Pediatric Basic and Advanced Life Support

Summary of Key Issues and Major Changes
More than 20,000 infants and children have a cardiac arrest each year in the United States. Despite increases in survival and comparatively good rates of good neurologic outcome after pediatric IHCA, survival rates from pediatric OHCA remain poor, particularly in infants. Recommendations for pediatric basic life support (PBLS) and CPR in infants, children, and adolescents have been combined with recommendations for pediatric advanced life support (PALS) in a single document in the 2020 Guidelines. The causes of cardiac arrest in infants and children differ from cardiac arrest in adults, and a growing body of pediatric-specific evidence supports these recommendations. Key issues, major changes, and enhancements in the 2020 Guidelines include the following:

- Algorithms and visual aids were revised to incorporate the best science and improve clarity for PBLS and PALS resuscitation providers.
- Based on newly available data from pediatric resuscitations, the recommended assisted ventilation rate has been increased to 1 breath every 2 to 3 seconds (20-30 breaths per minute) for all pediatric resuscitation scenarios.
- Cuffed ETTs are suggested to reduce air leak and the need for tube exchanges for patients of any age who require intubation.
- The routine use of cricoid pressure during intubation is no longer recommended.
- To maximize the chance of good resuscitation outcomes, epinephrine should be administered as early as possible, ideally within 5 minutes of the start of cardiac arrest from a nonshockable rhythm (asystole and pulseless electrical activity).
- For patients with arterial lines in place, using feedback from continuous measurement of arterial blood pressure may improve CPR quality.
- After ROSC, patients should be evaluated for seizures; status epilepticus and any convulsive seizures should be treated.
- Because recovery from cardiac arrest continues long after the initial hospitalization, patients should have formal assessment and support for their physical, cognitive, and psychosocial needs.
- A titrated approach to fluid management, with epinephrine or norepinephrine infusions if vasopressors are needed, is appropriate in resuscitation from septic shock.
- On the basis largely of extrapolation from adult data, balanced blood component resuscitation is reasonable for infants and children with hemorrhagic shock.
- Opioid overdose management includes CPR and the timely administration of naloxone by either lay rescuers or trained rescuers.
- Children with acute myocarditis who have arrhythmias, heart block, ST-segment changes, or low cardiac output are at high risk of cardiac arrest. Early transfer to an intensive care unit is important, and some patients may require mechanical circulatory support or extracorporeal life support (ECLS).
- Infants and children with congenital heart disease and single ventricle physiology who are in the process of staged reconstruction require special considerations in PALS management.
- Management of pulmonary hypertension may include the use of inhaled nitric oxide, prostacyclin, analgesia, sedation, neuromuscular blockade, the induction of alkalosis, or rescue therapy with ECLS.

Algorithms and Visual Aids
The writing group updated all algorithms to reflect the latest science and made several major changes to improve the visual training and performance aids:

- A new pediatric Chain of Survival was created for IHCA in infants, children, and adolescents (Figure 10).
- A sixth link, Recovery, was added to the pediatric OHCA Chain of Survival and is included in the new pediatric IHCA Chain of Survival (Figure 10).
- The Pediatric Cardiac Arrest Algorithm and the Pediatric Bradycardia With a Pulse Algorithm have been updated to reflect the latest science (Figures 11 and 12).
- The single Pediatric Tachycardia With a Pulse Algorithm now covers both narrow- and wide-complex tachycardias in pediatric patients (Figure 13).
- Two new Opioid-Associated Emergency Algorithms have been added for lay rescuers and trained rescuers (Figures 5 and 6).
- A new checklist is provided for pediatric post–cardiac arrest care (Figure 14).
The causes of cardiac arrest in infants and children differ from cardiac arrest in adults, and a growing body of pediatric-specific evidence supports these recommendations.

Figure 10. AHA Chains of Survival for pediatric IHCA and OHCA.
Figure 11. Pediatric Cardiac Arrest Algorithm.

