Part 12: Pediatric Advanced Life Support

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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Introduction

Over the past 13 years, survival to discharge from pediatric in-hospital cardiac arrest (IHCA) has markedly improved. From 2001 to 2013, rates of return of spontaneous circulation (ROSC) from IHCA increased significantly from 39% to 77%, and survival to hospital discharge improved from 24% to 36% to 43% (Girotra et al[1] and personal communication with Paul Chan, MD, MSc, April 3, 2015). In a single center, implementation of an intensive care unit (ICU)–based interdisciplinary debriefing program improved survival with favorable neurologic outcome from 29% to 50%.[2] Furthermore, new data show that prolonged cardiopulmonary resuscitation (CPR) is not futile: 12% of patients receiving CPR in IHCA for more than 35 minutes survived to discharge, and 60% of the survivors had a favorable neurologic outcome.[3] This improvement in survival rate from IHCA can be attributed to multiple factors, including emphasis on high-quality CPR and advances in post-resuscitation care. Over the past decade, the percent of cardiac arrests occurring in an ICU setting has increased (87% to 91% in 2000 to 2003 to 94% to 96% in 2004 to 2010).[4] While rates of survival from pulseless electrical activity and asystole have increased, there has been no change in survival rates from in-hospital ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT).

Conversely, survival from out-of-hospital cardiac arrest (OHCA) has not improved as dramatically over the past 5 years. Data from 11 US and Canadian hospital emergency medical service systems (the Resuscitation Outcomes Consortium) during 2005 to 2007 showed age-dependent discharge survival rates of 3.3% for infants (less than 1 year), 9.1% for children (1 to 11 years), and 8.9% for adolescents (12 to 19 years).[5] More recently published data (through 2012) from this network demonstrate 8.3% survival to hospital discharge across all age groups, with 10.5% survival for children aged 1 to 11 years and 15.8% survival for adolescents aged 12 to 18 years.[6]

Evidence Evaluation Process Informing This Guidelines Update

The American Heart Association (AHA) Emergency Cardiovascular Care (ECC) Committee uses a rigorous process to review and analyze the peer-reviewed published scientific evidence supporting the AHA Guidelines for CPR and ECC, including this update. In 2000, the AHA began collaborating with other resuscitation councils throughout the world, via the International Liaison Committee on Resuscitation (ILCOR), in a formal international process to evaluate resuscitation science. This process resulted in the publication of the International Consensus on CPR and ECC Science With Treatment Recommendations (CoSTR) in 2005 and 2010.[7,8] These publications provided the scientific support for AHA Guidelines revisions in those years.

In 2011, the AHA created an online evidence review process, the Scientific Evidence Evaluation and Review System (SEERS), to support ILCOR systematic reviews for 2015 and beyond. This new process includes the use of Grading of Recommendations Assessment, Development, and Evaluation (GRADE) software to create systematic reviews that will be available online and used by resuscitation councils to develop their guidelines for CPR and ECC. The drafts of the online reviews were posted for public comment, and ongoing reviews will be accessible to the public (https://volunteer.heart.org/apps/pico/Pages/default.aspx).

The AHA process for identification and management of potential conflicts of interest was used, and potential conflicts for writing group members are listed at the end of each Part of the *2015 AHA Guidelines Update for CPR and ECC*. For additional information about this systematic review or management of the potential conflicts of interest, see "Part 2: Evidence Evaluation and Management of Conflicts of Interest" in this supplement and the related article "Part 2: Evidence Evaluation and Management of Conflict of Interest" in the 2015 CoSTR publication.[9,10]

This update to the *2010 AHA Guidelines for CPR and ECC* for pediatric advanced life support (PALS) targets key questions related to pediatric resuscitation. Areas of update were selected by a group of international pediatric resuscitation experts from ILCOR, and the questions encompass resuscitation topics in prearrest care, intra-arrest care, and postresuscitation care. The ILCOR Pediatric Life Support Task Force experts reviewed the topics addressed in the 2010 Guidelines

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for PALS and, based on in-depth knowledge of new research developments, formulated 18 questions for further systematic evaluation.[11] Three questions that address pediatric basic life support appear in "Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality."

Beginning with the publication of the 2015 CoSTR, the ILCOR evidence evaluation process will be continuous, rather than "batched" into 5-year cycles. The goal of this continuous evidence review is to improve survival from cardiac arrest by shortening the time between resuscitation science discoveries and their application in resuscitation practice. As additional resuscitation topics are prioritized and reviewed, these Guidelines may be updated again. When the evidence supports sufficient changes to the Guidelines or a change in sequence or treatments that must be woven throughout the Guidelines, then the Guidelines will be revised completely.

Because the *2015 AHA Guidelines Update for CPR and ECC* represents the first update to the previous Guidelines, recommendations from both this 2015 Guidelines Update and the 2010 Guidelines are contained in the Appendix. If the 2015 ILCOR review resulted in a new or significantly revised Guidelines recommendation, that recommendation will be labeled as *New* or *Updated*.

As with all AHA Guidelines, each 2015 recommendation is labeled with a Class of Recommendation (COR) and a Level of Evidence (LOE). This update uses the newest AHA COR and LOE classification system, which contains modifications of the Class III recommendation and introduces LOE B-R (randomized studies) and B-NR (nonrandomized studies) as well as LOE C-LD (limited data) and LOE C-EO (consensus of expert opinion).

These PALS recommendations are informed by the rigorous systematic review and consensus recommendations of the ILCOR Pediatric Task Force, and readers are referred to the complete consensus document in the 2015 CoSTR.[12,13] In the online version of this document, live links are provided so the reader can connect directly to the systematic reviews on the SEERS website. These links are indicated by a superscript combination of letters and numbers (eg, Peds 397). We encourage readers to use the links and review the evidence and appendixes, including the GRADE tables.

This 2015 Guidelines Update for PALS includes science review in the following subjects:

Prearrest Care

- Effectiveness of **medical emergency teams or rapid response teams** to improve outcomes
- Effectiveness of a **pediatric early warning score (PEWS)** to improve outcomes
- **Restrictive volume of isotonic crystalloid** for resuscitation from septic shock
- **Use of atropine as a premedication** in infants and children requiring emergency tracheal intubation
- Treatment for infants and children with **myocarditis or dilated cardiomyopathy and impending cardiac arrest**

Intra-arrest Care

- Effectiveness of **extracorporeal membrane oxygenation (ECMO) resuscitation** compared to standard resuscitation without ECMO
- Targeting a **specific end-tidal CO_2 ($ETCO_2$) threshold** to improve chest compression technique
- Reliability of **intra-arrest prognostic factors** to predict outcome
- Use of **invasive hemodynamic monitoring during CPR** to titrate to a specific systolic/diastolic blood pressure to improve outcomes
- Effectiveness of NO **vasopressor** compared with ANY vasopressors for resuscitation from cardiac arrest
- Use of **amiodarone** compared with **lidocaine** for **shock-refractory VF or pVT**
- Optimal **energy dose** for **defibrillation**

Postarrest Care

- Use of **targeted temperature management** to improve outcomes
- Use of a **targeted Pao_2 strategy** to improve outcomes
- Use of a **specific $Paco_2$ target** to improve outcomes
- Use of **parenteral fluids and inotropes and/or vasopressors** to maintain targeted measures of perfusion such as blood pressure to improve outcomes
- Use of **electroencephalograms (EEGs)** to accurately predict outcomes
- Use **of any specific post–cardiac arrest factors** to accurately predict outcomes

Prearrest Care Updates

Medical Emergency Team/Rapid Response Team[Peds 397]

Medical emergency team or rapid response team activation by caregivers or parents ideally occurs as a response to changes noted in a patient's condition and may prevent cardiac or respiratory arrest. Several variables, including the composition of the team, the type of patient, the hospital setting, and the confounder of a wider "system benefit," further complicate objective analyses.

