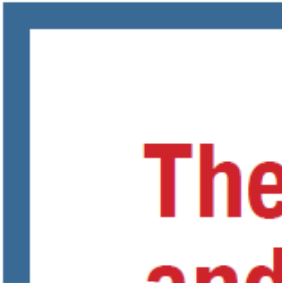


Updates in Pediatric Advanced Life Support (PALS): Science Behind the AHA Resuscitation Guidelines




- Dr. E. Shorafa
- Pediatric intensivist





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.



CLASS (STRENGTH) OF RECOMMENDATION

CLASS 1 (STRONG)

Benefit >>> Risk

Suggested phrases for writing recommendations:

- Is recommended
- Is indicated/useful/effective/beneficial
- Should be performed/administered/other
- Comparative-Effectiveness Phrases†:
 - Treatment/strategy A is recommended/indicated in preference to treatment B
 - Treatment A should be chosen over treatment B

CLASS 2a (MODERATE)

Benefit >> Risk

Suggested phrases for writing recommendations:

- Is reasonable
- Can be useful/effective/beneficial
- Comparative-Effectiveness Phrases†:
 - Treatment/strategy A is probably recommended/indicated in preference to treatment B
 - It is reasonable to choose treatment A over treatment B

CLASS 2b (WEAK)

Benefit ≥ Risk

Suggested phrases for writing recommendations:

- May/might be reasonable
- May/might be considered
- Usefulness/effectiveness is unknown/unclear/uncertain or not well-established

CLASS 3: No Benefit (MODERATE)

Benefit = Risk

(Generally, LOE A or B use only)

Suggested phrases for writing recommendations:

- Is not recommended
- Is not indicated/useful/effective/beneficial
- Should not be performed/administered/other

Class 3: Harm (STRONG)

Risk > Benefit

Suggested phrases for writing recommendations:

- Potentially harmful
- Causes harm
- Associated with excess morbidity/mortality
- Should not be performed/administered/other

LEVEL (QUALITY) OF EVIDENCE‡**LEVEL A**

- High-quality evidence‡ from more than 1 RCT
- Meta-analyses of high-quality RCTs
- One or more RCTs corroborated by high-quality registry studies

LEVEL B-R (Randomized)

- Moderate-quality evidence‡ from 1 or more RCTs
- Meta-analyses of moderate-quality RCTs

LEVEL B-NR (Nonrandomized)

- Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies
- Meta-analyses of such studies

LEVEL C-LD (Limited Data)

- Randomized or nonrandomized observational or registry studies with limitations of design or execution
- Meta-analyses of such studies
- Physiological or mechanistic studies in human subjects

LEVEL C-EO (Expert Opinion)

- Consensus of expert opinion based on clinical experience

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely-used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

Figure 10. AHA Chains of Survival for pediatric IHCA and OHCA.

IHCA



OHCA



Pediatric Medical Emergency/Rapid Response Teams (PLS 397: EvUp)

