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 56% to 43% (Girotra et al1 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.5

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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 International Consensus on Science With Treatment for infants and children requiring emergency tracheal intubation

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

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:
Intra-arrest Care
- Effectiveness of extracorporeal membrane oxygenation (ECMO) resuscitation compared to standard resuscitation without ECMO
- Targeting a specific end-tidal CO₂ (ETCO₂) 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 Pao₂ strategy to improve outcomes
- Use of a specific Pao₂ 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

PREAMREST CARE UPDATES

Medical Emergency Team/Rapid Response Team

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. The data addressing effects on hospital mortality were inconclusive.

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

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.

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

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. 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.

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.

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. 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. 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.

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) 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, which found that fluid boluses as part of resuscitation are not safe for all patients in all settings. This 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

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

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**Table 1**

<table>
<thead>
<tr>
<th>Illness Combinations</th>
<th>Studies</th>
<th>Survival to Hospital Discharge</th>
<th>Need for Transfusion or Diuretics</th>
<th>Need for Rescue Fluid</th>
<th>Mechanical Ventilation or Vasopressor</th>
<th>Time to Resolution of Shock</th>
<th>Total IV Fluids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe septic shock</td>
<td>Santhanam 2006; Camille 1991</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>No Studies Available</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>No Studies Available</td>
</tr>
<tr>
<td>Severe malaria</td>
<td>Maitland 2009; Maitland 2009</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>Harm</td>
<td>No Studies Available</td>
<td>No Benefit</td>
<td>No Studies Available</td>
</tr>
<tr>
<td>Severe febrile illness with some but not all signs of shock</td>
<td>Maitland 2011; Maitland 2013</td>
<td>Benefit</td>
<td>No Benefit</td>
<td>No Studies Available</td>
<td>No Studies Available</td>
<td>Harm</td>
<td>No Studies Available</td>
</tr>
</tbody>
</table>

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.
More recent in-hospital literature involves larger case series of critically ill neonates, infants, and children undergoing emergency intubation. 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. Evidence is conflicting as to whether preintubation atropine administration reduces the incidence of arrhythmias or postintubation shock. 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. 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.

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.

INTRA-ARREST CARE UPDATES

Extracorporeal CPR for In-Hospital Pediatric Cardiac Arrest

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

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 precardiac arrest use of ECMO in children with acute fulminant myocarditis.

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.
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 CO₂ Monitoring to Guide CPR QualityPeds 827
High-quality CPR is associated with improved outcomes after cardiac arrest. Animal data support a direct association between ETCO₂ 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 ETCO₂ 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 ETCO₂ monitoring improves outcomes from cardiac arrest. One pediatric animal study showed that ETCO₂-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 ETCO₂ values generated during CPR were significantly associated with chest compression depth and ventilation rate.46

2015 Recommendation—New
ETCO₂ 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 ArrestPeds 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_longer and presence with a nonshockable as opposed to a shockable rhythm__are all predictors of poor patient outcome. For infants and children with IHCA, negative predictive factors include age greater than 1 year,5,47 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 CPRPeds 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 ArrestPeds 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 had too many confounders to determine if vasopressors were beneficial. One adult OHCA randomized controlled trial 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 Ila, LOE C-LD).

Amiodarone and Lidocaine for Shock-Refractory VF and pVTPeds 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 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
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 or 2 to 4 J/kg. In 1 observational study of IHCA, 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 showed no benefit in achieving ROSC with a specific energy dose for initial defibrillation. Three small observational studies of IHCA and OHCA 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-ED). 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
Data suggest that fever after pediatric cardiac arrest is common and is associated with poor outcomes. The

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**Figure 3**
Pediatric Cardiac Arrest Algorithm—2015 Update
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). Observational data of pediatric patients resuscitated from IHCA or OHCA 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 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 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
Animal studies suggest that elevated levels of tissue Po2 after ROSC (hyperoxia) contribute to oxidative stress that may potentiate the postresuscitation syndrome, while some adult studies show associations between hyperoxemia and increased mortality.

2015 Evidence Summary
Three small observational studies of pediatric IHCA and OHCA survivors did not show an association between elevated PaO2 and outcome. In a larger observational study of 1427 pediatric IHCA and OHCA victims who survived to pediatric ICU admission, after adjustment of confounders, the presence of normoxemia (defined as a PaO2 of 60 mm Hg or greater and less than 300 mm Hg) when compared with hyperoxemia (PaO2 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 PaO2 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 hypoxia is strictly avoided. Ideally, oxygen is titrated to a value appropriate to the specific patient condition.

