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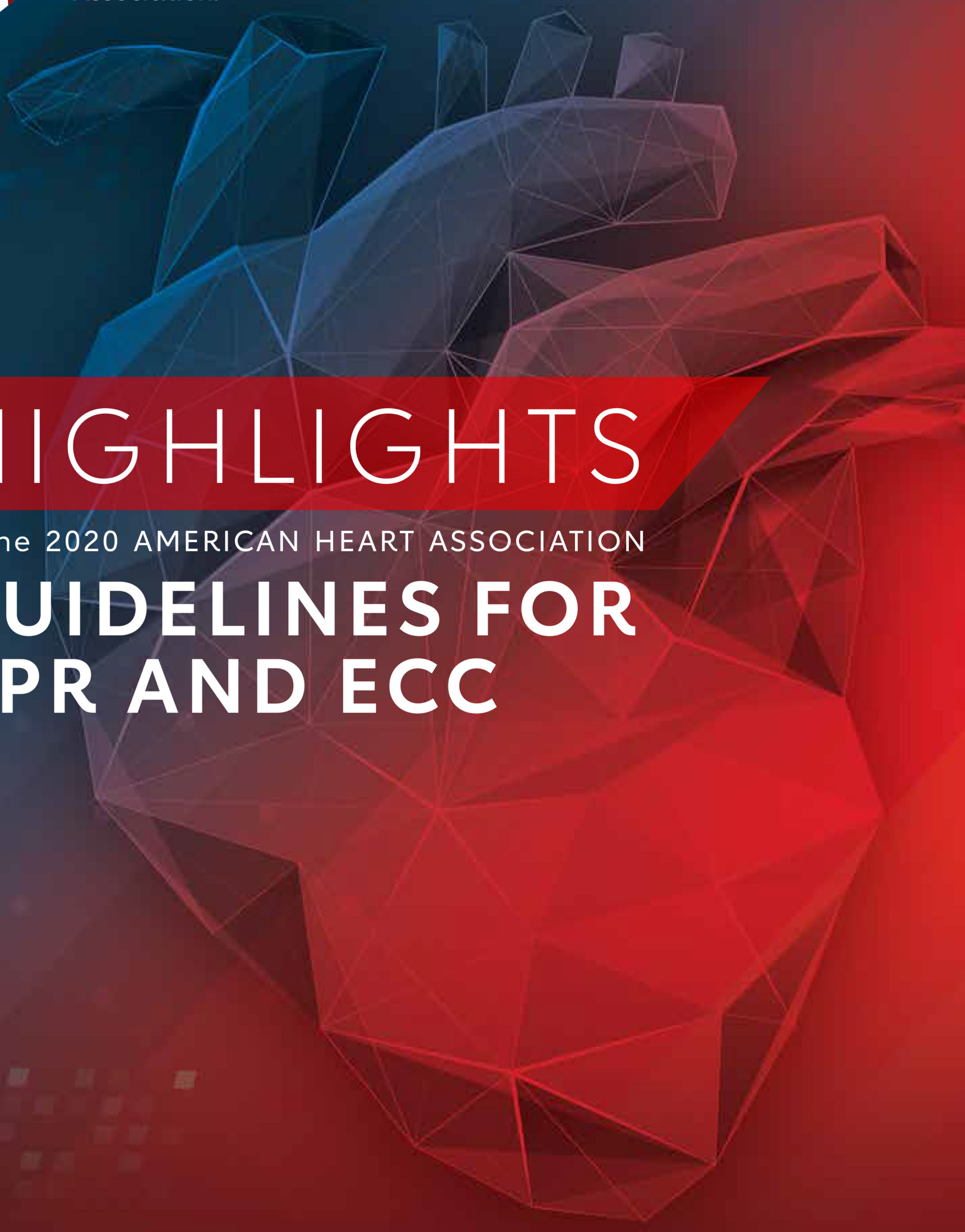

HIGHLIGHTS

of the 2020 AMERICAN HEART ASSOCIATION

GUIDELINES FOR CPR AND ECC

The Most Updated Science From the Leader in Resuscitation

As the global source of the official resuscitation science and education guidelines used by training organizations and healthcare professionals, the *2020 American Heart Association Guidelines for CPR and ECC* deliver the latest resuscitation science and education available to ensure the highest quality of care and improved outcomes.

Visit **ECCGuidelines.Heart.org** today for your official Guidelines resources:

- *2020 American Heart Association Guidelines for CPR and ECC* (Print and Digital)
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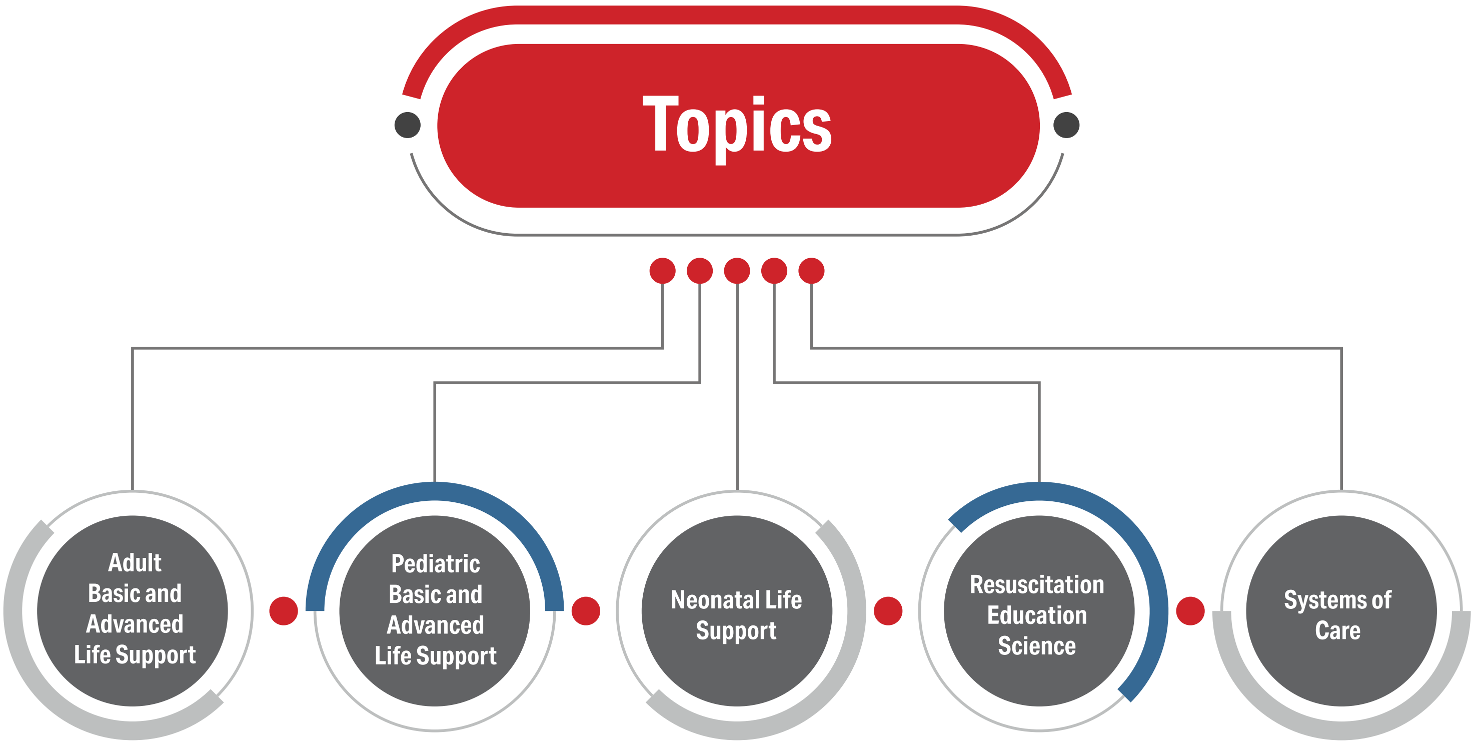
2020
CPR & ECC
GUIDELINES



Introduction

These Highlights summarize the key issues and changes in the *2020 American Heart Association* (AHA) *Guidelines for Cardiopulmonary Resuscitation* (CPR) *and Emergency Cardiovascular Care* (ECC). The 2020 Guidelines are a comprehensive revision of the AHA's guidelines for adult, pediatric, neonatal, resuscitation education science, and systems of care topics. They have been developed for resuscitation providers and AHA instructors to focus on the resuscitation science and guidelines recommendations that are most significant or controversial, or those that will result in changes in resuscitation training and practice, and to provide the rationale for the recommendations.

Because this publication is a summary, it does not reference the supporting published studies and does not list Classes of Recommendation (COR) or Levels of Evidence (LOE). For more detailed information and references, please read the *2020 AHA Guidelines for CPR and ECC*, including the Executive Summary,[1] published in *Circulation* in October 2020, and the detailed summary of resuscitation science in the *2020 International Consensus on CPR and ECC Science With Treatment Recommendations*, developed by the International Liaison Committee on Resuscitation (ILCOR) and published simultaneously in *Circulation*[2] and *Resuscitation*[3] in October 2020. The methods used by ILCOR to perform evidence evaluations[4] and by the AHA to translate these evidence evaluations into resuscitation guidelines[5] have been published in detail.

The 2020 Guidelines use the most recent version of the AHA definitions for the COR and LOE (Figure 1). Overall, 491 specific recommendations are made for adult, pediatric, and neonatal life support; resuscitation education science; and systems of care. Of these recommendations, 161 are class 1 and 293 are class 2 recommendations (Figure 2). Additionally, 37 recommendations are class 3, including 19 for evidence of no benefit and 18 for evidence of harm.

The American Heart Association thanks the following people for their contributions to the development of this publication: Eric J. Lavonas, MD, MS; David J. Magid, MD, MPH; Khalid Aziz, MBBS, BA, MA, MEd(IT); Katherine M. Berg, MD; Adam Cheng, MD; Amber V. Hoover, RN, MSN; Melissa Mahgoub, PhD; Ashish R. Panchal, MD, PhD; Amber J. Rodriguez, PhD; Alexis A. Topjian, MD, MSCE; Comilla Sasson, MD, PhD; and the AHA Guidelines Highlights Project Team.

Figure 1. Applying Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care (Updated May 2019)*

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.