1. **Start CPR**
   - Begin bag-mask ventilation and give oxygen
   - Attach monitor/defibrillator

2. **VF/pVT**

3. **Shock**

4. **CPR 2 min**
   - IV/IO access
   - **Rhythm shockable?**
     - Yes
     - **Shock**
     - No

5. **Rhythm shockable?**
   - Yes
   - **Shock**
   - No

6. **CPR 2 min**
   - Epinephrine every 3-5 min
   - Consider advanced airway

7. **Rhythm shockable?**
   - Yes
   - **Shock**
   - No

8. **CPR 2 min**
   - Amiodarone or lidocaine
   - Treat reversible causes

9. **Asystole/PEA**

10. **CPR 2 min**
    - IV/IO access
    - **Rhythm shockable?**
      - Yes
      - **Epinephrine ASAP**
      - No

11. **CPR 2 min**
    - Treat reversible causes

12. **If no signs of return of spontaneous circulation (ROSC), go to 10**
    - If ROSC, go to Post-Cardiac Arrest Care checklist

**CPR Quality**
- Push hard (≥⅓ of anteroposterior diameter of chest) and fast (100-120/min) and allow complete chest recoil
- Minimize interruptions in compressions
- Change compressor every 2 minutes, or sooner if fatigued
- If no advanced airway, 15:2 compression-ventilation ratio
- If advanced airway, provide continuous compressions and give a breath every 2-3 seconds

**Shock Energy for Defibrillation**
- First shock 2 J/kg
- Second shock 4 J/kg
- Subsequent shocks ≥4 J/kg, maximum 10 J/kg or adult dose

**Drug Therapy**
- **Epinephrine IV/IO dose:** 0.01 mg/kg (0.1 mL/kg of the 0.1 mg/mL concentration). Max dose 1 mg. Repeat every 3-5 minutes. If no IV/IO access, may give endotracheal dose: 0.1 mg/kg (0.1 mL/kg of the 1 mg/mL concentration).
- **Amiodarone IV/IO dose:** 5 mg/kg bolus during cardiac arrest. May repeat up to 3 total doses for refractory VF/pulseless VT or lidocaine IV/IO dose:
  - Initial: 1 mg/kg loading dose

**Advanced Airway**
- Endotracheal intubation or supraglottic advanced airway
- Waveform capnography or capnometry to confirm and monitor ET tube placement

**Reversible Causes**
- Hypovolemia
- Hypoxia
- Hydrogen ion (acidosis)
- Hypoglycemia
- Hypo-/hyperkalemia
- Hypothermia
- Tension pneumothorax
- Tamponade, cardiac
- Toxins
- Thrombosis, pulmonary
- Thrombosis, coronary

© 2020 American Heart Association
Figure 12. Pediatric Bradycardia With a Pulse Algorithm.

Patient with bradycardia

Cardiopulmonary compromise?
- Acutely altered mental status
- Signs of shock
- Hypotension

Yes

Assessment and support
- Maintain patent airway
- Assist breathing with positive pressure ventilation and oxygen as necessary
- Cardiac monitor to identify rhythm; monitor pulse, BP, and oximetry

Start CPR if HR <60/min despite oxygenation and ventilation.

Bradycardia persists?

Yes

- Continue CPR if HR <60/min
- IV/I0 access
- Epinephrine
- Atropine for increased vagal tone or primary AV block
- Consider transthoracic/transvenous pacing
- Identify and treat underlying causes

Check pulse every 2 minutes. Pulse present?

Yes

Go to Pediatric Cardiac Arrest Algorithm.

No

Support ABCs
- Consider oxygen
- Observe
- 12-Lead ECG
- Identify and treat underlying causes

Doses/Details

**Epinephrine IV/I0 dose:**
0.01 mg/kg (0.1 mL/kg of the 0.1 mg/mL concentration). Repeat every 3-5 minutes. If IV/I0 access not available but endotracheal (ET) tube in place, may give ET dose: 0.1 mg/kg (0.1 mL/kg of the 1 mg/mL concentration).

**Atropine IV/I0 dose:**
0.02 mg/kg. May repeat once. Minimum dose 0.1 mg and maximum single dose 0.5 mg.

Possible Causes
- Hypothermia
- Hypoxia
- Medications

© 2020 American Heart Association
Figure 13. Pediatric Tachycardia With a Pulse Algorithm.

