Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality

The 2015 Guidelines Update for pediatric BLS concentrated on modifications in the algorithms for lone- and 2-rescuer CPR, initial actions of rescuers, and CPR quality process measures. Algorithms for 1- and 2-person healthcare provider CPR have been separated to better guide rescuers through the initial stages of resuscitation. In an era where handheld cellular telephones with speakers are common, this technology can allow a single rescuer to activate the emergency response system while beginning CPR. Healthcare providers should perform an assessment of breathing and pulse check simultaneously, to minimize delays in starting CPR if the child is unresponsive with no breathing or only gasping.

Significant New and Updated Recommendations

The 3 major CPR process characteristics that were evaluated included C-A-B (Compressions, Airway, Breathing) versus A-B-C (Airway, Breathing, Compressions), compression-only CPR, and compression depth and rate. No major changes were made for the 2015 Guidelines Update; however, new concepts in CPR delivery were examined for children. Because of the limited amount and quality of the data, it may be reasonable to maintain the sequence from the 2010 Guidelines by initiating CPR with C-A-B over A-B-C (Class IIb, LOE C-E0). There are no pediatric human studies to evaluate C-A-B versus A-B-C, but manikin studies do demonstrate a shorter time to first chest compression. This recommendation was made to simplify training, provide consistency for teaching rescuers of adults and children, and hopefully increase the number of victims who receive bystander CPR.

Compression depth of at least one third of the anterior-posterior diameter, approximately 1.5 inches (4 cm) for infants and approximately 2 inches (5 cm) for children, was affirmed (Updated). The Class of Recommendation was downgraded from Class I to Class IIa, primarily based on the rigor of the evidence evaluation. There are limited clinical data on the effect of compression depth on resuscitation outcomes, but 2 clinical studies suggest that compression depth is also associated with survival.

Compression rate was not reviewed because of insufficient evidence, and we recommend that rescuers use the adult rate of 100 to 120/min (Updated).

The asphyxial nature of the majority of pediatric cardiac arrests necessitates ventilation as part of effective CPR, and 2 large database studies documented worse 30-day outcomes with compression-only CPR compared with conventional CPR. For this reason, conventional CPR (chest compressions and rescue breaths) is a Class I recommendation (LOE B-NR) for children. However, because compression-only CPR is effective in patients with a primary cardiac event, if rescuers are unwilling or unable to deliver breaths, we recommend rescuers perform compression-only CPR for infants and children in cardiac arrest (Class I, LOE B-NR).

Conventional CPR (chest compressions and rescue breaths) is a Class I recommendation (LOE B-NR).

Knowledge Gaps

Much of the data supporting pediatric BLS is primarily extrapolated from studies in adults. Multicenter pediatric studies from both in-hospital and out-of-hospital arrest are needed to optimize outcomes for children.

More knowledge is needed about the optimal sequence, feedback techniques and devices, and effect of different surfaces on CPR delivery in children.

Pediatric Advanced Life Support

Significant New and Updated Recommendations

The following are the most important changes and reinforcements to recommendations made in the 2010 Guidelines:
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Pediatric Cardiac Arrest Algorithm for the Single Rescuer—2015 Update

Verify scene safety.

Victim is unresponsive. Shout for nearby help. Activate emergency response system via mobile device (if appropriate).

- Normal breathing, has pulse
  - Look for no breathing or only gasping and check pulse (simultaneously). Is pulse definitely felt within 10 seconds?
  - No normal breathing, has pulse
    - Provide rescue breathing: 1 breath every 3-5 seconds, or about 12-20 breaths/min.
      - Add compressions if pulse remains <60/min with signs of poor perfusion.
      - Activate emergency response system (if not already done) after 2 minutes.
      - Continue rescue breathing; check pulse every 2 minutes. If no pulse, begin CPR (go to "CPR" box).
    - No breathing or only gasping, no pulse
      - Witnessed sudden collapse?
        - Yes
          - Activate emergency response system (if not already done), and retrieve AED/defibrillator.
        - No
          - CPR
            - 1 rescuer: Begin cycles of 30 compressions and 2 breaths. (Use 15:2 ratio if second rescuer arrives.) Use AED as soon as it is available.

After about 2 minutes, if still alone, activate emergency response system and retrieve AED (if not already done).

AED analyzes rhythm. Shockable rhythm?

- Yes, shockable
  - Give 1 shock. Resume CPR immediately for about 2 minutes (until prompted by AED to allow rhythm check). Continue until ALS providers take over or victim starts to move.

