Pediatric Resuscitation
Pearls and Pitfalls

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KEYWORDS

• Pediatric • Resuscitation • Equipment • Preparation • Airway • Circulation
• Cardiac arrest

KEY POINTS

- Use of tools, such as the Pediatric Readiness Assessment, can optimize preparation for pediatric resuscitation, knowledge of equipment, and comfort with local resources.
- Achieve sniffing position with a shoulder roll and/or headrest for optimal airway alignment for bag valve mask and intubation dependent on occiput size.
- In the peri-intubation period, utilize pre-oxygenation and apneic oxygenation, in addition to volume resuscitation and vasopressors as needed to optimize hemodynamics prior to induction.
- Minimize time off the chest during cardiac arrest; do not delay initiation of chest compressions, intra-osseous (IO)/intra-venous (IV) access, and early epinephrine administration.
- Pediatric patients are particularly susceptible to hypoglycemia, hypothermia, ingestion incidents, and missed trauma; keep differential broad in the altered or unresponsive pediatric patient.

INTRODUCTION

Despite pediatric emergency medicine visits accounting for approximately 25% of all emergency department (ED) visits in the United States, roughly 5% of those children are classified as critically ill or require hospital admission.[1] Secondary to this, exposure to pediatric resuscitation and frequency of high-acuity pediatric evaluations are generally lower during medical training and throughout the emergency providers' career. Pediatric resuscitation may be thought of as a "HALO" procedure, or High Acuity, Low Occurrence in that regard. The initial preparation, evaluation, and management of the critically-ill pediatric patient share principles across all resuscitations, both medical and trauma, with a few critical anatomic and physiologic differences.

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Abbreviations	
HFNC	high-flow nasal cannula
NPRP	National Pediatric Readiness Project
RSI	rapid sequence intubation
TXA	tranexamic acid

This article supplies the emergency provider, whether emergency medicine (EM), pediatric emergency medicine (PEM), or otherwise, with a general approach to pediatric resuscitation, tips to avoid common pitfalls, and current evidence-based pearls for effectively and optimally managing a pediatric resuscitation.

Preparedness

Site preparation for pediatric patients is critical to improved outcomes in pediatric resuscitation. The National Pediatric Readiness Project (NPRP) first published in 2013 aimed to standardize an assessment of emergency department preparation for pediatric patients with regards to supplies and available resources. A pediatric readiness score (>87) is associated with 76% lower mortality rate in ill children,[1] and 60% lower mortality rate in injured children[2] and a higher readiness score is associated with long-term survival in injured children as well.[2] The NPRP provides an assessment tool that is recommended for emergency departments to complete in order to receive a pediatric readiness score and assessment of preparation.[3] Every emergency department should have a minimum standard for pediatric equipment including vital sign monitoring (blood pressure cuffs, pulse oximetry "SPO2", end tidal capnography), airway equipment (including Magill forceps, bag valve mask (BVM) and nasal cannula, endotracheal tubes, nasopharyngeal airways and oropharyngeal airways), and venous/IO access that spans developmental stages (neonatal, infant, toddler, school age, and adolescent). The equipment should be organized in an easily accessible fashion, ideally by weight or age. It is important to catalog and restock this equipment regularly, as well as practice accessing this equipment. Regular simulations of pediatric resuscitations are recommended with team members to improve pediatric outcomes.

Given the infrequency of pediatric resuscitation, an ill child often attracts extra attention from clinical providers; however, additional teammates who are not actively involved in the care of a small patient can inhibit overall progress. If alerted by emergency medical services (EMS) of an incoming pediatric resuscitation, assigning critical roles prior to arrival is a key. A suggested general format includes a team leader (provider), primary assessor (provider), an airway provider (respiratory therapist or additional provider), medication nurse, access nurse, and a technician to apply monitors. Additional personnels, such as a pharmacist, extra technicians for CPR, and documenting nurse, are also helpful. This model may or may not be feasible with department staffing, but does highlights essential roles that must be assigned even if multiple tasks are shared by a single person. For the walk-in resuscitation, assigning team lead and roles remains critical and should not be skipped. Following role assignment, the next immediate priority should be obtaining a weight. A bed weight in kilograms would be considered the gold standard; however, if a weighted bed is not available, it is recommended that all hospitals have a reliable method (whether length-based tape, or age-based estimation method) to obtain an estimated weight. Length-based measurement tapes have been shown to be highly accurate, even in medically complex children.[4] Although not generally recommended as a standard procedure, there is some evidence to support parental estimation as a prediction method for pediatric weights.[5,6]