Initial assessment and support
- Maintain patent airway; assist breathing as necessary
- Administer oxygen
- Cardiac monitor to identify rhythm; monitor pulse, blood pressure, and oximetry
- IV/I/O access
- 12-Lead ECG if available

Evaluate rhythm with 12-lead ECG or monitor.

Cardiopulmonary compromise?
- Acutely altered mental status
- Signs of shock
- Hypotension

Yes

Search for and treat cause.

No

Probable sinus tachycardia if
- P waves present/normal
- Variable RR interval
- Infant rate usually <220/min
- Child rate usually <180/min

Narrow (≤0.09 sec)

Evaluate QRS duration.

Probable supraventricular tachycardia
- P waves absent/abnormal
- RR interval not variable
- Infant rate usually ≥220/min
- Child rate usually ≥180/min
- History of abrupt rate change

If IV/I/O access is present, give adenosine or
If IV/I/O access is not available, or if adenosine is ineffective, perform synchronized cardioversion

Possible ventricular tachycardia

Synchronized cardioversion
Expert consultation is advised before additional drug therapies.

Wide (>0.09 sec)

Probable supraventricular tachycardia
- P waves absent/abnormal
- RR interval not variable
- Infant rate usually ≥220/min
- Child rate usually ≥180/min
- History of abrupt rate change

If rhythm is regular and QRS monomorphic, consider adenosine.

Possible ventricular tachycardia

Consider vagal maneuvers.

Narrow (≤0.09 sec)

Evaluate QRS duration.

Wide (>0.09 sec)

Possible ventricular tachycardia

Expert consultation is recommended.

© 2020 American Heart Association
### Components of Post–Cardiac Arrest Care

<table>
<thead>
<tr>
<th>Component</th>
<th>Check</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oxygenation and ventilation</strong></td>
<td></td>
</tr>
<tr>
<td>Measure oxygenation and target normoxemia 94%-99% (or child’s normal/appropriate oxygen saturation).</td>
<td></td>
</tr>
<tr>
<td>Measure and target Paco₂ appropriate to the patient’s underlying condition and limit exposure to severe hypercapnia or hypocapnia.</td>
<td></td>
</tr>
<tr>
<td><strong>Hemodynamic monitoring</strong></td>
<td></td>
</tr>
<tr>
<td>Set specific hemodynamic goals during post–cardiac arrest care and review daily.</td>
<td></td>
</tr>
<tr>
<td>Monitor with cardiac telemetry.</td>
<td></td>
</tr>
<tr>
<td>Monitor arterial blood pressure.</td>
<td></td>
</tr>
<tr>
<td>Monitor serum lactate, urine output, and central venous oxygen saturation to help guide therapies.</td>
<td></td>
</tr>
<tr>
<td>Use parenteral fluid bolus with or without inotropes or vasopressors to maintain a systolic blood pressure greater than the fifth percentile for age and sex.</td>
<td></td>
</tr>
<tr>
<td><strong>Targeted temperature management (TTM)</strong></td>
<td></td>
</tr>
<tr>
<td>Measure and continuously monitor core temperature.</td>
<td></td>
</tr>
<tr>
<td>Prevent and treat fever immediately after arrest and during rewarming.</td>
<td></td>
</tr>
<tr>
<td>If patient is comatose apply TTM (32°C-34°C) followed by (36°C-37.5°C) or only TTM (36°C-37.5°C).</td>
<td></td>
</tr>
<tr>
<td>Prevent shivering.</td>
<td></td>
</tr>
<tr>
<td>Monitor blood pressure and treat hypotension during rewarming.</td>
<td></td>
</tr>
<tr>
<td><strong>Neuromonitoring</strong></td>
<td></td>
</tr>
<tr>
<td>If patient has encephalopathy and resources are available, monitor with continuous electroencephalogram.</td>
<td></td>
</tr>
<tr>
<td>Treat seizures.</td>
<td></td>
</tr>
<tr>
<td>Consider early brain imaging to diagnose treatable causes of cardiac arrest.</td>
<td></td>
</tr>
<tr>
<td><strong>Electrolytes and glucose</strong></td>
<td></td>
</tr>
<tr>
<td>Measure blood glucose and avoid hypoglycemia.</td>
<td></td>
</tr>
<tr>
<td>Maintain electrolytes within normal ranges to avoid possible life-threatening arrhythmias.</td>
<td></td>
</tr>
<tr>
<td><strong>Sedation</strong></td>
<td></td>
</tr>
<tr>
<td>Treat with sedatives and anxiolytics.</td>
<td></td>
</tr>
<tr>
<td><strong>Prognosis</strong></td>
<td></td>
</tr>
<tr>
<td>Always consider multiple modalities (clinical and other) over any single predictive factor.</td>
<td></td>
</tr>
<tr>
<td>Remember that assessments may be modified by TTM or induced hypothermia.</td>
<td></td>
</tr>
<tr>
<td>Consider electroencephalogram in conjunction with other factors within the first 7 days after cardiac arrest.</td>
<td></td>
</tr>
<tr>
<td>Consider neuroimaging such as magnetic resonance imaging during the first 7 days.</td>
<td></td>
</tr>
</tbody>
</table>
**Major New and Updated Recommendations**