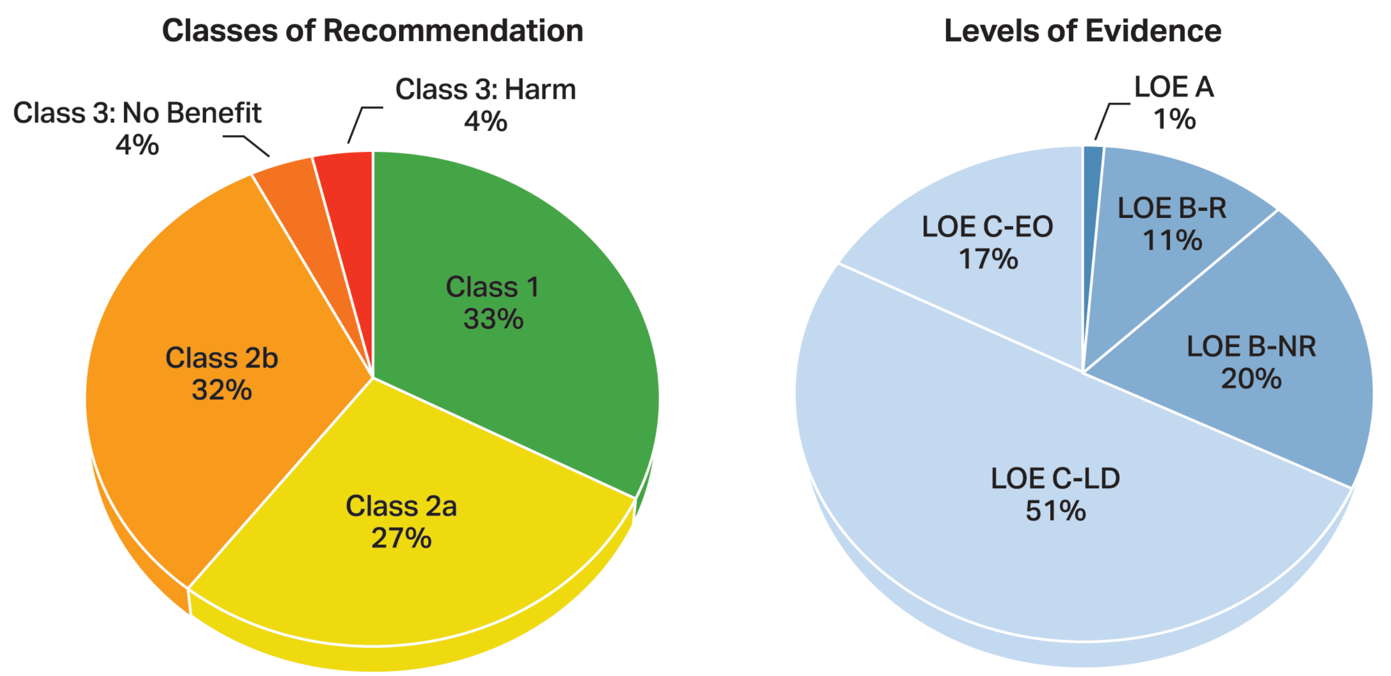
* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† 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 2. Distribution of COR and LOE as percent of 491 total recommendations in the *2020 AHA Guidelines for CPR and ECC*.*



*Results are percent of 491 recommendations in Adult Basic and Advanced Life Support, Pediatric Basic and Advanced Life Support, Neonatal Life Support, Resuscitation Education Science, and Systems of Care.

Abbreviations: COR, Classes of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, Randomized.

About the Recommendations

The fact that only 6 of these 491 recommendations (1.2%) are based on Level A evidence (at least 1 high-quality randomized clinical trial [RCT], corroborated by a second high-quality trial or registry study) testifies to the ongoing challenges in performing high-quality resuscitation research. A concerted national and international effort is needed to fund and otherwise support resuscitation research.

Both the ILCOR evidence-evaluation process and the AHA guidelines-development process are governed by strict AHA disclosure policies designed to make relationships with industry and other conflicts of interest fully transparent and to protect these processes from undue influence. The AHA staff processed conflict-of-interest disclosures from all participants. All guidelines writing group chairs and at least 50% of guidelines writing group members are required to be free of all conflicts of interest, and all relevant relationships are disclosed in the respective Consensus on Science With Treatment Recommendations and Guidelines publications.

Adult Basic and Advanced Life Support

Summary of Key Issues and Major Changes

In 2015, approximately 350 000 adults in the United States experienced nontraumatic out-of-hospital cardiac arrest (OHCA) attended by emergency medical services (EMS) personnel. Despite recent gains, less than 40% of adults receive layperson-initiated CPR, and fewer than 12% have an automated external defibrillator (AED) applied before EMS arrival. After significant improvements, survival from OHCA has plateaued since 2012.

In addition, approximately 1.2% of adults admitted to US hospitals suffer in-hospital cardiac arrest (IHCA). Outcomes from IHCA are significantly better than outcomes from OHCA, and IHCA outcomes continue to improve.

Recommendations for adult basic life support (BLS) and advanced cardiovascular life support (ACLS) are combined in the 2020 Guidelines. Major new changes include the following:

- Enhanced algorithms and visual aids provide easy-to-remember guidance for BLS and ACLS resuscitation scenarios.
- The importance of early initiation of CPR by lay rescuers has been re-emphasized.
- Previous recommendations about epinephrine administration have been reaffirmed, with emphasis on early epinephrine administration.
- Use of real-time audiovisual feedback is suggested as a means to maintain CPR quality.
- Continuously measuring arterial blood pressure and end-tidal carbon dioxide ($ETCO_2$) during ACLS resuscitation may be useful to improve CPR quality.
- On the basis of the most recent evidence, routine use of double sequential defibrillation is not recommended.
- Intravenous (IV) access is the preferred route of medication administration during ACLS resuscitation. Intraosseous (IO) access is acceptable if IV access is not available.
- Care of the patient after return of spontaneous circulation (ROSC) requires close attention to oxygenation, blood pressure control, evaluation for percutaneous coronary intervention, targeted temperature management, and multimodal neuroprognostication.
- 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.
- After a resuscitation, debriefing for lay rescuers, EMS providers, and hospital-based healthcare workers may be beneficial to support their mental health and well-being.
- Management of cardiac arrest in pregnancy focuses on maternal resuscitation, with preparation for early perimortem cesarean delivery if necessary to save the infant and improve the chances of successful resuscitation of the mother.

Algorithms and Visual Aids

The writing group reviewed all algorithms and made focused improvements to visual training aids to ensure their utility as point-of-care tools and reflect the latest science. The major changes to algorithms and other performance aids include the following:

- A sixth link, Recovery, was added to the IHCA and OHCA Chains of Survival (Figure 3).
- The universal Adult Cardiac Arrest Algorithm was modified to emphasize the role of early epinephrine administration for patients with nonshockable rhythms (Figure 4).
- Two new Opioid-Associated Emergency Algorithms have been added for lay rescuers and trained rescuers (Figures 5 and 6).
- The Post–Cardiac Arrest Care Algorithm was updated to emphasize the need to prevent hyperoxia, hypoxemia, and hypotension (Figure 7).
- A new diagram has been added to guide and inform neuroprognostication (Figure 8).
- A new Cardiac Arrest in Pregnancy Algorithm has been added to address these special cases (Figure 9).

Despite recent gains, less than 40% of adults receive layperson-initiated CPR, and fewer than 12% have an AED applied before EMS arrival.

Figure 3. AHA Chains of Survival for adult IHCA and OHCA.

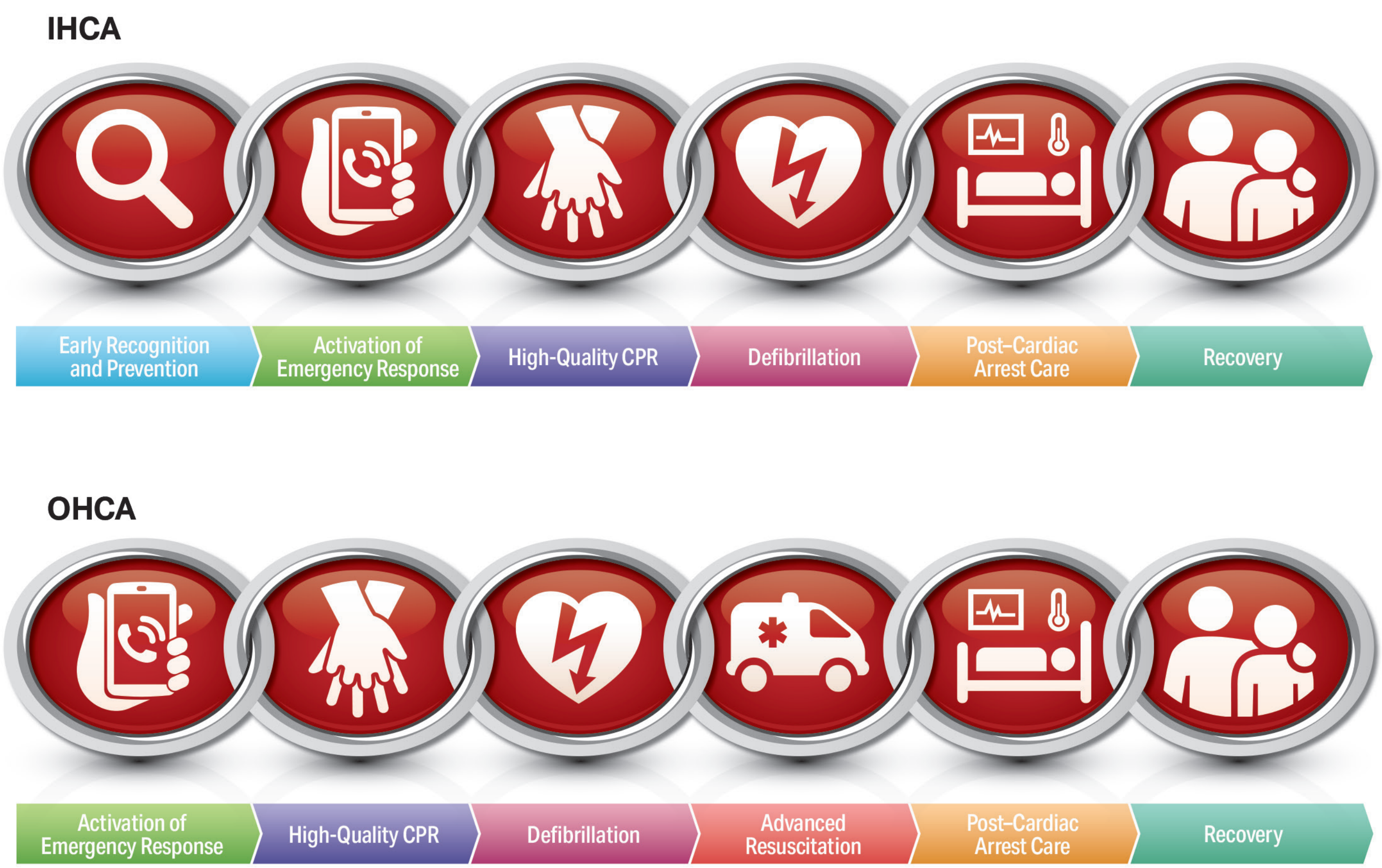
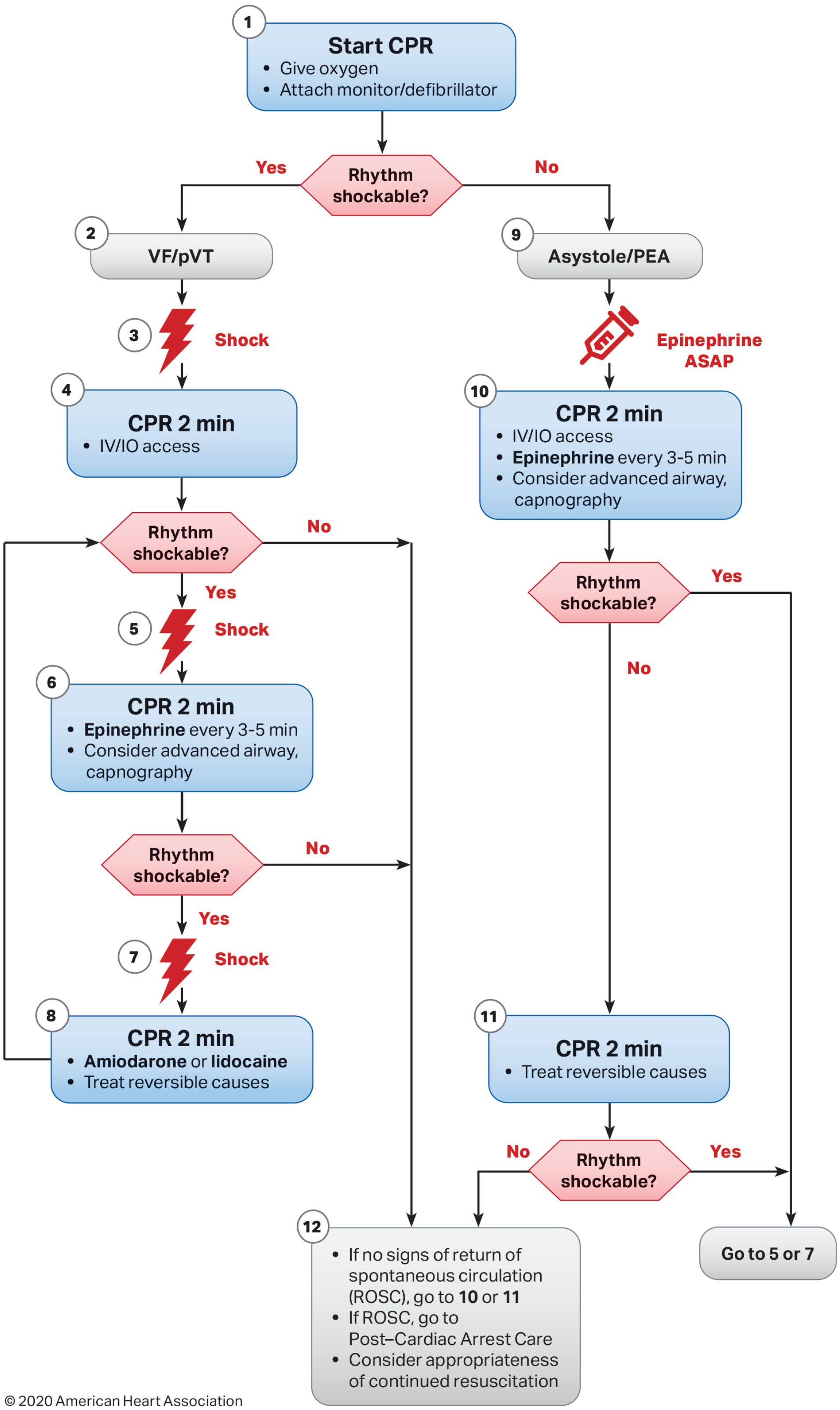


