AHA Pediatric Advanced Life Support Update 2020 - "More Breaths, Less Fluids, and a Focus on Recovery"

Manjinder Singh Randhawa, Vishwa Chenniganahosahalli Revaiah and Muralidharan Jayashree
From Division of Pediatric Critical Care, Department of Pediatrics, PGIMER, Chandigarh, India.
Correspondence to: Dr Jayashree Muralidharan, Advanced Pediatrics Centre, Post Graduate Institute of Medical Education and Research, Chandigarh, India.
mjshree@hotmail.com

Pediatric Advanced Life Support (PALS) guidelines are updated every five years and the new 2020 guidelines were issued recently. We briefly review the important changes in terms of rates of rescue breaths, timing of epinephrine, resuscitation in septic shock, use of extracorporeal therapies, and the new component in the chain of survival – recovery.

Keywords: *Extracorporeal therapies, Management, Resuscitation, Shock*.

The American Heart Association (AHA) 2020 guidelines with their changes for pediatric basic and advanced life support were issued recently [1]. We have discussed the changes made under three headings – pre-arrest, intra-arrest and post arrest care. This will make it convenient to compare these with the 2015 document, wherein a similar division was presented.

PRE-ARREST CARE

The updated guidelines reaffirm the importance of prevention and preparedness for a cardiac arrest in children as the first component in the chain of survival.

ECLS and ECPR in Children With Myocarditis

Newer evidence that has emerged since the last guidelines, shows that pre-arrest use of Extra Corporeal Life Support (ECLS) or Mechanical Circulatory Support (MCS) in patients with myocarditis may lead to better organ support and prevention of cardiac arrest. The survival to hospital discharge in patients with structurally normal hearts, receiving Extracorporeal Cardiopulmonary Resuscitation (ECPR) was 32% in adults. Myocarditis was a favorable prognostic marker for the use of ECPR in this study. Children with acute fulminant myocarditis had a 75% survival after ECLS/MCS either with recovery of native function (43.8%) or post cardiac transplant (31.3%) [2]. Retrospective analysis of the Extracorporeal Life Support Organization (ELSO) database showed a 61% survival to hospital discharge, 3% of these with heart transplantation. A recent German prospective registry showed weaning rates of 42% in children with myocarditis who received ECLS. Early transfer to ICU is also recommended for monitoring and initiation of therapy.

Resuscitation in Septic Shock

Type of fluid: The newer guidelines have jumped into the raging debate between balanced and unbalanced crystalloids as initial fluid of choice in septic shock. Balanced crystalloids, with a composition closer to that of normal human plasma, were postulated to reduce the incidence of hyperchloremic metabolic acidosis and acute kidney injury (AKI). A retrospective matched analysis showed better survival at 72 hours and lower rates of AKI with balanced crystalloids although another similar analysis showed no difference [3,4]. A pilot RCT, that failed to demonstrate any difference, however, established the feasibility of further research in this area. While the physiological rationale for using balanced over unbalanced crystalloids seems sound, one cannot be recommended over the other, based on the current evidence.

Volume of fluid: The updated guidelines suggest that it is reasonable to administer fluids in smaller aliquots of 10-20 mL/kg with careful reassessment for both fluid responsiveness and overload after each bolus to titrate further therapy. There is a growing inventory of evidence beginning with the FEAST Trial, warning against the perils of overzealous fluid administration in septic shock. The last AHA update in 2015 had recommended cautious fluid resuscitation in setups with limited access to intensive care resources. The current 2020 update, however, recommends it uniformly, irrespective of availability of intensive care resources. On the contrary, the Survival

Table I Summary of AHA Pediatric Advanced Life Support Update 2020 [1]