**Changes to the Assisted Ventilation Rate: Rescue Breathing**

2020 (Updated): (PBLS) For infants and children with a pulse but absent or inadequate respiratory effort, it is reasonable to give 1 breath every 2 to 3 seconds (20-30 breaths/min).

2010 (Old): (PBLS) If there is a palpable pulse 60/min or greater but there is inadequate breathing, give rescue breaths at a rate of about 12 to 20/min (1 breath every 3-5 seconds) until spontaneous breathing resumes.

**Changes to the Assisted Ventilation Rate: Ventilation Rate During CPR With an Advanced Airway**

2020 (Updated): (PALS) When performing CPR in infants and children with an advanced airway, it may be reasonable to target a respiratory rate range of 1 breath every 2 to 3 seconds (20-30/min), accounting for age and clinical condition. Rates exceeding these recommendations may compromise hemodynamics.

2010 (Old): (PALS) If the infant or child is intubated, ventilate at a rate of about 1 breath every 6 seconds (10/min) without interrupting chest compressions.

**Cuffed ETTs**

2020 (Updated): It is reasonable to choose cuffed ETTs over uncuffed ETTs for intubating infants and children. When a cuffed ETT is used, attention should be paid to ETT size, position, and cuff inflation pressure (usually <20–25 cm H₂O).

2010 (Old): Both cuffed and uncuffed ETTs are acceptable for intubating infants and children. In certain circumstances (eg, poor lung compliance, high airway resistance, or a large glottic air leak) a cuffed ETT may be preferable to an uncuffed tube, provided that attention is paid to [ensuring appropriate] ETT size, position, and cuff inflation pressure.

**Cricoid Pressure During Intubation**

2020 (Updated): Routine use of cricoid pressure is not recommended during endotracheal intubation of pediatric patients.

2010 (Old): There is insufficient evidence to recommend routine application of cricoid pressure to prevent aspiration during endotracheal intubation in children.

**Emphasis on Early Epinephrine Administration**

2020 (Updated): For pediatric patients in any setting, it is reasonable to administer the initial dose of epinephrine within 5 minutes from the start of chest compressions.

2015 (Old): It is reasonable to administer epinephrine in pediatric cardiac arrest.

**Invasive Blood Pressure Monitoring to Assess CPR Quality**

2020 (Updated): For patients with continuous invasive arterial blood pressure monitoring in place at the time of cardiac arrest, it is reasonable for providers to use diastolic blood pressure to assess CPR quality.
2015 (Old): 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.

Why: Providing high-quality chest compressions is critical to successful resuscitation. A new study shows that, among pediatric patients receiving CPR with an arterial line in place, rates of survival with favorable neurologic outcome were improved if the diastolic blood pressure was at least 25 mm Hg in infants and at least 30 mm Hg in children.8

Detecting and Treating Seizures After ROSC

2020 (Updated): When resources are available, continuous electroencephalography monitoring is recommended for the detection of seizures following cardiac arrest in patients with persistent encephalopathy.