2015 Evidence Summary

Observational data have been contradictory and have not consistently shown a decreased incidence of cardiac and/or respiratory arrest outside of the ICU setting.[14–16] The data addressing effects on hospital mortality were inconclusive.[16–21]

2015 Recommendation—Updated

Pediatric medical emergency team/rapid response team systems may be considered in facilities where children with high-risk illnesses are cared for on general in-patient units (Class IIb, LOE C-LD).

Pediatric Early Warning Scores[Peds 818]

In-hospital pediatric cardiac or respiratory arrest can potentially be averted by early recognition of and intervention for the deteriorating patient. The use of scoring systems might help to identify such patients sufficiently early so as to enable effective intervention.

2015 Evidence Summary

There is no evidence that the use of PEWS outside of the pediatric ICU setting reduces hospital mortality. In 1 observational study, PEWS use was associated with a reduction in cardiac

arrest rate when used in a single hospital with an established medical emergency team system.[22]

2015 Recommendation—New

The use of PEWS may be considered, but its effectiveness in the in-hospital setting is not well established (Class IIb, LOE C-LD).

Fluid Resuscitation in Septic Shock[Peds 545]

This update regarding intravenous fluid resuscitation in infants and children in septic shock in all settings addressed 2 specific therapeutic elements: (1) Withholding the use of bolus fluids was compared with the use of bolus fluids, and (2) noncrystalloid was compared with crystalloid fluids.

Early and rapid administration of intravenous fluid to reverse decompensated shock, and to prevent progression from compensated to decompensated shock, has been widely accepted based on limited observational studies.[23] Mortality from pediatric sepsis has declined in recent years, during which guidelines and publications have emphasized the role of early rapid fluid administration (along with early antibiotic and vasopressor therapy, and careful cardiovascular monitoring) in treating septic shock.[24,25] Since the 2010 Guidelines, a large randomized controlled trial of fluid resuscitation in pediatric severe febrile illness in a resource-limited setting found intravenous fluid boluses to be harmful.[26] This new information, contradicting long-held beliefs and practices, prompted careful analysis of the effect of fluid resuscitation on many outcomes in specific infectious illnesses.

2015 Evidence Summary

Specific infection-related shock states appear to behave differently with respect to fluid bolus therapy. Evidence was not considered to be specific to a particular setting, after determining that "resource-limited setting" is difficult to define and can vary greatly even within individual health systems and small geographic regions.

The evidence regarding the impact of restricting fluid boluses during resuscitation on outcomes in pediatric septic shock is summarized in Figure 1. There were no studies for many specific combinations of presenting illness and outcome. In the majority of scenarios, there was no benefit to restricting fluid boluses during resuscitation.

The most important exception is that in 1 large study, restriction of fluid boluses conveyed a benefit for survival to both 48 hours and 4 weeks after presentation. This study was conducted in sub-Saharan Africa, and inclusion criteria were severe febrile illness complicated by impaired consciousness (prostration or coma), respiratory distress (increased work of breathing), or both, and with impaired perfusion, as evidenced by 1 or more of the following: a capillary refill time of 3 or more seconds, lower limb temperature gradient, weak radial-pulse volume, or severe tachycardia. In this study, administration of 20 mL/kg or 40 mL/kg in the first hour was associated with decreased survival compared with the use of maintenance fluids alone.[26] Therefore, it appears that in this specific patient population, where critical care resources including inotropic and mechanical ventilator support were limited, bolus fluid therapy resulted in higher mortality.

The use of noncrystalloid fluid was compared with crystalloid fluid for the same diseases and outcomes listed in the preceding paragraph.[26–32] Evidence is summarized in Figure 2. In most scenarios, there was no benefit to noncrystalloids over crystalloids. In patients with Dengue shock, a benefit was conferred in using noncrystalloid compared with crystalloid fluid for the outcome of time to resolution of shock.[31]

2015 Recommendations—New

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 (Class IIa, LOE C-LD), severe malaria and Dengue (Class IIb, LOE B-R). When caring for children with severe febrile illness (such as those included in the FEAST trial[26]) in settings with limited access to critical care resources (ie, mechanical ventilation and inotropic support), administration of bolus intravenous fluids should be undertaken with extreme caution because it may be harmful (Class IIb, LOE B-R). Providers should reassess the patient after every fluid bolus (Class I, LOE C-EO).

Either isotonic crystalloids or colloids can be effective as the initial fluid choice for resuscitation (Class IIa, LOE B-R).

This recommendation takes into consideration the important work of Maitland et al,[26] which found that fluid boluses as part of resuscitation are not safe for all patients in all settings. This

	Studies	Survival to Hospital Discharge	Need for Transfusion or Diuretics	Need for Rescue Fluid	Mechanical Ventilation or Vasopressor	Time to Resolution of Shock	Total IV Fluids
Severe sepsis/ septic shock	Santhanam 2008; Carcillo 1991	No Benefit	No Benefit	No Studies Available	No Benefit	No Benefit	No Studies Available
Severe malaria	Maitland 2005; Maitland 2005	No Benefit	No Benefit	Harm	No Studies Available	No Benefit	No Benefit
Severe febrile illness with some but not all signs of shock	Maitland 2011; Maitland 2013	Benefit	No Benefit	No Studies Available	No Studies Available	Harm	No Benefit

Figure 1. Evidence for the use of restrictive volume of intravenous fluid resuscitation, compared with unrestrictive volume, by presenting illness and outcome. *Benefit* indicates that studies show a benefit to restricting fluid volume, *No Benefit* indicates that there is no benefit to restricting fluid volume, and *Harm* indicates that there is harm associated with restricting fluid volume. *No Studies Available* indicates no studies are available for a particular illness/outcome combination.

