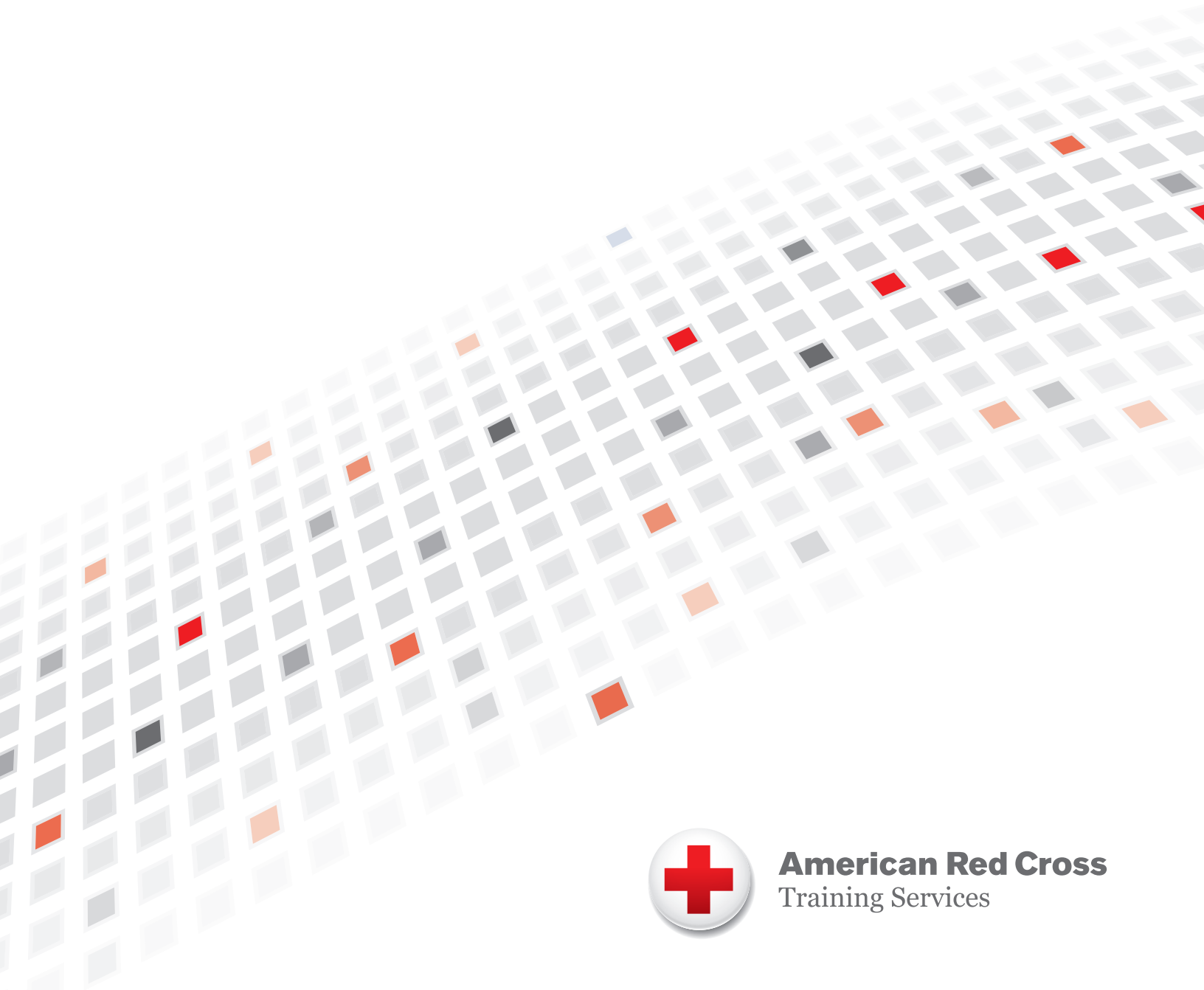
American Red Cross

# Focused Updates and Guidelines 2021

## HEALTHCARE



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Training Services

The American Red Cross Focused Updates and Guidelines 2021 is overseen by the American Red Cross Scientific Advisory Council and is part of the American Red Cross training services programs. The emergency care procedures outlined in these updates and guidelines reflect the standard of knowledge and accepted emergency practices in the United States at the time these updates and guidelines were published. It is the reader's responsibility to stay informed of changes in emergency care procedures.