Figure 4. Adult Cardiac Arrest Algorithm.



CPR Quality

- Push hard (at least 2 inches [5 cm]) 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, 30:2 compression-ventilation ratio.
- Quantitative waveform capnography
  - If $PETCO_2$ is low or decreasing, reassess CPR quality.

Shock Energy for Defibrillation

- **Biphasic**: Manufacturer recommendation (eg, initial dose of 120-200 J); if unknown, use maximum available. Second and subsequent doses should be equivalent, and higher doses may be considered.
- **Monophasic**: 360 J

Drug Therapy

- **Epinephrine IV/IO dose:** 1 mg every 3-5 minutes
- **Amiodarone IV/IO dose:** First dose: 300 mg bolus. Second dose: 150 mg.
  or
  Lidocaine IV/IO dose: First dose: 1-1.5 mg/kg. Second dose: 0.5-0.75 mg/kg.

Advanced Airway

- 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

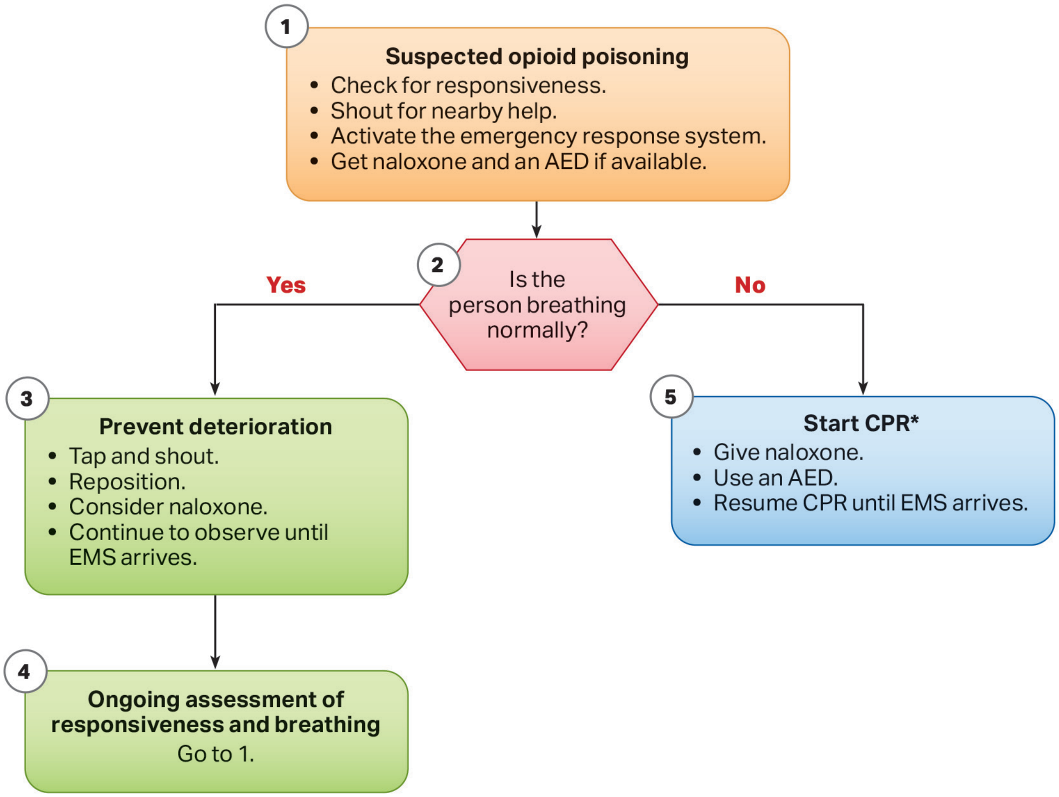
Return of Spontaneous Circulation (ROSC)

- Pulse and blood pressure
- Abrupt sustained increase in $PETCO_2$ (typically ≥40 mm Hg)
- Spontaneous arterial pressure waves with intra-arterial monitoring

Reversible Causes

- **H**ypovolemia
- **H**ypoxia
- **H**ydrogen ion (acidosis)
- **H**ypo-/hyperkalemia
- **H**ypothermia
- **T**ension pneumothorax
- **T**amponade, cardiac
- **T**oxins
- **T**hrombosis, pulmonary
- **T**hrombosis, coronary

Figure 5. Opioid-Associated Emergency for Lay Responders Algorithm.



*For adult and adolescent victims, responders should perform compressions and rescue breaths for opioid-associated emergencies if they are trained and perform Hands-Only CPR if not trained to perform rescue breaths. For infants and children, CPR should include compressions with rescue breaths.

Figure 6. Opioid-Associated Emergency for Healthcare Providers Algorithm.

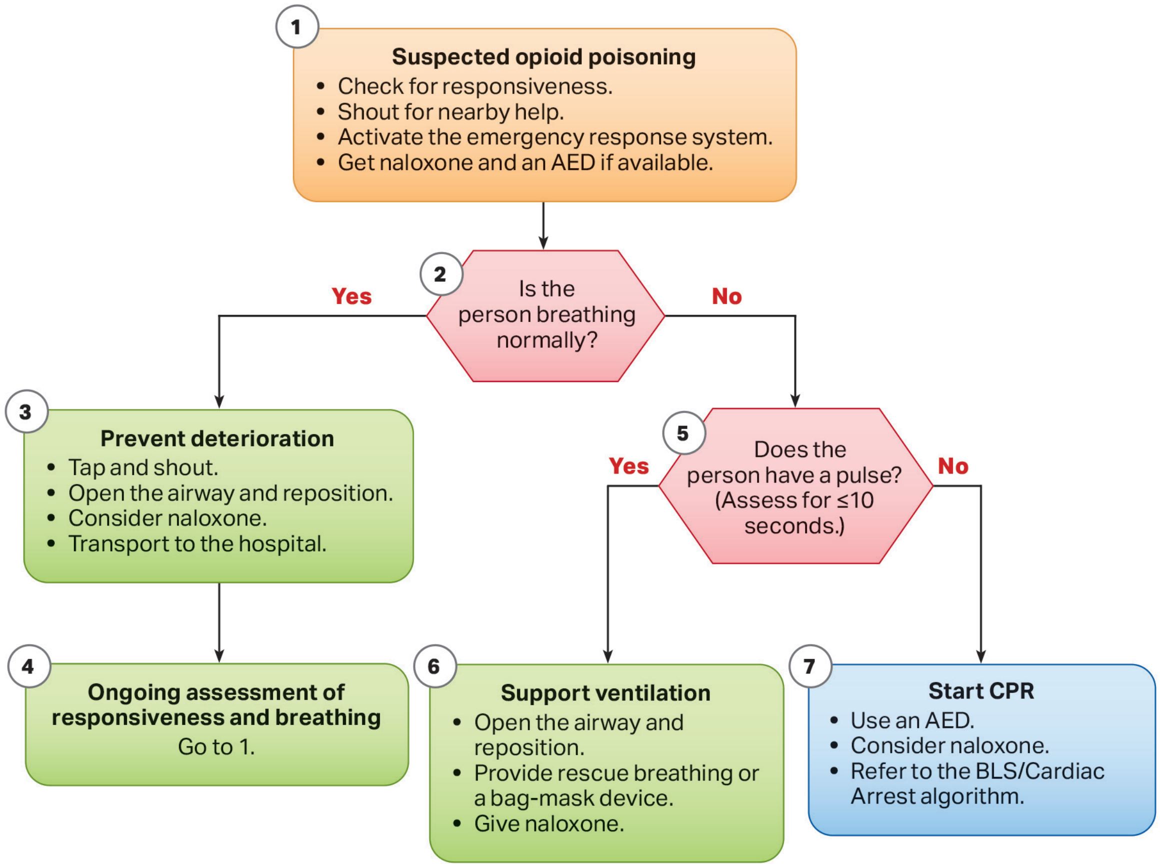
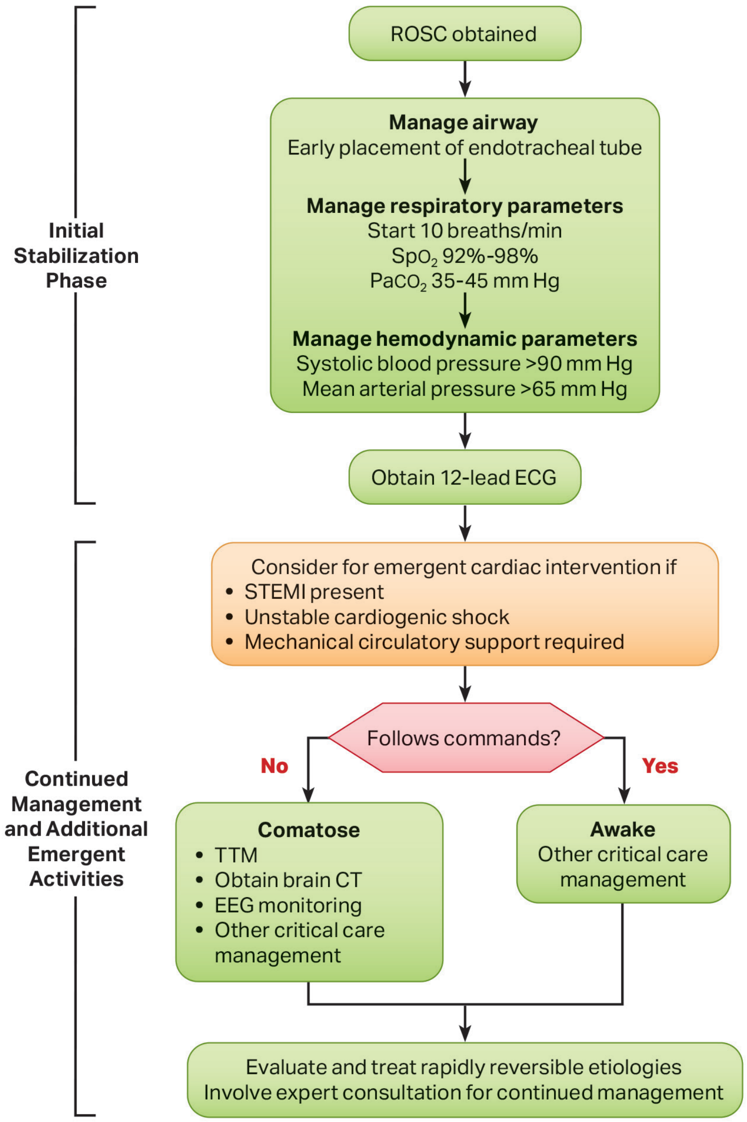