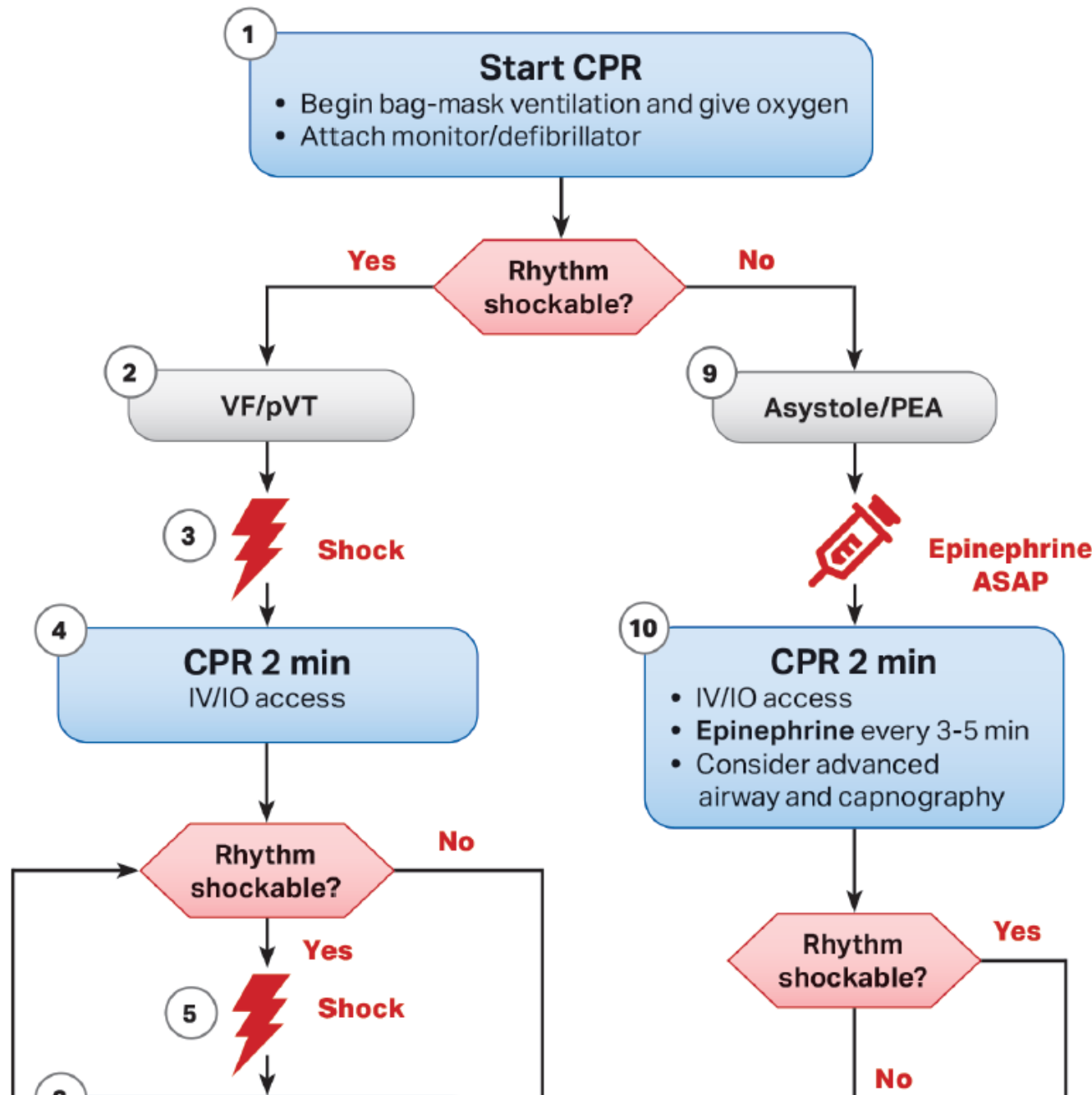
Rapid response teams (RRTs) are hospital teams that are activated to evaluate and respond to patients at risk for clinical deterioration. The topic of medical emergency teams (METs)/RRTs was last reviewed in 2015.^{11,12} This EvUp was requested to identify relevant evidence on the topic published after that date. Two preintervention/postintervention studies demonstrated a decrease in the number of resuscitation events, although there was no clear decrease in mortality. One observational registry study demonstrated no change in the mortality rate beyond that which was already expected from the preimplementation trends. This finding is not significantly different from the 2015 review. To review the EvUp, see [Supplement Appendix C-4](#). There is no indication to change the 2015 CoSTR recommendation.