	Studies	Survival to Hospital Discharge	Need for Other Treatment	Need for Rescue Fluid	Mechanical Ventilation or Vasopressor	Time to Resolution of Shock	Total IV Fluids	Hospital Duration of Stay
Severe sepsis/ septic shock	Upadhyay 2005	No Benefit	No Benefit	No Studies Available	No Benefit	No Benefit	No Studies Available	No Studies Available
Severe malaria	Maitland 2003; Maitland 2005	No Studies Available	No Benefit	No Studies Available	No Studies Available	No Benefit	No Studies Available	No Studies Available
Dengue shock	Cifra 2003; Dung 1999; Ngo 2001; Wills 2005	No Benefit	No Benefit	No Benefit	No Studies Available	Benefit	No Benefit	No Benefit
Severe febrile illness with some but not all signs of shock	Maitland 2011	No Benefit	No Benefit	No Benefit	No Studies Available	No Benefit	No Benefit	No Studies Available

Figure 2. Evidence for the use of noncrystalloid intravenous fluid resuscitation, compared with crystalloid, by presenting illness and outcome. *Benefit* indicates that studies show a benefit to the use of noncrystalloid intravenous fluid resuscitation compared with crystalloid, and *No Benefit* indicates that there is no benefit to the use of noncrystalloid intravenous fluid resuscitation compared with crystalloid. *No Studies Available* indicates no studies are available for a particular illness/outcome combination.

study showed that the use of fluid boluses as part of resuscitation increased mortality in a specific population in a resource-limited setting, without access to some critical care interventions such as mechanical ventilation and inotrope support.

The spirit of this recommendation is a continued emphasis on fluid resuscitation for both compensated (detected by physical examination) and decompensated (hypotensive) septic shock. Moreover, emphasis is also placed on the use of individualized patient evaluation before the administration of intravenous fluid boluses, including physical examination by a clinician and frequent reassessment to determine the appropriate volume of fluid resuscitation. The clinician should also integrate clinical signs with patient and locality-specific information about prevalent diseases, vulnerabilities (such as severe anemia and malnutrition), and available critical care resources.

Atropine for Premedication During Emergency Intubation[Peds 821]

Bradycardia commonly occurs during emergency pediatric intubation, resulting from hypoxia/ischemia, as a vagal response to laryngoscopy, as a reflex response to positive pressure ventilation, or as a pharmacologic effect of some drugs (eg, succinylcholine or fentanyl). Practitioners have often tried to blunt this bradycardia with prophylactic premedication with atropine.

2015 Evidence Summary

The evidence regarding the use of atropine during emergency intubation has largely been observational, including extrapolation from experience with elective intubation in the operating suite. More recent in-hospital literature involves larger case series of critically ill neonates, infants, and children undergoing emergency intubation.[33–35]

There is no evidence that preintubation use of atropine improves survival or prevents cardiac arrest in infants and children. Observational data suggest that it increases the likelihood of survival to ICU discharge in children older than 28 days.[33] Evidence is conflicting as to whether preintubation atropine administration reduces the incidence of arrhythmias or postintubation shock.[34,35]

In past Guidelines, a minimum atropine dose of 0.1 mg IV was recommended after a report of paradoxical bradycardia observed in very small infants who received very low atropine doses.[36] However, in 2 of the most recent case series cited above, preintubation doses of 0.02 mg/kg, with no minimum dose, were shown to be effective.[33,34]

2015 Recommendations—New

The available evidence does not support the routine use of atropine preintubation of critically ill infants and children. It may be reasonable for practitioners to use atropine as a premedication in specific emergency intubations when there is higher risk of bradycardia (eg, when giving succinylcholine as a neuromuscular blocker to facilitate intubation) (Class IIb, LOE C-LD). A dose of 0.02 mg/kg of atropine with no minimum dose may be considered when atropine is used as a premedication for emergency intubation (Class IIb, LOE C-LD). This new recommendation applies only to the use of atropine as a premedication for infants and children during emergency intubation.

Prearrest Care of Infants and Children With Dilated Cardiomyopathy or Myocarditis[Peds 819]

Optimal care of a critically ill infant or child with dilated cardiomyopathy or myocarditis should avert cardiac arrest. While significant global experience exists with the care of these patients, the evidence base is limited. The ILCOR systematic review ultimately restricted its analysis to patients with myocarditis and did not include the use of ventricular assist devices.

2015 Evidence Summary

No literature was identified evaluating best prearrest management strategies (including anesthetic technique) for infants

and children with dilated cardiomyopathy or myocarditis. Limited observational data support the pre–cardiac arrest use of ECMO in children with acute fulminant myocarditis.[37]

2015 Recommendation—New

Venoarterial ECMO use may be considered in patients with acute fulminant myocarditis who are at high risk of imminent cardiac arrest (Class IIb, LOE C-EO). Optimal outcomes from ECMO are achieved in settings with existing ECMO protocols, expertise, and equipment.

Intra-arrest Care Updates

Extracorporeal CPR for In-Hospital Pediatric Cardiac Arrest[Peds 407]

The 2010 AHA PALS Guidelines suggested the use of ECMO when dealing with pediatric cardiac arrest refractory to conventional interventions and when managing a reversible underlying disease process. Pediatric OHCA was not considered for the 2015 ILCOR systematic review.

2015 Evidence Summary

Evidence from 4 observational studies of pediatric IHCA has shown no overall benefit to the use of CPR with ECMO (ECPR) compared to CPR without ECMO.[38–41] Observational data from a registry of pediatric IHCA showed improved survival to hospital discharge with the use of ECPR in patients with surgical cardiac diagnoses.[42] For children with underlying cardiac disease, when ECPR is initiated in a critical care setting, long-term survival has been reported even after more than 50 minutes of conventional CPR.[43] When ECPR is used during cardiac arrest, the outcome for children with underlying cardiac disease is better than for those with noncardiac disease.[44]

2015 Recommendation—New

ECPR may be considered for pediatric patients with cardiac diagnoses who have IHCA in settings with existing ECMO protocols, expertise, and equipment (Class IIb, LOE C-LD).

End-Tidal CO_2 Monitoring to Guide CPR Quality[Peds 827]

High-quality CPR is associated with improved outcomes after cardiac arrest. Animal data support a direct association between $ETCO_2$ and cardiac output. Capnography is used during pediatric cardiac arrest to monitor for ROSC as well as CPR quality. The 2010 Guidelines recommended that if the partial pressure of $ETCO_2$ is consistently less than 15 mm Hg, efforts should focus on improving CPR quality, particularly improving chest compressions and ensuring that the victim does not receive excessive ventilation.

2015 Evidence Summary

There is no pediatric evidence that $ETCO_2$ monitoring improves outcomes from cardiac arrest. One pediatric animal study showed that $ETCO_2$-guided chest compressions are as effective as standard chest compressions optimized by marker, video, and verbal feedback for achieving ROSC.[45] A recent study in adults found that $ETCO_2$ values generated during CPR were significantly associated with chest compression depth and ventilation rate.[46]

2015 Recommendation—New

$ETCO_2$ monitoring may be considered to evaluate the quality of chest compressions, but specific values to guide therapy have not been established in children (Class IIb, LOE C-LD).

Intra-arrest Prognostic Factors for Cardiac Arrest[Peds 814]

Accurate and reliable prognostication during pediatric cardiac arrest would allow termination of CPR in patients where CPR is futile, while encouraging continued CPR in patients with a potential for good recovery.