Figure 7. Adult Post–Cardiac Arrest Care Algorithm.



Initial Stabilization Phase

Resuscitation is ongoing during the post-ROSC phase, and many of these activities can occur concurrently. However, if prioritization is necessary, follow these steps:

- Airway management: Waveform capnography or capnometry to confirm and monitor endotracheal tube placement
- Manage respiratory parameters: Titrate FIO_2 for SpO_2 92%-98%; start at 10 breaths/min; titrate to $PaCO_2$ of 35-45 mm Hg
- Manage hemodynamic parameters: Administer crystalloid and/or vasopressor or inotrope for goal systolic blood pressure >90 mm Hg or mean arterial pressure >65 mm Hg

Continued Management and Additional Emergent Activities

These evaluations should be done concurrently so that decisions on targeted temperature management (TTM) receive high priority as cardiac interventions.

- Emergent cardiac intervention: Early evaluation of 12-lead electrocardiogram (ECG); consider hemodynamics for decision on cardiac intervention
- TTM: If patient is not following commands, start TTM as soon as possible; begin at 32-36°C for 24 hours by using a cooling device with feedback loop
- Other critical care management
  - Continuously monitor core temperature (esophageal, rectal, bladder)
  - Maintain normoxia, normocapnia, euglycemia
  - Provide continuous or intermittent electroencephalogram (EEG) monitoring
  - Provide lung-protective ventilation

H's and T's

Hypovolemia
Hypoxia
Hydrogen ion (acidosis)
Hypokalemia/**h**yperkalemia
Hypothermia
Tension pneumothorax
Tamponade, cardiac
Toxins
Thrombosis, pulmonary
Thrombosis, coronary

Figure 8. Recommended approach to multimodal neuroprognostication in adult patients after cardiac arrest.

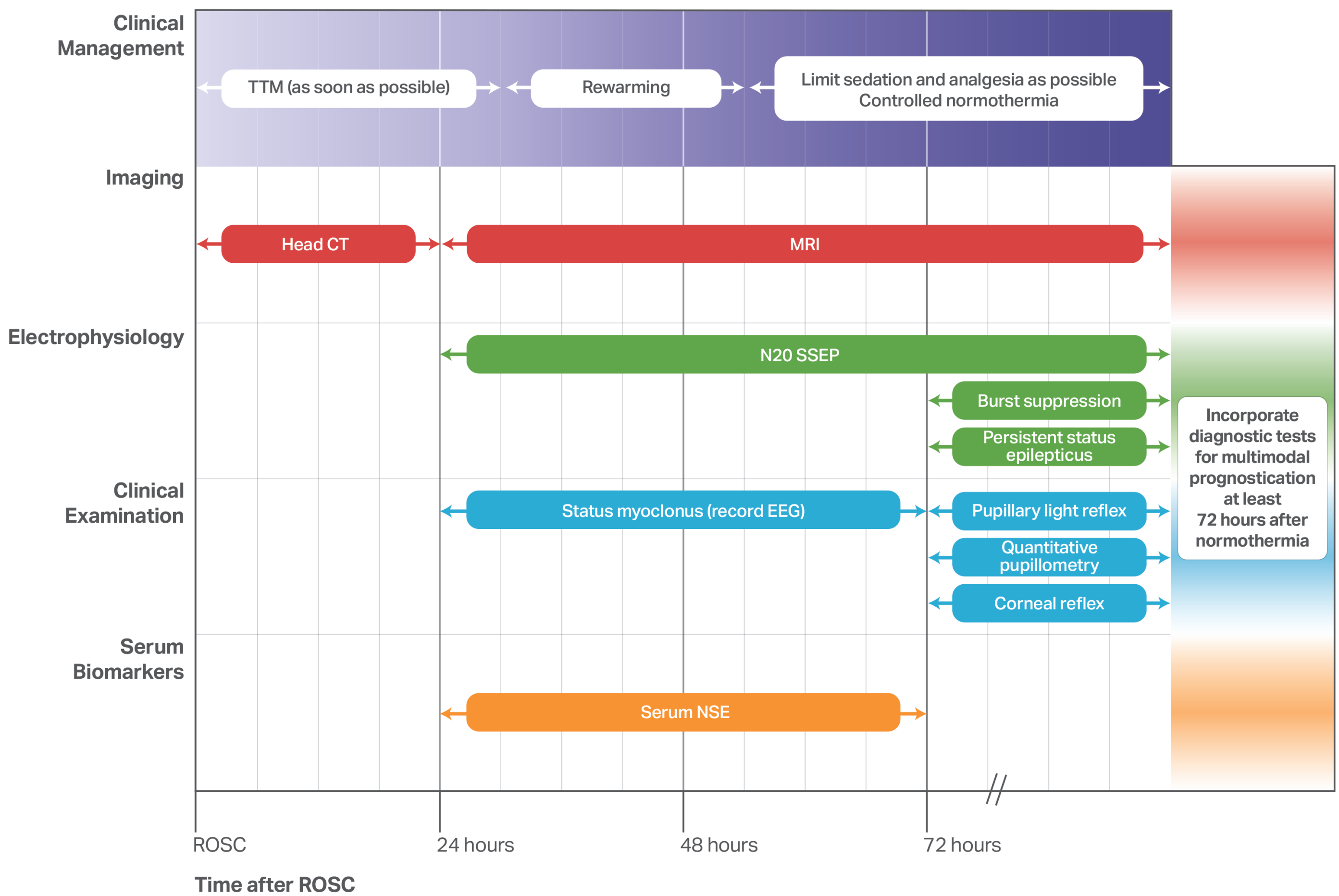
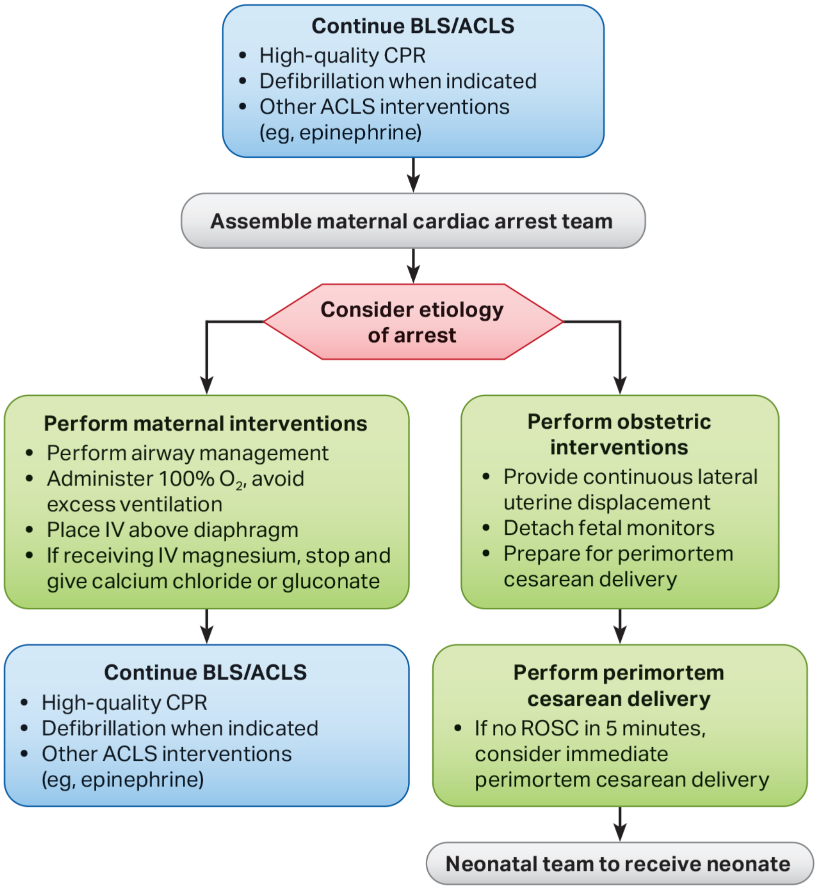


Figure 9. Cardiac Arrest in Pregnancy In-Hospital ACLS Algorithm.



Maternal Cardiac Arrest

- Team planning should be done in collaboration with the obstetric, neonatal, emergency, anesthesiology, intensive care, and cardiac arrest services.
- Priorities for pregnant women in cardiac arrest should include provision of high-quality CPR and relief of aortocaval compression with lateral uterine displacement.
- The goal of perimortem cesarean delivery is to improve maternal and fetal outcomes.
- Ideally, perform perimortem cesarean delivery in 5 minutes, depending on provider resources and skill sets.

Advanced Airway

- In pregnancy, a difficult airway is common. Use the most experienced provider.
- Provide endotracheal intubation or supraglottic advanced airway.
- Perform waveform capnography or capnometry to confirm and monitor ET tube placement.
- Once advanced airway is in place, give 1 breath every 6 seconds (10 breaths/min) with continuous chest compressions.

Potential Etiology of Maternal Cardiac Arrest

A Anesthetic complications
B Bleeding
C Cardiovascular
D Drugs
E Embolic
F Fever
G General nonobstetric causes of cardiac arrest (H's and T's)
H Hypertension

Major New and Updated Recommendations

Early Initiation of CPR by Lay Rescuers

2020 (Updated): We recommend that laypersons initiate CPR for presumed cardiac arrest because the risk of harm to the patient is low if the patient is not in cardiac arrest.

2010 (Old): The lay rescuer should not check for a pulse and should assume that cardiac arrest is present if an adult suddenly collapses or an unresponsive victim is not breathing normally. The healthcare provider should take no more than 10 seconds to check for a pulse and, if the rescuer does not definitely feel a pulse within that time period, the rescuer should start chest compressions.