Treatment Recommendation

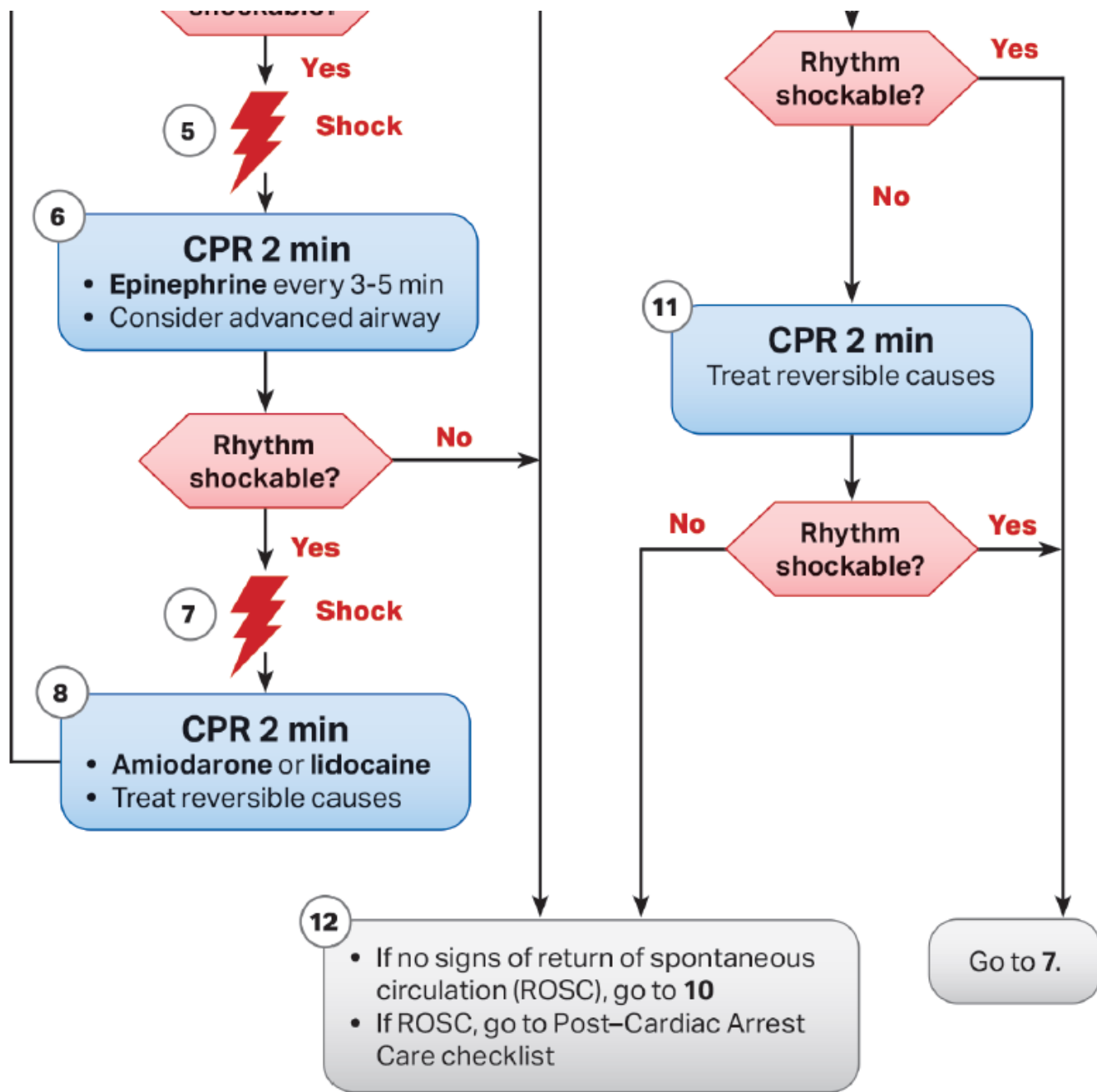
This treatment recommendation (below) is unchanged from 2015.^{11,12}

We suggest the use of pediatric MET/RRT systems in hospitals that care for children (weak recommendation, very low-quality evidence). In making this recommendation, we place a higher value on the potential to recognize and intervene for patients with deteriorating illness over the expense incurred by a healthcare system committing significant resources to implement a MET/RRT system. We recognize that the decision to use a MET/RRT system should be balanced by the existing resources and capabilities of the institution.

Figure 11. Pediatric Cardiac Arrest Algorithm.



CPR Quality
<ul style="list-style-type: none"> • Push hard ($\geq 1/3$ 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
<ul style="list-style-type: none"> • First shock 2 J/kg • Second shock 4 J/kg • Subsequent shocks ≥ 4 J/kg, maximum 10 J/kg or adult dose
Drug Therapy
<ul style="list-style-type: none"> • 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



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

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

Go to 7.

SEQUENCE OF RESUSCITATION

Rapid recognition of cardiac arrest, immediate initiation of high-quality chest compressions, and delivery of effective ventilations are critical to improve outcomes from cardiac arrest. Lay rescuers should not delay starting CPR in a child with no “signs of life.” Healthcare providers may consider assessing the presence of a pulse as long as the initiation of CPR is not delayed more than 10 seconds. Palpation for the presence or absence of a pulse is not reliable as the sole determinant of cardiac arrest and the need for chest compressions. In infants and children, asphyxial cardiac arrest is more common than cardiac arrest from a primary cardiac event; therefore, effective ventilation is important during resuscitation of children. When CPR is initiated, the sequence is compressions-airway-breathing.

Figure 14. Pediatric Post-Cardiac Arrest Care Checklist.