2015 Evidence Summary

For infants and children with OHCA, age less than 1 year,[5,47] longer durations of cardiac arrest[48–50] and presentation with a nonshockable as opposed to a shockable rhythm[5,47,49] are all predictors of poor patient outcome. For infants and children with IHCA, negative predictive factors include age greater than 1 year[3] and longer durations of cardiac arrest.[3,51–53] The evidence is contradictory as to whether a nonshockable (as opposed to shockable) initial cardiac arrest rhythm is a negative predictive factor in the in-hospital setting.[3,54,55]

2015 Recommendation—New

Multiple variables should be used when attempting to prognosticate outcomes during cardiac arrest (Class I, LOE C-LD). Although there are factors associated with better or worse outcomes, no single factor studied predicts outcome with sufficient accuracy to recommend termination or continuation of CPR.

Invasive Hemodynamic Monitoring During CPR[Peds 826]

Children often have cardiac arrests in settings where invasive hemodynamic monitoring already exists or is rapidly obtained. If a patient has an indwelling arterial catheter, the waveform can be used as feedback to evaluate chest compressions.

2015 Evidence Summary

Adjusting chest compression technique to a specific systolic blood pressure target has not been studied in humans. Two randomized controlled animal studies showed increased likelihood of ROSC and survival to completion of experiment with the use of invasive hemodynamic monitoring.[56,57]

2015 Recommendation—New

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 (Class IIb, LOE C-EO). Specific target values for blood pressure during CPR have not been established in children.

Vasopressors During Cardiac Arrest[Peds 424]

During cardiac arrest, vasopressors are used to restore spontaneous circulation by optimizing coronary perfusion and to help maintain cerebral perfusion. However, they also cause intense vasoconstriction and increase myocardial oxygen consumption, which might be detrimental.

2015 Evidence Summary

There are no pediatric studies that demonstrate the effectiveness of any vasopressors (epinephrine, or combination of vasopressors) in cardiac arrest. Two pediatric observational out-of-hospital studies[58,59] had too many confounders to determine if vasopressors were beneficial. One adult OHCA randomized controlled trial[60] showed epinephrine use was associated with increased ROSC and survival to hospital admission but no improvement in survival to hospital discharge.

2015 Recommendation—New

It is reasonable to administer epinephrine in pediatric cardiac arrest (Class IIa, LOE C-LD).

Amiodarone and Lidocaine for Shock-Refractory VF and pVT[Peds 825]

The 2005 and 2010 Guidelines recommended administering amiodarone in preference to lidocaine for the management of VF or pVT. This recommendation was based predominantly on pediatric case series or extrapolation from adult studies that used short-term outcomes.

2015 Evidence Summary

New pediatric observational data[61] showed improved ROSC with the use of lidocaine as compared with amiodarone. Use of lidocaine compared with no lidocaine was significantly associated with an increased likelihood of ROSC. The same study did not show an association between lidocaine or amiodarone use and survival to hospital discharge.

2015 Recommendation—New

For shock-refractory VF or pVT, either amiodarone or lidocaine may be used (Class IIb, LOE C-LD).

The Pediatric Cardiac Arrest Algorithm (Figure 3) reflects this change.

Energy Doses for Defibrillation[Peds 405]

The 2015 ILCOR systematic review addressed the dose of energy for pediatric manual defibrillation during cardiac arrest. Neither the energy dose specifically related to automated external defibrillators, nor the energy dose for cardioversion was evaluated in this evidence review.

2015 Evidence Summary

Two small case series demonstrated termination of VF/pVT with either 2 J/kg[62] or 2 to 4 J/kg.[63] In 1 observational study of IHCA,[64] a higher initial energy dose of more than 3 to 5 J/kg was less effective than 1 to 3 J/kg in achieving ROSC. One small observational study of IHCA[65] showed no benefit in achieving ROSC with a specific energy dose for initial defibrillation. Three small observational studies of IHCA and OHCA[63,65,66] showed no survival to discharge advantage of any energy dose compared with 2 to 4 J/kg for initial defibrillation.

2015 Recommendations—Updated

It is reasonable to use an initial dose of 2 to 4 J/kg of monophasic or biphasic energy for defibrillation (Class IIa, LOE C-LD), but for ease of teaching, an initial dose of 2 J/kg may be considered (Class IIb, LOE C-EO). For refractory VF, it is reasonable to increase the dose to 4 J/kg (Class IIa, LOE C-LD). For subsequent energy levels, a dose of 4 J/kg may be reasonable and higher energy levels may be considered, though not to exceed 10 J/kg or the adult maximum dose (Class IIb, LOE C-LD).

Postarrest Care Updates

Post–Cardiac Arrest Temperature Management[Peds 387]

Data suggest that fever after pediatric cardiac arrest is common and is associated with poor outcomes.[67] The 2010 AHA PALS Guidelines suggested a role for targeted temperature management after pediatric cardiac arrest (fever control for all patients, therapeutic hypothermia for some patients), but the recommendations were based predominantly on extrapolation from adult and asphyxiated newborn data.

2015 Evidence Summary

A large multi-institutional, prospective, randomized study of pediatric patients (aged 2 days to 18 years) with OHCA found no difference in survival with good functional outcome at 1 year and no additional complications in comatose patients who were treated with therapeutic hypothermia (32°C to 34°C), compared to those treated with normothermia (36°C to 37.5°C).[68] Observational data of pediatric patients resuscitated from IHCA or OHCA[69,70] have also shown that ICU duration of stay, neurologic outcomes, and mortality are unchanged with the use of therapeutic hypothermia. Only 1 small study of therapeutic hypothermia in survivors of pediatric asphyxial cardiac arrest[71] showed an improvement in mortality at hospital discharge, but with no difference in neurologic outcomes. Results are pending from a large multicenter randomized controlled trial of targeted temperature management for pediatric patients with IHCA (see Therapeutic Hypothermia After Cardiac Arrest website: www.THAPCA.org).

2015 Recommendations—New

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 (Class IIa, LOE B-R). Continuous measurement of temperature during this time period is recommended (Class I, LOE B-NR).

For infants and children remaining comatose after IHCA, there is insufficient evidence to recommend cooling over normothermia.

Fever (temperature 38°C or higher) should be aggressively treated after ROSC (Class I, LOE B-NR).

