Critical Care in Infants and Children: The Basics

Society of Critical Care Medicine

The Intensive Care Professionals

Participation in, or completion of, this course does not confer any credential, nor does it satisfy any board certification requirement apart from CME if offered for it. This course is not intended to replace, override, or conflict with any licensing or credentialing requirements.

Version 6.3

Objectives

- Review pediatric physiology and pathology
- Understand differences in adult and pediatric critical care
- Describe modifications to adult therapies needed to support children

Important Aspects of Physical Examination

- General appearance
  - Responsiveness and reactivity
  - Level of activity, muscle tone
  - Irritability, consolability, cry
- Skin perfusion
  - Color of mucosa and nail beds
  - Capillary refill <2 sec
- Degree of hydration
  - Fontanelle, presence/absence of tears, sunken eyes, skin tenting, moistness of mucous membranes
- Respiratory rate and respiratory effort
  - Tachypnea
  - Grunting, nasal flaring, retractions (subcostal, tracheal, intercostal)
- Bradypnea

General Examination: Vital Signs

Age Group	Heart Beat (beats/min)	Respiratory Rate (breaths/min)	Blood Pressure (mm Hg)
Preemie	120-170	40-70	55-75/35-45
Newborn	110-160	30-60	65-85/45-55
Infant	90-150	25-45	70-100/50-65
1-3 years	80-125	20-30	90-105/55-70
3-6 years	70-115	20-25	95-110/60-75
6-12 years	60-100	14-22	100-120/60-75
>12 years	60-100	12-18	100-120/70-80

- **In neonates, MAP can be estimated by gestational age**
- **MAP can be estimated by 55 + (age x 1.5)**

Case Study 1

- 6-month-old former 30 weeks gestational age infant with fever, rhinitis, and cough for 4 days
- T 38.5°C, HR 150 beats/min, RR 60 breaths/min, SaO_2 90%
- Tachypneic with subcostal and upper sternal retractions and copious upper airway secretions
- Minimal improvement with 100% O_2 and nebulized albuterol

What is the most important initial intervention?

What are the most immediate treatment strategies?

Evaluation by Organ System: Respiratory System/Airway

- **Increased chest wall compliance secondary to cartilaginous thoracic cavity**

What are some early signs of respiratory distress in an infant/child?

- **Hypoxemia occurs quickly in infants/children**
  - **Infant oxygen consumption is 2-3 times greater than adult**
  - **Children have lower hemoglobin levels than adults**

What is the most important step in treating a child with respiratory compromise?

What are simple early interventions in management of a child with respiratory compromise?

Evaluation by Organ System: Respiratory System/Airway

What are some anatomic differences between the pediatric and adult airways?

- Pediatric airway as compared to adult airway
- Tongue is larger in proportion to mouth
- Pharynx is smaller
- Epiglottis is larger and floppier
- Larynx is more anterior and superior
- Narrowest at cricoid
- Trachea narrow and less rigid

Evaluation by Organ System: Respiratory System/Airway

- **General considerations for intubation**
  - **Nasogastric tube may be needed**
  - **Obstruction can occur easily**
  - **Positioning in "sniffing" position with assistance of shoulder roll is important**
  - **Use of straight laryngoscope blade, cricoid pressure, or lateral displacement may help with visualization**

Uncuffed ETT size = (age/4) + 4

Estimate of ETT depth = inner diameter of ETT x 3

Evaluation by Organ System: Respiratory System/Airway

Causes of Respiratory Failure

Premature neonates	Apnea of prematurity Infant respiratory distress syndrome (surfactant deficiency and ineffective chest bellows)
Term neonates	Bacterial pneumonia Meconium aspiration Congenital airway abnormalities
Infants, toddlers	Pneumonia Bronchiolitis Asthma Foreign-body aspiration Upper airway obstruction due to infection

Primary respiratory disorders are the most common cause for cardiopulmonary arrest in children.

What are some of the conditions that can lead to upper airway obstruction in children?

Evaluation by Organ System: Respiratory System/Airway

- **Initial ventilator settings for children**
  - **Tidal volume 6-10 mL/kg in normal lungs**
  - **Tidal volume 6 mL/kg in acute lung injury or acute respiratory distress syndrome**
  - **Respiratory rates in children generally higher than those in adults**

Case Study 2

- 2-week-old term neonate presents with nonbilious projectile vomiting and agitation for 3 days
- Last wet diaper 1 day ago
- Fontanelle sunken, mucous membranes dry, and infant appears jaundiced
- T 37°C, HR 190 beats/min, RR 50 breaths/min, BP 44/25 mm Hg

What is the differential diagnosis and most likely etiology?

What initial intervention is indicated?

What diagnostic modalities are indicated?

