What is New in the 2015 PALS Update?

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he past decade has seen a marked improvement in the survival to discharge rates from pediatric in-hospital cardiac arrest (IHCA). Rates of return of spontaneous circulation (ROSC) from IHCA has increased significantly from 39% to 77%, and survival to hospital discharge improved from 24% to 36-43%, for the period from 2001 to 2013 [1]. However, the same survival benefit has not been reported for out-ofhospital cardiac arrest (OHCA); 8.3% survival to hospital-discharge across all age-groups [2].

The American Heart Association (AHA) Guidelines for CPR and ECC for Pediatric Advanced Life Support (PALS) are updated every 5 years based on the body of evidence that has accumulated over this period. The current update (2015) to the 2010 AHA Guidelines focuses on certain key areas related to pediatric resuscitation [3,4].

The questions to be addressed in PICO format (population, intervention, comparator, and outcome) were identified and prioritized by seven task forces. These questions pertained to three core areas *viz*, prearrest, intra-arrest, and post-resuscitation care. The patient outcomes studied were short term *i.e.*, beyond ROSC or discharge from the pediatric intensive care unit (PICU) and long term survival with favorable neurologic/ functional status at 30, 60 and 180 days, and 1 year.

A detailed search for relevant articles was performed in all the three online databases (PubMed, Embase, and the Cochrane Library) following which each task force carried out a detailed systematic review based on the recommendations of the Institute of Medicine of the National Academies [5].

Each recommendation is labeled with a Class of Recommendation (COR) and a Level of Evidence (LOE).The quality of the evidence was categorized into high, moderate, low, or very low, based on the study methodologies and the five core GRADE domains of risk of bias, inconsistency, indirectness, imprecision, and publication bias [6]. This update used the most recent AHA COR and LOE classification system that is a modification of the Class III recommendation and introduces LOE B-R (randomized studies) and B-NR (non-randomized studies) as well as LOE C-LD (limited data) and LOE C-EO (consensus of expert opinion) [3]. Based on the above, the task force then formulated 18 questions in the following areas and critically appraised the available evidence. The same is summarized in the accompanying tables (*Web Tables I-III*).

- A. *Pediatric Pre-arrest Care:* In pre-arrest scenario, the following five areas were considered important so as to prevent a cardiac or respiratory arrest (*WebTable I*).
- 1. Rapid response team (RRT)/Medical Emergency team (MET).
- 2. Pediatric Early Warning Score (PEWS).
- 3. Specific management in dilated cardiomyopathy (DCMP)/Mycarditis.
- 4. Use of atropine as premedication.
- 5. Use of restrictive volumes and non-crystalloids in septic shock.
- *B. Intra-arrest– Advanced Life Support*: Seven aspects during advanced life support delivery were looked at to improve outcomes (*Web Table II*).
- 1. Energy dose for initial and subsequent defibrillation.
- 2. Use of invasive hemodynamic monitoring for systolic and diastolic BP titration.
- 3. Chest compression techniques to achieve a specific ETCO₂ threshold.
- 4. Use of amiodarone for shock-refractory VF or pulseless VT (pVT).
- 5. Use of vasopressor/s during cardiac arrest *e.g.* epinephrine/vasopressin.
- 6. Use of ECMO for resuscitation (ECPR).
- 7. Significance of any intra-arrest prognostic factors.
- *C. Post arrest care:* Six key areas in post arrest management were reviewed to give recommendations (*WebTable III*).

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- 1. Role of targeted temperature management (TTM).
- 2. Use of targeted PaO_2 .
- 3. Ventilation to targeted PCO₂.
- 4. Targeted perfusion and BP with fluids, inotropes and/ or vasopressors.
- 5. Use of EEG.
- 6. Role of any prognostic factors.

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Sr. No	Target Population	Questions	Treatment recommendations
1.	Infants and children hospitalized in non ICU wards	 Whether the use of pediatric RRT/MET, changes the frequency of cardiac or pulmonary arrest and overall hospital mortality 	May be considered for admitted high risk children. Emphasis here is on the potential to recognize and intervene for patients with deteriorating illness so as to prevent them from progressing to cardiac/respiratory arrest
2.	Infants and children hospitalized in non ICU wards	 Whether the use of a PEWS changes overall hospital mortality, and cardiac arrest frequency 	Very-low-quality evidence from one pediatric observational study. Hence no recommendation possible.
3.	Infants and children with myocarditis/ DCMP with imminent cardiac arrest	 Whether a specific approach like ECMO changes cardiac arrest frequency ROSC survival to hospital discharge survival with favorable neurologic/functional outcome at discharge, 30,60, 180 days, and/or 1 year 	No evidence in favor, though veno-arterial ECMO may be considered in acute fulminant myocarditis with imminent arrest. (very-low-quality evidence)
4.	Emergency tracheal intubation	 Whether premedication with atropine changes survival with favorable neurologic/functional outcome at discharge,30, 60, 90 ,180 days, and/or 1 year after event incidence of cardiac arrest incidence of arrhythmias and periintubation shock 	Not recommended for routine use. May be used in situation where risk of bradycardia is high (e.g. succinyl choline use). Atropine to be given as 0.02mg/Kg with no minimal dose concept
5.	Infants and children with septic shock	 Whether the use of restrictive volumes of resuscitation fluid(< 20 mL/kg) or the use of non-crystalloid fluids, change time to resolution of shock need for ventilation or vasopressor support, frequency of complications total intravenous (IV) fluids administered length of hospital stay ventilator-free days survival to hospital discharge 	Routine use of bolus intravenous fluids (crystalloids or colloids) for infants and children with a "severe febrile illness" and who are not in shock is not recommended Initial bolus of 20 ml/Kg is indicated in shock associated with severe sepsis, severe malaria, Dengue shock syndrome, with emphasis on frequent reassessments to detect deterioration at an early stage. No advantage of non crystalloids except in Dengue Shock Syndrome (time to resolution of shock) [7].

