

Pediatric Basic and Advanced Life Support: An Update on Practice and Education

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Abstract

This review aims to summarize the major changes in the 2010 Heart and Stroke foundation of Canada (HSFC) and the American Heart Association (AHA) Pediatric Basic and Advanced Life Support Guidelines. The Guidelines were based on the International Liaison Committee on Resuscitation's (ILCOR) comprehensive, evidence-based review of the resuscitation literature. The key recommendations from the Guidelines include: the removal of "look, listen and feel" and a de-emphasis on the use of the pulse check by healthcare providers to diagnose cardiac arrest; a change in the sequence of resuscitation for patients in cardiac arrest from the previously well-known "A-B-C" i.e. Airway, Breathing, and Chest Compressions to "C-A-B" i.e. Chest Compressions first; modification to the appropriate depth of compression (at least 1/3 of the anterior-posterior depth of the chest wall or about 4 cm in infants and 5 cm in children); end-tidal CO₂ monitoring (in intubated patients) to assess the quality of chest compressions and optimize cardiopulmonary resuscitation (CPR); and titrating FiO₂ once "Return of Spontaneous Circulation" (ROSC) is achieved to maintain an oxygen saturation between 94-99%. Overall, pediatricians, family and community physicians who may care for acutely ill children should be aware of these updated guidelines in order to provide the best possible care to their patients.

Introduction

In October 2010, the American Heart Association (AHA) and Heart and Stroke Foundation of Canada (HSFC) published updated Guidelines on Pediatric Basic Life Support (PBLIS) and Pediatric Advanced Life Support (PALS). The present

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review highlights the significant changes made to the PBLIS and PALS Guidelines relevant to pediatricians as well as family and community physicians. The complete guidelines are published in the journal *Circulation*, and can be accessed at www.circulationaha.org. Neonatal resuscitation is not included in this article, however the complete Neonatal Resuscitation Guidelines are available online at *Circulation* (*Circulation*, 2010; 122(suppl 3): S909-S919).¹

Quality of evidence

The AHA/HSFC Guidelines for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care (ECC) are based on the ILCOR "Consensus on Science and Treatment Recommendations", the most up-to-date and comprehensive review of resuscitation literature.² The 'Levels of Evidence' of these Guidelines is consistent with the format used by the American College of Cardiology Foundation and the American Heart Association. (Table 1)

Part I: Pediatric Basic Life Support (PBLIS)

A number of changes have been made to the Pediatric Basic Life Support Guidelines and a summary of the key changes is presented below.

Key PBLIS issues and major changes in the 2010 HSFC and AHA Guidelines:

- Elimination of "Look, Listen and Feel" for assessment of cardiac arrest
- No Pulse check for lay rescuers. Healthcare providers (HCPs) may take up to 10 sec to feel for a pulse. If in doubt, start CPR.
- C-A-B instead of A-B-C: Initiate chest compressions before giving rescue breaths
- Increased emphasis on high quality CPR
- An automated external defibrillator (AED)* may be used for an infant if a manual defibrillator is not available.

Elimination of "look, listen and feel"

The Guidelines have removed the use of "look, listen and feel" to diagnose a potential cardiac arrest victim. The new recommendation is to initiate CPR if the victim is unresponsive and not breathing (or only gasping). (Table 1 Class IIa, LOE C)