Post–Cardiac Arrest Paco2
Cerebral vascular autoregulation may be abnormal after ROSC. Adult data show an association between post-ROSC hypocapnia and worse patient outcomes. In other types of pediatric brain injury, hypocapnia is associated with worse clinical outcomes.

2015 Evidence Summary
There were no studies in children after cardiac arrest specifically comparing ventilation with a predetermined PaCO2 target. One small observational study of both pediatric IHCA and OHCA demonstrated no association between hypercapnia (Paco2 greater than 50 mm Hg) or hypocapnia (Paco2 less than 30 mm Hg) and outcome. However, in an observational study of pediatric IHCA, hypercapnia (Paco2 50 mm Hg or greater) was associated with worse survival to hospital discharge.

2015 Recommendation—New
It is reasonable for practitioners to target a Paco2 after ROSC that is appropriate to the specific patient condition, and limit exposure to severe hypercapnia or hypocapnia (Class Ib, LOE C-LD).

Post–Cardiac Arrest Fluids and Inotropes
Myocardial dysfunction and vascular instability are common after resuscitation from cardiac arrest.

2015 Evidence Summary
Three small observational studies involving pediatric IHCA and OHCA demonstrated worse survival to hospital discharge when children were exposed to post-ROSC hypotension. One of these studies 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.
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-E0).

Postresuscitation Use of EEG for Prognosis

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 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

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, 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.

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.

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

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).

REFERENCES


27. Upadhyay M, Singh S, Muridiharan J, Kaur N, Majumdar S. Randomized evaluation of fluid resuscitation with crystalloid (saline)
28. Maitland K, Pamba A, Newton CR, Levin M. Response to volume resuscitation in chil-
PCC.00000929.332810.4E.


30. Dung NM, Day NP, Tam DT, Loan HT, Chau HT, Minh LN, Diet TV, Bethell DB, Kneen R, Hien 
TT, White NJ, Farrar JJ. Fluid replacement in dengue shock syndrome: a randomized, 
794. doi:10.1086/520435.

31. Ngo NT, Cao XT, Kneen R, Wills B, Nguyen VM, Nguyen TQ, Chu VT, Nguyen TT, Simpson JA, 
Solomon T, White NJ, Farrar J. Acute management of dengue shock syndrome: a randomized 
doi:10.1086/318479.

32. Wills BA, Nguyen MD, Ha TL, Dong TH, Tran TN, Le TT, Tran VN, Nguyen TH, Nguyen VC, 
Stepniewska K, White NJ, Farrar JJ. Comparison of three fluid solutions for res-
NEJMoa040457.

for critical care intubation in a cohort of 264 children and reduced mortality unrelated to effects on brady-

34. Jones P, Dauerg S, Denjoy I, Pinto da Costa N, Alberti C, Boukedid R, Peters MJ. The effect of atropine on rhythm and conduc-
tion disturbances during 322 critical care intubations. Pediatr Crit Care Med. 2013;14: 
e289–e297. doi:10.1097/PCC.0b013e3182b8a862.

35. Fastle RK, Roback MG. Pediatric rapid se-
quence intubation: incidence of reflex bra-
655.

36. Dauchot P, Gravenstein JS. Effects of atro-
pine on the electrocardiogram in different age groups. Clin Pharmacol Ther. 1971;12: 
274–280.

37. Teele SA, Allan CK, Laussen PC, Newberger 
JW, Gauvreau K, Thiagarajan RR. Management and outcomes in pediatric patients 
presenting with acute fulminant myocar-

38. de Mos N, van Litsenburg RR, McCrindle 
B, Bohn DJ, Parshuram CS. Pediatric in-
tensive-care-unit cardiac arrest: inci-
dence, survival, and predictive factors. Crit 
Care Med. 2006;34:1209–1215. doi: 10.1097/ 
01.CCM.0000208440.66756.C2.