Post–Cardiac Arrest Oxygenation[Peds 544]

Animal studies suggest that elevated levels of tissue Po_2 after ROSC (hyperoxia) contribute to oxidative stress that may potentiate the postresuscitation syndrome, while some adult studies show associations between hyperoxemia and increased mortality.[72,73]

2015 Evidence Summary

Three small observational studies of pediatric IHCA and OHCA survivors[74–76] did not show an association between elevated Pao_2 and outcome. In a larger observational study of 1427 pediatric IHCA and OHCA victims who survived to

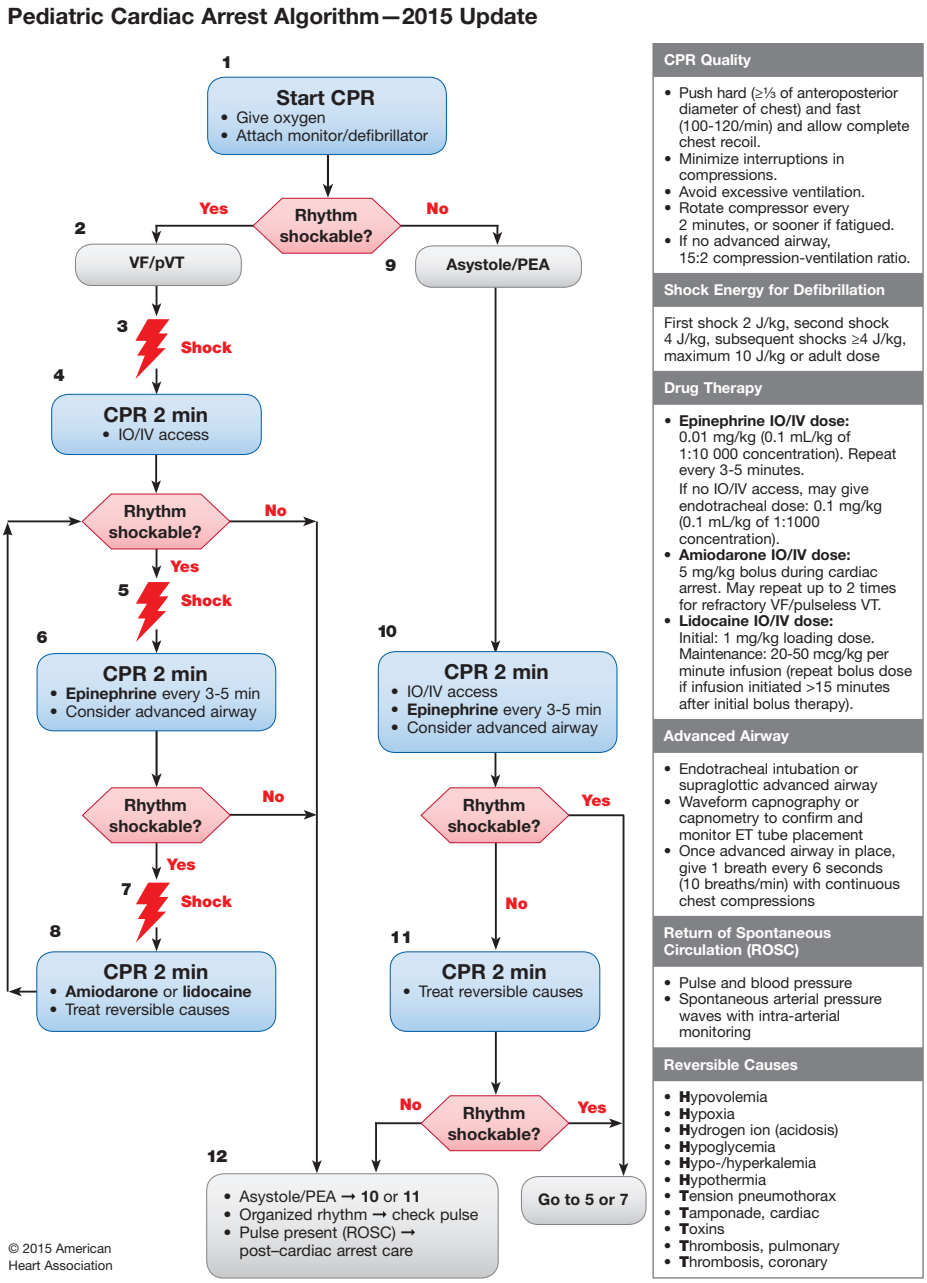

Figure 3. Pediatric Cardiac Arrest Algorithm—2015 Update.

pediatric ICU admission,[77] after adjustment of confounders, the presence of normoxemia (defined as a Pao_2 60 mm Hg or greater and less than 300 mm Hg) when compared with hyperoxemia (Pao_2 greater than 300 mm Hg) after ROSC was associated with improved survival to pediatric ICU discharge.

2015 Recommendations—New

It may be reasonable for rescuers to target normoxemia after ROSC (Class IIb, LOE B-NR). Because an arterial oxyhemoglobin saturation of 100% may correspond to a Pao_2 anywhere between 80 and approximately 500 mm Hg, it may be reasonable—when the necessary equipment is available—for rescuers to wean oxygen to target an oxyhemoglobin saturation of less than 100%, but 94% or greater. The goal of such an approach is to achieve normoxemia while ensuring that hypoxemia is strictly avoided. Ideally, oxygen is titrated to a value appropriate to the specific patient condition.

Post–Cardiac Arrest $Paco_2$ Peds 815

Cerebral vascular autoregulation may be abnormal after ROSC. Adult data show an association between post-ROSC hypocapnia and worse patient outcomes.[78,79] In other types of pediatric brain injury, hypocapnia is associated with worse clinical outcomes.[80–83]

2015 Evidence Summary

There were no studies in children after cardiac arrest specifically comparing ventilation with a predetermined $Paco_2$ target. One small observational study of both pediatric IHCA and OHCA[74] demonstrated no association between hypercapnia

($Paco_2$ greater than 50 mm Hg) or hypocapnia ($Paco_2$ less than 30 mm Hg) and outcome. However, in an observational study of pediatric IHCA,[76] hypercapnia ($Paco_2$ 50 mm Hg or greater) was associated with worse survival to hospital discharge.

2015 Recommendation—New

It is reasonable for practitioners to target a $Paco_2$ after ROSC that is appropriate to the specific patient condition, and limit exposure to severe hypercapnia or hypocapnia (Class IIb, LOE C-LD).

Post–Cardiac Arrest Fluids and Inotropes[Peds 820]

Myocardial dysfunction and vascular instability are common after resuscitation from cardiac arrest.[84–90]

2015 Evidence Summary

Three small observational studies involving pediatric IHCA and OHCA[91–93] demonstrated worse survival to hospital discharge when children were exposed to post-ROSC hypotension. One of these studies[91] associated post-ROSC hypotension (defined as a systolic blood pressure less than fifth percentile for age) after IHCA with lower likelihood of survival to discharge with favorable neurologic outcome. There are no studies evaluating the benefit of specific vasoactive agents after ROSC in infants and children.

2015 Recommendations—New

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 (Class I, LOE C-LD). When appropriate resources are available, continuous arterial pressure monitoring is recommended to identify and treat hypotension (Class I, LOE C-EO).

Postresuscitation Use of EEG for Prognosis[Peds 822]

Early and reliable prognostication of neurologic outcome in pediatric survivors of cardiac arrest is essential to enable effective planning and family support (whether it be to continue or discontinue life-sustaining therapy).

2015 Evidence Summary

Observational data from 2 small pediatric studies[94,95] showed that a continuous and reactive tracing on an EEG performed in the first 7 days after cardiac arrest was associated with a significantly higher likelihood of good neurologic outcome at hospital discharge, while an EEG demonstrating a discontinuous or isoelectric tracing was associated with a poorer neurologic outcome at hospital discharge. There are no data correlating EEG findings with neurologic outcome after hospital discharge.

