Stabilization Essentials in Pediatrics Pre-reading

Summarized information from the textbook *Pediatric Fundamental Critical Care Support* (3rd edition) from the Society of Critical Care Medicine.

Assessment of the Critically Ill Child

Critically ill children require rapid, systematic evaluation because their physiology differs significantly from adults. They have smaller airways, higher oxygen consumption, and limited reserves, which means deterioration can occur quickly. Respiratory failure is the most common cause of pediatric cardiopulmonary arrest, so early recognition and intervention are essential.

Initial Approach and Observation

The first step is to determine whether the child appears ill. Observation begins the moment the patient is seen. Ask: "Does this child look sick?" A child who appears lethargic, irritable, or unable to maintain a position of comfort may be in serious distress. **Young children often compensate well initially, so subtle signs must be recognized early**. Increased work of breathing such as tachypnea, nasal flaring, grunting, and chest wall retractions signals respiratory compromise. Bradypnea is a late and ominous sign. Mental status changes such as confusion or decreased responsiveness often indicate inadequate oxygenation or perfusion.

Primary Survey and Immediate Priorities

The evaluation follows a structured approach best performed simultaneously while applying basic monitors including oximetry, ECG and BP cuff:

- **Airway**: Assess airway patency. Secure the airway if required, while maintaining cervical spine alignment if trauma is suspected.
- **Breathing**: Assess oxygenation and ventilation; apply supplemental oxygen immediately.
- **Circulation**: Obtain vascular access and begin fluid resuscitation if indicated. Non invasive BP monitors can be inaccurate with poor pulses and poor perfusion
- **Disability**: Check neurological status using pupillary response with point of care glucose testing.
- **Exposure**: Remove clothing to identify hidden injuries while preventing hypothermia.

Airway and Respiratory Management

Children's airways are anatomically distinct. The tongue is proportionally larger, the epiglottis is long and floppy, and the larynx is positioned more superiorly. The chest wall is highly compliant, and intercostal muscles are immature, making effective ventilation more challenging. Even minor airway narrowing can cause severe obstruction because resistance increases exponentially as diameter decreases. Pediatric patients have a functional residual capacity (FRC) approaching their closing volume (CV) at baseline, and at times with illness FRC may be reduced to less than the CV, resulting in atelectasis and desaturation. This highlights the importance of PEEP in pediatric patients and explains why non-invasive positive pressure ventilation is more common in children compared to adults. Oxygen should be administered as the monitors are applied. Positioning, suctioning, and airway adjuncts may be necessary. Pulse oximetry

monitors oxygenation, while capnography provides information on ventilation and confirms endotracheal tube placement if intubation becomes necessary. Specific nasal cannula with ETCO2 detection are useful adjuncts. Blood gases and chest radiographs help guide therapy but should not delay urgent interventions.

Cardiovascular Assessment and Shock Recognition
Perfusion is assessed through mental status, capillary refill, urine output, and extremity temperature. **Hypotension is a late finding in children**; unexplained tachycardia is an early compensatory sign and should alert the clinician to be vigilant and consider fluids. Shock may be hypovolemic, cardiogenic, distributive (such as septic or anaphylactic), or obstructive. Fluid resuscitation with isotonic solutions is the cornerstone of initial therapy for most forms of shock. Boluses of 10-20 mL/kg are commonly used, with reassessment after each dose. Persistent instability may require vasoactive medications. In cardiogenic shock, aggressive fluid administration can worsen cardiac function, so inotropes may be preferred. Obstructive shock in neonates (such as congenital heart disease) often requires prostaglandin E1 infusions to maintain ductal patency.

Neurological Status and Associated Risks
Depressed consciousness, seizures, or coma in infants and young children should prompt evaluation for traumatic brain injury, sepsis, encaphalitis or metabolic causes such as hypoglycemia and electrolyte imbalances. A point-of-care glucose test is essential early in the assessment. Hyponatremia and hypocalcemia can also precipitate seizures. Neurological deterioration often reflects systemic compromise and requires immediate attention to airway and circulation.