Why: New evidence shows that the risk of harm to a victim who receives chest compressions when not in cardiac arrest is low. Lay rescuers are not able to determine with accuracy whether a victim has a pulse, and the risk of withholding CPR from a pulseless victim exceeds the harm from unneeded chest compressions.

Early Administration of Epinephrine

2020 (Unchanged/Reaffirmed): With respect to timing, for cardiac arrest with a nonshockable rhythm, it is reasonable to administer epinephrine as soon as feasible.

2020 (Unchanged/Reaffirmed): With respect to timing, for cardiac arrest with a shockable rhythm, it may be reasonable to administer epinephrine after initial defibrillation attempts have failed.

Why: The suggestion to administer epinephrine early was strengthened to a recommendation on the basis of a systematic review and meta-analysis, which included results of 2 randomized trials of epinephrine enrolling more than 8500 patients with OHCA, showing that epinephrine increased ROSC and survival. At 3 months, the time point felt to be most meaningful for neurologic recovery, there was a nonsignificant increase in survivors with both favorable and unfavorable neurologic outcome in the epinephrine group.

Of 16 observational studies on timing in the recent systematic review, all found an association between earlier epinephrine and ROSC for patients with nonshockable rhythms, although improvements in survival were not universally seen. For patients with shockable rhythm, the literature supports prioritizing defibrillation and CPR initially and giving epinephrine if initial attempts with CPR and defibrillation are not successful.

Any drug that increases the rate of ROSC and survival but is given after several minutes of downtime will likely increase both favorable and unfavorable neurologic outcome. Therefore, the most beneficial approach seems to be continuing to use a drug that has been shown to increase survival while focusing broader efforts on shortening time to drug for all patients; by doing so, more survivors will have a favorable neurologic outcome.

Real-Time Audiovisual Feedback

2020 (Unchanged/Reaffirmed): It may be reasonable to use audiovisual feedback devices during CPR for real-time optimization of CPR performance.

Why: A recent RCT reported a 25% increase in survival to hospital discharge from IHCA with audio feedback on compression depth and recoil.

Physiologic Monitoring of CPR Quality

2020 (Updated): It may be reasonable to use physiologic parameters such as arterial blood pressure or $ETCO_2$ when feasible to monitor and optimize CPR quality.

2015 (Old): Although no clinical study has examined whether titrating resuscitative efforts to physiologic parameters during CPR improves outcome, it may be reasonable to use physiologic parameters (quantitative waveform capnography, arterial relaxation diastolic pressure, arterial pressure monitoring, and central venous oxygen saturation) when feasible to monitor and optimize CPR quality, guide vasopressor therapy, and detect ROSC.

Why: Although the use of physiologic monitoring such as arterial blood pressure and $ETCO_2$ to monitor CPR quality is an established concept, new data support its inclusion in the guidelines. Data from the AHA's Get With The Guidelines®-Resuscitation registry show higher likelihood of ROSC when CPR quality is monitored using either $ETCO_2$ or diastolic blood pressure.

This monitoring depends on the presence of an endotracheal tube (ETT) or arterial line, respectively. Targeting compressions to an $ETCO_2$ value of at least 10 mm Hg, and ideally 20 mm Hg or greater, may be useful as a marker of CPR quality. An ideal target has not been identified.

Double Sequential Defibrillation Not Supported

2020 (New): The usefulness of double sequential defibrillation for refractory shockable rhythm has not been established.

Why: Double sequential defibrillation is the practice of applying near-simultaneous shocks using 2 defibrillators. Although some case reports have shown good outcomes, a 2020 ILCOR systematic review found no evidence to support double sequential defibrillation and recommended against its routine use. Existing studies are subject to multiple forms of bias, and observational studies do not show improvements in outcome.

A recent pilot RCT suggests that changing the direction of defibrillation current by repositioning the pads may be as effective as double sequential defibrillation while avoiding the risks of harm from increased energy and damage to defibrillators. On the basis of current evidence, it is not known whether double sequential defibrillation is beneficial.

IV Access Preferred Over IO

2020 (New): It is reasonable for providers to first attempt establishing IV access for drug administration in cardiac arrest.

2020 (Updated): IO access may be considered if attempts at IV access are unsuccessful or not feasible.

2010 (Old): It is reasonable for providers to establish intraosseous (IO) access if intravenous (IV) access is not readily available.

Why: A 2020 ILCOR systematic review comparing IV versus IO (principally pretibial placement) drug administration during cardiac arrest found that the IV route was associated with better clinical outcomes in 5 retrospective studies; subgroup analyses of RCTs that focused on other clinical questions found comparable outcomes when IV or IO were used for drug administration. Although IV access is preferred, for situations in which IV access is difficult, IO access is a reasonable option.

Post–Cardiac Arrest Care and Neuroprognostication

The 2020 Guidelines contain significant new clinical data about optimal care in the days after cardiac arrest. Recommendations from the *2015 AHA Guidelines Update for CPR and ECC* about treatment of hypotension, titrating oxygen to avoid both hypoxia and hyperoxia, detection and treatment of seizures, and targeted temperature management were reaffirmed with new supporting evidence.

In some cases, the LOE was upgraded to reflect the availability of new data from RCTs and high-quality observational studies, and the post–cardiac arrest care algorithm has been updated to emphasize these important components of care. To be reliable, neuroprognostication should be performed no sooner than 72 hours after return to normothermia, and prognostic decisions should be based on multiple modes of patient assessment.

The 2020 Guidelines evaluate 19 different modalities and specific findings and present the evidence for each. A new diagram presents this multimodal approach to neuroprognostication.

Care and Support During Recovery

2020 (New): We recommend that cardiac arrest survivors have multimodal rehabilitation assessment and treatment for physical, neurologic, cardiopulmonary, and cognitive impairments before discharge from the hospital.

2020 (New): We recommend that cardiac arrest survivors and their caregivers receive comprehensive, multidisciplinary discharge planning, to include medical and rehabilitative treatment recommendations and return to activity/work expectations.

2020 (New): We recommend structured assessment for anxiety, depression, posttraumatic stress, and fatigue for cardiac arrest survivors and their caregivers.

Why: The process of recovering from cardiac arrest extends long after the initial hospitalization. Support is needed during recovery to ensure optimal physical, cognitive, and emotional well-being and return to social/role functioning. This process should be initiated during the initial hospitalization and continue as long as needed. These themes are explored in greater detail in a 2020 AHA scientific statement.[6]

Debriefings for Rescuers

2020 (New): Debriefings and referral for follow up for emotional support for lay rescuers, EMS providers, and hospital-based healthcare workers after a cardiac arrest event may be beneficial.

Why: Rescuers may experience anxiety or posttraumatic stress about providing or not providing BLS. Hospital-based care providers may also experience emotional or psychological effects of caring for a patient with cardiac arrest. Team debriefings may allow a review of team performance (education, quality improvement) as well as recognition of the natural stressors associated with caring for a patient near death. An AHA scientific statement devoted to this topic is expected in early 2021.

Cardiac Arrest in Pregnancy

2020 (New): Because pregnant patients are more prone to hypoxia, oxygenation and airway management should be prioritized during resuscitation from cardiac arrest in pregnancy.

2020 (New): Because of potential interference with maternal resuscitation, fetal monitoring should not be undertaken during cardiac arrest in pregnancy.

2020 (New): We recommend targeted temperature management for pregnant women who remain comatose after resuscitation from cardiac arrest.

2020 (New): During targeted temperature management of the pregnant patient, it is recommended that the fetus be continuously monitored for bradycardia as a potential complication, and obstetric and neonatal consultation should be sought.

Why: Recommendations for managing cardiac arrest in pregnancy were reviewed in the 2015 Guidelines Update and a 2015 AHA scientific statement.[7] Airway, ventilation, and oxygenation are particularly important in the setting of pregnancy because of an increase in maternal metabolism, a decrease in functional reserve capacity due to the gravid uterus, and the risk of fetal brain injury from hypoxemia.

Evaluation of the fetal heart is not helpful during maternal cardiac arrest, and it may distract from necessary resuscitation elements. In the absence of data to the contrary, pregnant women who survive cardiac arrest should receive targeted temperature management just as any other survivors would, with consideration for the status of the fetus that may remain in utero.

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

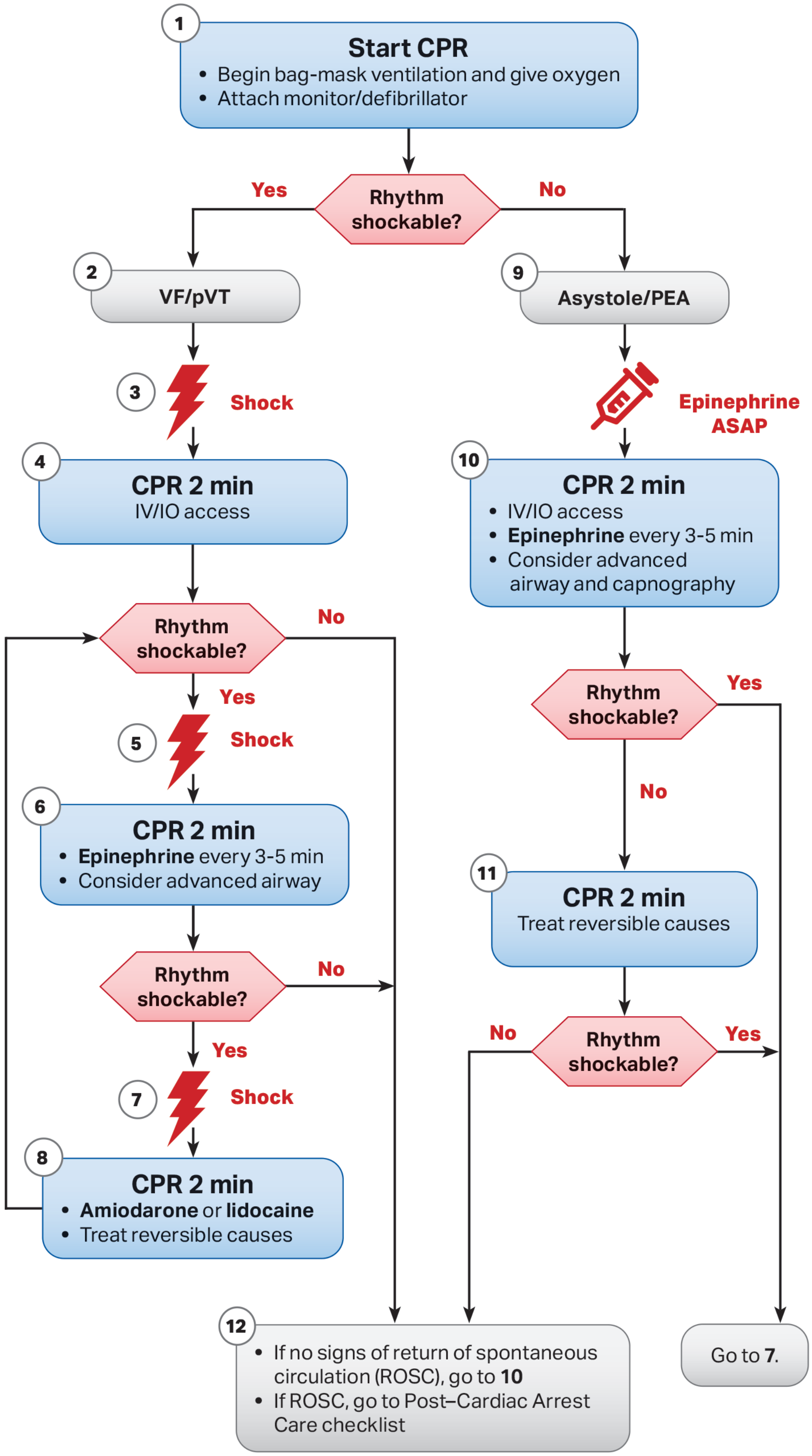
The writing group updated all algorithms to reflect the latest science and made several major changes to improve the visual training and performance aids:

- 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.