2015 Recommendation—New

EEGs performed within the first 7 days after pediatric cardiac arrest may be considered in prognosticating neurologic outcome at the time of hospital discharge (Class IIb, LOE C-LD) but should not be used as the sole criterion.

Predictive Factors After Cardiac Arrest[Peds 813]

Several post-ROSC factors have been studied as possible predictors of survival and neurologic outcome after pediatric cardiac arrest. These include pupillary responses, the presence of hypotension, serum neurologic biomarkers, and serum lactate.

2015 Evidence Summary

Four observational studies supported the use of pupillary reactivity at 12 to 24 hours after cardiac arrest in predicting survival to discharge,[49,53,95,96] while 1 observational study found that reactive pupils 24 hours after cardiac arrest were associated with improved survival at 180 days with favorable neurologic outcome.[97]

Several serum biomarkers of neurologic injury have been considered for their prognostic value. Two small observational studies found that lower neuron-specific enolase and S100B serum levels after arrest were associated with improved survival to hospital discharge and with improved survival with favorable neurologic outcome.[97,98]

One observational study found that children with lower lactate levels in the first 12 hours after arrest had an improved survival to hospital discharge.[99]

2015 Recommendation—New

The reliability of any 1 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 (Class I, LOE C-LD).

Disclosures

Part 12: Pediatric Advanced Life Support: 2015 Guidelines Update Writing Group Disclosures

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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 12 Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
2015	Prearrest Care Updates	Pediatric medical emergency team/rapid response team systems may be considered in facilities where children with high-risk illnesses are cared for on general in-patient units (Class IIb, LOE C-LD).	updated for 2015
2015	Prearrest Care Updates	The use of PEWS may be considered, but its effectiveness in the in-hospital setting is not well established (Class IIb, LOE C-LD).	new for 2015
2015	Prearrest Care Updates	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 (Class IIa, LOE C-LD), malaria and Dengue (Class IIb, LOE B-R).	new for 2015
2015	Prearrest Care Updates	When caring for children with severe febrile illness (such as those included in the FEAST trial), in settings with limited access to critical care resources (ie mechanical ventilation and inotropic support), administration of bolus intravenous fluids should be undertaken with extreme caution because it may be harmful (Class IIb, LOE B-R).	new for 2015
2015	Prearrest Care Updates	Providers should reassess the patient after every fluid bolus (Class I, LOE C-EO).	new for 2015
2015	Prearrest Care Updates	Either isotonic crystalloids or colloids can be effective as the initial fluid choice for resuscitation (Class IIa, LOE B-R).	new for 2015
2015	Prearrest Care Updates	The available evidence does not support the routine use of atropine preintubation of critically ill infants and children. It may be reasonable for practitioners to use atropine as a premedication in specific emergent intubations when there is higher risk of bradycardia (eg, when giving succinylcholine as a neuromuscular blocker to facilitate intubation) (Class IIb, LOE C-LD).	new for 2015
2015	Prearrest Care Updates	A dose of 0.02 mg/kg of atropine with no minimum dose may be considered when atropine is used as a premedication for emergency intubation (Class IIb, LOE C-LD).	new for 2015
2015	Prearrest Care Updates	Venoarterial ECMO use may be considered in patients with acute fulminant myocarditis who are at high risk of imminent cardiac arrest (Class IIb, LOE C-EO).	new for 2015
2015	Intra-arrest Care Updates	ECPR may be considered for pediatric patients with cardiac diagnoses who have IHCA in settings with existing ECMO protocols, expertise, and equipment (Class IIb, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	$ETCO_2$ monitoring may be considered to evaluate the quality of chest compressions, but specific values to guide therapy have not been established in children (Class IIb, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	Multiple variables should be used when attempting to prognosticate outcomes during cardiac arrest (Class I, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	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 (Class IIb, LOE C-EO).	new for 2015
2015	Intra-arrest Care Updates	It is reasonable to administer epinephrine in pediatric cardiac arrest (Class IIa, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	For shock-refractory VF or pVT, either amiodarone or lidocaine may be used (Class IIb, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	It is reasonable to use an initial dose of 2 to 4 J/kg of monophasic or biphasic energy for defibrillation (Class IIa, LOE C-LD), but for ease of teaching, an initial dose of 2 J/kg may be considered (Class IIb, LOE C-EO).	updated for 2015
2015	Intra-arrest Care Updates	For refractory VF, it is reasonable to increase the dose to 4 J/kg (Class IIa, LOE C-LD).	updated for 2015
2015	Intra-arrest Care Updates	For subsequent energy levels, a dose of 4 J/kg may be reasonable and higher energy levels may be considered, though not to exceed 10 J/kg or the adult maximum dose (Class IIb, LOE C-LD).	updated for 2015
2015	Postarrest Care Updates	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 (Class IIa, LOE B-R).	new for 2015
2015	Postarrest Care Updates	Continuous measurement of temperature during this time period is recommended (Class I, LOE B-NR).	new for 2015
2015	Postarrest Care Updates	Fever (temperature 38°C or higher) should be aggressively treated after ROSC (Class I, LOE B-NR).	new for 2015
2015	Postarrest Care Updates	It may be reasonable for rescuers to target normoxemia after ROSC (Class IIb, LOE B-NR).	new for 2015
2015	Postarrest Care Updates	It is reasonable for practitioners to target a Pa_{CO_2} after ROSC that is appropriate to the specific patient condition, and limit exposure to severe hypercapnia or hypocapnia (Class IIb, LOE C-LD).	new for 2015
2015	Postarrest Care Updates	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 (Class I, LOE C-LD).	new for 2015

(*Continued*)