Table 1: Classification of recommendation and level of Evidence

		SIZE OF TREATMENT EFFECT →			
		CLASS I	CLASS IIa	CLASS IIb	CLASS III
		Benefit >>> Risk Procedure/Treatment SHOULD be performed/administered	Benefit >> Risk Additional studies with focused objectives needed IT IS REASONABLE to perform procedure/administer treatment	Benefit ≥ Risk Additional studies with broad objectives needed; additional registry data would be helpful Procedure/Treatment MAY BE CONSIDERED	Risk ≥ Benefit Procedure/Treatment should NOT be performed/administered SINCE IT IS NOT HELPFUL AND/OR MAY BE HARMFUL
ESTIMATE OF CERTAINTY (PRECISION) OF TREATMENT EFFECT	LEVEL A Multiple populations evaluated* Data derived from multiple randomized clinical trials or meta-analyses	<ul style="list-style-type: none"> Recommendation that procedure or treatment is useful/effective Sufficient evidence from multiple randomized trials or meta-analyses 	<ul style="list-style-type: none"> Recommendation in favor of treatment or procedure being useful/effective Some conflicting evidence from multiple randomized trials or meta-analyses 	<ul style="list-style-type: none"> Recommendation's usefulness/efficacy less well established Greater conflicting evidence from multiple randomized trials or meta-analyses 	<ul style="list-style-type: none"> Recommendation that procedure or treatment is not useful/effective and may be harmful Sufficient evidence from multiple randomized trials or meta-analyses
	LEVEL B Limited populations evaluated* Data derived from a single randomized trial or nonrandomized studies	<ul style="list-style-type: none"> Recommendation that procedure or treatment is useful/effective Evidence from single randomized trial or nonrandomized studies 	<ul style="list-style-type: none"> Recommendation in favor of treatment or procedure being useful/effective Some conflicting evidence from single randomized trial or nonrandomized studies 	<ul style="list-style-type: none"> Recommendation's usefulness/efficacy less well established Greater conflicting evidence from single randomized trial or nonrandomized studies 	<ul style="list-style-type: none"> Recommendation that procedure or treatment is not useful/effective and may be harmful Evidence from single randomized trial or nonrandomized studies
	LEVEL C Very limited populations evaluated* Only consensus opinion of experts, case studies, or standard of care	<ul style="list-style-type: none"> Recommendation that procedure or treatment is useful/effective Only expert opinion, case studies, or standard of care 	<ul style="list-style-type: none"> Recommendation in favor of treatment or procedure being useful/effective Only diverging expert opinion, case studies, or standard of care 	<ul style="list-style-type: none"> Recommendation's usefulness/efficacy less well established Only diverging expert opinion, case studies, or standard of care 	<ul style="list-style-type: none"> Recommendation that procedure or treatment is not useful/effective and may be harmful Only expert opinion, case studies, or standard of care

The Utility of the Pulse Check

Lay rescuers should not use the pulse check to diagnose cardiac arrest. In addition, the assessment of a pulse by healthcare providers is not reliable. They should take no more than 10 seconds to check for a pulse (brachial in infant and carotid or femoral in a child). If within 10 seconds, no pulse can be felt or the provider is unsure of its presence, chest compressions should be started immediately. (Table 1 Class IIa, LOE C)

The Change of Sequence from ABC to CAB

The 2010 HSCF and AHA Guidelines for PBLIS changed the sequence of resuscitation for patients in cardiac arrest from the previously well-known "A-B-C" i.e. Airway, Breathing, and Chest Compression to "C-A-B" i.e. Chest Compressions first. The rationale for this change is as follows:

Bystander CPR dramatically improves survival from out-of-hospital cardiac arrest in both pediatric and adult populations.³⁻⁵ Unfortunately, only 15-30% of out-of-hospital sudden cardiac arrest victims receive CPR prior to the arrival of Emergency Medical Services (EMS).^{6,7} Reluctance to initiate CPR may, in part, relate to the technical difficulty in opening the airway and delivering rescue breaths. Therefore, starting with chest compressions (the 'simpler' component of CPR) may encourage more witnesses to act when faced with victims of cardiac arrest.

2. The majority of cardiac arrest victims are adults where Ventricular Fibrillation (VF) or pulseless Ventricular

Tachycardia (VT) is common. Those victims have better survival when the arrest is witnessed and when chest compression and defibrillation are initiated rapidly. The change to the CAB sequence will simplify BLS training and make teaching consistent for arrest victims of all age groups (infants, children and adults) with the hope that more bystanders will be willing to provide at least chest compressions when faced with a cardiac arrest victim.