Components of Post-Cardiac Arrest Care	Check
Oxygenation and ventilation	
Measure oxygenation and target normoxemia 94%-99% (or child's normal/appropriate oxygen saturation).	<input type="checkbox"/>
Measure and target $Paco_2$ appropriate to the patient's underlying condition and limit exposure to severe hypercapnia or hypocapnia.	<input type="checkbox"/>
Hemodynamic monitoring	
Set specific hemodynamic goals during post-cardiac arrest care and review daily.	<input type="checkbox"/>
Monitor with cardiac telemetry.	<input type="checkbox"/>
Monitor arterial blood pressure.	<input type="checkbox"/>
Monitor serum lactate, urine output, and central venous oxygen saturation to help guide therapies.	<input type="checkbox"/>
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.	<input type="checkbox"/>
Targeted temperature management (TTM)	

Targeted temperature management (TTM)	
Measure and continuously monitor core temperature.	<input type="checkbox"/>
Prevent and treat fever immediately after arrest and during rewarming.	<input type="checkbox"/>
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).	<input type="checkbox"/>
Prevent shivering.	<input type="checkbox"/>
Monitor blood pressure and treat hypotension during rewarming.	<input type="checkbox"/>
Neuromonitoring	
If patient has encephalopathy and resources are available, monitor with continuous electroencephalogram.	<input type="checkbox"/>
Treat seizures.	<input type="checkbox"/>
Consider early brain imaging to diagnose treatable causes of cardiac arrest.	<input type="checkbox"/>
Electrolytes and glucose	
Measure blood glucose and avoid hypoglycemia.	<input type="checkbox"/>
Maintain electrolytes within normal ranges to avoid possible life-threatening arrhythmias.	<input type="checkbox"/>
Sedation	

Sedation

Treat with sedatives and anxiolytics.

Prognosis

Always consider multiple modalities (clinical and other) over any single predictive factor.

Remember that assessments may be modified by TTM or induced hypothermia.

Consider electroencephalogram in conjunction with other factors within the first 7 days after cardiac arrest.

Consider neuroimaging such as magnetic resonance imaging during the first 7 days.

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.

Why: A study of children with IHCA who received epinephrine for an initial nonshockable rhythm (asystole and pulseless electrical activity) demonstrated that, for every minute of delay in administration of epinephrine, there was a significant decrease in ROSC, survival at 24 hours, survival to discharge, and survival with favorable neurological outcome.

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

Evaluation and Support for Cardiac Arrest Survivors

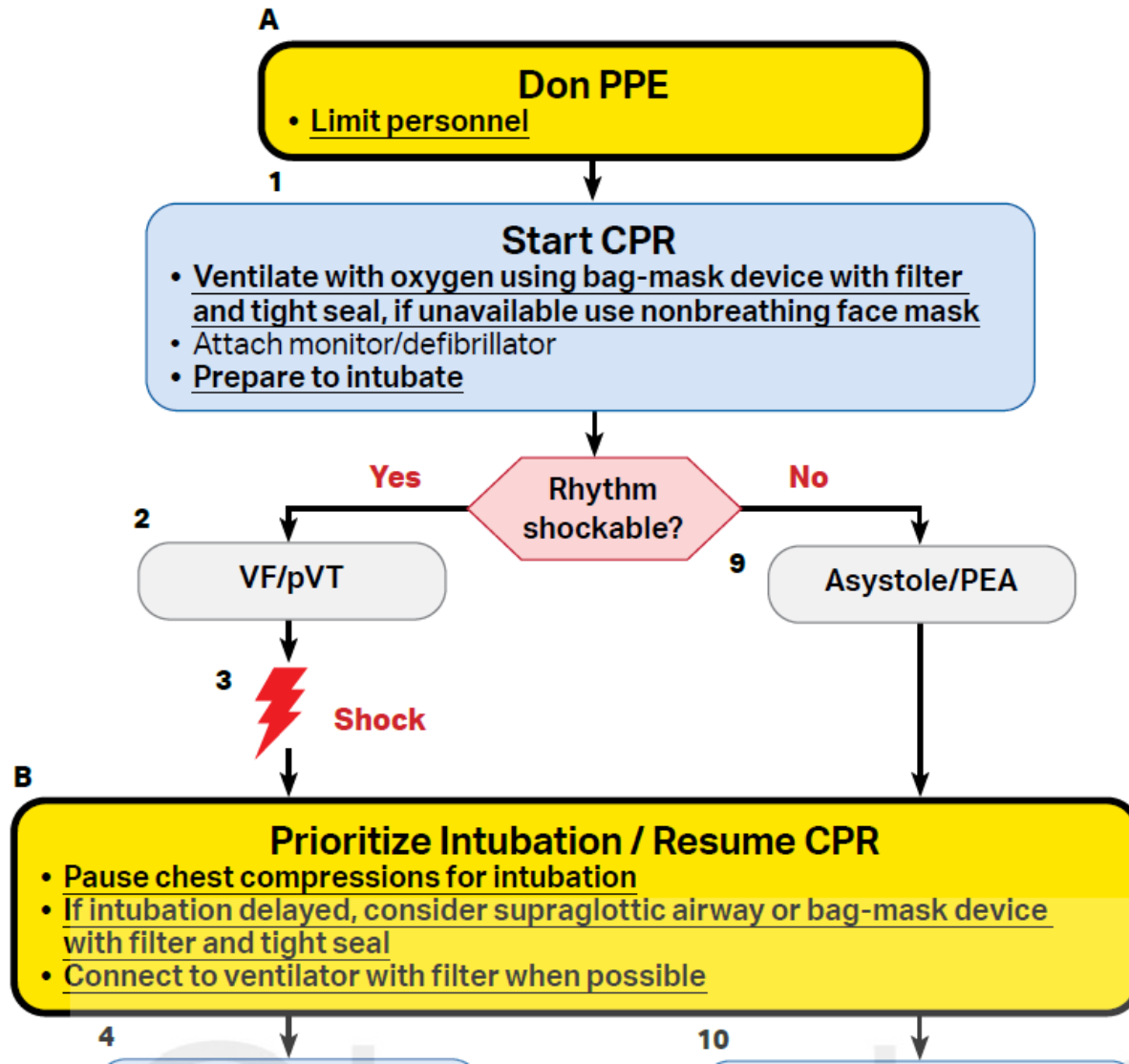
2020 (New): It is recommended that pediatric cardiac arrest survivors be evaluated for rehabilitation services.