2015 Guidelines Update: Part 12 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Postarrest Care Updates	When appropriate resources are available, continuous arterial pressure monitoring is recommended to identify and treat hypotension (Class I, LOE C-EO).	new for 2015
2015	Postarrest Care Updates	EEGs performed within the first 7 days after pediatric cardiac arrest may be considered in prognosticating neurologic outcome at the time of hospital discharge (Class IIb, LOE C-LD) but should not be used as the sole criterion.	new for 2015
2015	Postarrest Care Updates	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 (Class I, LOE C-LD).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 14: Pediatric Advanced Life Support."			
2010	Family Presence During Resuscitation	Whenever possible, provide family members with the option of being present during resuscitation of an infant or child (Class I, LOE B).	not reviewed in 2015
2010	Laryngeal Mask Airway (LMA)	When bag-mask ventilation (see "Bag-Mask Ventilation," below) is unsuccessful and when endotracheal intubation is not possible, the LMA is acceptable when used by experienced providers to provide a patent airway and support ventilation (Class IIa, LOE C).	not reviewed in 2015
2010	Bag-Mask Ventilation	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 (Class IIa, LOE B).	not reviewed in 2015
2010	Precautions	Use only the force and tidal volume needed to just make the chest rise visibly (Class I, LOE C)	not reviewed in 2015
2010	Precautions	Avoid delivering excessive ventilation during cardiac arrest (Class III, LOE C).	not reviewed in 2015
2010	Precautions	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 (Class I, LOE C).	not reviewed in 2015
2010	Precautions	It may be reasonable to do the same if an LMA is in place (Class IIb, LOE C).	not reviewed in 2015
2010	Precautions	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 (Class I, LOE C).	not reviewed in 2015
2010	Two-Person Bag-Mask Ventilation	Apply cricoid pressure in an unresponsive victim to reduce air entry into the stomach (Class IIa, LOE B).	not reviewed in 2015
2010	Two-Person Bag-Mask Ventilation	Avoid excessive cricoid pressure so as not to obstruct the trachea (Class III, LOE B)	not reviewed in 2015
2010	Cricoid Pressure During Intubation	Do not continue cricoid pressure if it interferes with ventilation or the speed or ease of intubation (Class III, LOE C).	not reviewed in 2015
2010	Cuffed Versus Uncuffed Endotracheal Tubes	Both cuffed and uncuffed endotracheal tubes are acceptable for intubating infants and children (Class IIa, LOE C).	not reviewed in 2015
2010	Cuffed Versus Uncuffed Endotracheal Tubes	In certain circumstances (eg, poor lung compliance, high airway resistance, or a large glottic air leak) a cuffed endotracheal tube may be preferable to an uncuffed tube, provided that attention is paid to endotracheal tube size, position, and cuff inflation pressure (Class IIa, LOE B).	not reviewed in 2015
2010	Endotracheal Tube Size	For children between 1 and 2 years of age, it is reasonable to use a cuffed endotracheal tube with an internal diameter of 3.5 mm (Class IIa, LOE B).	not reviewed in 2015
2010	Endotracheal Tube Size	After age 2 it is reasonable to estimate tube size with the following formula (Class IIa, LOE B): Cuffed endotracheal tube ID (mm) 3.5+ (age/4).	not reviewed in 2015
2010	Esophageal Detector Device (EDD)	If capnography is not available, an esophageal detector device (EDD) may be considered to confirm endotracheal tube placement in children weighing >20 kg with a perfusing rhythm (Class IIb, LOE B), but the data are insufficient to make a recommendation for or against its use in children during cardiac arrest.	not reviewed in 2015
2010	Transtracheal Catheter Oxygenation and Ventilation	Attempt this procedure only after proper training and with appropriate equipment (Class IIb, LOE C).	not reviewed in 2015
2010	CPR Guidelines for Newborns With Cardiac Arrest of Cardiac Origin	It is reasonable to resuscitate newborns with a primary cardiac etiology of arrest, regardless of location, according to infant guidelines, with emphasis on chest compressions (Class IIa, LOE C).	not reviewed in 2015
2010	Echocardiography	When appropriately trained personnel are available, echocardiography may be considered to identify patients with potentially treatable causes of the arrest, particularly pericardial tamponade and inadequate ventricular filling (Class IIb, LOE C).	not reviewed in 2015
2010	Intraosseous (IO) Access	IO access is a rapid, safe, effective, and acceptable route for vascular access in children, and it is useful as the initial vascular access in cases of cardiac arrest (Class I, LOE C).	not reviewed in 2015
2010	Medication Dose Calculation	If the child's weight is unknown, it is reasonable to use a body length tape with precalculated doses (Class IIa, LOE C).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Part 12 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Medication Dose Calculation	Regardless of the patient's habitus, use the actual body weight for calculating initial resuscitation drug doses or use a body length tape with precalculated doses (Class IIb, LOE C).	not reviewed in 2015
2010	Calcium	Calcium administration is not recommended for pediatric cardiopulmonary arrest in the absence of documented hypocalcemia, calcium channel blocker overdose, hypermagnesemia, or hyperkalemia (Class III, LOE B).	not reviewed in 2015
2010	Glucose	Check blood glucose concentration during the resuscitation and treat hypoglycemia promptly (Class I, LOE C).	not reviewed in 2015
2010	Sodium Bicarbonate	Routine administration of sodium bicarbonate is not recommended in cardiac arrest (Class III, LOE B).	not reviewed in 2015
2010	AEDs	If an AED with an attenuator is not available, use an AED with standard electrodes (Class IIa, LOE C).	not reviewed in 2015
2010	AEDs	An AED without a dose attenuator may be used if neither a manual defibrillator nor one with a dose attenuator is available (Class IIb, LOE C).	not reviewed in 2015
2010	Bradycardia	Continue to support airway, ventilation, oxygenation, and chest compressions (Class I, LOE B).	not reviewed in 2015
2010	Bradycardia	Emergency transcutaneous pacing may be lifesaving if the bradycardia is due to complete heart block or sinus node dysfunction unresponsive to ventilation, oxygenation, chest compressions, and medications, especially if it is associated with congenital or acquired heart disease (Class IIb, LOE C).	not reviewed in 2015
2010	Supraventricular Tachycardia	Attempt vagal stimulation first, unless the patient is hemodynamically unstable or the procedure will unduly delay chemical or electric cardioversion (Class IIa, LOE C).	not reviewed in 2015
2010	Supraventricular Tachycardia	An IV/IO dose of verapamil, 0.1 to 0.3 mg/kg is also effective in terminating SVT in older children, but it should not be used in infants without expert consultation (Class III, LOE C) because it may cause potential myocardial depression, hypotension, and cardiac arrest.	not reviewed in 2015
2010	Supraventricular Tachycardia	Use sedation, if possible. Start with a dose of 0.5 to 1 J/kg. If unsuccessful, increase the dose to 2 J/kg (Class IIb, LOE C).	not reviewed in 2015
2010	Supraventricular Tachycardia	Consider amiodarone 5 mg/kg IO/IV or procainamide 15 mg/kg IO/IV236 for a patient with SVT unresponsive to vagal maneuvers and adenosine and/or electric cardioversion; for hemodynamically stable patients, expert consultation is strongly recommended prior to administration (Class IIb, LOE C).	not reviewed in 2015