Running the Resuscitation

Airway

Airway and ventilation assessment. The first priority in evaluation of the airway includes an assessment for obstruction. Evaluation includes visualization: Is there blood, loose teeth, mandibular laxity or fixation, concern for cervical spine injury, which requires stabilization that will limit airway positioning? This also includes an assessment for obstruction: Is there vocalization, audible stridor, decreased air movement, or visible foreign body? Evidence of airway obstruction requires immediate intervention to intervene and the delayed recognition of airway obstruction in a child can be detrimental as respiratory failure accounts for the majority of arrests. Also recall that patient's less than 2 mo old are obligate nose breathers, and can have their air movement negatively impacted due to increased airway resistance from secretions or other nasal obstruction (such as external pressure from holding, masks, etc).

Pearl: Have blown-by O2 nearby for possible desaturation events in infants with poor reserve and remember nasal suctioning/aspiration has similar clinical outcomes to deep suctioning and is an appropriate initial intervention.[7]

Airway management. Pitfall: overlooking the basics.

Positioning A patient who is awake, but with impending obstruction, will typically position themselves in a position of comfort (ie., tripoding); preserve this positioning while assessing the airway and planning interventions. If the patient is unconscious, obtunded, or in arrest, evaluate for obvious signs of obstruction and take care to position the head to avoid artificial obstruction. Particularly, in children less than 2 y old who have a relatively large occiput, the sniffing position is optimal and obtained by tilting the head back or placing a small, rolled towel/sheet under the patient's shoulders. Pay extra attention to the positioning of those under 2 y, as the combination of large occiput, large tongue, floppy epiglottis, and decreased hypopharyngeal tone, can lead to a deadly combination of collapsed airway tissue.[8] Infants, toddlers, and older children will require different positioning to obtain "sniffing position." Due to the large occiput, infants may require both shoulder rolls and headrests (**Fig. 1**). In children greater than 2, the sniffing position can be obtained by placing a small rolled towel/sheet under the occiput. Older children may be best suited with a headrest alone. Regardless, ensure that the external auditory meatus and sternal notch are aligned on the horizontal plane, the anterior neck space is open visually, and the glabella and chin are horizontally aligned, paying special attention to ensure head is not hyperextended.[9] Optimal positioning is critical to optimizing oxygenation, ventilation, as well as success with advanced airway interventions.

Airway Adjuncts Do not overlook the importance of oral and nasal airways as an assistive adjunct to more advanced airway interventions. Oral airways and nasal airways may be advantageous for patients with evidence of airway obstruction thought to be secondary to large tongue, decreased mental status with associated hypotonia, or immature and floppy airway tissue. Oropharyngeal airways should be reserved for patients without intact gag reflex not to induce emesis. Nasopharyngeal airways can be used in responsive, but depressed mental status patients. These adjuncts can be combined with oxygen delivery, or to assist effective bag valve mask.

Supraglottic airways Do not underestimate the value of supraglottic devices. Many different brands exist. Be familiar with your institutional resources and confirm organization and rapid access to appropriate size supraglottic airways. Specific benefits to note include management of obstruction,[10] ease, and speed of placement with