- In contrast to adults, cardiac arrests in infants and children are usually asphyxial in nature i.e. secondary to hypoxia or shock (which, if left untreated, leads to progressive bradycardia and ultimately asystole, not primary VF as in adults). Thus ventilation is critically important in pediatric resuscitation. However, performing 30 chest compressions before ventilation will theoretically only delay ventilation by approximately 18 seconds (for the lone rescuer) and even less for two healthcare providers. This minimal delay is unlikely to affect the outcome of resuscitation, but will probably generate blood flow to vital organs sooner. There is no evidence to suggest that starting with ventilation (as in ABC) is superior to starting with chest compressions (as in CAB).

Compression-Ventilation Ratio for Infants and Children

The compression-to-ventilation ratio of 30:2, for the lone rescuer, and 15:2, for two healthcare providers, is the same as the previous 2005 Guidelines. Once an advanced airway is in place, synchronization of chest compressions with ventilation is not required. Instead, chest compressions should be continued with

no /or minimal interruption, at a rate of at least 100/min without pause for ventilation. The ventilation rate should be 8-10 breaths/min to avoid excessive ventilation. It is important to note the differences in resuscitation of the newly born in the delivery room as compared to that in infants and children. The compression-to-ventilation ratio for neonatal resuscitation is 3:1 with a pause for ventilation whether or not the infant has an advanced airway. This compression-to-ventilation ratio applies only to newborns in the delivery room and in the newborn nursery /or neonatal intensive care unit (NICU). Once the infant leaves the hospital, the resuscitation should be conducted with the usual 30:2 (one rescuer) or 15:2 (two rescuer) compression-to-ventilation ratios.

Hands-only CPR is NOT Recommended for Children

Cardiac arrests in children are typically asphyxial in nature precipitated by hypoxia or shock which progresses to cardiac arrest compared to that in adults where sudden cardiac arrest is frequent from a primary cardiac etiology. Animal studies demonstrate that hands-only CPR is sufficient to resuscitate VF cardiac arrest (which is common in adults) but not asphyxial cardiac arrest (which is common in children).^{8,9}

A recent meta-analysis of randomized control trials showed an increase in survival to hospital discharge with hands-only compared to conventional CPR in adult cardiac arrest victims.¹⁰ However, a large pediatric out-of-hospital cardiac arrest study showed that cardiac arrest victims receiving conventional CPR had more favourable neurological outcomes compared to those who received hands-only CPR.

Thus, the new guidelines consider optimal CPR for infants and children to include both ventilation and chest compression (Table 1 Class I, LOE B). However, chest compression alone is preferable to no CPR if the bystander is unwilling or unable to perform conventional CPR.

Emphasis on Effective Chest Compression

High quality chest compressions are the cornerstone of successful CPR. Inadequate chest compression rate and depth are common during CPR even among healthcare providers.^{11,12} Evidence shows that cardiac arrest victims frequently receive excessive ventilation during CPR which increases intrathoracic pressure causing a decrease in venous return and cardiac output, barotrauma and aspiration.¹¹ The new Guidelines recommend using only the force and tidal volume (TV) needed to just make the chest rise visibly. Each breath should be given over approximately one second at a rate of 8-10 breaths/minute if the patient is intubated.

Key elements of high quality CPR:

- Push fast (at least 100/min)
- Push hard (4 cm in infant, 5 cm or 1/3 of chest depth in children)
- Allow full chest recoil between compressions
- Avoid excessive ventilation

- Minimize interruptions
- Avoid pre-shock pause
- Resume CPR immediately after a shock
- Rotate compressor role every 2 min (to avoid fatigue).