Sepsis and Infection Risk
Clinical signs of sepsis include apnea and temperature instability in neonates, respiratory distress, poor perfusion or unexplained tachycardia. Children, especially neonates, are highly vulnerable to infection due to immature immune systems. Fever in infants younger than one months is considered an emergency. Empiric antibiotics should be initiated promptly when sepsis is suspected, often before a source is identified. Common pathogens in neonates include group B streptococcus, Escherichia coli, with Listeria monocytogenes in high risk populations. In older infants and children, Streptococcus pneumoniae, Staphylococcus aureus, and Neisseria meningitidis are frequent causes of severe infection.

Pediatric Airway

Children's airways differ from adults in both anatomy and physiology, and those differences drive clinical priorities. Infants and young children have proportionally larger tongues and occiputs, a higher and apparent anterior larynx, a long, soft, Ω shaped epiglottis, a funnel shaped subglottic region and a shorter, narrower trachea. While the narrowest part of the airway is the glottis, the complete ring of the cricoid cartilage is often the most impacted by airway edema,. Chest walls are more compliant, intercostal muscles are immature and diaphragmatic mechanics dominate. As a result, work of breathing rises quickly when resistance

increases. Even a 50% reduction in airway radius can multiply resistance sixteen-fold (Poiseuille's law, resistance $\propto 1/r^4$). Young children also have higher oxygen consumption and resting energy expenditure (≈2–3× adults), less physiologic reserve, and a tendency for respiratory failure to precede cardiovascular compromise.

Assessment starts with a calm, focused inspection: Does the child look sick? Maintain the child's position of comfort; avoid agitation that can convert partial upper airway obstruction to complete obstruction. Look for tachypnea, nasal flaring, grunting, and retractions (subcostal, intercostal, suprasternal). Bradypnea is ominous. Mental status is a sensitive indicator of oxygenation and perfusion although all experienced clinicians can recall a child talking just before collapse; lethargy or irritability may reflect hypoxemia or hypercarbia. Colour and perfusion (capillary refill, extremity temperature), urine output, and pupillary reactions add context. Auscultation must distinguish inspiratory sounds (stridor/stertor—extra thoracic airway problems) from expiratory wheeze (intrathoracic narrowing) and note asymmetry that suggests focal pathology (eg, pneumothorax, mucous plug, foreign body).

Upper and Lower Airway Disease

Upper airway problems in infants and children range from benign, self-limited conditions to life threatening obstructions. A recurring principle is to **keep the child calm and in a preferred position with initial assessment**, since agitation increases airflow velocity and turbulence, worsens dynamic collapse of the extra thoracic trachea, and can precipitate full obstruction.

Anatomic or functional causes include macroglossia, micrognathia, Pierre Robin sequence (glossoptosis with cleft palate and micrognathia), choanal stenosis/atresia in obligate nasal breathers (young infants), laryngomalacia (inspiratory stridor, may improve prone), tracheomalacia (biphasic stridor if both extra and intrathoracic segments collapse), subglottic stenosis (congenital or postintubation), and tonsillar/adenoidal hypertrophy (obstructive sleep apnea and acute obstruction).

Infectious upper airway disorders demand rapid differentiation and graded responses:

- **Viral laryngotracheobronchitis (croup):** Barking cough, inspiratory stridor, subglottic edema; treat with dexamethasone (eg, 0.6 mg/kg). Nebulized epinephrine will result in transient relief (onset 1–5 min; effect 1–3 h), but there is potential for relapse when the effect of the epinephrine wanes. Intubate only when necessary, often with a smaller uncuffed tube, ideally in a controlled environment (ie OR).
- **Supraglottitis/epiglottitis:** Rapid onset high fever, drooling, muffled voice, tripod positioning; minimize stimulation, avoid oral/pharyngeal examination with tongue blades. This is an uncommon now with immunizations against the most common cause *Hemophilus Influenza*. Controlled airway management in the OR by skilled personnel, keeping the child upright and spontaneously breathing and prompt treatment with antibiotics.
- **Bacterial tracheitis:** This patient will have a toxic appearance after viral prodrome; thick mucopurulent secretions and pseudomembranes obstruct the trachea. Typically requires

intubation for pulmonary toilet, broad-spectrum antibiotics covering *Staphylococcus* and *Streptococcus*, and several days of support until edema resolves.