- No, nonshockable
  - Resume CPR immediately for about 2 minutes (until prompted by AED to allow rhythm check). Continue until ALS providers take over or victim starts to move.

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BLS Healthcare Provider
Pediatric Cardiac Arrest Algorithm for 2 or More Rescuers—2015 Update

Verify scene safety.

Victim is unresponsive. Shout for nearby help. First rescuer remains with victim. Second rescuer activates emergency response system and retrieves AED and emergency equipment.

Provide rescue breathing: 1 breath every 3-5 seconds, or about 12-20 breaths/min.
- Add compressions if pulse remains ≤60/min with signs of poor perfusion.
- Activate emergency response system (if not already done) after 2 minutes.
- Continue rescue breathing; check pulse about every 2 minutes. If no pulse, begin CPR (go to “CPR” box).

Look for no breathing or only gasping and check pulse (simultaneously). Is pulse definitely felt within 10 seconds?

Normal breathing, has pulse

Monitor until emergency responders arrive.

No normal breathing, has pulse

No breathing or only gasping, no pulse

CPR
First rescuer begins CPR with 30:2 ratio (compressions to breaths). When second rescuer returns, use 15:2 ratio (compressions to breaths). Use AED as soon as it is available.

Yes, shockable

Give 1 shock. Resume CPR immediately for about 2 minutes (until prompted by AED to allow rhythm check). Continue until ALS providers take over or victim starts to move.

No, nonshockable

Resume CPR immediately for about 2 minutes (until prompted by AED to allow rhythm check). Continue until ALS providers take over or victim starts to move.

AED analyzes rhythm. Shockable rhythm?

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There is new evidence that when treating pediatric septic shock in specific settings, the use of restricted volume of isotonic crystalloid leads to improved survival, contrasting with the long-standing belief that all patients benefit from aggressive volume resuscitation. New guidelines suggest a cautious approach to fluid resuscitation, with frequent patient reassessment, to better tailor fluid therapy and supportive care to children with febrile illness. New literature suggests limited survival benefit to the routine use of atropine as a premedication for emergency tracheal intubation of non-neonates, and that any benefit in preventing arrhythmias is controversial. Recent literature also provides new evidence suggesting there is no minimum dose required for atropine use.

Children in cardiac arrest may benefit from the titration of CPR to blood pressure targets, but this strategy is suggested only if they already have invasive blood pressure monitoring in place.

New evidence suggests that either amiodarone or lidocaine is acceptable for treatment of shock-refractory pediatric ventricular fibrillation and pulseless ventricular tachycardia.

Recent literature supports the need to avoid fever when caring for children remaining unconscious after OHCA (Out of hospital cardiac arrest).

The writing group reviewed a newly published multicenter clinical trial of targeted temperature management that demonstrated that a period of either 2 days of moderate therapeutic hypothermia (32° to 34° C) or the strict maintenance of normothermia (36° to 37.5° C) were equally beneficial. As a result, the writing group feels either of these approaches is appropriate for infants and children remaining comatose after OHCA.

Hemodynamic instability after cardiac arrest should be treated actively with fluids and/or isotropes/vasopressors to maintain systolic blood pressure greater than the fifth percentile for age. Continuous arterial pressure monitoring should be used when the appropriate resources are available.

Knowledge Gaps

What clinical or physiologic parameters reflect high-quality pediatric CPR and improve outcome in children? Do devices to monitor these parameters improve survival?

What is the role of targeted temperature management in the care of children who remain unconscious after in-hospital cardiac arrest?

Does a postarrest bundle of care with specific targets for temperature, oxygenation and ventilation, and hemodynamic parameters improve outcomes after pediatric cardiac arrest?

Does a combination of intra-arrest factors reliably predict successful resuscitation in children with either OHCA or IHCA?

Neonatal Resuscitation

“Neonatal Resuscitation” presents new guidelines for resuscitation of primarily newly born infants transitioning from intrauterine to extraterine life. The recommendations are also applicable to neonates who have completed newborn transition and require resuscitation during the first weeks after birth.

Much of the neonatal resuscitation guidelines remains unchanged from 2010, but there is increasing focus on umbilical cord management, maintaining a normal temperature after birth, accurate determination of heart rate, optimizing oxygen use during resuscitation, and de-emphasis of routine suctioning for meconium in nonvigorous newborns. The etiology of neonatal arrest is almost always asphyxia, and therefore, establishing effective ventilation remains the most critical step.