2010	Wide-Complex (>0.09 Second) Tachycardia	Consider electric cardioversion after sedation using a starting energy dose of 0.5 to 1 J/kg. If that fails, increase the dose to 2 J/kg (Class IIb, LOE C).	not reviewed in 2015
2010	Wide-Complex (>0.09 Second) Tachycardia	Electric cardioversion is recommended using a starting energy dose of 0.5 to 1 J/kg. If that fails, increase the dose to 2 J/kg (Class I, LOE C).	not reviewed in 2015
2010	Septic Shock	Early assisted ventilation may be considered as part of a protocol-driven strategy for septic shock (Class IIb, LOE C).	not reviewed in 2015
2010	Septic Shock	Etomidate has been shown to facilitate endotracheal intubation in infants and children with minimal hemodynamic effect, but do not use it routinely in pediatric patients with evidence of septic shock (Class III, LOE B).	not reviewed in 2015
2010	Trauma	Do not routinely hyperventilate even in case of head injury (Class III, LOE C).	not reviewed in 2015
2010	Trauma	If the patient has maxillofacial trauma or if you suspect a basilar skull fracture, insert an orogastric rather than a nasogastric tube (Class IIa, LOE C).	not reviewed in 2015
2010	Trauma	In the very select circumstances of children with cardiac arrest from penetrating trauma with short transport times, consider performing resuscitative thoracotomy (Class IIb, LOE C).	not reviewed in 2015
2010	Single Ventricle	Neonates in a prearrest state due to elevated pulmonary-to-systemic flow ratio prior to Stage I repair might benefit from a $Paco_2$ of 50 to 60 mm Hg, which can be achieved during mechanical ventilation by reducing minute ventilation, increasing the inspired fraction of CO_2, or administering opioids with or without chemical paralysis (Class IIb, LOE B).	not reviewed in 2015
2010	Single Ventricle	Neonates in a low cardiac output state following stage I repair may benefit from systemic vasodilators such as α-adrenergic antagonists (eg, phenoxybenzamine) to treat or ameliorate increased systemic vascular resistance, improve systemic oxygen delivery, and reduce the likelihood of cardiac arrest (Class IIa, LOE B).	not reviewed in 2015
2010	Single Ventricle	Other drugs that reduce systemic vascular resistance (eg, milrinone or nipride) may also be considered for patients with excessive Qp:Qs (Class IIa, LOE B).	not reviewed in 2015
2010	Single Ventricle	During cardiopulmonary arrest, it is reasonable to consider extracorporeal membrane oxygenation (ECMO) for patients with single ventricle anatomy who have undergone Stage I procedure (Class IIa, LOE B).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Part 12 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Single Ventricle	Hypoventilation may improve oxygen delivery in patients in a prearrest state with Fontan or hemi-Fontan/bidirectional Glenn (BDG) physiology (Class IIa, LOE B).	not reviewed in 2015
2010	Single Ventricle	Negative-pressure ventilation may improve cardiac output (Class IIa, LOE C).	not reviewed in 2015
2010	Single Ventricle	During cardiopulmonary arrest, it is reasonable to consider extracorporeal membrane oxygenation (ECMO) for patients with Fontan physiology (Class IIa, LOE C).	not reviewed in 2015
2010	Pulmonary Hypertension	If intravenous or inhaled therapy to decrease pulmonary hypertension has been interrupted, reinstitute it (Class IIa, LOE C).	not reviewed in 2015
2010	Pulmonary Hypertension	Consider administering inhaled nitric oxide (iNO) or aerosolized prostacyclin or analogue to reduce pulmonary vascular resistance (Class IIa, LOE C).	not reviewed in 2015
2010	Pulmonary Hypertension	If iNO is not available, consider giving an intravenous bolus of prostacyclin (Class IIa, LOE C).	not reviewed in 2015
2010	Pulmonary Hypertension	ECMO may be beneficial if instituted early in the resuscitation (Class IIa, LOE C).	not reviewed in 2015
2010	Cocaine	For coronary vasospasm consider nitroglycerin (Class IIa, LOE C), a benzodiazepine, and phentolamine (an α-adrenergic antagonist) (Class IIb, LOE C).	not reviewed in 2015
2010	Cocaine	Do not give β-adrenergic blockers (Class III, LOE C).	not reviewed in 2015
2010	Cocaine	For ventricular arrhythmia, consider sodium bicarbonate (1 to 2 mEq/kg) administration (Class IIb, LOE C) in addition to standard treatment.	not reviewed in 2015
2010	Cocaine	To prevent arrhythmias secondary to myocardial infarction, consider a lidocaine bolus followed by a lidocaine infusion (Class IIb, LOE C).	not reviewed in 2015
2010	Tricyclic Antidepressants and Other Sodium Channel Blockers	Do not administer Class IA (quinidine, procainamide), Class IC (flecainide, propafenone), or Class III (amiodarone and sotalol) antiarrhythmics, which may exacerbate cardiac toxicity (Class III, LOE C).	not reviewed in 2015
2010	Calcium Channel Blockers	The effectiveness of calcium administration is variable (Class IIb, LOE C).	not reviewed in 2015
2010	Calcium Channel Blockers	For bradycardia and hypotension, consider vasopressors and inotropes such as norepinephrine or epinephrine (Class IIb, LOE C).	not reviewed in 2015
2010	Beta-Adrenergic Blockers	High-dose epinephrine infusion may be effective (Class IIb, LOE C).	not reviewed in 2015
2010	Beta-Adrenergic Blockers	Consider glucagon (Class IIb, LOE C).	not reviewed in 2015
2010	Beta-Adrenergic Blockers	Consider an infusion of glucose and insulin (Class IIb, LOE C).	not reviewed in 2015
2010	Beta-Adrenergic Blockers	There are insufficient data to make a recommendation for or against using calcium (Class IIb, LOE C).	not reviewed in 2015
2010	Beta-Adrenergic Blockers	Calcium may be considered if glucagon and catecholamines are ineffective (Class IIb, LOE C).	not reviewed in 2015
2010	Opioids	Support of oxygenation and ventilation is the initial treatment for severe respiratory depression from any cause (Class I).	not reviewed in 2015
2010	Opioids	Naloxone reverses the respiratory depression of narcotic overdose (Class I, LOE B).	not reviewed in 2015
2010	Respiratory System	Monitor exhaled CO_2 (P_{ETCO_2}), especially during transport and diagnostic procedures (Class IIa, LOE B).	not reviewed in 2015
2010	Dopamine	Titrate dopamine to treat shock that is unresponsive to fluids and when systemic vascular resistance is low (Class IIb, LOE C).	not reviewed in 2015
2010	Inodilators	It is reasonable to use an inodilator in a highly monitored setting for treatment of myocardial dysfunction with increased systemic or pulmonary vascular resistance (Class IIa, LOE B).	not reviewed in 2015
2010	Neurologic System	It is reasonable for adolescents resuscitated from sudden, witnessed, out-of-hospital VF cardiac arrest (Class IIa, LOE C).	not reviewed in 2015
2010	Neurologic System	Monitor temperature continuously, if possible, and treat fever (>38°C) aggressively with antipyretics and cooling devices because fever adversely influences recovery from ischemic brain injury (Class IIa, LOE C).	not reviewed in 2015
2010	Interhospital Transport	Monitor exhaled CO_2 (qualitative colorimetric detector or capnography) during interhospital or intrahospital transport of intubated patients (Class IIa, LOE B).	not reviewed in 2015
2010	Family Presence During Resuscitation	Whenever possible, provide family members with the option of being present during resuscitation of an infant or child (Class I, LOE B).	not reviewed in 2015
2010	Family Presence During Resuscitation	If the presence of family members creates undue staff stress or is considered detrimental to the resuscitation, then family members should be respectfully asked to leave (Class IIa, LOE C).	not reviewed in 2015
2010	Sudden Unexplained Deaths	Refer families of patients that do not have a cause of death found on autopsy to a healthcare provider or center with expertise in arrhythmias (Class I, LOE C).	not reviewed in 2015

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