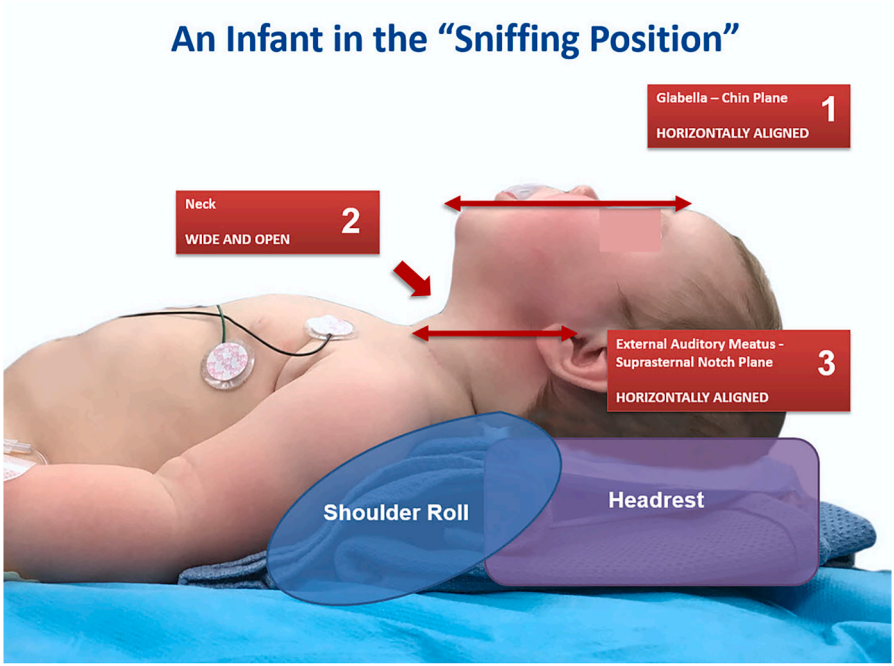

Fig. 1. Appropriate infant airway positioning with the external auditory meatus in plane with the suprasternal notch, as well as the glabella in line with the chin; open neck and in plane alignment of the oral, pharyngeal, and laryngeal axis.[9] (*From* Kalra A. Positioning Infants and Children for Airway Management. Pediatric Anesthesia Digital Handbook. 2014. Accessed November 20, 2024. https://www.maskinduction.com/positioning-infants-and-children-for-airway-management.html; Copyright 2017 Aman Kaira, MD. Department of Anesthesiology)

minimal equipment requirements, and high first pass success rates for placement.[11] Anesthesia literature supports use of supraglottic airways with similar or higher first pass success rates compared to video laryngoscopy in standard and difficult airways, respectively.[12] Supraglottic devices may be the initial airway intervention in patient with ineffective bag valve mask, particularly in limited resource or limited personnel contexts. They are also the preferred initial airway interventions for those patients in active arrest.

Intubation Pre-hospital intubation should be reserved for inadequate or unsustainable ventilation, such as the need for a definitive airway for transport. The 2024 International Consensus on Cardiopulmonary Resuscitation specifically recommends the use of bag valve mask rather than advanced airways, in pre-hospital cardiac arrest.[13] During in-hospital cardiac arrest, a study of over 2000 patients ranging from neonate to adolescent, showed a majority of patients were intubated during cardiac arrest (68%); however, survival was lower in patient's who were intubated compared to not intubated during cardiac arrest.[14] Further, there was no significant difference in return of spontaneous circulation or favorable neurologic outcome between the 2 groups. Intubation during cardiac arrest or active resuscitation is common, although there is insufficient evidence to support its benefit. Focus on delivery of effective oxygenation and effective ventilation during active resuscitation rather than more advanced airway techniques.

The decision to intubate may occur after active resuscitation, return of spontaneous circulation (ROSC), or with inability to oxygenate or ventilate without a definitive airway. There are numerous shapes, sizes, and technologies associated with airway interventions. Historically, it has been supported to use the approach that is most familiar to you for higher first pass success rates (when considering direct vs indirect laryngoscopy). In the advance of video laryngoscopy, studies primarily focused on the longer duration of time for intubation with video laryngoscopy compared to direct laryngoscopy, thought to be primarily related to the physical insertion of the tube given the indirect view.[15] However, a recent systemic review supports the use of video laryngoscopy over direct laryngoscopy with significantly greater first pass success rates for video compared to direct laryngoscopy.[16] As a reminder, the elevation of the head of the bed is not routinely recommended during intubation in pediatric patients.[9] There is limited evidence to support the routine use of hyperangulated blades in pediatric populations; one study comparing the use of standard geometry to hyperangulated video blades in patients 14 and older found no difference in first pass success,[17] whereas a different observational study found higher first pass success with standard geometry video laryngoscopy blades compared to hyperangulated video laryngoscopy blades in infants <5 kg, and no difference in patients >5 kg.[18] Utilizing hyperangulated blades may be considered when familiar and comfortable with the technique, and when anticipating specific challenges related to head/neck positioning, size, or stability.