Significant New and Updated Recommendations

Umbilical cord management: The 2015 Guidelines Update includes for the first time recommendations regarding umbilical cord management. Until recently, it was common practice to clamp the umbilical cord immediately after birth to facilitate rapid transfer of the baby to the pediatric provider for stabilization. A significant issue with the available evidence is that the published studies enrolled very few babies who were considered to need resuscitation.

There is evidence, primarily in babies who do not require resuscitation, that delayed cord clamping is associated with less intraventricular hemorrhage, higher blood pressure and blood volume, less need for transfusion after birth, and less necrotizing enterocolitis. Delayed cord clamping conferred no benefit on mortality or severe intraventricular
Neonatal Resuscitation Algorithm—2015 Update

1. Antenatal counseling
   Team briefing and equipment check

2. Birth

3. Term gestation? Good tons? Breathing or crying?
   Yes
   Infant stays with mother for routine care: warm and maintain normal temperature, position airway, clear secretions if needed, dry, stimulate
   No
   Warm and maintain normal temperature, position airway, clear secretions if needed, dry, stimulate

4. Apnea or gasping? HR below 100/min?
   Yes
   PPV
   SpO₂ monitor
   Consider ECG monitor
   No
   Labored breathing or persistent cyanosis?
   Yes
   Position and clear airway
   SpO₂ monitor
   Supplementary O₂ as needed
   Consider CPAP
   No
   Postresuscitation care
   Team debriefing

5. HR below 100/min?
   Yes
   Check chest movement
   Ventilation corrective steps if needed
   ETT or laryngeal mask if needed
   No
   Targeted Postnatal SpO₂ After Birth
   1 min 60%-65%
   2 min 65%-70%
   3 min 70%-75%
   4 min 75%-80%
   5 min 80%-85%
   10 min 85%-95%

6. HR below 60/min?
   Yes
   Intubate if not already done
   Chest compressions
   Coordinate with PPV
   100% O₂
   ECG monitor
   Consider emergency UVC
   No
   IV epinephrine
   If HR persistently below 60/min
   Consider hypovolemia
   Consider pneumothorax
hemorrhage. The only negative consequence seems to be a slightly increased level of bilirubin, associated with more need for phototherapy.2,3

Delayed cord clamping for longer than 30 seconds is reasonable for both term and preterm infants who do not require resuscitation at birth (Class IIa, LOE C-LD). There is still insufficient evidence to recommend an approach to cord clamping or cord “milking” for babies who require resuscitation at birth.

Assessment of heart rate: Immediately after birth, assessment of the newborn’s heart rate is used to evaluate the effectiveness of spontaneous respiratory effort and determine the need for subsequent interventions. An increase in the newborn’s heart rate is considered the most sensitive indicator of a successful response to resuscitation interventions. Therefore, identifying a rapid, reliable, and accurate method to measure the newborn’s heart rate is critically important.

Available evidence comparing clinical assessment with ECG in the delivery room and simultaneous pulse oximetry and ECG heart rate determination found that clinical assessment was both unreliable and inaccurate.

ECG (3-lead) displayed a reliable heart rate faster than pulse oximetry. Pulse oximetry tended to underestimate the newborn’s heart rate and would have led to potentially unnecessary interventions.2,3

During resuscitation of term and preterm newborns, the use of 3-lead ECG for the rapid and accurate measurement of the newborn’s heart rate may be reasonable (Class IIb, LOE C-LD).

Maintaining normal temperature of the newborn after birth: It is recommended that the temperature of newly born non asphyxiated infants be maintained between 36.5°C and 37.5°C after birth through admission and stabilization (Class I, LOE C-LD).1 There is new evidence supporting a variety of interventions that may be used alone or in combination to reduce hypothermia. Temperature must be monitored to avoid hyperthermia as well.

Management of the meconium stained infant: For more than a decade, vigorous infants born through meconium stained amniotic fluid have been treated no differently than if they had been born through clear fluid. However, there remained a long standing practice to intubate and suction infants born through meconium stained amniotic fluid who have poor muscle tone and inadequate breathing efforts at birth. Routine intubation for tracheal suction in this setting is not suggested because there is insufficient evidence to continue recommending this practice (Class IIb, LOE C-LD).2,3

In making this suggested change, greater value has been placed on harm avoidance (delays in providing positive-pressure ventilation, potential harm of the procedure) over the unknown benefit of the intervention of routine trachea intubation and suctioning.