40. Lowry AW, Morales DL, Graves DE, Knudson 
JD, Shamszad P, Mott AR, Cabrera AG, 
Rossano JW. Characterization of extracor-
poral membrane oxygenation for pedi-
tiatric cardiac arrest in the United States: analysis of the kids’ inpatient database. Pediatr 

41. Odegård KC, Bergersen L, Thiagarajan R, 
192. doi:10.1213/ANE.0b013e3182908bcb.

42. Ortmann L, Prodhon P, Gossett J, Schexnayder 
S, Berg R, Nadkarni V, Bhutta A. American 
Heart Association’s Get With The Guidelines– 
Resuscitation Investigators. Outcomes after in-hospital cardiac arrest in chil-
dren with cardiac disease: a report from Get With The Guidelines–Resuscitation. 
Circulation. 2011;124:2329–2337. doi: 10.1161/ 
CIRCULATIONAHA.110.134546.

43. Morris MC, Wernovsky G, Nadkarni VM. 
Survival outcomes after extracorporeal cardiopulmonary resuscitation instituted during active chest compressions follow-
 ing refractory in-hospital pediatric cardiac 
arrest. Pediatr Crit Care Med. 2004;5: 
440–446.

44. Raymond TT, Cunyngham CB, Thompson MT, 
Thomas JA, Dalton HJ, Nadkarni VM, Ameri-
can Heart Association National Registry of 
CPR Investigators. Outcomes among neo-
nates, infants, and children after extracor-
poral cardiopulmonary resuscitation for refractory inhospital pediatric cardiac ar-
rest: a report from the National Registry of Cardiopulmonary Resuscitation. Pediatr 
PCC.0b013e3181c0411b.

45. Hamrick JL, Hamrick JT, Lee JK, Lee BH, 
Koehler RC, Shaffner DH. Efficacy of chest 
compressions directed by end-tidal CO2 
feedback in a pediatric resuscitation model of basic life support. J Am Heart Assoc. 2014; 
3:e000450. doi:10.1161/JAHA.113.000450.

46. Skeel KR, Wiebe DJ, Leary M, Babaeizadeh 
S, Yuen TC, Zive D, Owens PC, Edelson DP, 
Daya MR, Idris AH, Abella BS. Quantitative relationship between end-tidal carbon di-
oxide and CPR quality during both in-
j.resuscitation.2015.01.026.

47. Kitamura T, Iwami T, Kawamura T, Nagao K, 
Tanaka H, Nadkarni VM, Berg RA, Hiraide A; 
implementation working group for All-
Japan Utstein Registry of the Fire and 
Disaster Management Agency. Conventional 
and chest-compression-only cardiopulmo-
nary resuscitation by bystanders for chil-
dren who have out-of-hospital cardiac arrests: a prospective, nationwide, population-
based cohort study. Lancet. 2010;375: 
1347–1354. doi:10.1016/S0140-6736(10) 
60064-5.

48. Young KD, Gausche-Hill M, McClung CD, 
Lewis RJ. A prospective, population-based 
study of the epidemiology and outcome of out-of-hospital pediatric cardiopulmonary 

49. Moler FW, Donaldson AE, Meert K, Brilli RJ, 
Nadkarni V, Shaffner DH, Schlein CL, Clark 
RS, Dalton HJ, Statler K, Tieves KS, Hack-
barth R, Pretzlaff R, van der Jagt EW, 
Pineda J, Hernan L, Dean JM; Pediatric 
Emergency Care Applied Research Net-
work. Multicenter cohort study of out-of-
hospital pediatric cardiac arrest. Crit Care 
CCM.0b013e3181f3c1e7.

50. López-Herce J, García C, Rodríguez-Núñez A, 
Domínguez P, Carrillo A, Calvo C, Delgado 
MA; Spanish Study Group of Cardiopulmo-
nary Arrest in Children. Long-term outcome of paediatric cardiopulmonary resuscitation in 

51. Reis AG, Nadkarni V, Perondi MB, Grisi S, 
Berg RA. A prospective investigation into the 
epidemiology of in-hospital pediatric cardiopulmonary resuscitation using the interna-
tional Utstein reporting style. Pedi-

52. Haque A, Rizvi A, Bano S. Outcome of in-
hospital pediatric cardiopulmonary arrest from a single center in Pakistan. Indian J 
Pediatri. 2011;78:1356–1360. doi: 10.1007/ 
s12098-011-0439-4.

53. Meert KL, Donaldson A, Nadkarni V, Tieves 
KS, Schlein CL, Brilli RJ, Clark RS, Shaffner 
DH, Levy F, Statler K, Dalton HJ, van der Jagt 
EW, Hackbarth R, Pretzlaff R, Hernan L, Dean JM, Moler FW. Pediatric Emergency 
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ter cohort study of in-hospital pediatric 
10:544–553. doi:10.1097/PCC.0b013e3181a7045c.