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.⁶

Pediatric Cardiac Arrest Algorithm for Suspected or Confirmed COVID-19 Patients

Updated April 2020



CPR Quality

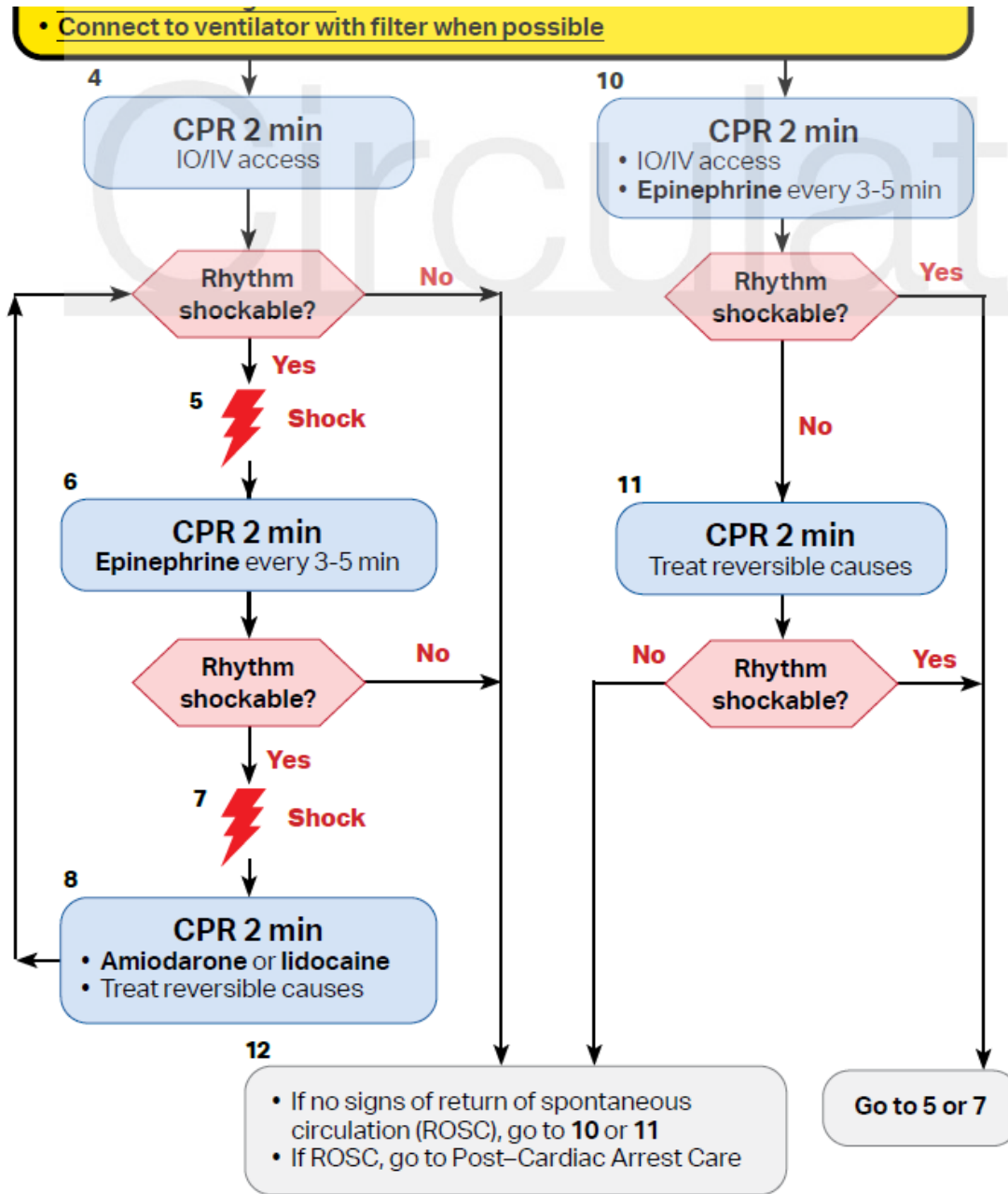
- Push hard ($\geq 1/3$ of anteroposterior diameter of chest) and fast (100-120/min) and allow complete chest recoil.
- Minimize interruptions in compressions.
- Avoid excessive ventilation.
- Change compressor every 2 minutes, or sooner if fatigued.
- If no advanced airway, 15:2 compression-ventilation ratio.