# Science and Technical Content

The scientific content and evidence within the American Red Cross Focused Updates and Guidelines 2021 are consistent with the most current science and treatment recommendations from:

- The International Liaison Committee on Resuscitation (ILCOR)
- The International Federation of Red Cross and Red Crescent Societies (IFRC)
- The Policy Statements, Evidence Reviews and Guidelines of:
  - American Academy of Pediatrics (AAP)
  - American College of Emergency Physicians (ACEP)
  - American College of Obstetrics and Gynecology (ACOG)
  - American College of Surgeons (ACS)
  - Committee on Tactical Combat Casualty Care (CoTCCC)
  - Obstetric Life Support™ (OBLS™)
  - Society of Critical Care Medicine (SCCM) and the American College of Critical Care Medicine (ACCM)
  - Surviving Sepsis Campaign (SSC)

# Dedication

The American Red Cross Focused Updates and Guidelines 2021 are dedicated to the nurses, physicians, prehospital professionals, therapists, technicians, law enforcement, fire/rescue, advanced practice professionals, lifeguards, first responders, lay responders and all other professionals and individuals who are prepared and willing to take action when an emergency strikes or when a person is in need of care. These updates and guidelines are also dedicated to the employees and volunteers of the American Red Cross who contribute their time and talent to supporting and teaching lifesaving skills worldwide.

# Acknowledgments

Many individuals shared in the development of the American Red Cross Focused Updates and Guidelines 2021 in various scientific, technical, editorial, creative and supportive ways. Their commitment to excellence made these updates and guidelines possible.

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The development of these updates and guidelines would not have been possible without the leadership, valuable insights and dedication of the subject matter experts, who generously shared their time to ensure the highest quality programs.

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Since 1909, the American Red Cross has provided best-in-class resuscitation, first aid and safety education and certification, enabling students to obtain the competency required for effective recognition and care and leading to better outcomes for all those treated.

Behind every course stands a team of experts ensuring that what is taught is based on the latest clinical and educational science. This team, known as the American Red Cross Scientific Advisory Council, is a panel of 60+ nationally and internationally recognized experts from a variety of medical, nursing, EMS, scientific, educational and academic disciplines.

With members from a broad range of professional specialties, the Council has an important advantage: a broad, multidisciplinary expertise in evaluating existing and new assessment methodologies and technologies, therapies, and procedures, and the educational methods to teach them. Additionally, with on-the-ground experience, its members bring the know-how for real-world experience. The Council provides authoritative guidance on resuscitation, first aid, CPR, nursing, prehospital medicine, emergency and critical care, rescue practices, emergency preparedness, aquatics, disaster health and education.

We encourage you to visit our Scientific Advisory Resource Center at redcross.org/science.

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# Introduction

## About the Focused Updates and Guidelines 2021

This focused update summarizes results of the scientific evidence evaluations and guideline reviews overseen by the American Red Cross Scientific Advisory Council (ARCSAC) from 2020 to 2021 on topics related to Basic Life Support, Advanced Life Support, Pediatric Advanced Life Support, Neonatal Life Support and Education. Evidence summaries are provided that include data, reviews and guidance from:

- The American Red Cross Scientific Advisory Council (ARCSAC)
- The International Liaison Committee on Resuscitation (ILCOR)
- The World Health Organization (WHO)
- The Society for Critical Care Medicine (SCCM)/American College of Critical Care Medicine (ACCM)
- The Surviving Sepsis Campaign (SSC)
- The American Academy of Pediatrics (AAP)
- The American College of Emergency Physicians (ACEP)
- Obstetric Life Support™ (OBLS™)
- The American College of Obstetrics and Gynecology (ACOG)
- The American College of Surgeons (ACS)
- The Stop the Bleed Campaign (STB)
- The Committee on Tactical Combat Casualty Care (Co-TCCC)
- Cardiac Arrest Registry to Enhance Survival (CARES)

Each chapter is organized by topic and contains the following recurring sections:

- **An Evidence Summary**, highlighting the most recent and important science, when available, to support the guidelines
- **Insights and Implications**, providing ARCSAC expert guidance and decisions, related observations, reviewer opinions or important gaps in knowledge or research

The **Red Cross Guidelines** include recommended actions for healthcare professionals and emergency responders, as appropriate. The American Red Cross Guidelines Highlights 2021 include those that are new, updated and reaffirmed:

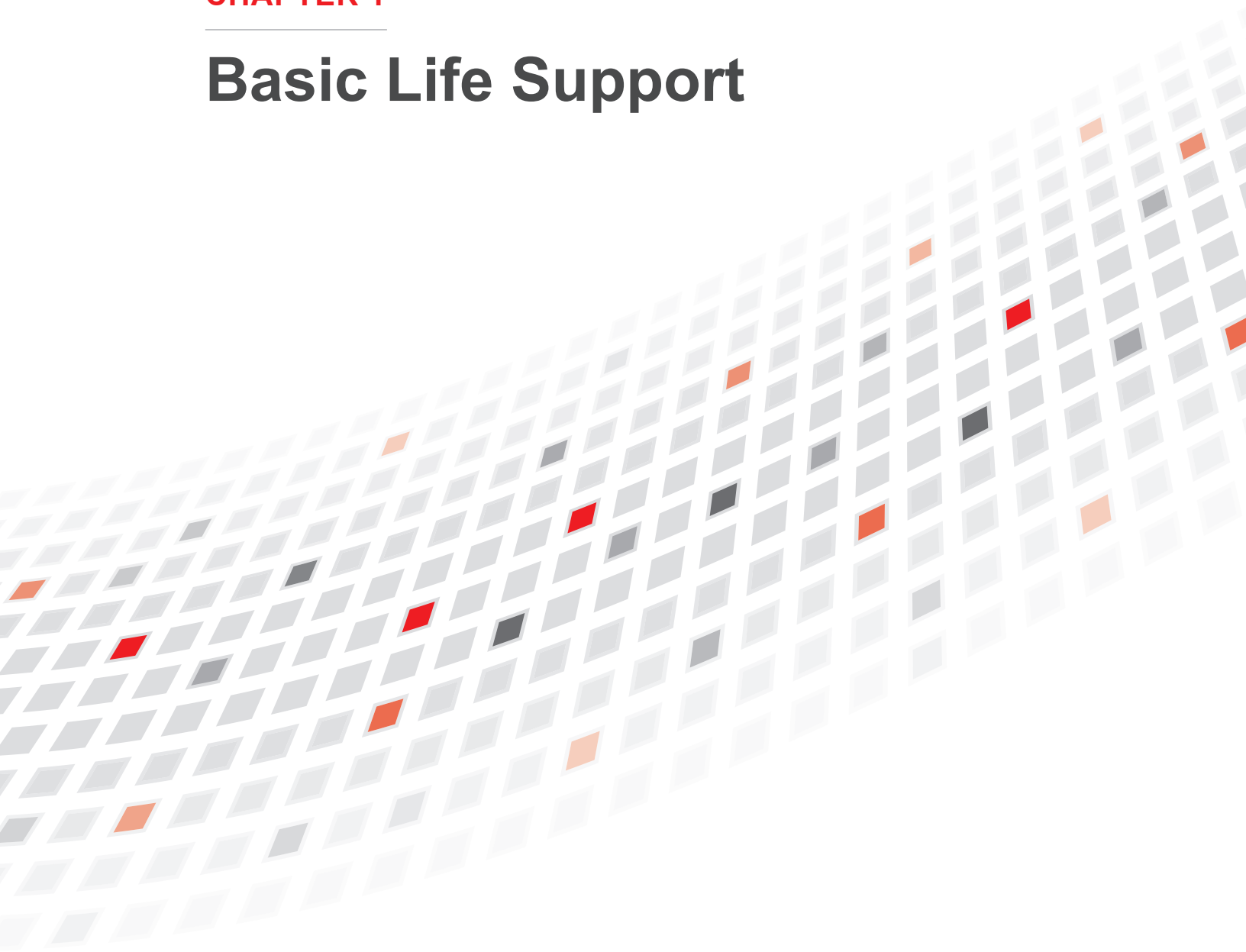
- *New*: Guidelines are new for 2021.
- *Updated*: Guidelines have minor wording changes primarily for clarity.
- *Reaffirmed*: Guidelines are those that have undergone an updated systematic review, scoping review or search for new scientific literature and determined to remain valid.