Pearl: when utilizing hyperangulated blades, a neutral head position is okay, rather than the standard sniffing position required for direct and standard geometry blades.

The routine use of uncuffed endotracheal is no longer recommended, regardless of age. Cuffed endotracheal tubes are associated with less frequent tube exchange, more accurate capnography, and reduced pulmonary aspiration. A meta-analysis showed similar rates of post-extubation symptoms, including laryngospasm and stridor between cuffed and uncuffed tubes.[19] Even in neonates, 2 different cohort studies showed no significant difference in development of intubation-associated subglottic stenosis with the use of cuffed endotracheal tubes in comparison to uncuffed endotracheal tubes.[20,21]

When initiating mechanical ventilation, choose the most familiar mode. Generally, a volume control mode should be initiated, with attention to maintenance of plateau pressure <30 cm H2O.[8] **Fig. 2** notes initial setting recommendations for initiation of mechanical ventilation.

	Initial Settings (Healthy Lungs)			**ARDS**	**Asthma**
Tidal Volume	6-8 mL/kg			4-6 mL/kg	CPAP/PS if able, or PC-SIMV with high PIP
PEEP	5			8-14	5-14
	Infant	Child	Teens		
Rate	25-30	20-25	12-16	May need higher RR	Low rate
Inspiratory Time	0.5	0.7	1	Longer i-Time OK	Aim for 1:4 ratio
CO2 goal	40-45			pH > 7.25	pH > 7.1 Acceptable hypercarbia
SpO2 goal	>90%			>88%	>88%

Fig. 2. Suggested initial invasive ventilation settings. (*Adapted from* Reid Farris, MD (Pediatric Critical Care, Seattle Children's Hospital); with permission.)

Pearl: Ensure pre-intubation resuscitation and adequate volume resuscitation prior to proceeding with medication administration for rapid sequence intubation (RSI). RSI medications can cause hypotension, particularly when the patient is already in a shock state or with poor physiologic reserve. Prepare adjunct vasoactive medications to proactively manage anticipated post-intubation hypotension.

Breathing

Pitfall: hypoxia.

Pre-oxygenation. Children have significantly increased basal oxygen consumption rate when compared to adults. They also have decreased functional residual capacity. The combination of airway anatomy discussed earlier, with increased consumption, and decreased reserve places them at significant risk for hypoxia, often developing rapidly. In addition, hypoxia in children can cause bradycardia, which is less tolerated and associated with hemodynamic compromise quicker than when compared to adults. The goal of pre-oxygenation is to maintain adequate oxygen saturation and delay onset of hypoxia during apnea. Routine pre-oxygenation is supported in pediatric patients prior to intubation.[22,23]

Apneic oxygenation. Apneic oxygenation, the delivery of oxygen during suppression of endogenous respiratory function, has been widely supported in the adult emergency airway literature. The goal is to reduce dead space ventilation. However, there has been minimal literature investigating the use of apneic oxygenation in pediatric populations until recent years. In 2021, Dancy published a review in support of apneic oxygenation with 100% FiO2 in pediatric populations with longer time to initial desaturation event.[24] There have been no significant negative outcomes reported in association with apneic oxygenation. Apneic oxygenation can be accomplished with simple nasal cannula.

Pearl: Utilize both pre-oxygenation and apneic oxygenation during pediatric intubation in the emergency department to reduce risk for hypoxic events.

Non-invasive ventilation. *Pearl:* refer to 2021 Clinic article "Just Breathe" for complete review of non-invasive respiratory support in pediatric respiratory distress.[25]