WEB TABLE I PEDIATRIC PRE ARREST CARE [3, 4]

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Sr. No	Target Population (infants & children)	Questions	Treatment recommendations
1.	With VF or pVT	 Whether any specific energy dose/s for defibrillation attempt(s), changes termination of arrhythmia ROSC survival to hospital discharge, survival with favorable neurologic/functional outcome at discharge, 30, 60, 180 days , and/or 1 year 	For initial dose use of monophasic/biphasic shock at 2 to 4 J/kg For further shock use escalating doses of \geq 4J/kg. Should not exceed 10 J/kg or maximum dose in adults
2.	Requiring CPR	 Whether use of invasive hemodynamic monitoring targeting specific blood pressure values for both systolic and diastolic, changes likelihood of ROSC survival to hospital discharge survival to hospital discharge, 60 days and 180days after event with favorable neurologic outcome 	Invasive blood pressure monitoring to guide CPR quality may be used.(very-low-quality evidence) No specific target values of BP are available
3.	With cardiac arrest	 Whether chest compression technique to achieve a specific ETCO2 threshold, changes ROSC the likelihood of survival on discharge survival at 180 days with good neurologic outcome 	The quality of Chest Compression, may be evaluated by capnography (very low) Specific target values to guide chest compression have not been established
4.	With refractory VF/pVT	 Whether use of Amiodarone versus Lidocaine, changes termination of arrhythmias ROSC recurrence of VF risk of complications (e.g., need for tube change, airway injury, aspiration) survival at hospital discharge 	For shock-refractory VF or pVT, either of the drugs amiodarone or lidocaine may be used
5.	With cardiac arrest	 Whether the use of vasopressor (epinephrine, vasopressin, combination of vasopressors) changes ROSC survival at hospital discharge survival to 180 days with good neurologic outcome 	No pediatric studies that demonstrate the effectiveness of any vasopressors or its combination. Give standard-dose epinephrine for pediatric cardiac arrest, which is mainly based on one adult OHCA RCT [8](very-low-quality evidence)
6.	In hospital cardiac arrest	 Whether use of ECMO for resuscitation(ECPR), changes survival to intensive care discharge survival at hospital discharge survival to 180 days with good neurologic outcome 	In settings with protocols, expertise and equipment for ECMO, ECPR might be considered in patients with underlying cardiac diseases.
7.	With cardiac arrest	 Whether presence of any specific intra-arrest prognostic factors, changes survival to hospital discharge with good neurologic outcome survival at discharge, 30 days, 60 days, 180 days, and/or one year survival to 30, 60 days with good neurologic outcome survival to 180 days with good neurologic outcome 	For OHCA , age < 1 year, longer durations of cardiac arrest and non-shockable rhythm are poor prognostic markers [9] In IHCA , positive predictors are age < 1 year and initial presence of a shockable rhythm.

WEB TABLE II INTRA ARREST - ADVANCED LIFE SUPPORT [3,4]

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S. No.	Target Population (infants and children)	Questions	Treatment recommendations
1.	ROSC post cardiac arrest	 Whether use of therapeutic hypothermia (TTM) changes ICU length of stay survival to hospital discharge 	For persisting coma after OHCA, TTM be used. However, ideal target temperature range and duration are unknown, use either hypothermia (32°C-34°C) or normothermia (36°C-37.5°C) [10] For pediatric survivors after IHCA insufficient data exists Temperature ≥38°C should not be allowed after ROSC
2.	Post cardiac arrest ROSC	 Whether use of a targeted PaO2 target , changes survival at ICU discharge survival at hospital discharge survival at 6 months survival at 180 days with good neurologic outcome, 	Target normoxemia (Pao $2 \ge 60$ and <300 mmHg) after ROSC Wean O ₂ to target SpO $2 < 100\%$, but >94%.
3.	Post cardiac arrest ROSC	 Whether ventilation to a specific Paco2target, change survival to ICU discharge survival to hospital discharge survival to 30, 60 days, 6 months with good neurologic out-come survival to 180 days with good neurologic outcome 	The limits of PaCO2(both upper and lower)are unknown and no specific PaCO2 in pediatric patients with ROSC has been demonstrated to have better outcomes Worse survival outcome was associated with Paco2 \geq 50 mmHg [11]. Avoid hypercapnia
4.	Post arrest ROSC	 Whether use of intravenous fluids and inotropes and/or vasopressors to maintain blood pressure, changes patient satisfaction survival to hospital discharge survival with favorable neurologic/functional outcome at discharge, 30, 60, 180 days, and/or 1 year 	Parenteral fluids, inotropes/ vasoactive drugs are recommended to maintain SBP > 5th %tile for age Continuous arterial BP monitoring is desirable
5.	Post cardiac arrests	 Whether use of neuro-electrophysiology information (EEG), predict survival to hospital discharge with or without good neurologic outcome survival at 6 months survival with favorable neurologic outcome at 30, 60, 180 days and 1 year 	On hospital discharge EEG within first 7 days showing discontinuous/ iso-electric line predicts poor neurologic outcome
6.	After ROSC	 Whether presence of any specific prognostic factors, changes survival at hospital discharge with good neurologic outcome survival at discharge, 30 days, 60 days, 180 days, and/or1 year survival to 30, 60, 180 days with good neurologic outcome 	Multiple factors should be taken into account while predicting outcomes (e.g. pupillary size at 12-24 hrs, serum neurologic markers, and lactate)

WEB TABLE III PEDIATRIC POST CARDIAC ARREST CARE [3,4]

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