Evaluation by Organ System: Cardiovascular

- Cardiac output (CO) = HR x SV
- CO is heart rate-dependent
  - Myocardium is noncompliant
  - Minimal change in stroke volume in response to changes in preload and afterload
- Bradycardia is NOT tolerated in infants/children
  - May be sign of significant hypoxemia or acidosis

Evaluation by Organ System: Cardiovascular

Detection	• Evaluate and perform assessment of general appearance, airway, breathing, circulation, pertinent history, and physical exam • Attach appropriate monitors • Recognize the type of shock and categorize the severity
Intervention	• Provide 100% oxygen • Obtain appropriate intravenous/intraosseus access (preferred). • Administer appropriate intravenous fluids – 20 mL/kg bolus isotonic crystalloids – Repeat fluid bolus with reassessment • Place urinary catheter
Reassessment	• Re-evaluate airway, breathing, circulation, and mental status after each intervention. • Repeat fluid at 20 mL/kg • Monitor ongoing losses • Check the therapeutic end points in resuscitation – End-organ function – Heart rate, blood pressure, signs of perfusion – Mental status – Obtain serum electrolyte measurements, monitor hypo/hypernatremia, acidosis, blood urea nitrogen/creatinine/glucose
Effective Communication	• Define team member roles and responsibilities • Communicate effectively with other caregivers • Promote collegial interaction and knowledge sharing

Evaluation by Organ System: Cardiovascular (Hypovolemic Shock)

- Most common type of shock in children
- Tachycardia is an early nonspecific sign
- Early recognition before onset of hypotension is critical
  - Children maintain their blood pressures longer in cases of hypovolemia than adults
- Management includes:
  - Aggressive fluid resuscitation
  - Control of ongoing losses (diarrhea, vomiting, hemorrhage)
  - Correction of metabolic/electrolyte derangements

Evaluation by Organ System: Cardiovascular (Distributive Shock)

- Characterized by changes in mental status, fever or hypothermia, and perfusion abnormalities such as vasodilation (warm shock) or vasoconstriction (cold shock)
- Causes
  - Sepsis (most common)
  - Anaphylaxis
- Management
  - Restoration and maintenance of organ perfusion and oxygenation
  - Aggressive fluid resuscitation
  - Vasopressor (norepinephrine) support in fluid-refractory shock

Evaluation by Organ System: Cardiovascular (Cardiogenic Shock)

- Pump failure: decreased systolic function and cardiac output
- Newborns with ductal-dependent lesions (e.g., coarctation of aorta, transposition of the great vessels, tricuspid atresia) may present in cardiogenic shock
  - Administer PGE_1 (0.05-0.1 mcg/kg/min) to newborns in shock until a ductal-dependent lesion can be ruled out
- Nonductal-dependent lesions can present beyond newborn period with a history of tachycardia, gallop, murmur, tachypnea, hepatomegaly, and failure to thrive

Evaluation by Organ System: Cardiovascular (Obstructive Shock)

- Obstruction to blood flow (e.g., pulmonary embolism, cardiac tamponade, and tension pneumothorax)
- Uncommon in children

Case Study 3

- 2 year-old male with vomiting, diarrhea for 1 week
- T 37.5°C, HR 150 beats/min, RR 20 breaths/min, BP 70/50 mm Hg
- Lethargic, dry mucous membranes and poor skin turgor on physical examination
- Tonic-clonic seizures broken with rectal diazepam

What is the most likely etiology of seizures?

What is your initial management strategy?

What diagnostic modalities are indicated?

Evaluation by Organ System: Metabolism/Temperature

Pediatric Management of Water and Electrolyte Abnormalities

Detection	• Evaluate and perform assessment of general appearance, airway, breathing, circulation, pertinent history, and physical exam. • Attach appropriate monitoring devices. • Recognize the respiratory physiology disorder and type of dehydration (hyponatremic), and categorize the severity
Intervention	• Provide ventilation with bag-mask with 100% oxygen • Obtain appropriate intravenous/intraosseus access (preferred) – Administer appropriate intravenous fluids – 20-mL/kg bolus of isotonic crystalloids – Repeat fluid boluses with reassessment • Place urinary catheter • Obtain serum electrolytes measurements; monitor hypo-/hypernatremia, calcium, and glucose
Reassessment	• Reevaluate airway, breathing, circulation, and mental status after each intervention • Repeat fluid at 20 mL/kg if needed – Correct confirmed hyponatremia with 3% saline to bring sodium >120 mmol/L. Start 3% saline 3 mL/kg over 15 min – Administer lorazepam 0.05 mg/kg if patient actively having a seizure • Monitor ongoing losses • Check therapeutic end points in resuscitation – End-organ function – Heart rate, blood pressure, signs of perfusion – Mental Status – Urinary output • Monitor serum electrolytes, hypo-/hypernatremia, acidosis, blood urea nitrogen/creatinine, glucose at least every 4-6 h
Effective Communication	• Define team member roles and responsibilities • Communicate effectively with other team members and pediatric intensive care unit • Promote collegial interaction and knowledge sharing