High-flow nasal cannula. High-flow nasal cannula (HFNC) can be considered in patients with significant work of breathing and low O2 from parenchymal disease, such as pneumonia, in bronchiolitis, post-extubation, or time allowing, in pre-intubation for optimization. HFNC utilizes heated and humidified air to deliver higher O2 flow to improve oxygenation and decrease risk of breathing. The device primarily addresses poor oxygenation, with a small augmentation of positive end-expiratory pressure (PEEP) in higher flows (approximately 1 cm H20 per 10 L/min).[26] Although HFNC does require some titration to allow pediatric patients to adjust to the sensation and reduce irritation, the major pitfall is starting support too low. Some institutional protocols recommend initiating HFNC at 2 L/kg, with FiO2 at 0.4 to reduce work of breathing. Frequent reassessments and titration of support are necessary to ensure adequate support. Titrate FiO2 to keep O2 > 90% when awake, and 88% while asleep. Ensure proper sizing of nasal prongs and closed mouth when able to ensure most effective delivery. Parental or caregiver support in maintenance of tubing and to minimize pulling is essential.

Continuous positive airway pressure (CPAP)/bi-level positive airway pressure (BiPAP). Non-invasive positive pressure ventilation should be considered in patients with hypercarbic respiratory failure, ineffective ventilation with increased work of

breathing, such as hypotonia, restrictive lung disease, pulmonary edema, or poor respiratory drive, when mental status allows. Failure to recognize a need to escalate support, a change in mental status, a change in hemodynamics, or a lack of improvement are the primary pitfalls of utilization of non-invasive positive pressure ventilation. Generally, in infants <12 mo, the use of nasal CPAP will be better tolerated due to size restrictions on face masks and availability.[8] Recommended initial settings for nasal CPAP in infants include a pressure of 5 cm H2O. For BiPAP, ensure appropriate fit of mask and consider trial of full face mask or nasal BiPAP if available and inadequate seal with standard face mask. Continuous reassessment of work of breathing and mental status is critical to ensuring safe and effective delivery of ventilatory support. As with intubation, prudent attention to ventilator alarms is critical to identify need to transition support to a different technique or adjust current settings. Refer to **Fig. 3** for recommended initiation settings for non-invasive positive pressure ventilation. Settings are recommended as starting point, with titration of inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP) in generally recommended in increments of 2 cm H20.

Pearl: know what equipment is available in your department and practice sizing nasal prongs and face masks to ensure adequate seal.

Bag valve mask. This is the most important airway skill to maintain. Ensure appropriate face mask size and bag volume. Utilize two-handed face mask hold for adequate seal. Understand which type of bag your institution supplies. Remember that self-inflating bags do not deliver passive oxygenation without squeezing the bag. Ensure appropriate PEEP set on PEEP valve for effective delivery.

Pearl: The "MR SOPA" pneumonic still applies to pediatric airways; adjust the *mask*, *reposition* the head, *suction* the mouth/nose, *open* mouth and jaw thrust, increase *pressure* gradually until chest rise, and finally proceed with advanced *airway*, such as ETT or laryngeal mask airway (LMA).[27]

Invasive Ventilation. Refer to Airway section mentioned earlier.

Circulation

Pulse. Ensure access to up-to-date and easy-to-follow Pediatric Advanced Life Support (PALS) algorithms. Along with appropriate applications of PALS strategies, remember to lead the resuscitation and focus on effective communication and direction of the room.

Pitfall: delayed recognition of weak or absent pulse.

Ensure prompt identification of pulseless cardiac arrest. Detecting a pulse can be difficult: one study showed only 78% of doctors and nurses correctly identified the presence or absence of a pulse, and a pulse was reported as present in 14% of cases where there was no pulse.[28] This can lead to delay in initiation of compressions and prolonged no-flow state, which is associated with worse outcomes. The average time to determine the lack of pulse in the same study was 30 sec.[28] The decision to initiate compressions is made after 10 sec of palpation regardless, if uncertainty exists at 10 sec begin compressions. This is further supported by evidence, which shows

Age	Settings	FiO2
1-2 yrs	IPAP 8 cm H20, EPAP 4 cm H20	1.0
> 2 yrs	IPAP 10 cm H20, EPAP 5 cm H20	1.0

Fig. 3. Suggested initial non-invasive BiPAP settings.

improved likelihood to survive to hospital discharge with initiation of cardiopulmonary resuscitation for bradycardia with poor perfusion prior to onset of pulseless arrest.[29] Consider the use of Doppler ultrasound of the femoral artery to detect pulse, which is effective in adults[30] and likely helpful in pediatric patients as well. Only do so if sufficient team members available to continue critical actions, such as access, medication administration, and high-quality CPR.