2020 (Updated): It is recommended to treat clinical seizures following cardiac arrest.

2020 (Updated): It is reasonable to treat nonconvulsive status epilepticus following cardiac arrest in consultation with experts.

2015 (Old): An electroencephalography for the diagnosis of seizure should be promptly performed and interpreted and then should be monitored frequently or continuously in comatose patients after ROSC.

2015 (Old): The same anticonvulsant regimens for the treatment of status epilepticus caused by other etiologies may be considered after cardiac arrest.

Why: For the first time, the Guidelines provide pediatric-specific recommendations for managing seizures after cardiac arrest. Nonconvulsive seizures, including nonconvulsive status epilepticus, are common and cannot be detected without electroencephalography. Although outcome data from the post–cardiac arrest population are lacking, both convulsive and nonconvulsive status epilepticus are associated with poor outcome, and treatment of status epilepticus is beneficial in pediatric patients in general.

Evaluation and Support for Cardiac Arrest Survivors

2020 (New): It is recommended that pediatric cardiac arrest survivors be evaluated for rehabilitation services.

2020 (New): It is reasonable to refer pediatric cardiac arrest survivors for ongoing neurologic evaluation for at least the first year after cardiac arrest.

Why: There is growing recognition that recovery from cardiac arrest continues long after the initial hospitalization. Survivors may require ongoing integrated medical, rehabilitative, caregiver, and community support in the months to years after their cardiac arrest. A recent AHA scientific statement highlights the importance of supporting patients and families during this time to achieve the best possible long-term outcome.5

Septic Shock

Fluid Boluses

2020 (Updated): In patients with septic shock, it is reasonable to administer fluid in 10 mL/kg or 20 mL/kg aliquots with frequent reassessment.

2015 (Old): 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, severe malaria, and dengue.

Choice of Vasopressor

2020 (New): In infants and children with fluid-refractory septic shock, it is reasonable to use either epinephrine or norepinephrine as an initial vasoactive infusion.

2020 (New): In infants and children with fluid-refractory septic shock, if epinephrine or norepinephrine are unavailable, dopamine may be considered.

Corticosteroid Administration

2020 (New): For infants and children with septic shock unresponsive to fluids and requiring vasoactive support, it may be reasonable to consider stress-dose corticosteroids.

Why: Although fluids remain the mainstay of initial therapy for infants and children in shock, especially in hypovolemic and septic shock, fluid overload can lead to increased morbidity. In recent trials of patients with septic shock, those who received higher fluid volumes or faster fluid resuscitation were more likely to develop clinically significant fluid overload and require mechanical ventilation. The writing group reaffirmed previous recommendations to reassess patients after each fluid bolus and to use either crystalloid or colloid fluids for septic shock resuscitation.

Previous versions of the Guidelines did not provide recommendations about choice of vasopressor or the use of corticosteroids in septic shock. Two RCTs suggest that epinephrine is superior to dopamine as the initial vasopressor in pediatric septic shock, and norepinephrine is also appropriate. Recent clinical trials suggest a benefit from corticosteroid administration in some pediatric patients with refractory septic shock.

Hemorrhagic Shock

2020 (New): Among infants and children with hypotensive hemorrhagic shock following trauma, it is reasonable to administer blood products, when available, instead of crystalloid for ongoing volume resuscitation.

Why: Previous versions of the Guidelines did not differentiate the treatment of hemorrhagic shock from other causes of hypovolemic shock. A growing body of evidence (largely from adults but with some pediatric data) suggests a benefit to early, balanced resuscitation using packed red blood cells, fresh frozen plasma, and platelets. Balanced resuscitation is supported by recommendations from the several US and international trauma societies.
Opioid Overdose

2020 (Updated): For patients in respiratory arrest, rescue breathing or bag-mask ventilation should be maintained until spontaneous breathing returns, and standard PBLS or PALS measures should continue if return of spontaneous breathing does not occur.

2020 (Updated): For a patient with suspected opioid overdose who has a definite pulse but no normal breathing or only gasping (ie, a respiratory arrest), in addition to providing standard PBLS or PALS, it is reasonable for responders to administer intramuscular or intranasal naloxone.