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

- **H**ypovolemia
- **H**ypoxia
- **H**ydrogen ion (acidosis)
- **H**ypoglycemia
- **H**ypo-/hyperkalemia
- **H**ypothermia
- **T**ension pneumothorax
- **T**amponade, cardiac
- **T**oxins
- **T**hrombosis, pulmonary
- **T**hrombosis, coronary

Figure 12. Pediatric Bradycardia With a Pulse Algorithm.

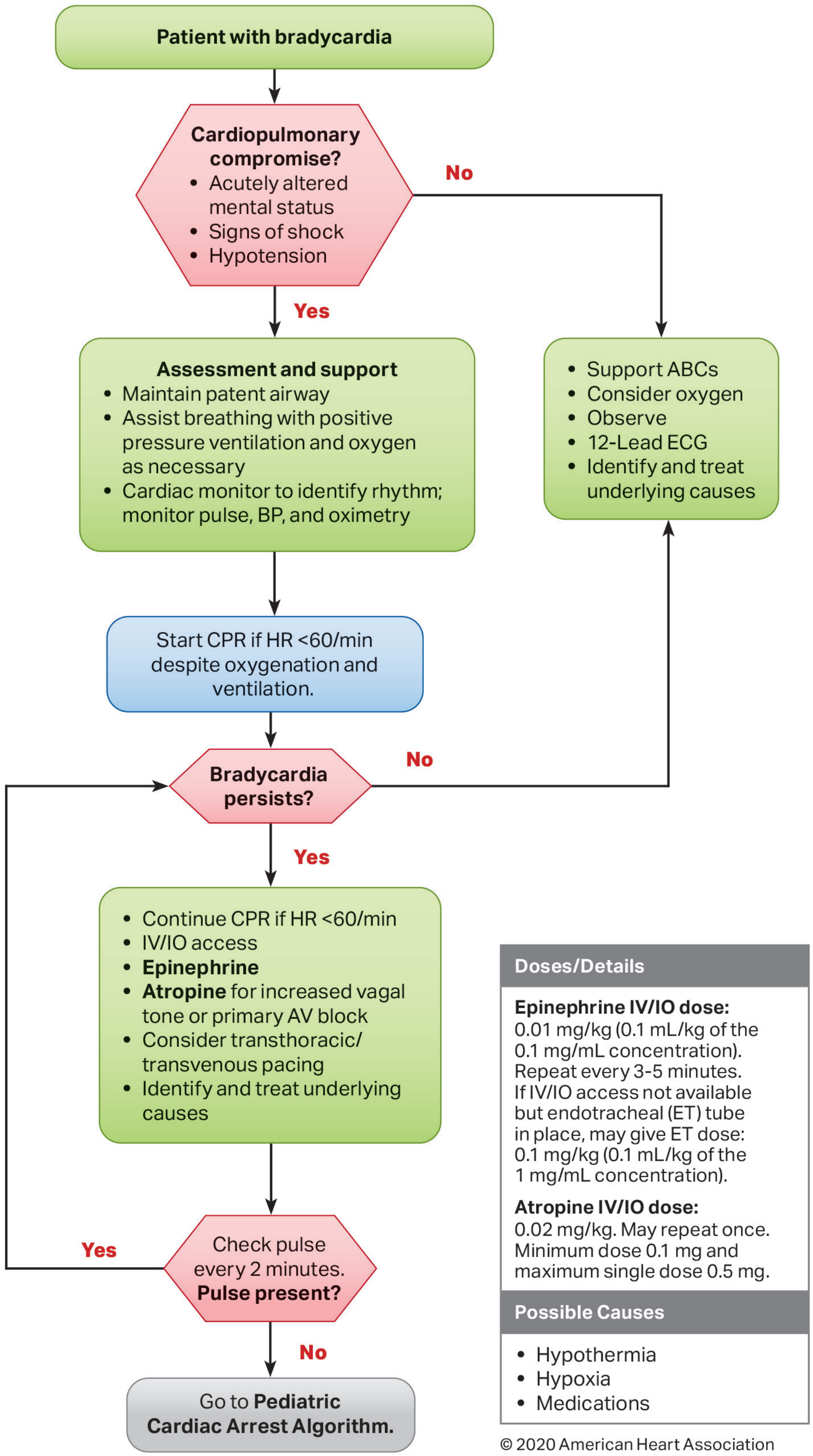


Figure 13. Pediatric Tachycardia With a Pulse Algorithm.

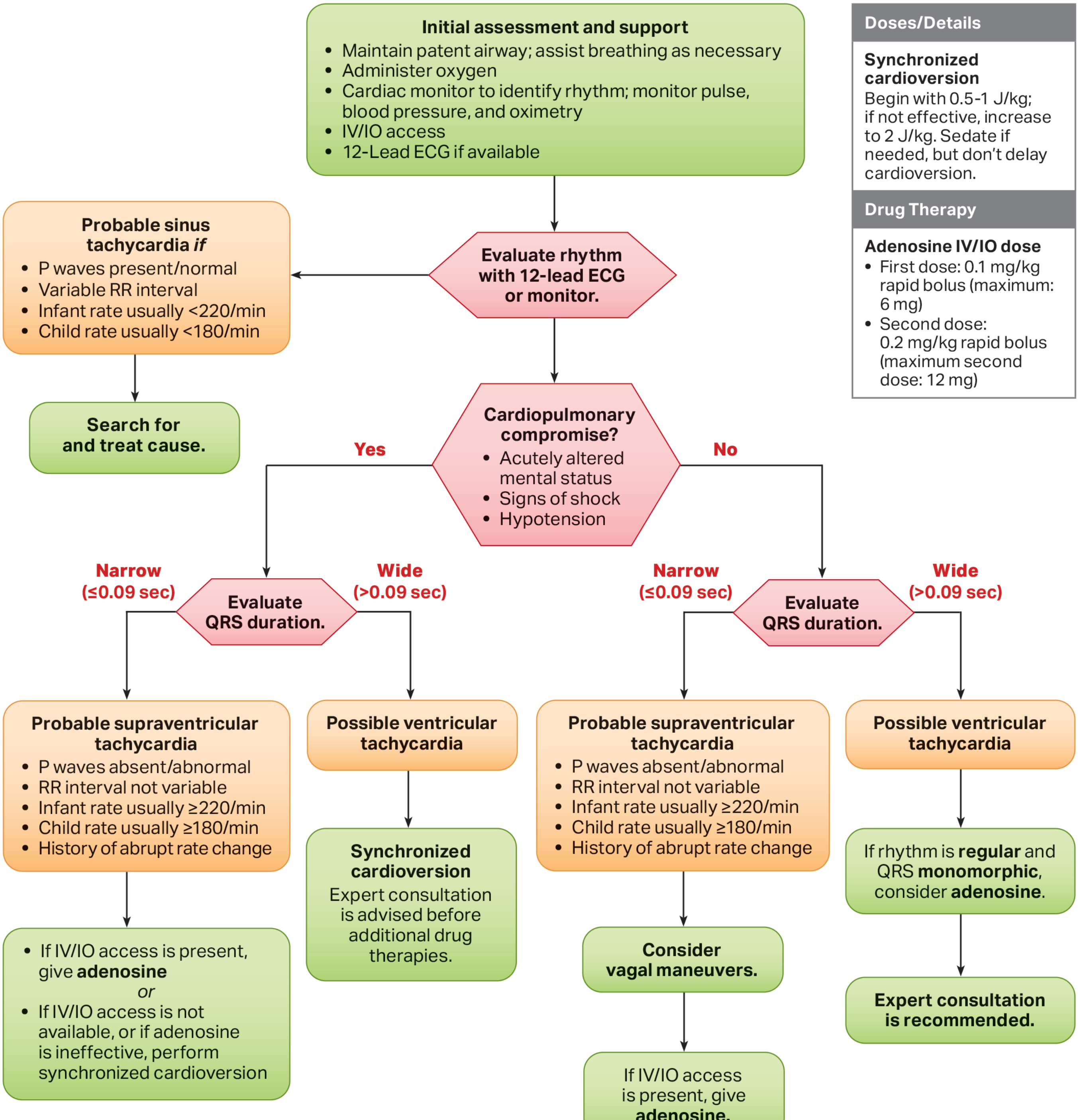


Figure 14. Pediatric Post–Cardiac Arrest Care Checklist.

Components of Post–Cardiac Arrest Care	Check
Oxygenation and ventilation	
Measure oxygenation and target normoxemia 94%-99% (or child's normal/appropriate oxygen saturation).	☐
Measure and target $Paco_2$ appropriate to the patient's underlying condition and limit exposure to severe hypercapnia or hypocapnia.	☐
Hemodynamic monitoring	
Set specific hemodynamic goals during post–cardiac arrest care and review daily.	☐
Monitor with cardiac telemetry.	☐
Monitor arterial blood pressure.	☐
Monitor serum lactate, urine output, and central venous oxygen saturation to help guide therapies.	☐
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.	☐
Targeted temperature management (TTM)	
Measure and continuously monitor core temperature.	☐
Prevent and treat fever immediately after arrest and during rewarming.	☐
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).	☐
Prevent shivering.	☐
Monitor blood pressure and treat hypotension during rewarming.	☐
Neuromonitoring	
If patient has encephalopathy and resources are available, monitor with continuous electroencephalogram.	☐
Treat seizures.	☐
Consider early brain imaging to diagnose treatable causes of cardiac arrest.	☐
Electrolytes and glucose	
Measure blood glucose and avoid hypoglycemia.	☐
Maintain electrolytes within normal ranges to avoid possible life-threatening arrhythmias.	☐
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.	☐

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.

Why: New data show that higher ventilation rates (at least 30/min in infants [younger than 1 year] and at least 25/min in children) are associated with improved rates of ROSC and survival in pediatric IHCA. Although there are no data about the ideal ventilation rate during CPR without an advanced airway, or for children in respiratory arrest with or without an advanced airway, for simplicity of training, the respiratory arrest recommendation was standardized for both situations.

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 H_2O).

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.

Why: Several studies and systematic reviews support the safety of cuffed ETTs and demonstrate decreased need for tube changes and reintubation. Cuffed tubes may decrease the risk of aspiration. Subglottic stenosis is rare when cuffed ETTs are used in children and careful technique is followed.

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.

Why: New studies have shown that routine use of cricoid pressure reduces intubation success rates and does not reduce the rate of regurgitation. The writing group has reaffirmed previous recommendations to discontinue cricoid pressure if it interferes with ventilation or the speed or ease of intubation.

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.

Patients who received epinephrine within 5 minutes of CPR initiation compared with those who received epinephrine more than 5 minutes after CPR initiation were more likely to survive to discharge. Studies of pediatric OHCA demonstrated that earlier epinephrine administration increases rates of ROSC, survival to intensive care unit admission, survival to discharge, and 30-day survival.