Overall, minimize time-off of the chest.

Never overlook the basic tenets of delivering high-quality chest compressions. Utilize a hard backboard and step stool for all CPR events. Utilize a CPR coach to guide CPR depth, rate, and communication in anticipation of pauses. The use of a trained CPR coach is associated with decreased pause in CPR duration, shorter pauses during intubation, and improved coordination of tasks during CPR pause.[31] Chest compression quality decreases as time of chest compressions increases.[32] The utilization of a CPR coach can identify deterioration in compression quality and arrange for minimal interruption in compressions for exchange in compressors. If a CPR coach is not available, consider utilization of a CPR feedback device.

Pearl: Adequate depth of compressions (at least 3.8 mm) improves arterial blood pressure during arrest and ROSC rates.[33,34]

Access. Pitfall: delayed time to obtaining access.

Intravenous access on small pediatric patients during active resuscitation has numerous challenges. It is well-known that it can take time to set up, stabilize, obtain, and secure intravenous access in a critically-ill patient or active resuscitation. Do not delay placement of an intraosseous line. If there have been 2 unsuccessful IV attempts, or greater than 90 sec have passed, proceed with intraosseous line placement. IO placement is associated with lower failure rate and lower complication rates in pediatric patients when compared to intravenous, central venous, and arterial lines in pediatric patients.[35] Accessible and safe locations for placement include the proximal and distal tibia, distal femur, and proximal humerus. After initial resuscitation and stabilization, consider the use of ultrasound guidance when available to assist in intravenous access. Central-line placement may be necessary if multiple lumens are required, prolonged vasoactive use, or other caustic agents, such as higher concentration dextrose, or prolonged vasoactives. Central lines should be placed after initial resuscitation and stabilization, with sterile technique, and ultrasound guidance. It is generally recommended to avoid subclavian central access in pediatrics due to vascular anatomy and high risk for pneumothorax.[8]

Vasoactive Medication. Pitfall: delayed use of vasoactive medications.

Early epinephrine administration in cardiac arrest has been associated with ROSC, survival to hospital discharge, and survival with good neurologic outcomes. This has been shown both out of hospital and with in-hospital cardiac arrest.[36,37] Do not delay epinephrine administration in non-shockable pediatric cardiac arrest.

In the same light, the early consideration of vasoactive medications in the resuscitation, peri-arrest, and peri-intubation period is a proactive approach to preventing hypotension, which is associated with worse outcomes overall. Norepinephrine is generally the preferred vasoactive medication for emergency department resuscitation in both pediatric and adult patients, particularly in sepsis, and undifferentiated shock. There are not ample data on epinephrine versus norepinephrine in the pediatric population in the setting of shock. Consider a bedside cardiac ultrasound to assess for myocardial dysfunction, and if present, epinephrine may be the preferred agent. If no, significant dysfunction, either epinephrine or norepinephrine, is appropriate.

Although associated with reduced time to administration, the utilization of push dose vasopressors, such as epinephrine or phenylephrine, is associated with higher preparation and administration errors in both the emergency department and ICU, even when prepared by pharmacists.[38,39]

Volume resuscitation

Crystalloid Utilization of crystalloid for fluid resuscitation is well-supported in both pediatric and adult populations. Although normal saline continues to be favored by pediatric providers, multiple studies have shown no difference in outcomes, particularly in sepsis, when comparing normal saline to lactated ringers.[40]

Blood Prompt identification of hemorrhagic shock is imperative in resuscitation. In patients with suspected significant blood loss pre-hospital, or concern for ongoing blood loss, early administration of *blood products* is critical. Specifically, balanced blood product administration is the mainstay of resuscitation. Advanced Trauma Life Support (ATLS) guidelines for pediatric trauma recommend an initial bolus of 20 mL/kg of isotonic crystalloid, followed by balanced ratio of packed red blood cells, plasma, and platelets. While this is extrapolated practice from adult literature, it is generally supported as a safe approach.[41] Each administration of balanced products should be accompanied by a dose of calcium gluconate or calcium chloride, if central access is available. Critical illness is associated with hypocalcemia at baseline, exacerbated by chelation of citrate in blood products. Ultimately, hypocalcemia leads to worsened coagulopathy, therefore it is imperative to correct ongoing and balanced with blood administration. See **Fig. 4** for an example protocol for Massive Transfusion Protocol, by weight.