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<th>Employment</th>
<th>Research Grant</th>
<th>Other Research Support</th>
<th>Speakers' Bureau/ Honoraria</th>
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<td>Marc D. Berg</td>
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<td>Leon Chameides</td>
<td>Connecticut Children's Medical Center</td>
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<td>Robert W. Hickey</td>
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<td>Halden F. Scott</td>
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<td>The Children's Hospital of Philadelphia; University of Pennsylvania School of Medicine</td>
<td>NIH†</td>
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<td>Janice A. Tijssen</td>
<td>London Health Services Center</td>
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<td>Alexis Topjian</td>
<td>The Children's Hospital of Philadelphia; University of Pennsylvania School of Medicine</td>
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<td>Expert witness for defense and plaintiff*</td>
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<td>Élise W. van der Jagt</td>
<td>University of Rochester School of Medicine</td>
<td>NHLBI*</td>
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<td>Ricardo A. Samson</td>
<td>The University of Arizona</td>
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<td>University of Arkansas; Arkansas Children's Hospital</td>
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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.
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<tr>
<td>2015</td>
<td>Prearrest Care Updates</td>
<td>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).</td>
<td>updated for 2015</td>
</tr>
<tr>
<td>2015</td>
<td>Prearrest Care Updates</td>
<td>The use of PEWS may be considered, but its effectiveness in the in-hospital setting is not well established (Class IIb, LOE C-LD).</td>
<td>new for 2015</td>
</tr>
<tr>
<td>2015</td>
<td>Prearrest Care Updates</td>
<td>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).</td>
<td>new for 2015</td>
</tr>
<tr>
<td>2015</td>
<td>Prearrest Care Updates</td>
<td>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).</td>
<td>new for 2015</td>
</tr>
<tr>
<td>2015</td>
<td>Prearrest Care Updates</td>
<td>Providers should reassess the patient after every fluid bolus (Class I, LOE C-EO).</td>
<td>new for 2015</td>
</tr>
<tr>
<td>2015</td>
<td>Prearrest Care Updates</td>
<td>Either isotonic crystalloids or colloids can be effective as the initial fluid choice for resuscitation (Class IIa, LOE B-R).</td>
<td>new for 2015</td>
</tr>
<tr>
<td>2015</td>
<td>Prearrest Care Updates</td>
<td>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).</td>
<td>new for 2015</td>
</tr>
<tr>
<td>2015</td>
<td>Prearrest Care Updates</td>
<td>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).</td>
<td>new for 2015</td>
</tr>
<tr>
<td>2015</td>
<td>Prearrest Care Updates</td>
<td>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).</td>
<td>new for 2015</td>
</tr>
<tr>
<td>2015</td>
<td>Intra-arrest Care Updates</td>
<td>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).</td>
<td>new for 2015</td>
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<tr>
<td>2015</td>
<td>Intra-arrest Care Updates</td>
<td>ETCO₂ 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).</td>
<td>new for 2015</td>
</tr>
<tr>
<td>2015</td>
<td>Intra-arrest Care Updates</td>
<td>Multiple variables should be used when attempting to prognosticate outcomes during cardiac arrest (Class I, LOE C-LD).</td>
<td>new for 2015</td>
</tr>
<tr>
<td>2015</td>
<td>Intra-arrest Care Updates</td>
<td>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).</td>
<td>new for 2015</td>
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<tr>
<td>2015</td>
<td>Intra-arrest Care Updates</td>
<td>It is reasonable to administer epinephrine in pediatric cardiac arrest (Class IIa, LOE C-LD).</td>
<td>new for 2015</td>
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<tr>
<td>2015</td>
<td>Intra-arrest Care Updates</td>
<td>For shock-refractory VF or VT, either amiodarone or lidocaine may be used (Class IIb, LOE C-LD).</td>
<td>new for 2015</td>
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<td>2015</td>
<td>Intra-arrest Care Updates</td>
<td>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).</td>
<td>updated for 2015</td>
</tr>
<tr>
<td>2015</td>
<td>Intra-arrest Care Updates</td>
<td>For refractory VF, it is reasonable to increase the dose to 4 J/kg (Class IIa, LOE C-LD).</td>
<td>updated for 2015</td>
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<tr>
<td>2015</td>
<td>Intra-arrest Care Updates</td>
<td>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).</td>
<td>updated for 2015</td>
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<td>2015</td>
<td>Postarrest Care Updates</td>
<td>For infants and children remaining comatose after OHCA, it is reasonable either to maintain 5 days of continuous normothermia (35°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).</td>
<td>new for 2015</td>
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<td>2015</td>
<td>Postarrest Care Updates</td>
<td>Continuous measurement of temperature during this time period is recommended (Class I, LOE B-NR).</td>
<td>new for 2015</td>
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<td>2015</td>
<td>Postarrest Care Updates</td>