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

Advanced Airway

- Minimize closed-circuit disconnection
- Use intubator with highest likelihood of first pass success
- Consider video laryngoscopy
- Prefer cuffed endotracheal tube if available
- Endotracheal intubation or supraglottic advanced airway
- Waveform capnography or capnometry to confirm and monitor ET tube placement
- Once advanced airway in place, give 1 breath every 6 seconds (10 breaths/min) with continuous chest compressions



• Once advanced airway in place, give 1 breath every 6 seconds (10 breaths/min) with continuous chest compressions

Drug Therapy

- **Epinephrine IO/IV dose:** 0.01 mg/kg (0.1 mL/kg of the 0.1 mg/mL concentration). Repeat every 3-5 minutes.
- **Amiodarone IO/IV dose:** 5 mg/kg bolus during cardiac arrest. May repeat up to 2 times for refractory VF/pulseless VT.
- or
- **Lidocaine IO/IV dose:** Initial: 1 mg/kg loading dose. Maintenance: 20-50 mcg/kg per minute infusion (repeat bolus dose if infusion initiated >15 minutes after initial bolus therapy).

Return of Spontaneous Circulation (ROSC)

- Pulse and blood pressure
- Spontaneous arterial pressure waves with intra-arterial monitoring

Reversible Causes

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

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Have a nice time

Abbreviations

Abbreviation	Meaning/Phrase
ACLS	advanced cardiovascular life support
AED	automated external defibrillator
ALS	advanced life support
AHA	American Heart Association
BLS	basic life support
COI	conflict of interest
COR	Class of Recommendation
CPR	cardiopulmonary resuscitation
ECC	emergency cardiovascular care
ECLS	extracorporeal life support
ECMO	extracorporeal membrane oxygenation
ECPR	extracorporeal cardiopulmonary resuscitation
EO	Expert Opinion
ETI	endotracheal intubation
FBAO	foreign body airway obstruction
IHCA	in-hospital cardiac arrest
ILCOR	International Liaison Committee on Resuscitation
LD	limited data
LOE	Level of Evidence
MCS	mechanical circulatory support
NR	nonrandomized
OHCA	out-of-hospital cardiac arrest

PALS	pediatric advanced life support
PICO	population, intervention, comparator, outcome
pVT	pulseless ventricular tachycardia
RCT	randomized clinical trial
ROSC	return of spontaneous circulation
SGA	supraglottic airway
TTM	targeted temperature management
VF	ventricular fibrillation