	AHA 2010/2015	*AHA 2020*	*COR*	*LOE*
Pre-arrest care				
Use of ECLS and ECPR in children with Myocarditis	No Recommendation	Given the high risk of cardiac arrest in children with acute myocarditis with arrhythmias, heart block, ST-segment changes, and/or low cardiac output, early consideration for ICU transfer, monitoring and therapy is recommended	1	C-LD
	Venoarterial ECMO use may be considered in patients with acute fulminant myocarditis who are at high risk of imminent cardiac arrest	For children with myocarditis or cardiomyopathy and refractory low cardiac output, prearrest use of ECLS or MCS can be beneficial to provide end-organ support and prevent cardiac arrest	2a	B-NR
	No Recommendation	Given the challenges to successful resuscitation of children with myocarditis and cardiomyopathy, early consideration of ECPR once cardiac arrest occurs, can be beneficial	2a	B-NR
Resuscitation in Septic Shock	Providers should reassess the patient after every fluid bolus	Providers should reassess after every fluid bolus for fluid responsiveness and signs of volume overload	1	C-LD
	Either isotonic crystalloids or colloids can be effective as initial fluid for resuscitation	Either isotonic crystalloids or colloids can be effective as initial fluid for resuscitation	2a	B-R
	No Recommendation	Either balanced or unbalanced solutions can be effective as fluid choice for resuscitation	2a	B-NR
	Administration of an initial fluid bolus of 20 mL/kg to infants and children with shock is reasonable, including those with conditions such as severe sepsis, malaria and dengue	In patients with septic shock, it is reasonable to administer fluid in 10 mL/kg or 20 mL/kg aliquots with frequent reassessment	2a	C-LD
	No Recommendation	In infants and children with fluid-refractory septic shock, it is reasonable to use either epinephrine or norepinephrine as an initial vasoactive infusion	2a	C-LD
Intra-arrest care				
Airway during CPR	In the prehospital setting it is reasonable to ventilate and oxygenate infants and children with a bag-mask device, especially if transport time is short	Bag-mask ventilation is reasonable compared with advanced airway interventions (SGA and ETI) in the management of children during cardiac arrest in OHCA	2a	C-LD
Respiratory Rates with an Advanced Airway	If the infant or child is intubated, ventilate at a rate of about 1 breath every 6 to 8 seconds (8 to 10 times per minute) without interrupting chest compressions	When performing CPR in infants and children with an advanced airway, it may be reasonable to target a respiratory rate of 1 breath every 2–3 s (20–30 breaths/min), accounting for age and clinical condition. Rates exceeding these may compromise hemodynamics.	2b	C-LD
	In the victim with a perfusing rhythm but absent or inadequate respiratory effort, give 1 breath every 3 to 5 seconds (12 to 20 breaths per minute), using the higher rate for the younger child	For infants and children with a pulse but absent or inadequate respiratory effort, it is reasonable to give 1 breath every 2 to 3 s (20-30 breaths/min)	2a	C-EO
Use of Cuffed Endotracheal Tubes	Both cuffed and uncuffed endotracheal tubes are acceptable for intubating infants andchildren	It is reasonable to choose cuffed over uncuffed ETTs for intubating infants and children	2a	C-LD
	No Recommendation	When a cuffed ETT is used, attention should be paid to ETT size, position, and cuff inflation pressure (usually <20–25 cm H2O)	1	C-EO

Table contd...