<td>Fever (temperature 38°C or higher) should be aggressively treated after ROSC (Class I, LOE B-NR).</td>
<td>new for 2015</td>
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<tr>
<td>2015</td>
<td>Postarrest Care Updates</td>
<td>It may be reasonable for rescuers to target normoxemia after ROSC (Class IIb, LOE B-R).</td>
<td>new for 2015</td>
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<tr>
<td>2015</td>
<td>Postarrest Care Updates</td>
<td>It is reasonable for practitioners to target a PaCO2 after ROSC that is appropriate to the specific patient condition, and limit exposure to severe hypercapnia or hypocapnia (Class IIb, LOE C-LD).</td>
<td>new for 2015</td>
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<td>2015</td>
<td>Postarrest Care Updates</td>
<td>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).</td>
<td>new for 2015</td>
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<tr>
<td>2015</td>
<td>Postarrest Care Updates</td>
<td>When appropriate resources are available, continuous arterial pressure monitoring is recommended to identify and treat hypotension (Class I, LOE C-EO).</td>
<td>new for 2015</td>
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<td>2015</td>
<td>Postarrest Care Updates</td>
<td>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 IIa, LOE C-LD) but should not be used as the sole criterion.</td>
<td>new for 2015</td>
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<td>2015</td>
<td>Postarrest Care Updates</td>
<td>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).</td>
<td>new for 2015</td>
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<td></td>
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<td>The following recommendations were not reviewed in 2015. For more information, see the 2010 AHA Guidelines for CPR and ECC, &quot;Part 14: Pediatric Advanced Life Support.&quot;</td>
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<td>2010</td>
<td>Family Presence During Resuscitation</td>
<td>Whenever possible, provide family members with the option of being present during resuscitation of an infant or child (Class I, LOE B).</td>
<td>not reviewed in 2015</td>
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<td>2010</td>
<td>Laryngeal Mask Airway (LMA)</td>
<td>When bag-mask ventilation (see &quot;Bag-Mask Ventilation,&quot; 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-LD).</td>
<td>not reviewed in 2015</td>
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<td>2010</td>
<td>Bag-Mask Ventilation</td>
<td>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).</td>
<td>not reviewed in 2015</td>
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<tr>
<td>2010</td>
<td>Precautions</td>
<td>Use only the force and tidal volume needed to just make the chest rise visibly (Class I, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Precautions</td>
<td>Avoid delivering excessive ventilation during cardiac arrest (Class III, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Precautions</td>
<td>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).</td>
<td>not reviewed in 2015</td>
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<tr>
<td>2010</td>
<td>Precautions</td>
<td>It may be reasonable to do the same if an LMA is in place (Class IIb, LOE C).</td>
<td>not reviewed in 2015</td>
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<td>2010</td>
<td>Precautions</td>
<td>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).</td>
<td>not reviewed in 2015</td>
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<td>2010</td>
<td>Two-Person Bag-Mask Ventilation</td>
<td>Apply cricoid pressure in an unresponsive victim to reduce air entry into the stomach (Class IIa, LOE B).</td>
<td>not reviewed in 2015</td>
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<td>2010</td>
<td>Two-Person Bag-Mask Ventilation</td>
<td>Avoid excessive cricoid pressure so as not to obstruct the trachea (Class III, LOE B).</td>
<td>not reviewed in 2015</td>
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<td>Cricoid Pressure During Intubation</td>
<td>Do not continue cricoid pressure if it interferes with ventilation or the speed or ease of intubation (Class III, LOE C).</td>
<td>not reviewed in 2015</td>
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<td>2010</td>
<td>Cuffed Versus Uncuffed Endotracheal Tubes</td>
<td>Both cuffed and uncuffed endotracheal tubes are acceptable for intubating infants and children (Class IIa, LOE C).</td>
<td>not reviewed in 2015</td>
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<tr>
<td>2010</td>
<td>Cuffed Versus Uncuffed Endotracheal Tubes</td>
<td>In certain circumstances (e.g., 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).</td>
<td>not reviewed in 2015</td>
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<td>2010</td>
<td>Endotracheal Tube Size</td>
<td>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).</td>
<td>not reviewed in 2015</td>
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<td>2010</td>
<td>Endotracheal Tube Size</td>
<td>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).</td>
<td>not reviewed in 2015</td>
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<td>Esophageal Detector Device (EDD)</td>
<td>If capnography is not available, an esophageal detector device (EDD) may be considered to confirm endotracheal tube placement in children weighing &gt;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.</td>
<td>not reviewed in 2015</td>
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<td>2010</td>