In the 2018 version of the Pediatric Cardiac Arrest Algorithm, patients with nonshockable rhythms received epinephrine every 3 to 5 minutes, but early administration of epinephrine was not emphasized. Although the sequence of resuscitation has not changed, the algorithm and recommendation language have been updated to emphasize the importance of giving epinephrine as early as possible, particularly when the rhythm is nonshockable.

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.[6]

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,[9] 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.[10]

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,[11] 5% of sudden cardiovascular deaths in children,[11] and 6% to 20% of sudden cardiac death in athletes, previous[12,13] 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.[14]

Single Ventricle: Recommendations for the Treatment of Preoperative and Postoperative Stage I Palliation (Norwood/Blalock-Tausig 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 (DO_2.)

2020 (New): ECLS after stage I Norwood palliation can be useful to treat low systemic DO_2.

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 DO_2, it is reasonable to target a $PaCO_2$ 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 $PaCO_2$ of 50 to 60 mm Hg, which can be achieved during mechanical ventilation by reducing minute ventilation, increasing the inspired fraction of CO_2, or administering opioids with or without chemical paralysis.

Single Ventricle: Recommendations for the Treatment of Postoperative Stage II (Bidirectional Glenn/Hemi-Fontan) and Stage III (Fontan) Palliation Patients

2020 (New): For patients in a prearrest state with superior cavopulmonary anastomosis physiology and severe hypoxemia due to inadequate pulmonary blood flow (Qp), ventilatory strategies that target a mild respiratory acidosis and a minimum mean airway pressure without atelectasis can be useful to increase cerebral and systemic arterial oxygenation.

2020 (New): ECLS in patients with superior cavopulmonary anastomosis or Fontan circulation may be considered to treat low DO_2 from reversible causes or as a bridge to a ventricular assist device or surgical revision.

Why: Approximately 1 in 600 infants and children are born with critical congenital heart disease. Staged surgery for children born with single ventricle physiology, such as hypoplastic left heart syndrome, spans the first several years of life.[15] Resuscitation of these infants and children is complex and differs in important ways from standard PALS care. Previous PALS guidelines did not contain recommendations for this specialized patient population. These recommendations are consistent with the 2018 AHA scientific statement on CPR in infants and children with cardiac disease.[14]

Pulmonary Hypertension

2020 (Updated): Inhaled nitric oxide or prostacyclin should be used as the initial therapy to treat pulmonary hypertensive crises or acute right-sided heart failure secondary to increased pulmonary vascular resistance.

2020 (New): Provide careful respiratory management and monitoring to avoid hypoxia and acidosis in the postoperative care of the child with pulmonary hypertension.

2020 (New): For pediatric patients who are at high risk for pulmonary hypertensive crises, provide adequate analgesics, sedatives, and neuromuscular blocking agents.

2020 (New): For the initial treatment of pulmonary hypertensive crises, oxygen administration and induction of alkalosis through hyperventilation or alkali administration can be useful while pulmonary-specific vasodilators are administered.

2020 (New): For children who develop refractory pulmonary hypertension, including signs of low cardiac output or profound respiratory failure despite optimal medical therapy, ECLS may be considered.

2010 (Old): Consider administering inhaled nitric oxide or aerosolized prostacyclin or analogue to reduce pulmonary vascular resistance.

Why: Pulmonary hypertension, a rare disease in infants and children, is associated with significant morbidity and mortality and requires specialized management. Previous PALS guidelines did not provide recommendations for managing pulmonary hypertension in infants and children. These recommendations are consistent with guidelines on pediatric pulmonary hypertension published by the AHA and the American Thoracic Society in 2015,[16] and with recommendations contained in a 2020 AHA scientific statement on CPR in infants and children with cardiac disease.[14]

Neonatal Life Support

There are over 4 million births every year in the United States and Canada. Up to 1 of every 10 of these newborns will need help to transition from the fluid-filled environment of the womb to the air-filled room. It is essential that every newborn have a caregiver dedicated to facilitating that transition and for that caregiver to be trained and equipped for the role. Also, a significant proportion of newborns who need facilitated transition are at risk for complications that require additional trained personnel. All perinatal settings should be ready for this scenario.

The process of facilitating transition is described in the Neonatal Resuscitation Algorithm that starts with the needs of every newborn and proceeds to steps that address the needs of at-risk newborns. In the 2020 Guidelines, we provide recommendations on how to follow the algorithm, including anticipation and preparation, umbilical cord management at delivery, initial actions, heart rate monitoring, respiratory support, chest compressions, intravascular access and therapies, withholding and discontinuing resuscitation, postresuscitation care, and human factors and performance. Here, we highlight new and updated recommendations that we believe will have a significant impact on outcomes from cardiac arrest.

Summary of Key Issues and Major Changes

- Newborn resuscitation requires anticipation and preparation by providers who train individually and as teams.
- Most newly born infants do not require immediate cord clamping or resuscitation and can be evaluated and monitored during skin-to-skin contact with their mothers after birth.
- Prevention of hypothermia is an important focus for neonatal resuscitation. The importance of skin-to-skin care in healthy babies is reinforced as a means of promoting parental bonding, breastfeeding, and normothermia.

- Inflation and ventilation of the lungs are the priority in newly born infants who need support after birth.
- A rise in heart rate is the most important indicator of effective ventilation and response to resuscitative interventions.
- Pulse oximetry is used to guide oxygen therapy and meet oxygen saturation goals.
- Routine endotracheal suctioning for both vigorous and nonvigorous infants born with meconium-stained amniotic fluid (MSAF) is not recommended. Endotracheal suctioning is indicated only if airway obstruction is suspected after providing positive-pressure ventilation (PPV).
- Chest compressions are provided if there is a poor heart rate response to ventilation after appropriate ventilation-corrective steps, which preferably include endotracheal intubation.
- The heart rate response to chest compressions and medications should be monitored electrocardiographically.
- When vascular access is required in newly born infants, the umbilical venous route is preferred. When IV access is not feasible, the IO route may be considered.
- If the response to chest compressions is poor, it may be reasonable to provide epinephrine, preferably via the intravascular route.
- Newborns who fail to respond to epinephrine and have a history or an exam consistent with blood loss may require volume expansion.
- If all these steps of resuscitation are effectively completed and there is no heart rate response by 20 minutes, redirection of care should be discussed with the team and family.

Major New and Updated Recommendations

Anticipation of Resuscitation Need

2020 (New): Every birth should be attended by at least 1 person who can perform the initial steps of newborn resuscitation and initiate PPV and whose only responsibility is the care of the newborn.

Why: To support a smooth and safe newborn transition from being in the womb to breathing air, every birth should be attended by at least 1 person whose primary responsibility is to the newly born and who is trained and equipped to begin PPV without delay. Observational and quality-improvement studies indicate that this approach enables identification of at-risk newborns, promotes use of checklists to prepare equipment, and facilitates team briefing. A systematic review of neonatal resuscitation training in low-resourced settings showed a reduction in both stillbirth and 7-day mortality.

Temperature Management for Newly Born Infants

2020 (New): Placing healthy newborn infants who do not require resuscitation skin-to-skin after birth can be effective in improving breastfeeding, temperature control, and blood glucose stability.

Why: Evidence from a Cochrane systematic review showed that early skin-to-skin contact promotes normothermia in healthy newborns. In addition, 2 meta-analyses of RCTs and observational studies of extended skin-to-skin care after initial resuscitation and/or stabilization showed reduced mortality, improved breastfeeding, shortened length of stay, and improved weight gain in preterm and low-birth-weight babies.

Clearing the Airway When Meconium Is Present

2020 (Updated): For nonvigorous newborns (presenting with apnea or ineffective breathing effort) delivered through MSAF, routine laryngoscopy with or without tracheal suctioning is not recommended.

2020 (Updated): For nonvigorous newborns delivered through MSAF who have evidence of airway obstruction during PPV, intubation and tracheal suction can be beneficial.

2015 (Old): When meconium is present, routine intubation for tracheal suction in this setting is not suggested because there is insufficient evidence to continue recommending this practice.

Why: In newly born infants with MSAF who are not vigorous at birth, initial steps and PPV may be provided. Endotracheal suctioning is indicated only if airway obstruction is suspected after providing PPV. Evidence from RCTs suggests that nonvigorous newborns delivered through MSAF have the same outcomes (survival, need for respiratory support) whether they are suctioned before or after the initiation of PPV. Direct laryngoscopy and endotracheal suctioning are not routinely required for newborns delivered through MSAF, but they can be beneficial in newborns who have evidence of airway obstruction while receiving PPV.

Vascular Access

2020 (New): For babies requiring vascular access at the time of delivery, the umbilical vein is the recommended route. If IV access is not feasible, it may be reasonable to use the IO route.

Why: Newborns who have failed to respond to PPV and chest compressions require vascular access to infuse epinephrine and/or volume expanders. Umbilical venous catheterization is the preferred technique in the delivery room. IO access is an alternative if umbilical venous access is not feasible or care is being provided outside of the delivery room. Several case reports have described local complications associated with IO needle placement.

Termination of Resuscitation

2020 (Updated): In newly born babies receiving resuscitation, if there is no heart rate and all the steps of resuscitation have been performed, cessation of resuscitation efforts should be discussed with the healthcare team and the family. A reasonable time frame for this change in goals of care is around 20 minutes after birth.

2010 (Old): In a newly born baby with no detectable heart rate, it is appropriate to consider stopping resuscitation if the heart rate remains undetectable for 10 minutes.

Why: Newborns who have failed to respond to resuscitative efforts by approximately 20 minutes of age have a low likelihood of survival. For this reason, a time frame for decisions about discontinuing resuscitation efforts is suggested, emphasizing engagement of parents and the resuscitation team before redirecting care.

Human and System Performance

2020 (Updated): For participants who have been trained in neonatal resuscitation, individual or team booster training should occur more frequently than every 2 years at a frequency that supports retention of knowledge, skills, and behaviors.

2015 (Old): Studies that explored how frequently healthcare providers or healthcare students should train showed no differences in patient outcomes but were able to show some advantages in psychomotor performance and knowledge and confidence when focused training occurred every 6 months or more frequently. It is therefore suggested that neonatal resuscitation task training occur more frequently than the current 2-year interval.

Why: Educational studies suggest that cardiopulmonary resuscitation knowledge and skills decay within 3 to 12 months after training. Short, frequent booster training has been shown to improve performance in simulation studies and reduce neonatal mortality in low-resource settings. To anticipate and prepare effectively, providers and teams may improve their performance with frequent practice.

Resuscitation Education Science

Effective education is a key variable in improving survival outcomes from cardiac arrest. Without effective education, lay rescuers and healthcare providers would struggle to consistently apply the science supporting the evidence-based treatment of cardiac arrest. Evidence-based instructional design is critical to improving provider performance and patient-related outcomes from cardiac arrest. Instructional design features are the active ingredients, the key elements of resuscitation training programs that determine how and when content is delivered to students.

In the 2020 Guidelines, we provide recommendations about various instructional design features in resuscitation training and describe how specific provider considerations influence resuscitation education. Here, we highlight new and updated recommendations in education that we believe will have a significant impact on outcomes from cardiac arrest.