# About the American Red Cross Scientific Advisory Council

The American Red Cross Scientific Advisory Council (ARCSAC) ensures the clinical and educational basis for Red Cross programs, products and guidance. The ARCSAC is a panel of 60+ nationally and internationally recognized experts in resuscitation, emergency medicine, critical care, infectious disease, trauma, nursing, first aid, education, special populations, prehospital medicine and systems, hospital-based medicine, quality and performance improvement, graduate and undergraduate medical education, continuing education, aquatics, and preparedness and disaster health. They review the available evidence to create scientific reviews, answers to questions, literature updates, and position statements. Their guidance is incorporated into curricula for all Red Cross courses. The ARCSAC has been instrumental in providing scientific reviews used in formulating evidence-based guidelines for the Focused Updates and Guidelines 2021, and for providing expert opinion when evidence is lacking. The digital publication of the Focused Updates and Guidelines 2021 will allow incorporation of critical new evidence or guidelines as needed, including sepsis, where the science is rapidly evolving.

CHAPTER 1

# Basic Life Support



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# Early Access

## Public Access Defibrillation Programs

Public access defibrillation (PAD) programs have been shown to improve survival with favorable neurological outcome in adults and children. Strategies for placement and deployment of automated external defibrillators (AEDs) used in PAD programs are active research topics.

## Red Cross Guidelines

REAFFIRMED • Public access defibrillation programs should be an essential part of the management of out-of-hospital cardiac arrest.

REAFFIRMED • Community leaders may consider determining the locations that have a high incidence of cardiac arrest in the local area and develop methods to have public access defibrillators available at these locations at the time of arrests.

## Evidence Summary

A 2017 ARCSAC review[1] evaluated public access defibrillator placement and found a weak correlation between accessibility of public access defibrillators and the location of cardiac arrests. Additionally, a 2020 ILCOR systematic review and consensus on science with treatment recommendations (CoSTR)[2] evaluated the implementation of a PAD program compared with traditional emergency medical service (EMS) response for adults and children with out-of-hospital cardiac arrest (OHCA), demonstrating survival benefits with favorable neurological outcome at different timepoints associated with a PAD program.

A 2021 ARCSAC literature update identified seven new relevant studies.[3-9] Simulation studies and mathematical models were excluded. The identified studies focused on the use of public access AEDs, survival following use of public access AEDs and strategies for public access AED locations. One study looked at gender disparities in AED use. A brief summary of relevant studies follows.

A retrospective observational study evaluated the survival among persons with OHCA at the Copenhagen (Denmark) airport.[3] The study reported that of 23 nontraumatic OHCAs, nearly all of which were witnessed by bystanders, 73.9% received bystander CPR and 43.5% received bystander defibrillation. There was 100% survival among persons with an initial shockable rhythm and 56% survival of all persons. Those with OHCA at the airport were more likely to receive bystander defibrillation, to have return of spontaneous circulation (ROSC) and to survive to hospital discharge. The authors concluded that the high proportion of bystander defibrillation indicates that bystanders will quickly apply and use an AED, when accessible. The findings also support developing and updating guidelines to strategically deploy accessible AEDs in areas with a high risk of OHCA.[3]

The use of and/or effectiveness of PAD was analyzed using data from a population-based registry of OHCA in Tokyo.[4] Another retrospective review using registry data in Osaka, Japan, reported improved clinical outcomes with public access AED use for OHCA irrespective of the first documented rhythm.[5] A retrospective review reported OHCA and public access AED use over a 10-year period in Poland.[6]

Gender disparities was the focus of a retrospective observational study[7] that analyzed data from the Resuscitation Outcomes Consortium registry between 2011 and 2015. The study looked for gender-based differences in OHCA location to determine what proportion might be eligible for a PAD program, and if gender is associated with AED use. Results reported that women have fewer OHCAs than men in public locations where an AED is available and are less likely to have AED application in public OHCA, even with bystander interventions.

One observational study[8] and a systematic review[9] focused on placement of public access AEDs. A retrospective observational study between 2014 and 2018 in Switzerland used a geodata processing tool to evaluate locations of historical OHCAs and public access AEDs and median distances between public access AEDs.[8] Analysis of areas with a high density of uncovered OHCAs, or hotspots, was used to identify proposed locations for placement of additional public access AEDs. OHCAs at home only had a coverage rate of 4.5%, although 79.3% of OHCAs occurred at home in this study.[8]

A systematic review with qualitative analysis evaluated studies of deployment strategies for public access AEDs.[9] Strategies identified for the deployment of AEDs included guidelines-based, grid-based and landmark-based deployment. The authors reported that the use of a grid-based AED deployment method increased the use of bystander defibrillation threefold and doubled survival at 30 days. It was concluded that while the optimal method could not be fully identified, a more efficient public access AED deployment method could be beneficial for coverage of OHCA and potential survival. The authors suggested optimizing public access defibrillator location by mathematical modeling and evaluation feedback.[9]

### Insights and Implications

Although PAD programs are an active research topic, the literature update did not identify sufficient evidence to warrant a new scientific review and the guidelines remain unchanged. In the United States, use of public access defibrillators remains low, and further research is needed to identify barriers to their use.