<td>Transtracheal Catheter Oxygenation and Ventilation</td>
<td>Attempt this procedure only after proper training and with appropriate equipment (Class IIb, LOE C).</td>
<td>not reviewed in 2015</td>
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<td>2010</td>
<td>CPR Guidelines for Newborns With Cardiac Arrest of Cardiac Origin</td>
<td>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).</td>
<td>not reviewed in 2015</td>
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<td>Echocardiography</td>
<td>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).</td>
<td>not reviewed in 2015</td>
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<td>Intraosseous (IO) Access</td>
<td>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).</td>
<td>not reviewed in 2015</td>
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<td>2010</td>
<td>Medication Dose Calculation</td>
<td>If the child's weight is unknown, it is reasonable to use a body length tape with precalculated doses (Class IIa, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Medication Dose Calculation</td>
<td>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).</td>
<td>not reviewed in 2015</td>
</tr>
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<td>2010</td>
<td>Calcium</td>
<td>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).</td>
<td>not reviewed in 2015</td>
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<td>2010</td>
<td>Glucose</td>
<td>Check blood glucose concentration during the resuscitation and treat hypoglycemia promptly (Class I, LOE C).</td>
<td>not reviewed in 2015</td>
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<td>2010</td>
<td>Sodium Bicarbonate</td>
<td>Routine administration of sodium bicarbonate is not recommended in cardiac arrest (Class III, LOE B).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>AEDs</td>
<td>If an AED with an attenuator is not available, use an AED with standard electrodes (Class IIa, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>AEDs</td>
<td>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).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Bradycardia</td>
<td>Continue to support airway, ventilation, oxygenation, and chest compressions (Class I, LOE B).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Bradycardia</td>
<td>Emergency transcatheter 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).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Supraventricular Tachycardia</td>
<td>Attempt vagal stimulation first, unless the patient is hemodynamically unstable or the procedure will unduly delay chemical or electric cardioversion (Class IIa, LOE C).</td>
<td>not reviewed in 2015</td>
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<tr>
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<tr>
<td>2010</td>
<td>Supraventricular Tachycardia</td>
<td>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.</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Supraventricular Tachycardia</td>
<td>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).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Supraventricular Tachycardia</td>
<td>Consider amiodarone 5 mg/kg ID/IV or procainamide 15 mg/kg ID/IV23G 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).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Wide-Complex (&gt;0.09 Second) Tachycardia</td>
<td>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 I, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Wide-Complex (&gt;0.09 Second) Tachycardia</td>
<td>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 IIb, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Septic Shock</td>
<td>Early assisted ventilation may be considered as part of a protocol-driven strategy for septic shock (Class IIb, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Septic Shock</td>
<td>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).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Trauma</td>
<td>Do not routinely hyperventilate even in case of head injury (Class III, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Trauma</td>
<td>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).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Trauma</td>
<td>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).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Single Ventricle</td>
<td>Neonates in a prearrest state due to elevated pulmonary-to-systemic flow ratio prior to Stage I repair might benefit from a PacO2 of 50 to 60 mm Hg, which can be achieved during mechanical ventilation by reducing minute ventilation, increasing the inspired fraction of CO2, or administering opioids with or without chemical paralysis (Class IIb, LOE B).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Single Ventricle</td>
<td>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).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Single Ventricle</td>
<td>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).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Single Ventricle</td>
<td>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).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Single Ventricle</td>
<td>Hypoventilation may improve oxygen delivery in patients in a prearrest state with Fontan or hemi-Fontan/bidirectional Glenn (BDG) physiology (Class IIa, LOE B).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Single Ventricle</td>