Defibrillation and the use of Automated External Defibrillators (AEDs)

Pediatric cardiac arrest victims with a shockable rhythm (VF or pulseless VT) require rapid defibrillation, which may be achieved through either a manual defibrillator or an AED. Manual defibrillation is preferred in infants and children and the recommended first shock energy dose is 2-4 J/kg. Subsequent defibrillation attempts should use energy doses of at least 4 J/kg (but not to exceed 10 J/kg). If a manual defibrillator is not available, an AED with a pediatric dose attenuator is preferred for both infants (below one year of age) and in children below eight years of age. However, if neither is available, an AED without a dose attenuator may be used (Table 1 Class IIb, LOE C). It is important to resume chest compressions immediately after the shock, without stopping to analyze the cardiac rhythm, and continue until it is time for the next rhythm check (2 minutes or about 5 cycles of CPR).

Part II: Pediatric Advanced Life Support (PALS)

Several changes have been made to the Pediatric Advanced Life Support Guidelines and a summary of the key changes is presented below.

Key PALS issues and major changes in the 2010 HSFC and AHA Guidelines:

- End Tidal (ET) CO₂ monitoring is recommended to confirm endotracheal intubation and may be used to assess and improve the quality of chest compressions.
- Cuffed endotracheal tubes are acceptable for use in infants and children.
- Routine use of cricoid pressure is not recommended.
- Once ROSC is achieved, titrate FiO₂ to achieve arterial oxyhemoglobin saturation between 94% and 99% to limit the risk of hyperoxemia.
- Therapeutic hypothermia may be considered for infants and children if they remain comatose after resuscitation from cardiac arrest.
- Limit administration of calcium in resuscitation to specific circumstances (e.g. documented hypocalcemia, calcium channel blocker overdose, hypermagnesemia or hyperkalemia).
- Adenosine may be used for the diagnosis and treatment of regular, monomorphic wide-complex tachycardia in patients who are not known to have Wolff-Parkinson-White (WPW) syndrome.
- Young victims with unexplained sudden cardiac death should have an unrestricted, complete autopsy with preservation of tissue for genetic analysis. The results may help identify other family members with an inherited channelopathy.

End-Tidal CO₂ Monitoring and the Quality of CPR

ETCO₂ monitoring may be used as an indicator of the quality of chest compressions and be useful to guide therapy. If the ETCO₂ is consistently <10-15 mm Hg, CPR may need to be modified to ensure adequate cardiac output by pushing fast and hard, avoiding hyperventilation and minimizing interruptions. Hyperventilation increases intra-thoracic pressure, decreases preload to the heart and hence decreases cardiac output.

Return of Spontaneous Circulation (ROSC) may be preceded by an abrupt and sustained increase in ETCO₂ which is a marker of increased pulmonary blood flow. It can be used as a physiological marker of ROSC, instead of pulse checks, thus avoiding unnecessary interruptions in chest compressions.

Cuffed versus Uncuffed Endotracheal Tubes

The use of both cuffed and uncuffed endotracheal tubes are acceptable when intubating infants and children (Table 1 Class IIa, LOE C). The cuffed endotracheal tube size can be estimated by using the following formula for children older than two years of age:

$$\text{Cuffed endotracheal tube size ID (mm)} = 3.5 + (\text{age}/4)$$

For infants less than 1 year of age, and children between 1 and 2 years of age, it is reasonable to use a cuffed endotracheal tube with an internal diameter of 3.0 mm and 3.5 mm, respectively.

Cricoid Pressure

There is inadequate evidence to recommend the routine use of cricoid pressure when intubating a child or infant with cardiac arrest. (Table 1 Class III, LOC C)

Post-Resuscitation Care

Titrating oxygen to appropriate levels after ROSC

Resuscitation should be conducted with 100% oxygen until circulation is restored. Once ROSC is achieved, adjust the FiO₂ to maintain oxygen saturation between 94% and 99% (Table 1 Class IIb, LOE C), as hyperoxia can increase reperfusion injury after an ischemic insult. In a recent multicenter, cohort study of patients admitted to ICU after resuscitation from cardiac arrest, the mortality was significantly higher in the hyperoxia group compared to the hypoxia and normoxia groups.¹³

Therapeutic hypothermia after cardiac arrest

The use of therapeutic hypothermia (32°C-34°C) is reasonable for adolescents who remain comatose after resuscitation from sudden, witnessed, out-of-hospital VF arrest (Table 1 Class IIb, LOE C). It may be considered for infants and children who remain comatose after cardiac arrest (Table 1 Class IIb, LOE C).