The use of whole blood has been shown to be safe, associated with faster resolution of shock and coagulopathy, and lower volume of transfused blood products. Furthermore, whole blood resuscitation is independently associated with increased survival in massive transfusion protocol.[42] If whole blood is available at your institution, it can be utilized in place of component blood resuscitation safely in pediatric and adult populations.

In undifferentiated shock, consider blood administration as an adjunct to crystalloid resuscitation. Combine with point of care ultrasound for focused assessment with sonography in trauma (FAST) or rapid ultrasound for shock and hypotension (RUSH) protocol to further investigate undifferentiated hypotension that may benefit from blood administration.

Tranexamic Acid (TXA). The use of tranexamic acid (TXA) in adult literature is well-supported in trauma and other bleeding, such as post-operative, or disseminated intravascular coagulation (DIC). Pediatric literature supports the use of TXA in surgical cases, with a strong safety profile.[43] There is support for the use of TXA in pediatric

Product	Weight < 15 kg	Weight > 15 kg
pRBC	10 mL/kg	1 unit
FFP	10 mL / kg	1 unit
Platelets	10 mL / kg	1 unit
Cryoprecipitate	5 mL / kg	1 unit
*Calcium	Consider when activating MTP	
*TXA		

Fig. 4. Sample massive transfusion protocol.

trauma associated with decreased mortality and no safety events.[44,45] In massive transfusion, the use of TXA is felt to be a safe and potentially effective adjunct to combat coagulopathy when administered early.[46] The recommended dose in pediatric patients <12 y old is 15 mg/kg over 10 min with max dose 1 g, and in children >12 y old, 1 g administered over 10 min.

Pitfall: use of temporizing agents.

Both sodium bicarbonate and calcium are still used frequently during pediatric cardiac arrest, in more than 40% of patients across 4 major studies.[47–50] The routine use of sodium bicarbonate, or calcium, is not recommended. Sodium bicarbonate use during pediatric cardiac arrest is associated with lower survival at 24 h,[47] lower survival rate to hospital discharge, less favorable neurologic outcomes, and not associated with ROSC.[47,48] It is not recommended outside of cardiac arrest secondary to hyperkalemia, tricyclic antidepressant (TCA) overdose, or sodium channel blockade. Calcium is associated with lower rate of survival to hospital discharge, and less favorable neurologic outcome at hospital discharge, and not associated with sustained ROSC.[49,50] Calcium is recommended in arrest secondary to hypocalcemia, hyperkalemia, hypermagnesemia, or calcium channel blocker overdose.

Disability

Dextrose. Pitfall: delayed glucose administration.

During assessment of disability, complete pupillary examination and evaluate mental status with glascow coma scale (GCS) appropriate for developmental stage. Check a point-of-care glucose immediately. Recall that children are at increased risk for hypoglycemia. Neonates are particularly at risk for hypoglycemia, with higher risk for hypoglycemia associated with maternal diabetes, premature birth, growth restriction, and macrosomic infants.[51] Young children are also at higher risk secondary to decreased glycogen stores in the liver and all acutely ill children are also at increased risk of hypoglycemia secondary to increased utilization of glucose. If unable to obtain a point-of-care (POC) glucose, consider administration of glucose empirically. Typical administration recommendations include D10 W for neonatal patients <2 mo at 2 to 5 mL/kg, D25 W for pediatric patients 2mo to 8 y at 2 mL/kg, and D50 W for patients >8 y of age at 1 amp (50 mL) or 1 mL/kg. Multiple studies have shown similar efficacy in treatment of hypoglycemia in pediatric and adult patients with D10 as opposed to D50, with decreased rates of extravasation and rebound hypoglycemia.[52] Keep in mind that use of D10 may require subsequent doses or continuous dextrose source. Ensure that the glucose is re-checked to ensure appropriate response to dextrose administration. And remember that children who are acutely ill will remain at risk for hypoglycemia and, therefore, have a low threshold to initiate continuous dextrose containing source after initial isotonic fluid resuscitation.