- **Retropharyngeal and peritonsillar abscesses:** High fevers, neck pain/stiffness, muffled "hot potato" voice, bulging posterior pharynx, widened prevertebral space or fluid level on imaging. Treat with antibiotics with anaerobic coverage and surgical drainage if refractory; anticipate and manage airway risk.

Miscellaneous upper airway concerns such as foreign body aspiration and inhalation or caustic injuries also appear in pediatrics; each benefit from early recognition, judicious imaging, and escalation to definitive airway control by experienced teams.

Airway management spans a range of supports: suctioning, oropharyngeal/nasopharyngeal airways (NPAs are particularly valuable in Pierre Robin sequence), non-invasive ventilation (CPAP/BiPAP) to stent collapsible segments, and careful planning for intubation when needed. In severe craniofacial or subglottic disease, having the most experienced physician is crucial (ie. Anesthesiologist if available); the child should remain spontaneously breathing for airway instrumentation when feasible.

Lower airway disease centers on asthma and bronchiolitis. **In asthma**, the triad of bronchospasm, mucosal edema, and mucus impaction produces expiratory airflow obstruction, hyperinflation, flattened diaphragms, increased work of breathing, ventilation-perfusion mismatch, and, when severe, respiratory failure. Clinically, wheeze may be absent in severe "silent chest" presentations, which is a worrisome sign. Pulsus paradoxus, an active expiratory phase, and inability to speak in full sentences mark severity. Patients with asthma are usually over 1 year of age. Management is layered: oxygen titrated to maintain saturations >92%; inhaled βagonists (intermittent or continuous salbutamol) with anticholinergics (ipratropium) as adjuncts; systemic corticosteroids (eg, methylprednisolone 1 mg/kg q6h); magnesium sulfate for bronchodilation; **early fluids** to support preload in the face of tachycardia, dynamic hyperinflation, and possible non-invasive ventilation (NIV) or intubation. Non-invasive ventilation reduces work of breathing and may avert intubation. If invasive ventilation is required, it should be carefully planned, mindful that overzealous bagging or high ventilator rates worsen air trapping, intrathoracic pressure, hypotension, pneumothorax, and can precipitate arrest. Once intubated, you should aim for permissive hypercapnia (pH ≥7.20), long expiratory times, and vigilant hemodynamic support.

Bronchiolitis usually presents in children under 2 years of age, with the most severe presentations in very young infants. These patients present with tachypnea, retractions, nasal flaring, crackles/wheeze, and feeding difficulty, with **apnea** as a potential symptom in neonates. Management is supportive with oxygen, hydration, suction, and escalation to high-flow nasal cannula or NIV and intubation when needed. Because infants are obligate nasal breathers early in life, simple nasal suctioning often markedly improves respirations.

Ventilation

Non-Invasive Ventilation

Non-invasive ventilation (NIV) provides positive pressure support without an artificial airway, using interfaces such as nasal or full-face masks. It is increasingly used for acute and chronic pediatric respiratory conditions where airway resistance or lung compliance is compromised. It is demonstrating an increased use for acute conditions such as asthma and bronchiolitis.

Positive pressure ventilation delivers distending pressures that counter soft tissue or cartilaginous collapse to improve gas exchange. BiPAP delivers two pressures: EPAP (expiratory positive airway pressure) to maintain functional residual capacity and prevent collapse, and IPAP (inspiratory positive airway pressure) to support ventilation and CO_2 clearance. Typical starting points are EPAP 5–6 cmH_2O and IPAP 10–12 cmH_2O, adjusted for chest rise, tidal volume, work of breathing, and patient comfort. The pressure gradient (ΔP = IPAP – EPAP) determines ventilatory support.