# Dispatcher/Telecommunicator-Assisted CPR

Instructions provided to individuals who call 9-1-1 may be provided by an EMS dispatcher, or by a person designated as an EMS telecommunicator, separate from performing dispatch operations. The use of EMS dispatchers and telecommunicators to provide instructions for CPR and first aid has become an active research area, evaluating both skill performance and, to a lesser extent, patient-centered outcomes. Throughout this section, the term “dispatcher” is considered to include “telecommunicators” who function within an EMS system and who communicate with callers or provide instructions for care.

## Video-Based Dispatcher-Assisted Instruction

Communication between dispatch centers and lay responders at the scene of a cardiac arrest are typically through an audio connection on a cell phone. Recently, some dispatch centers have been able to provide cardiopulmonary resuscitation (CPR) instruction by both audio and video communication modes. Does the addition of video to audio dispatcher CPR instructions improve clinical outcomes following cardiac arrest?

### Red Cross Guidelines

- Video-based dispatcher instruction may be considered by dispatch centers as a supplement to standard audio instructions.

## Evidence Summary

A 2021 systematic review by ILCOR[10] identified a single human observational study[11] with 1,720 adult OHCAs that reported benefits for outcomes of good neurological function at discharge, survival to discharge and prehospital ROSC with use of video-based dispatcher-assisted CPR instruction as compared with standard audio-based dispatcher instruction; however, these benefits were not observed when using adjusted data or propensity score matching analysis. Manikin simulation studies identified in this review showed improvement in chest compression rates and time to compressions with the use of video-based dispatcher-assisted instruction. A difference was not shown for other outcomes such as compression depth, hand position or recoil. Despite this, the reviewers felt that it is important to encourage research in this area and made a weak recommendation that the usefulness of video-based dispatch systems be assessed in clinical trials or research initiatives.[10,12,13]

## Insights and Implications

An older systematic review included simulation studies showing a significantly improved chest compression rate with the use of video-based dispatcher-assisted CPR compared with audio-based dispatcher assistance, but with an associated delay in commencing bystander CPR.[14] Further clinical research is needed to identify potential benefits or harm associated with video-based dispatcher-assisted CPR. In light of the delay of CPR initiation, without further research, a new guideline cannot be supported at this time.

# Dispatcher Recognition of Cardiac Arrest

Recognition of cardiac arrest by dispatchers is critical for the rapid response by EMS and for assistance with bystander CPR instructions. How well a dispatcher can recognize cardiac arrest may be influenced by call characteristics, such as words, language, idioms or the emotional state of the caller.

## Red Cross Guidelines

REAFFIRMED • Dispatch centers should employ standardized and evidence-based protocols for recognition of cardiac arrest.

NEW • Dispatch centers should monitor the diagnostic accuracy of recognition of cardiac arrest from use of any specific dispatch criteria or algorithms.

## Evidence Summary

A 2021 diagnostic systematic review[15] by ILCOR evaluated studies of dispatcher recognition of cardiac arrest and call characteristics that might influence their ability to recognize cardiac arrest. Significant heterogeneity between studies and high risk of bias precluded meta-analyses. The use of different dispatching criteria or algorithms and the level of education was not found to impact diagnostic accuracy. Sensitivity for cardiac arrest from 46 studies ranged between 0.46 to 0.98, while specificity for cardiac arrest from 12 studies ranged from 0.32 to 1.00.[15]

## Insights and Implications

Studies included in the systematic review were from a variety of countries, with most from the European Union and the United Kingdom, and 10 from the United States. Differing standardized algorithms were used, such as the Advanced Medical Priority Dispatch™ software, while other dispatch centers used dispatcher judgment or other criteria.