<td>Negative-pressure ventilation may improve cardiac output (Class IIa, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Single Ventricle</td>
<td>During cardiopulmonary arrest, it is reasonable to consider extracorporeal membrane oxygenation (ECMO) for patients with Fontan physiology (Class IIa, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
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<tr>
<td>2010</td>
<td>Pulmonary Hypertension</td>
<td>If intravenous or inhaled therapy to decrease pulmonary hypertension has been interrupted, reinstitute it (Class IIa, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Pulmonary Hypertension</td>
<td>Consider administering inhaled nitric oxide (iNO) or aerosolized prostacyclin or analogue to reduce pulmonary vascular resistance (Class IIa, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Pulmonary Hypertension</td>
<td>If iNO is not available, consider giving an intravenous bolus of prostacyclin (Class IIa, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Pulmonary Hypertension</td>
<td>ECMO may be beneficial if instituted early in the resuscitation (Class IIa, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Cocaine</td>
<td>For coronary vasospasm consider nitroglycerin (Class IIa, LOE C), a benzodiazepine, and phenolamine (an α-adrenergic antagonist) (Class IIb, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Cocaine</td>
<td>Do not give β-adrenergic blockers (Class III, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Cocaine</td>
<td>For ventricular arrhythmia, consider sodium bicarbonate (1 to 2 mEq/kg) administration (Class IIb, LOE C) in addition to standard treatment.</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Cocaine</td>
<td>To prevent arrhythmias secondary to myocardial infarction, consider a lidocaine bolus followed by a lidocaine infusion (Class IIb, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Tricyclic Antidepressants and Other Sodium Channel Blockers</td>
<td>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).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Calcium Channel Blockers</td>
<td>The effectiveness of calcium administration is variable (Class IIb, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Calcium Channel Blockers</td>
<td>For bradycardia and hypotension, consider vasopressors and inotropes such as norepinephrine or epinephrine (Class IIb, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Beta-Adrenergic Blockers</td>
<td>High-dose epinephrine infusion may be effective (Class IIb, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Beta-Adrenergic Blockers</td>
<td>Consider glucagon (Class IIb, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Beta-Adrenergic Blockers</td>
<td>Consider an infusion of glucose and insulin (Class IIb, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Beta-Adrenergic Blockers</td>
<td>There are insufficient data to make a recommendation for or against using calcium (Class IIb, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Beta-Adrenergic Blockers</td>
<td>Calcium may be considered if glucagon and catecholamines are ineffective (Class IIb, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Opioids</td>
<td>Support of oxygenation and ventilation is the initial treatment for severe respiratory depression from any cause (Class I).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Opioids</td>
<td>Naloxone reverses the respiratory depression of narcotic overdose (Class I, LOE B).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Respiratory System</td>
<td>Monitor exhaled CO₂ (PETCO₂), especially during transport and diagnostic procedures (Class IIa, LOE B).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Dopamine</td>
<td>Titrate dopamine to treat shock that is unresponsive to fluids and when systemic vascular resistance is low (Class IIb, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Inodilators</td>
<td>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).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Neurologic System</td>
<td>It is reasonable for adolescents resuscitated from sudden, witnessed, out-of-hospital VF cardiac arrest (Class IIa, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Neurologic System</td>
<td>Monitor temperature continuously, if possible, and treat fever (&gt;38°C) aggressively with antipyretics and cooling devices because fever adversely influences recovery from ischemic brain injury (Class IIa, LOE C).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Interhospital Transport</td>
<td>Monitor exhaled CO₂ (qualitative colorimetric detector or capnography) during interhospital or intrahospital transport of intubated patients (Class IIa, LOE B).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Family Presence During Resuscitation</td>
<td>Whenever possible, provide family members with the option of being present during resuscitation of an infant or child (Class I, LOE B).</td>
<td>not reviewed in 2015</td>
</tr>
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<tr>
<td>2010</td>
<td>Family Presence During Resuscitation</td>
<td>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).</td>
<td>not reviewed in 2015</td>
</tr>
<tr>
<td>2010</td>
<td>Sudden Unexplained Deaths</td>
<td>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).</td>
<td>not reviewed in 2015</td>
</tr>
</tbody>
</table>
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*Pediatrics* originally published online October 14, 2015;

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