Table I *continued*

	AHA 2010/2015	*AHA 2020*	*COR*	*LOE*
Use of Cricoid Pressure	Apply cricoid pressure in an unresponsive victim to reduce air entry into the stomach	Cricoid pressure during bag-mask ventilation may be considered to reduce gastric insufflation.	2b	C-LD
		Routine use of cricoid pressure is not recommended during endotracheal intubation of children.	3: No Benefit	C-LD
	Do not continue cricoid pressure if it interferes with ventilation or the speed or ease of intubation	If cricoid pressure is used, discontinue if it interferes with ventilation or the speed or ease of intubation.	3: Harm	C-LD
Early Epinephrine	It is reasonable to administer epinephrine in pediatric cardiac arrest	For pediatric patients in any setting, it is reasonable to administer the initial dose of epinephrine within 5 min from the start of chest compressions.	2a	C-LD
Use of Invasive BP monitoring during CPR	For patients with invasive hemodynamic monitoring in place at the time of cardiac arrest, it may be reasonable for rescuers to use blood pressure to guide CPR quality	For patients with continuous invasive arterial blood pressure monitoring in place at the time of cardiac arrest, it is reasonable for providers to use *diastolic* blood pressure to assess CPR quality.	2a	C-LD
Opioid Related Cardiac Arrest	Naloxone reverses the respiratory depression of narcotic overdose	For patients known or suspected to be in cardiac arrest, in the absence of a proven benefit from the use of naloxone, standard resuscitative measures should take priority over naloxone administration, with a focus on high-quality CPR (compressions plus ventilation).	1	C-EO
Post arrest care				
Targeted Temperature Management (TTM)	Continuous measurement of temperature during this time period is recommended	Continuous measurement of core temperature during TTM is recommended	1	A
	For infants and children remaining comatose after OHCA, it is reasonable either to maintain 5 days of continuous normothermia (36°C to 37.5°C) or to maintain 2 days of initial continuous hypothermia (32°C to 34°C) followed by 3 days of continuous normothermia	For infants and children between 24h and 18 yr of age who remain comatose after OHCA or IHCA, it is reasonable to use either TTM 32-34 C followed by TTM 36-37.5 C or only TTM 36-37.5 C	2a	B-R
Hemodynamic Monitoring and Ventilation	When appropriate resources are available, continuous arterial pressure monitoring is recommended to identify and treat hypotension	When appropriate resources are available, continuous arterial pressure monitoring is recommended to identify and treat hypotension	1	C-EO
	After ROSC, we recommend that parenteral fluids and/or inotropes or vasoactive drugs be used to maintain a systolic blood pressure greater than fifth percentile for age	After ROSC, parenteral fluids and/or vasoactive drugs to maintain a systolic blood pressure greater than the fifth percentile for age are recommended	1	C-LD
	It may be reasonable for rescuers to target normoxemia after ROSC	It may be reasonable for rescuers to wean oxygen to target an oxyhemoglobin saturation 94-99%	2b	C-LD
Neuromonitoring and Seizure Treatment	No Recommendation	When resources are available, continuous electroencephalography (EEG) monitoring is recommended for detection of non-convulsive seizures following cardiac arrest in patients with persistent encephalopathy	1	C-LD
	No Recommendation	It is recommended to treat clinical seizures following cardiac arrest	1	C-LD
	No Recommendation	It is reasonable to treat nonconvulsive status epilepticus following cardiac arrest in consultation	2a	C-EO

Table contd...

Table I *continued*

	AHA 2010/2015	*AHA 2020*	*COR*	*LOE*
		with experts		
Prognostication following Cardiac Arrest	EEGs performed within the first 7 days after pediatric cardiac arrest may be considered in prognosticating neurologic outcome at the time of hospital discharge but should not be used as the sole criterion.	EEG in the first week post cardiac arrest can be a useful factor for prognostication, augmented by other information	2a	B-NR
	The reliability of any one variable for prognostication in children after cardiac arrest has not been established. Practitioners should consider multiple factors when predicting outcomes in infants and children who achieve ROSC after cardiac arrest	It is reasonable for providers to consider multiple factors when predicting outcomes in infants and children who survive cardiac arrests	2a	B-NR
Recovery	No Recommendation	It is recommended that pediatric cardiac arrest survivors be evaluated for rehabilitation needs	1	C-LD
	No Recommendation	It is reasonable to refer pediatric cardiac arrest survivors for ongoing neurological evaluation for at least the first year after cardiac arrest	2a	C-LD

Class of recommendation (COR): 1: strong (Benefit>>>Risk); 2a: moderate (Benefit>>Risk); 2b: weak (Benefit³Risk); 3: no Benefit (Benefit=Risk); 3: harm (Risk>Benefit). Level of evidence (LOE):A-high quality; B-R: moderate from randomised trials; B-NR: moderate from nonrandomised data; C-LD: data with limitations of design or execution; C-EO: consensus of expert opinion.

Sepsis Campaign (SSC) Guidelines 2020 recommend smaller volume boluses of 10-20 ml/kg, upto 40-60 mL/kg in the first hour of resuscitation, where intensive care resources are available. In settings with a lack of access to intensive care, SSC recommendations differ; in the absence of hypotension (compensated shock), fluid boluses are not recommended but if hypotension is present, 10-20 mL/kg bolus may be administered with close monitoring and utmost caution [5].

Inotropes during septic shock: It is reasonable to use either epinephrine or norepinephrine as a vasoactive infusion in septic shock. This is the first time the AHA has made such a recommendation for use of inotropes, specifically for septic shock. This is based on two important trials demonstrating superiority of epinephrine over dopamine in pediatric septic shock. The American College of Critical Care Medicine recommended use of either epinephrine or norepinephrine in septic shock depending on its 'cold' or 'warm' nature [6]. The distinctions into warm and cold shock have since been abandoned by newer guidelines [5]. Norepinephrine, however, has been found to be safe and effective as a first line agent in pediatric septic shock.