The Key highlights with regards to medications during cardiac arrest

Medication Dose Calculation

To calculate resuscitation medication, use the actual (and not the ideal) body weight of the child, or use a body length tape with pre-calculated

doses (Table 1 Class IIa, LOE C) regardless of the habitus of the child, but not to exceed the standard dose recommended for adults.

Adenosine

Wide complex tachycardia may be ventricular or supraventricular in origin. Consultation with an expert in pediatric arrhythmias is strongly recommended before treatment in stable patients as all anti-arrhythmics can cause serious side effects. Recent evidence suggests that adenosine is relatively safe for both treatment and diagnosis of regular, monomorphic, wide-complex tachycardia (Table 1 Class IIb, LOE B). However, adenosine should not be given if the rhythm is irregular, or polymorphic and/or an unstable wide-complex tachycardia as it may cause VF. Adenosine should not be used for wide-complex tachycardia in patients with known Wolff-Parkinson-White syndrome.

Evaluation of unexplained, Sudden Cardiac Death victims

Cardiac ion channelopathies such as long QT syndrome are increasingly recognized as an important cause of Sudden Cardiac Death (SCD) in young people. When SCD occurs in children or young adults, a complete past medical and family history are essential (see important screening questions) and review of previous ECGs, if available, may be helpful in identifying families at risk. Victims of unexplained SCD should, if resources allow, have an unrestricted, complete autopsy ideally performed by a pathologist with experience in cardiovascular pathology. Their family members should be referred for screening (Table 1 Class I, LOE C) to healthcare providers or centers with expertise in arrhythmias.

Important past medical and family screening questions for sudden cardiac arrest include:

- History of syncopal episodes
- History of seizures
- Unexplained accidents or drowning
- Sudden, unexplained death at <50 years of age

Education and Implementation

Cardiac arrest outcomes depend heavily on the performance of CPR by lay rescuers and healthcare providers. Maximizing survival from cardiac arrest requires improvements in education and the implementation of systems that support the delivery of high-quality resuscitation and post-arrest care, including mechanisms to systematically monitor resuscitation performance of community-based and hospital-based systems.

For lay rescuers, one significant factor that can affect their willingness to perform CPR (a major determinant of survival) is recent training.¹⁴ Family physicians may be able to improve survival from cardiac arrest by promoting CPR training of their patients and families and may themselves serve as examples by keeping their basic life support certification up to date. Interestingly, CPR skills can be learned equally well and retained with short (e.g. 22 minutes) video-based self-instruction courses combined with synchronous hands-on practice and by longer traditional training courses. (Table 1 Class I, LOE A)

Emergency Medical Services dispatchers should provide CPR instructions to callers reporting a potential cardiac arrest victim who is unresponsive and not breathing or gasping as this has been shown to increase the willingness of bystanders to perform CPR and patient survival. For a complete reference on the important issues in education and implementation of resuscitation programs, the reader is referred to the complete guidelines in the journal *Circulation* (*Circulation*, 2010;122(suppl 3):S920-S933).

Conclusion

Cardiac arrest remains an important issue in the care of pediatric and adult patients. This article reminds practitioners of the differences in the etiology of pediatric and adult cardiac arrests while also describing the major updates to the new guidelines for the management of pediatric cardiac arrest. Further improvement in the care of all cardiac arrest patients is likely to occur through education and appropriate implementation of resuscitation programs and quality assurance.

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