Do not worry about hyperglycemia as a stress response, do not correct in the immediate resuscitation period.

Opioid overdose. Opioids are now the most common cause of fatal poisoning in young children.[53] Consider accidental or intentional opioid overdose in the pediatric patient with decreased mental status and poor respiratory effort or other clinical toxidromes of opioid use. The prompt use of naloxone is critical in the peri-arrest patient with opioid toxidrome. Consider the use of naloxone in undifferentiated cardiac arrest or with a convincing history, only if there is no interruption to or impact on high-quality CPR, which should remain the primary focus. The use of naloxone use is not associated with improved outcomes in pediatric cardiac arrest.[53]

Hypertonic saline. In addition to hypoglycemia, consider intra-cranial pathology as a potential etiology for decreased mental status. Have a low threshold for administration of 3% hypertonic saline at 5 mL/kg if concern for increased intracranial pressure, or intracranial hemorrhage.[54]

Exposure

Pitfall: missed trauma.

All patients should have a complete primary and secondary assessment with full exposure. In non-verbal and non-ambulatory children, the assessment of potential trauma can often be challenging. Assure complete exposure to obtain weight, and complete initial assessment. The primary survey may require intervention as discussed earlier. However, during the secondary survey, a full skin assessment to evaluate for potential source of infection or clues to occult trauma should be completed. Particular attention should be made to the genitourinary and extremity examinations, as well as for scalp hematomas. Parietal/temporal hematomas are associated with higher risk for underlying skull fracture. It has been found that there are high rates of missed musculoskeletal trauma during initial assessment.[55] Consider trauma in an otherwise undifferentiated hypotensive or unresponsive pediatric patient.

Pitfall: hypothermia.

Although exposure is critical during initial assessment and for reassessment with decompensation, hypothermia is a risk for smaller patients. Infants, particularly preterm neonates, are at high risk for environmental hypothermia secondary to large surface to volume ratio and high loss of heat relative to stored heat, and thermoregulation immaturity in pre-term infants. Hypothermia is associated with increased mortality in both pediatric and adult trauma patients, thought to be secondary to coagulopathy. Less data exist for medical resuscitations; however, some data supporting therapeutic normothermia/mild hypothermia after ROSC, it is critical to reserve this for the small ROSC population rather than applied to the general resuscitation. External warmers may be helpful during initial assessment and resuscitation. Swaddling/warm blankets should be reserved for after the initial assessment so as not to miss associated trauma or delay access as discussed earlier. However, following initial stabilization and assessment, bundling is an effective tool for temperature regulation in smaller children.[56]

SUMMARY

In summary, pediatric resuscitation can be stressful, challenging, and decompensation can occur rapidly. Because of this, it is imperative that there is a strong organizational system to access your equipment on a weight or age-based system. Teams should practice pediatric resuscitation often and in a variety of environments. Utilize the fundamental interventions often, such as airway positioning, bag valve mask, nasal cannula, and intraosseous access. Be aware of vital sign trends and recognize signs of decompensation promptly, with early intervention including oxygenation, access, balanced volume resuscitation, early vasopressor administration, and early escalation of care.

CLINICS CARE POINTS

- Practice pediatric resuscitation with simulation, including team composition, accessing equipment, and obtaining weights for medication dosing.

- Worsening tachycardia or tachypnea may precede hypotension and hypoxia in pediatric shock.
- Airway positioning with utilization of airway adjuncts, such as supraglottic airways, is imperative during the immediate resuscitation period to minimize peri-intubation hypoxemia.
- Minimize time off the chest during CPR and utilize step stool and compression feedback tools when available to optimize CPR during a code event.
- Two quick attempts at IV access are acceptable, followed immediately by IO placement without delay. Early administration of epinephrine and volume resuscitation is associated with improved outcomes. Remember that early dextrose administration may be required given the minimal glucose stores in younger children.
- Utilize POC tools, such as glucose check, electrolytes, venous blood gas and lactate, and POCUS to guide resuscitation and evaluate for reversible etiologies of decompensation.

DISCLOSURE

The authors declare no relevant financial relationships or personal relationships that have influenced the work reported in this paper.

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