Optimization includes airway positioning, suctioning, bronchodilator delivery and sedation if required. NG tube placement helps reduce gastric distension. Continuous assessment of work of breathing, respiratory rate, oxygen saturation, and chest movement is required while a child is being established on NIV. Blood gases (venous or capillary) can support management but are an adjunct to the bedside clinical exam. Management also requires attention to mask fit and leak prevention, ensuring the patient can trigger breaths effectively. Regular face care and suctioning prevent skin breakdown and maintain airway patency. If stability cannot be achieved despite escalating settings and FiO_2, anticipate the need for intubation.

Invasive Mechanical Ventilation

The guiding objective in pediatric ventilation is to support oxygenation and ventilation while avoiding iatrogenic injury. Volutrauma and barotrauma are real risks in small lungs with limited reserve; tidal volumes should be referenced to **the lesser of predicted/ideal body weight or actual body weight**. For most children, initial tidal volume targets are 6–8 mL/kg (lower in parenchymal disease), with careful titration based on chest rise, auscultation (from superior to inferior lobes), capnography, oxygenation, and clinical response. Positive end expiratory pressure (PEEP) of 5–7 cmH_2O (common starting settings) helps prevent atelectasis at end exhalation and support oxygenation; inspiratory times vary by age and compliance.

Mode selection balances accuracy of delivered volume against the benefits of pressure control. Newer hybrid modes (eg, pressure regulated volume control) strive to minimize ventilator induced lung injury. In obstructive disease (eg, severe asthma), **long expiratory times** and **lower rates** are essential to reduce dynamic hyperinflation. Judicious PEEP (5–10 cmH_2O) can prevent expiratory airway collapse but may worsen hyperinflation if overapplied; ventilator waveforms and targeting an autoPEEP of 5cmH2O should be used in tandem with bedside exam to titrate settings. The application of PEEP will be affected by whether the patient is breathing spontaneously, or the patient is paralyzed with all breaths delivered by the ventilator without patient trigger.

During intubation, plan meticulously and utilize a checklist to support the team. Prepare all sizes of blades (straight Miller often helpful to directly lift the long, floppy epiglottis in infants; curved Macintosh for older children), appropriately sized cuffed tubes, stylets that do not protrude, suction (rigid Yankauer and flexible catheters), capnography, and backup devices (laryngeal mask airway/ iGel, bougie). Preoxygenate; limit attempts to ~30 seconds or saturation trend (whichever is the shortest); resume bag mask ventilation promptly between attempts to prevent desaturation. Confirm placement with $ETCO_2$ capnography and bilateral breath sounds (auscultate in anterior axillary lines to avoid transmitted sounds). Secure the tube carefully at an age-appropriate depth (depth ≈ 3 × internal diameter as a rough estimate), obtain a chest radiograph, and continue continuous monitoring.

Watch for complications such as loss of tube position ("DOPE": dislodgement, obstruction, pneumothorax, equipment failure), barotrauma including tension pneumothorax (decompress immediately; do not wait for imaging), and decreased cardiac output due to high intrathoracic pressures.

In parenchymal lung disease and pediatric ARDS, protective strategies dominate: tidal volumes are often initiated at 6-8mls/kg and may be reduced based on pressure measurement; plateau pressures ≤28 cmH_2O when measurable; and optimization of PEEP for oxygen needs. Oxygenation depends on mean airway pressure and FiO_2; both hypoxia and hyperoxia harm—target SpO_2 92–97% initially, with potential modification dependent on severity of lung disease. FiO_2 should be titrated down as soon as feasible. Ventilation should be guided by capnography and blood gases; many children tolerate controlled hypercapnia as long as pH stays ≥7.20, provided cerebral perfusion and intracranial pressures are not compromised.
Finally, sedation and analgesia must match goals: adequate comfort and amnesia with minimal hemodynamic impact, preserving spontaneous breathing when advantageous. Preferred sedatives for intubated patients include dexmedetomidine infusions (if available). Ketamine offers bronchodilation and can be used as a bolus or infusion. Neuromuscular blockers eliminate respiratory effort but **do not provide sedation or analgesia.**