Summary of Key Issues and Major Changes

- The use of deliberate practice and mastery learning during life support training, and incorporating repetition with feedback and minimum passing standards, can improve skill acquisition.
- Booster training (ie, brief retraining sessions) should be added to massed learning (ie, traditional course based) to assist with retention of CPR skills. Provided that individual students can attend all sessions, separating training into multiple sessions (ie, spaced learning) is preferable to massed learning.
- For laypersons, self-directed training, either alone or in combination with instructor-led training, is recommended to improve willingness and ability to perform CPR. Greater use of self-directed training may remove an obstacle to more widespread training of laypersons in CPR.
- Middle school– and high school–age children should be trained to provide high-quality CPR.
- In situ training (ie, resuscitation education in actual clinical spaces) can be used to enhance learning outcomes and improve resuscitation performance.
- *Virtual reality*, which is the use of a computer interface to create an immersive environment, and *gamified learning*, which is play and competition with other students, can be incorporated into resuscitation training for laypersons and healthcare providers.
- Laypersons should receive training in how to respond to victims of opioid overdose, including the administration of naloxone.
- Bystander CPR training should target specific socioeconomic, racial, and ethnic populations who have historically exhibited lower rates of bystander CPR. CPR training should address gender-related barriers to improve rates of bystander CPR performed on women.
- EMS systems should monitor how much exposure their providers receive in treating cardiac arrest victims. Variability in exposure among providers in a given EMS system may be supported by implementing targeted strategies of supplementary training and/or staffing adjustments.
- All healthcare providers should complete an adult ACLS course or its equivalent.

- Use of CPR training, mass training, CPR awareness campaigns, and hands-only CPR promotion should continue on a widespread basis to improve willingness to provide CPR to cardiac arrest victims, increase the prevalence of bystander CPR, and improve outcomes from OHCA.

Major New and Updated Recommendations

Deliberate Practice and Mastery Learning

2020 (New): Incorporating a deliberate practice and mastery learning model into basic or advanced life support courses may be considered for improving skill acquisition and performance.

Why: Deliberate practice is a training approach where students are given a discrete goal to achieve, immediate feedback on their performance, and ample time for repetition to improve performance. *Mastery learning* is defined as the use of deliberate practice training and testing that includes a set of criteria to define a specific passing standard, which implies mastery of the tasks being learned.

Evidence suggests that incorporating a deliberate practice and mastery learning model into basic or advanced life support courses improves multiple learning outcomes.

Booster Training and Spaced Learning

2020 (New): It is recommended to implement booster sessions when utilizing a massed-learning approach for resuscitation training.

2020 (New): It is reasonable to use a spaced-learning approach in place of a massed-learning approach for resuscitation training.

Why: The addition of *booster training sessions*, which are brief, frequent sessions focused on repetition of prior content, to resuscitation courses improves the retention of CPR skills.

The frequency of booster sessions should be balanced against student availability and the provision of resources that support implementation of booster training. Studies show that *spaced-learning courses*, or training that is separated into multiple sessions, are of equal or greater effectiveness when compared with courses delivered as a single training event. Student attendance across all sessions is required to ensure course completion because new content is presented at each session.

Lay Rescuer Training

2020 (Updated): A combination of self-instruction and instructor-led teaching with hands-on training is recommended as an alternative to instructor-led courses for lay rescuers. If instructor-led training is not available, self-directed training is recommended for lay rescuers.

2020 (New): It is recommended to train middle school– and high school–age children in how to perform high-quality CPR.

2015 (Old): A combination of self-instruction and instructor-led teaching with hands-on training can be considered as an alternative to traditional instructor-led courses for lay providers. If instructor-led training is not available, self-directed training may be considered for lay providers learning AED skills.

Why: Studies have found that self-instruction or video-based instruction is as effective as instructor-led training for lay rescuer CPR training. A shift to more self-directed training may lead to a higher proportion of trained lay rescuers, thus increasing the chances that a trained lay rescuer will be available to provide CPR when needed. Training school-age children to perform CPR instills confidence and a positive attitude toward providing CPR. Targeting this population with CPR training helps build the future cadre of community-based, trained lay rescuers.

In Situ Education

2020 (New): It is reasonable to conduct in situ simulation-based resuscitation training in addition to traditional training.

2020 (New): It may be reasonable to conduct in situ simulation-based resuscitation training in place of traditional training.

Why: *In situ simulation* refers to training activities that are conducted in actual patient care areas, which has the advantage of providing a more realistic training environment. New evidence shows that training in the in situ environment, either alone or in combination with traditional training, can have a positive impact on learning outcomes (eg, faster time to perform critical tasks and team performance) and patient outcomes (eg, improved survival, neurological outcomes).

When conducting in situ simulation, instructors should be wary of potential risks, such as mixing training supplies with real medical supplies.

Gamified Learning and Virtual Reality

2020 (New): The use of gamified learning and virtual reality may be considered for basic or advanced life support training for lay rescuers and/or healthcare providers.

Why: Gamified learning incorporates competition or play around the topic of resuscitation, and virtual reality uses a computer interface that allows the user to interact within a virtual environment. Some studies have demonstrated positive benefits on learning outcomes (eg, improved knowledge acquisition, knowledge retention, and CPR skills) with these modalities. Programs looking to implement gamified learning or virtual reality should consider high start-up costs associated with purchasing equipment and software.

Bystander CPR training should target specific socioeconomic, racial, and ethnic populations who have historically exhibited lower rates of bystander CPR. CPR training should address gender-related barriers to improve rates of bystander CPR performed on women.

Opioid Overdose Training for Lay Rescuers

2020 (New): It is reasonable for lay rescuers to receive training in responding to opioid overdose, including provision of naloxone.

Why: Deaths from opioid overdose in the United States have more than doubled in the past decade. Multiple studies have found that targeted resuscitation training for opioid users and their families and friends is associated with higher rates of naloxone administration in witnessed overdoses.

Disparities in Education

2020 (New): It is recommended to target and tailor layperson CPR training to specific racial and ethnic populations and neighborhoods in the United States.

2020 (New): It is reasonable to address barriers to bystander CPR for female victims through educational training and public awareness efforts.

Why: Communities with low socioeconomic status and those with predominantly Black and Hispanic populations have lower rates of bystander CPR and CPR training. Women are also less likely to receive bystander CPR, which may be because bystanders fear injuring female victims or being accused of inappropriate touching.

Targeting specific racial, ethnic, and low-socioeconomic populations for CPR education and modifying education to address gender differences could eliminate disparities in CPR training and bystander CPR, potentially enhancing outcomes from cardiac arrest in these populations.

EMS Practitioner Experience and Exposure to Out-of-Hospital Cardiac Arrest

2020 (New): It is reasonable for EMS systems to monitor clinical personnel's exposure to resuscitation to ensure treating teams have members competent in managing cardiac arrest cases. Competence of teams may be supported through staffing or training strategies.

Why: A recent systematic review found that EMS provider exposure to cardiac arrest cases is associated with improved patient outcomes, including rates of ROSC and survival. Because exposure can be variable, we recommend that EMS systems monitor provider exposure and develop strategies to address low exposure.

ACLS Course Participation

2020 (New): It is reasonable for healthcare professionals to take an adult ACLS course or equivalent training.

Why: For more than 3 decades, the ACLS course has been recognized as an essential component of resuscitation training for acute care providers. Studies show that resuscitation teams with 1 or more team members trained in ACLS have better patient outcomes.

Willingness to Perform Bystander CPR

2020 (New): It is reasonable to increase bystander willingness to perform CPR through CPR training, mass CPR training, CPR awareness initiatives, and promotion of Hands-Only CPR.

Why: Prompt delivery of bystander CPR doubles a victim's chances of survival from cardiac arrest. CPR training, mass CPR training, CPR awareness initiatives, and promotion of Hands-Only CPR are all associated with increased rates of bystander CPR.

Systems of Care

Survival after cardiac arrest requires an integrated system of people, training, equipment, and organizations. Willing bystanders, property owners who maintain AEDs, emergency service telecommunicators, and BLS and ALS providers working within EMS systems all contribute to successful resuscitation from OHCA. Within hospitals, the work of physicians, nurses, respiratory therapists, pharmacists, and other professionals supports resuscitation outcomes.

Successful resuscitation also depends on the contributions of equipment manufacturers, pharmaceutical companies, resuscitation instructors, guidelines developers, and many others. Long-term survivorship requires support from family and professional caregivers, including experts in cognitive, physical, and psychological rehabilitation and recovery. A systems-wide commitment to quality improvement at every level of care is essential to achieving successful outcomes.

Summary of Key Issues and Major Changes

- Recovery continues long after the initial hospitalization and is a critical component of the resuscitation Chains of Survival.
- Efforts to support the ability and willingness of the members of the general public to perform CPR and use an AED improve resuscitation outcomes in communities.
- Novel methods to use mobile phone technology to alert trained lay rescuers of events that require CPR are promising and deserve more study.
- Emergency system telecommunicators can instruct bystanders to perform hands-only CPR for adults and children. The No-No-Go framework is effective.
- Early warning scoring systems and rapid response teams can prevent cardiac arrest in both pediatric and adult hospitals, but the literature is too varied to understand what components of these systems are associated with benefit.
- Cognitive aids may improve resuscitation performance by untrained laypersons, but in simulation settings, their use delays the start of CPR. More development and study are needed before these systems can be fully endorsed.
- Surprisingly little is known about the effect of cognitive aids on the performance of EMS or hospital-based resuscitation teams.
- Although specialized cardiac arrest centers offer protocols and technology not available at all hospitals, the available literature about their impact on resuscitation outcomes is mixed.
- Team feedback matters. Structured debriefing protocols improve the performance of resuscitation teams in subsequent resuscitation.
- System-wide feedback matters. Implementing structured data collection and review improves resuscitation processes and survival both inside and outside the hospital.

Major New and Updated Recommendations

Using Mobile Devices to Summon Rescuers

New (2020): The use of mobile phone technology by emergency dispatch systems to alert willing bystanders to nearby events that may require CPR or AED use is reasonable.

Why: Despite the recognized role of lay first responders in improving OHCA outcomes, most communities experience low rates of bystander CPR and AED use. A recent ILCOR systematic review found that notification of lay rescuers via a smartphone app or text message alert is associated with shorter bystander response times, higher bystander CPR rates, shorter time to defibrillation, and higher rates of survival to hospital discharge for people who experience OHCA. The differences in clinical outcomes were seen only in the observational data. The use of mobile phone technology has yet to be studied in a North American setting, but the suggestion of benefit in other countries makes this a high priority for future research, including the impact of these alerts on cardiac arrest outcomes in diverse patient, community, and geographic contexts.

Data Registries to Improve System Performance

New (2020): It is reasonable for organizations that treat cardiac arrest patients to collect processes-of-care data and outcomes.

Why: Many industries, including healthcare, collect and assess performance data to measure quality and identify opportunities for improvement. This can be done at the local, regional, or national level through participation in data registries that collect information on processes of care (eg, CPR performance data, defibrillation times, adherence to guidelines) and outcomes of care (eg, ROSC, survival) associated with cardiac arrest.

Three such initiatives are the AHA's Get With The Guidelines-Resuscitation registry (for IHCA), the Cardiac Arrest Registry to Enhance Survival registry (for OHCA), and the Resuscitation Outcomes Consortium Cardiac Epistry (for OHCA), and many regional databases exist. A 2020 ILCOR systematic review found that most studies assessing the impact of data registries, with or without public reporting, demonstrate improvement in cardiac arrest survival in organizations and communities that participated in cardiac arrest registries.

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