2020 (Updated): For patients known or suspected to be in cardiac arrest, in the absence of a proven benefit from the use of naloxone, standard resuscitative measures should take priority over naloxone administration, with a focus on high-quality CPR (compressions plus ventilation).

2015 (Old): Empiric administration of intramuscular or intranasal naloxone to all unresponsive opioid-associated life-threatening emergency patients may be reasonable as an adjunct to standard first aid and non–healthcare provider BLS protocols.

2015 (Old): ACLS providers should support ventilation and administer naloxone to patients with a perfusing cardiac rhythm and opioid-associated respiratory arrest or severe respiratory depression. Bag-mask ventilation should be maintained until spontaneous breathing returns, and standard ACLS measures should continue if return of spontaneous breathing does not occur.

2015 (Old): We can make no recommendation regarding the administration of naloxone in confirmed opioid-associated cardiac arrest.

Why: The opioid epidemic has not spared children. In the United States in 2018, opioid overdose caused 65 deaths in children younger than 15 years and 3618 deaths in people 15 to 24 years old, and many more children required resuscitation. The 2020 Guidelines contain new recommendations for managing children with respiratory arrest or cardiac arrest from opioid overdose.

These recommendations are identical for adults and children, except that compression-ventilation CPR is recommended for all pediatric victims of suspected cardiac arrest. Naloxone can be administered by trained providers, laypersons with focused training, and untrained laypersons. Separate treatment algorithms are provided for managing opioid-associated resuscitation emergencies by laypersons, who cannot reliably check for a pulse (Figure 5), and by trained rescuers (Figure 6). Opioid-associated OHCA is the subject of a 2020 AHA scientific statement.

Myocarditis

2020 (New): Given the high risk of cardiac arrest in children with acute myocarditis who demonstrate arrhythmias, heart block, ST-segment changes, and/or low cardiac output, early consideration of transfer to ICU monitoring and therapy is recommended.

2020 (New): For children with myocarditis or cardiomyopathy and refractory low cardiac output, prearrest use of ECLS or mechanical circulatory support can be beneficial to provide end-organ support and prevent cardiac arrest.

2020 (New): Given the challenges to successful resuscitation of children with myocarditis and cardiomyopathy, once cardiac arrest occurs, early consideration of extracorporeal CPR may be beneficial.

Why: Although myocarditis accounts for about 2% of sudden cardiovascular deaths in infants, 5% of sudden cardiovascular deaths in children, and 6% to 20% of sudden cardiac death in athletes, previous PALS guidelines did not contain specific recommendations for management. These recommendations are consistent with the 2018 AHA scientific statement on CPR in infants and children with cardiac disease.

Single Ventricle: Recommendations for the Treatment of Preoperative and Postoperative Stage I Palliation (Norwood/Blalock-Taussig Shunt) Patients

2020 (New): Direct (superior vena cava catheter) and/or indirect (near infrared spectroscopy) oxygen saturation monitoring can be beneficial to trend and direct management in the critically ill neonate after stage I Norwood palliation or shunt placement.

2020 (New): In the patient with an appropriately restrictive shunt, manipulation of pulmonary vascular resistance may have little effect, whereas lowering systemic vascular resistance with the use of systemic vasodilators (alpha-adrenergic antagonists and/or phosphodiesterase type III inhibitors), with or without the use of oxygen, can be useful to increase systemic delivery of oxygen (DO₂).

2020 (New): ECLS after stage I Norwood palliation can be useful to treat low systemic DO₂.

2020 (New): In the situation of known or suspected shunt obstruction, it is reasonable to administer oxygen, vasoactive agents to increase shunt perfusion pressure, and heparin (50-100 units/kg bolus) while preparing for catheter-based or surgical intervention.

2020 (Updated): For neonates prior to stage I repair with pulmonary overcirculation and symptomatic low systemic cardiac output and DO₂, it is reasonable to target a PaCO₂ of 50 to 60 mm Hg. This can be achieved during mechanical ventilation by reducing minute ventilation or by administering analgesia/sedation with or without neuromuscular blockade.

2010 (Old): 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.