Diagnosis and Management of Shock in Children

Shock is a state of inadequate delivery of oxygen and essential substrates to vital organs, leading to cellular dysfunction and metabolic derangements. Oxygen delivery depends on arterial oxygen content and cardiac output, which is a product of heart rate and stroke volume. In children, hypotension and bradycardia are late signs; early indicators include tachycardia, poor perfusion, prolonged capillary refill, cool extremities, and altered mental status. Shock in children can be hypovolemic, cardiogenic, distributive (including **septic** and anaphylactic), or obstructive, with **hypovolemic** and **septic shock** being the most frequent.

Immediate Priorities

All ill-appearing children with abnormal vital signs should receive high-flow oxygen via face mask within the first five minutes. Vascular access, peripheral or intraosseous, must be secured promptly, ideally within five minutes. If IV access is difficult, intraosseous placement should not be delayed.

Fluid Resuscitation
Rapid administration of isotonic crystalloid (0.9% saline, lactated Ringer or Plasmalyte) in boluses of 10-20 mL/kg, with reassessment after each dose, up to 40-60 mL/kg titrated to clinical response. Early correction of intravascular volume is critical to prevent end-organ damage. Monitoring for signs of fluid overload is essential, such as **hepatomegaly or pulmonary congestion**, and therapy adjusted such as the addition of inotropes and consideration of ventilation.

Medications and Investigations
Broad-spectrum antibiotics should be administered **within the first hour** when septic shock is suspected, ideally with a blood culture take prior. Airway control may be necessary, and ventilation may be needed to support the cardiovascular system; ketamine is the preferred agent in shock due to its cardiovascular stability. A point-of-care glucose test and comprehensive labs should be obtained early including lactate and blood cultures.

Vasoactive Support
If perfusion remains inadequate after fluids, initiate vasoactive drugs promptly, selecting agents based on the desired effect (e.g., norepinephrine for vasoconstriction, epinephrine for inotropy). Continuous monitoring of heart rate, blood pressure, urine output, and mental status is essential.

Special Considerations
In neonates and young infants, consider ductus-dependent congenital heart disease, sepsis, metabolic disorders, adrenal insufficiency and non-accidental trauma as potential causes.

Pediatric Trauma Care

Trauma in children requires rapid, structured assessment because their physiology makes them vulnerable to rapid deterioration. The initial approach begins by performing a primary survey, identifying and treating life threatening injuries as identified : airway, breathing, circulation, disability, and exposure.

“Life Threatening Injuries”

- Exsanguinating hemorrhage - torniquet or compress, depending on the source
- Upper airway obstruction – high flow oxygen, suction, jaw thrust, oral/nasal airway
- Tension pneumothorax
- Pericardial tamponade
- Flail chest injury
- Impending herniation

Airway and Breathing
Airway management must consider cervical spine injury. Maintain neutral alignment during airway interventions. Use jaw thrust rather than head tilt if spinal injury is suspected. Oxygen

should be administered immediately to all trauma patients regardless of saturation. Assess breathing with pulse oximetry and capnography. Look for signs of chest injury such as asymmetric chest movement, decreased breath sounds, or tracheal deviation. Pneumothorax or hemothorax requires immediate intervention with needle decompression or chest tube, and placement should not be delayed for imaging when clinical suspicion is high.

Circulation and Shock

Children have smaller circulating blood volume (approximately 80 mL/kg in young children), so even modest blood loss can cause shock. Early signs include tachycardia, prolonged capillary refill (>3 seconds), cool extremities, and altered mental status. **Hypotension is a late sign** and indicates severe compromise. Rapid vascular access is essential: site 2 large-bore peripheral IV lines or intraosseous access if IV attempts fail. Hypotension from presumed hemorrhagic shock requires rapid replacement of blood volume with PRBCs and massive hemorrhage protocols where available. Compensated **s**hock may be treated with isotonic fluid resuscitation with frequent reassessment and early consideration of blood products. Monitor urine output (goal: 1–2 mL/kg/hr in children) as an indicator of perfusion.