INTRA-ARREST CARE

Advanced Airway During CPR

It has been seen in one prospective and 2 retrospective studies that endotracheal intubation and bag-mask ventilation (BMV) have comparable outcomes in out-of-hospital cardiac arrest (OHCA) in children [7]. Similar comparative data is however not available for in-hospital cardiac arrest (IHCA).

Respiratory Rates with an Advanced Airway

While formulating the previous guidelines, there was lack of evidence to support the use of respiratory rates different from those recommended in adults. Since then, newer evidence has emerged that higher respiratory rates may improve survival in children undergoing CPR, with a rider that overventilation may lead to hypotension [8]. Thus, rescue breaths should now be given at the rate of one breath every 2-3s (20-30/min) when an advanced airway is in place and while performing chest compressions.

Cuffed Endotracheal Tubes (ETT)

The guidelines suggest that it may be reasonable to use cuffed over uncuffed ETT in infants and children. This is based on evidence that cuffed tubes improve ventilation and reduce the incidence of ETT changes, leading to lesser trauma [9]. Care should be given towards choosing the appropriate size and maintaining cuff pressures <20-25 cm H2O.

Cricoid Pressure

Contrary to the previous guidelines, which recommended routine use of cricoid pressure (unless the maneuver

interferes with ventilation) in unresponsive children, the current guidelines recommend it in select cases primarily to prevent stomach insufflation. Routine use can hamper visualization during laryngoscopy and BMV. Newer data has shown that cricoid pressure during intubation and ventilation did not result in lower rates of regurgitation while decreasing success rates for first-attempt intubation.

Early Epinephrine

It has been established in past guidelines that epinephrine has an important role in improving coronary and cerebral perfusion during CPR. The newer guidelines put a renewed emphasis on the timing of administration of epinephrine. Early (<5 min) administration of epinephrine from the start of chest compressions in pediatric cardiac arrest was associated with improved outcomes in multiple recent multicenter data [10,11].

Use of Invasive BP monitoring during CPR

It has been suggested that in patients with invasive arterial BP monitoring lines in place, it is reasonable to use diastolic BP as a guide for quality of CPR. This recommendation stems from the evidence that a DBP >25 mmHg in infants and >30 mm Hg in children during CPR was associated with greater chances of survival to hospital discharge and better neurological outcome.

Opioid Related Cardiac Arrest

Updated guidelines emphasize the importance of routine CPR protocol over naloxone use in opioid related cardiac arrest. This arises from lack of evidence for benefit of naloxone in opioid related cardiac arrest. Once CPR has been initiated as per protocol, it is reasonable to administer naloxone in suspected or confirmed opioid related cardiac arrests.

POST-ARREST CARE

Achieving Return of Spontaneous Circulation (ROSC) is just the beginning for the healthcare providers. Following ROSC, the patient moves into the "Post Cardiac Arrest Syndrome" which includes ischemia and reperfusion injury to organs along with persisting pathophysiological derangement related to inciting trigger.

Targeted Temperature Management (TTM)

The guidelines bring into the main fold, the focused update issued in 2019 about TTM. Continuous core temperature management is recommended for post cardiac arrest patients (Both IHCA and OHCA). Hyperthermia should be strictly prevented. Either hypothermia followed by normothermia or only normothermia had similar outcomes at 1 year in 2 pediatric RCTs [12,13] and hence either may be used.

Hemodynamic Monitoring and Ventilation

The guidelines strongly advocate use of invasive arterial BP for post cardiac arrest monitoring when available and to maintain SBP >5th percentile for age. The recommendation comes from the fact that BP is labile in the period following ROSC and intermittent NIBP may be unreliable. While ventilating patients post ROSC, it has been re-emphasized that normoxemia and normocarbia should be maintained. Hyperoxemia (Spo2 100%) was not associated with better outcomes and therefore targeting SpO2 of 94-99% may be more prudent.

Neuromonitoring and Seizure Treatment

When available, continuous EEG monitoring is recommended following ROSC as evidence has shown that non convulsive status epilepticus (NCSE) is common in these children. It has also been seen that children with clinical or non-convulsive seizures following ROSC have worse outcomes. However, no recommendation has been made regarding prophylactic use of AEDs in children without clinical or non-convulsive seizures.

