 mg/dL	0%	100%

Most DKA patients will be suffering from moderate to severe dehydration. Estimated degree of dehydration and associated symptoms:

Mild (<5% dehydration)	**Moderate (5–7%)**	**Severe (≥10%)**
Dry mucous membranes Tachycardia	Capillary refill >2 s Sunken eyes Reduced skin turgor Absent tears All mild symptoms	Weak or non-palpable peripheral pulses Hypotension Shock Oliguria All mild and moderate symptoms

Quick Hit DKA Pearls

- *Aggressive rehydration increases risk of cerebral edema: consider **CT HEAD and VBG/ABG**.*
- Q1H blood glucose checks once insulin infusion initiated.
- If patient has insulin pump, it must be removed prior to initiating insulin.
- Insulin infusion should not be stopped until patient is no longer acidotic; anion gap is closed, and able to tolerate PO.
- Most common causes of DKA:
  - Poor or noncompliance with insulin
  - Acute illness
  - Undiagnosed type 1 diabetes

Chapter 22
Pediatric Metabolic Emergencies

Sadiqa A. I. Kendi

Abstract Metabolic emergencies must be considered in the vomiting, lethargic, irritable, or seizing neonate or child. This chapter includes "Quick Hits" and a pathway for consideration of adrenal crisis versus inborn errors of metabolism (IEM). The metabolic emergency pearls are a must-know in pediatric emergency medicine.

S. A. I. Kendi
Pediatric Emergency Medicine, Children's National Health System, Washington, DC, USA
e-mail: skendi@cnmc.org

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1_22

Pediatric Metabolic Emergencies

Ill-appearing neonate or child with **vomiting, lethargy, irritability, seizures, shock acidosis, ketosis, or hypoglycemia**, you should consider inborn error of metabolism (IEM) and adrenal crisis

↓

Address ABC's if needed. May require **intubation** if not maintaining airway, and **rapid fluid resuscitation** with normal saline (20cc/kg bolus pushed) if hypotensive

↓

Order a **stat glucose*, venous blood gas*, electrolytes*, lactate*,** complete blood count, basic metabolic panel, hepatic function panel, ammonia, and urinalysis
(*****Should be done via bedside point of care test or other stat bedside testing if possible)

↓

Address any **abnormalities** found on labs.
Consider **transfer after stabilization** if not at a Children's Hospital
Can begin to differentiate adrenal crisis from inborn error of metabolism with labs

Hyponatremia
Hyperkalemia
Hypoglycemia

→ **Consider adrenal crisis**

Labs for Confirmation

1. Cortisol
2. 17-hydroxyprogesterone
3. Dehydroepiandrosterone
4. Androstenedione
5. Testosterone

Treatment

1. NS bolus
2. Give hydrocortisone: 2 mg/kg IM/IV (max 100 mg)

Metabolic acidosis
Hypoglycemia
High lactate
High ammonia

→ **Consider IEM**

Labs for Confirmation

1. Ammonia (send on ice)
2. Acylcarnitine Plasma amino acids
3. Urine organic acids
4. Carbohydrate deficient transferrin
5. Pyruvate

Treatment

1. Stop any dietary protein sources
2. Correct hypoglycemia
3. NS bolus if dehydrated
4. D10 fluids at 1.5–2xmaint stat
5. Treatment for hyperammonemia in consultation with a geneticist (may require dialysis)

Interpretation of Serum Ammonia and ABG in metabolic diseases

ABG	Elevated serum ammonia	Normal serum ammonia
Metabolic Acidosis	Fatty Acid Oxidation defects Methymalonic Acidemia Propionic Acidemia	Some Organic Acidemias Maple Syrup Urine Disease
Normal ABG	Urea Cycle Defect	Galactosemia Aminoacidopathy Non-ketotic hyperglycinemia

Quick Hits Pediatric Metabolic Emergency Pearls

- Consider in any ill-appearing child, especially an ill-appearing neonate.
- Remember a child with a history of chronic steroid use who is ill may present with a secondary adrenal crisis.
- Look for electrolyte abnormalities, hypoglycemia.
- Think dextrose (D10) fluids and give hydrocortisone early if IEM or adrenal crisis diagnosis is suspected.

Index

C. M. Zeretzke-Bien et al. (eds.), *Quick Hits for Pediatric Emergency Medicine*, https://doi.org/10.1007/978-3-319-93830-1