Hypothermia Prevention

Hypothermia worsens the coagulopathy of trauma. Children lose heat quickly due to a large surface area-to-body mass ratio. Remove wet clothing, use warm blankets, and administer warmed IV fluids. Hypothermia worsens coagulopathy and acidosis, increasing mortality risk.

Secondary Survey and Imaging

Once stabilized, perform a head-to-toe examination to identify hidden injuries. Laboratory evaluation includes hemoglobin, hematocrit, coagulation profile, liver enzymes and blood gas analysis. Imaging should be prioritized based on clinical findings: chest and pelvic X-rays for suspected thoracic or abdominal trauma, and focused assessment with sonography for trauma (FAST) for internal bleeding.

Special Considerations

Head injuries are common in pediatric trauma. Monitor for signs of increased intracranial pressure such as bulging fontanelle in infants, unequal pupils, or decreased responsiveness. A**void hypotension and hypoxia**, as both worsen neurological outcomes. Cervical spine injuries should be suspected in high-impact trauma and immobilize until cleared. Abdominal injuries may present with subtle signs; serial examinations and imaging are often required. Splenic and liver injuries are common.

Pain Management and Support

Provide adequate analgesia early using weight-based dosing of opioids or non-opioid agents as appropriate. Maintain vigilance for respiratory depression when using opioids. Emotional support for the child and family is important throughout care.

Key Clinical Actions

- Immediate oxygen administration and airway support/rapid identification of immediate life threatening injuries
- Neutral cervical spine alignment during airway management
- Rapid vascular access and warmed isotonic fluid boluses
- Early recognition of shock and escalation to blood products if needed
- Aggressive hypothermia prevention
- Continuous monitoring of vital signs and perfusion indicators
- Imaging and labs guided by clinical suspicion without delaying stabilization

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Sedation and Analgesia in Pediatric Critical Care

Sedation and analgesia are essential for comfort, safety, and physiologic stability in critically ill children, particularly during invasive procedures, mechanical ventilation, and painful interventions. The primary goals are to relieve pain, reduce anxiety, prevent agitation, allow invasive procedures and facilitate life-support measures while minimizing adverse effects.

Assessment and Planning

Pain and sedation levels should be assessed regularly using age-appropriate scales. Therapy must be individualized based on clinical status, underlying disease, and hemodynamic stability. Continuous monitoring of vital signs, respiratory function, and neurologic status is mandatory.

Analgesia

Opioids are the cornerstone for pain control.

- **Fentanyl**: Rapid onset, short duration, minimal hemodynamic impact.
- **Morphine**: Effective for sustained analgesia but may cause hypotension and histamine release.
- **Hydromorphone**: Alternative for prolonged pain control or used if renal dysfunction.

Non-opioid adjuncts

- Acetaminophen and NSAIDs can reduce opioid requirements when appropriate.
- Ketamine is an excellent adjunct to opiates in incremental doses as it allow airway protection while providing analgesia and control of agitation

Sedation

- **Midazolam (infusion or bolus**): Common benzodiazepine for anxiolysis and amnesia; monitor for respiratory depression and hypotension. Often used as an infusion in intubated patients.
- **Lorazepam (bolus)**: Longer duration; useful for sustained sedation.
- **Dexmedetomidine (infusion)**: Provides sedation without respiratory depression; may cause bradycardia and rarely hypotension.
- **Ketamine (bolus or infusion)**: Preserves airway reflexes and offers bronchodilation; useful in hemodynamic instability but increases secretions (use anticholinergic prophylaxis).

Adjuncts and Special Considerations

- Neuromuscular blockers should be used for intubation. Rocuronium is preferred over succinylcholine. Ongoing use of neuromuscular blockers should **only be used when absolutely necessary** and never without adequate sedation and analgesia.
- Avoid oversedation to reduce risk of delirium and prolonged ventilation.
- Titrate medications to the lowest effective dose; consider daily sedation interruptions when clinically feasible.
- Continuous infusions require vigilant monitoring for accumulation and withdrawal syndromes.