Evaluation by Organ System: Metabolism/Temperature (Water)

- **Estimating fluid requirements**

Body weight	Fluid
<10 kg	100 mL/kg/day
11-20 kg	1000 mL + 50 mL/kg for each kg above 10 kg
>20 kg	1500 mL + 20 mL/kg for each kg above 20 kg

- **Use isotonic fluids (5% dextrose in normal saline, 5% lactated Ringer solution) in hospitalized patients to prevent development of hyponatremia**

Evaluation by Organ System: Metabolism/Temperature (Glucose)

- Hypoglycemia more common in infants during stress
  - Low glycogen stores
  - Increased metabolic rate
  - Bedside glucose testing for any child presenting in distress
- Treatment
  - 10% glucose 0.5-1 g/kg (or 5-10 mL/kg) in neonates
  - 25% glucose (2-4 mL/kg) in older children

Evaluation by Organ System: Metabolism/Temperature (Sodium)

- **Hyponatremia**
  - Sodium <135 mmol/L
  - Symptoms include irritability, poor feeding, nausea/vomiting, lethargy, seizures, coma/death (if untreated)
  - Treatment with hypertonic saline: 2% or 3%
- **Hypernatremia**
  - Sodium >145 mmol/L
  - Calculation of free water deficit important in treatment
  - Serum sodium lowered no faster than 0.5 mmol/L/h over 48-72 h

Evaluation by Organ System: Metabolism/Temperature (Potassium)

Treatment of hyperkalemia

If significant electrocardiographic abnormalities are presented (peaked T waves, QRS widening, PR-interval prolongation:

- Administer calcium gluconate (10%) 50 mg/kg intravenously OR
- Administer calcium chloride (10%) 10 mg/kg intravenously via central line

For redistribution of potassium:

- Administer sodium bicarbonate 1 mmol/kg intravenously AND/OR
- Administer 25% dextrose 2-3 mL/kg (0.5-1 g/kg) + regular insulin 0.1 U/kg intravenously (IU for each 5 g dextrose)
- Administer inhaled beta-2-agonist (albuterol 2.5-5 mg per dose has been used successfully)

To remove potassium:

- Administer loop diuretic: furosemide 0.5-1 mL/kg
- Administer sodium polysterene sulfonate 1 g/kg per dose orally/rectally every 6 h
- Perform dialysis

Evaluation by Organ System: Immune System

What are some of the factors that place neonates at risk for infections?

- **Prompt evaluation and empiric antibiotics important in all neonates presenting with fever**
- **Understanding of organisms associated with life-threatening infections in different age groups of pediatric patients aids in selection of appropriate antibiotic treatment**

Evaluation by Organ System: Nervous System

Glasgow Coma Scale Modified for Infants and Children

Clinical Parameter	Infants (Ages 0-12 months)	Children (ages 1-5 years)	Points
Eye Opening	Spontaneous Response to speech Response to pain No response	Spontaneous Response to speech Response to pain No response	4 3 2 1
Verbal Response	Coos/babbles Irritable cries Cries Moans No response	Appropriate words Inappropriate words Persistent cry Grunts No response	5 4 3 2 1
Best Motor Response	Normal Withdraws to touch Withdraws from pain Flexor response Extensor response No response	Spontaneous Localized pain Withdraws from pain Flexor response Extensor response No response	6 5 4 3 2 1

Questions

Key Points

- Early signs of respiratory of distress include tachypnea, grunting, and nasal flaring
- Airway management is the most important step in management of child with respiratory compromise
- Understanding the anatomic differences between infant/child and adult airways is important for successful pediatric intubation
- Initial ventilator settings for children
  - Tidal volume 6-10 mL/kg in normal lungs
  - Respiratory rates in children generally higher than those in adults

Key Points

- Tachycardia is an early finding in children with shock
- Hypotension is a late finding in children with shock
- Early fluid resuscitation with 40-60 mL/kg is important for treatment of hypovolemic shock
- Norepinephrine is indicated in patients with fluid-refractory vasodilatory shock
- Infants with congenital lesions that interfere with cardiac function (e.g., coarctation of aorta or interrupted aortic arch) can present with cardiogenic or (rarely) obstructive shock

Key Points

- Low glycogen stores and higher metabolic rates place infants at risk for hypoglycemia during stress
- Irritability is an early sign of changes in mental status in young children
- Febrile neonates (<2 mo) should receive empiric antibiotics promptly