Prognostication Following Cardiac Arrest

Certain EEG patterns have been seen to be associated with favorable (Sleep spindles, normal background, reactivity) and poor (burst suppression, flat/attenuated) outcomes but the sensitivity and specificity are not high enough to recommend use of isolated EEG for prognostication [14]. Multiple factors including but not limited to EEG, neuroimaging and biomarkers should be taken into account for prognostication. In the absence of robust data, one should avoid being dogmatic while predicting outcomes following cardiac arrest.

Recovery – A New Addition to the Chain of Survival

One of the major changes in the new guidelines is the updated chain of survival. It has been recognized that IHCA and OHCA have very different outcomes and different chains of survival have been formed for them. Both these chains now have a new sixth component which is 'recovery'. Cognitive, neuropsychological and physical impairments continue post discharge [15]. Ongoing assessment and support following hospital discharge is essential for improving long term outcomes in these children.

Contributors: MSR,VCR: drafted the manuscript; MJ: editing, review and final approval. All authors approved the final version of manuscript, and are accountable for all aspects related to the study.
Funding: None; *Competing Interest*: None stated.

REFERENCES

1. Topjian AA, Tia RT, Atkins D, et al. Part 4: Pediatric Basic and Advanced Life Support: 2020 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2020;142:S469-523.
2. Wilmot I, Morales DLS, Price JF, et al. Effectiveness of mechanical circulatory support in children with acute fulminant and persistent myocarditis. J Card Fail. 2011;17:487-94.
3. Emrath ET, Fortenberry JD, Travers C, McCracken CE, Hebbar KB. Resuscitation with balanced fluids is associated with improved survival in pediatric severe sepsis. Crit Care Med. 2017;45:1177-83.
4. Weiss SL, Keele L, Balamuth F, et al. Crystalloid fluid choice and clinical outcomes in pediatric sepsis: a matched retrospective cohort study. J Pediatr. Elsevier; 2017;182:304-310.e10.
5. Weiss SL, Peters MJ, Alhazzani W, et al. Surviving sepsis campaign international guidelines for the management of septic shock and sepsis-associated organ dysfunction in children. Pediatr Crit Care Med. 2020;21:e52.
6. Davis AL, Carcillo JA, Aneja RK, et al. American college of critical care medicine clinical practice parameters for hemodynamic support of pediatric and neonatal septic shock. Crit Care Med. 2017;45:1061-93.
7. Hansen ML, Lin A, Eriksson C, et al. A comparison of pediatric airway management techniques during out-of-hospital cardiac arrest using the CARES database. Resuscitation. 2017;120:51-6.
8. Sutton RM, Reeder RW, Landis WP, et al. Ventilation rates and pediatric in-hospital cardiac arrest survival outcomes. Crit Care Med. 2019;47:1627-36.
9. De Orange FA, Andrade RG, Lemos A, et al. Cuffed versus uncuffed endotracheal tubes for general anaesthesia in children aged eight years and under. Cochrane Database Syst Rev 2017. Available from: *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6486166/.* Accessed on October 31, 2020.
10. Hansen M, Schmicker RH, Newgard CD, et al. Time to epinephrine administration and survival from nonshockable out-of-hospital cardiac arrest among children and adults. Circulation. 2018;137:2032-40.
11. Andersen LW, Berg KM, Saindon BZ, et al. Time to epinephrine and survival after pediatric in-hospital cardiac arrest. JAMA. 2015;314:802-10.
12. Moler FW, Silverstein FS, Holubkov R, Slomine BS, Christensen JR, Nadkarni VM, et al. Therapeutic hypothermia after out-of-hospital cardiac arrest in Children. N Engl J Med. Massachusetts Medical Society; 2015;372:1898–908.
13. Moler FW, Silverstein FS, Holubkov R, et al. Therapeutic hypothermia after in-hospital cardiac arrest in children. N Engl J Med. Massachusetts Medical Society; 2017;376:318-29.
14. Topjian AA, Sánchez SM, Shults J, et al. Early EEG Background features predict outcomes in children resuscitated from cardiac arrest. Pediatr Crit Care Med J Soc Crit Care Med World Fed Pediatr Intensive Crit Care Soc. 2016;17:547-57.
15. van Zellem L, Utens EM, Madderom M, et al. Cardiac arrest in infants, children, and adolescents: long-term emotional and behavioral functioning. Eur J Pediatr. 2016;175:977-86.