Oxygen use for preterm infants in the delivery room: Since the release of the 2010 Guidelines, additional randomized trials have been published that examine the use of oxygen during resuscitation and stabilization of preterm newborns. These additional publications have allowed an increase from Class IIb to a Class I recommendation.

Meta-analysis of the randomized trials that compared initiating resuscitation of preterm newborns (less than 35 weeks of gestation) with high oxygen (65% or greater) versus low oxygen (21%–30%) showed no improvement in survival or morbidity to hospital discharge with the use of high oxygen.2,3

Resuscitation of preterm newborns of less than 35 weeks of gestation should be initiated with low oxygen (21%–30%), and the oxygen concentration should be titrated to achieve preductal oxygen saturation approximating the interquartile range measured in healthy term infants after vaginal birth at sea level (Class I, LOE B-R). This recommendation reflects a preference for not exposing preterm newborns to additional oxygen without data demonstrating a proven benefit for important outcomes.

Oxygen use during neonatal cardiac compressions: The evidence for optimal oxygen use during neonatal cardiac compressions was not reviewed for the 2010 Guidelines. Unfortunately, there are no clinical studies to inform the neonatal guidelines, but the available animal evidence demonstrated no obvious advantage of 100% oxygen over air. However, by the time resuscitation of a newborn includes cardiac
compressions, the steps of trying to improve the heart rate via effective ventilation with low concentrations of oxygen should have already been tried. Thus, the 2015 Guidelines Task Force thought it was reasonable to increase the supplementary oxygen concentration during cardiac compressions and then subsequently wean the oxygen as soon as the heart rate recovers. Structure of educational programs to teach neonatal resuscitation: Currently, neonatal resuscitation training that includes simulation and debriefing is recommended at 2-year intervals.

Studies that examined how frequently healthcare providers or healthcare students should train showed no differences in patient outcomes, but demonstrated some advantages in psychomotor performance, knowledge, and confidence when focused task training occurred every 6 months or more frequently.2,3 It is therefore suggested that neonatal resuscitation task training occur more frequently than the current 2-year interval (Class IIb, LOE B-R, LOE C-EO, LOE C-LD).1

Knowledge Gaps

Umbilical cord management for newborns needing resuscitation: As noted previously, the risks and benefits of delayed cord clamping for newborns who need resuscitation after birth remains unknown because such infants have thus far been excluded from the majority of trials. Concern remains that delay in establishing ventilation may be harmful. Further study is strongly endorsed. Some studies have suggested that cord milking might accomplish goals similar to delayed cord clamping.2,3 Cord milking is rapid and can be accomplished within 15 seconds, before resuscitation might ordinarily be initiated. However, there is insufficient evidence of either the safety or utility of cord milking in babies requiring resuscitation. The effect of delayed cord clamping or cord milking on initial heart rate and oxygen saturations is also unknown. New normal ranges may need to be determined. The risks and benefits of inflating the lungs to establish breathing before clamping of the umbilical cord needs to be explored.

Utility of a sustained inflation during the initial breaths after birth: Several recent animal studies suggested that a longer sustained inflation may be beneficial for establishing functional residual capacity during transition from fluid-filled to air-filled lungs after birth. Some clinicians have suggested applying this technique for transition of human newborns.

It was the consensus of the 2015 CoSTR and the 2015 Guidelines Task Force that there was inadequate study of the benefits and risks to recommend sustained inflation at this time. Further study using carefully designed protocols was endorsed (see “Part 13: Neonatal Resuscitation” in this 2015 Guidelines Update and Perlman et al2,3).

Determination of heart rate: Neonatal resuscitation success has classically been determined by detecting an increase in heart rate through auscultation. Heart rate also determines the need for changing interventions and escalating care. However, recent evidence demonstrates that auscultation of heart rate is inaccurate, and pulse oximetry takes several minutes to achieve a signal and also may be inaccurate during the early minutes after birth. Use of ECG in the delivery room has been suggested as a possible alternative.

Although data suggest that the ECG provides a more accurate heart rate in the first 3 minutes of life, there are no available data to determine how outcomes would change by acting (or not acting) on the information. Some transient bradycardia may be normal and be reflective of timing of cord clamping. More studies are needed.

The human factors issues associated with introducing ECG leads in the delivery room are unknown. In addition, improved technologies for rapid application of ECG are needed.

References