The chain of survival for cardiac arrest starts with recognition of cardiac arrest and activation of EMS, followed by early CPR. Thus, the ability of EMS dispatchers to accurately identify cardiac arrest is critical to saving lives, and monitoring accuracy in dispatcher recognition of cardiac arrest will aid future research. Machine learning as a supportive tool to assist dispatchers with recognition of cardiac arrest is a promising area of research. A recent randomized controlled trial (RCT)[16] of 5,242 emergency calls used a machine learning model listening to calls to determine if it could alert dispatchers in cases of suspected cardiac arrest. While there was no significant improvement in recognition of OHCA during calls in which the model alerted dispatchers compared with those in which it did not alert dispatchers, the machine learning model had a higher sensitivity than the dispatchers without alerts for recognizing confirmed cardiac arrest (85.0% versus 77.5%; $P<0.001$).

# Harm from CPR to Victims Not in Arrest

Bystanders who witness a possible cardiac arrest in the out-of-hospital setting may hesitate to perform CPR for fear they may cause harm to the person if they are not truly in cardiac arrest. When dispatchers provide direction, is this a valid concern and how should it be addressed?

## Red Cross Guidelines

UPDATED

- Dispatchers should provide guidance to bystanders to begin CPR based on their assessment and without concern for harm to persons not in cardiac arrest.

## Evidence Summary

This topic underwent a literature update by ARCSAC in 2021 following a systematic review by ILCOR in 2020.[2] The 2021 ARCSAC literature update did not identify new studies directly addressing the question, and the Red Cross guidelines remain unchanged. However, a recent retrospective study[17] identified in the update used a legal research database to search for verdicts and settlements from all 50 states between 1989 and 2019 for personal injury or wrongful death lawsuits involving CPR. The authors identified and reviewed 170 cases directly related to CPR. Of the 170 cases, only three alleged harm due to providing CPR, while the other 167 cases were due to inadequate or delayed bystander CPR.

The 2020 systematic review[2] sought to identify studies demonstrating harm from the provision of chest compressions by lay responders to adults and children not in cardiac arrest in the out-of-hospital setting. Pooled data from retrospective reviews of 345 patients who were not in cardiac arrest but who received CPR by lay responders, found the most common injury reported was pain in the area of chest compression (incidence, 8.7%; 95% CI, 5.7–11.7%) followed by rib and clavicle fractures (1.7%; 95% CI, 0.4–3.1%). No clinically relevant visceral injury was reported.[2]

## Insights and Implications

The potential survival benefits from CPR initiated by lay responders for those in cardiac arrest outweigh the low risk of injury should a person not be in cardiac arrest when CPR is performed. Although the evidence was indirect, the legal database review[17] findings also support the guideline that lay responders should begin CPR based on their assessment and without concern for harm to persons not in cardiac arrest.

# Dispatcher-Assisted Compression-Only CPR Versus Conventional CPR

Red Cross guidelines call for dispatchers to provide instructions to callers who are untrained in CPR, or who are unable to recall CPR performance steps, when providing care for adults with suspected OHCA. Is there evidence to show improved patient outcomes with dispatcher-assisted standard or compression-only CPR (CO-CPR)?

## Red Cross Guidelines

REAFFIRMED
- Dispatchers should provide instructions to perform compression-only CPR for suspected out-of-hospital cardiac arrest to those untrained in CPR or who are unable to recall CPR performance steps.

NEW
- Dispatchers should provide support as needed for performance of compression-ventilation CPR by those trained in standard CPR who are able to recall CPR performance steps.

## Evidence Summary

No new studies meeting inclusion criteria were identified by a 2021 ARCSAC literature update. However, studies were identified on dispatcher-assisted CPR versus no CPR, and for dispatcher-assisted CPR versus bystander CPR. A 2017 ILCOR systematic review[18] included one RCT[19] that did not show a benefit for the outcome of favorable neurologic function with dispatcher-assisted instructions to give CO-CPR compared with instructions to give standard CPR with a compression-to-ventilation (CV) ratio of 15:2. Additionally, a meta-analysis of three RCTs[19-21] using a random-effect model showed no significant survival benefit from dispatcher-assisted instructions to give CO-CPR compared with dispatcher-assisted instructions to give standard CPR with a CV ratio of 15:2.[18]

Despite the lack of new evidence, the Red Cross recommends, as a good practice statement, that dispatchers also provide standard CPR instructional support, when needed, to those trained in standard CPR who are able to recall CPR performance steps.

## Insights and Implications

Although the evidence from the 2017 ILCOR review compared dispatcher-assisted CO-CPR with dispatcher-assisted standard CPR with a CV ratio of 15:2, it is unlikely that these studies will be replicated with the use of the current CV ratio of 30:2 CPR.

# CPR Techniques and Sequence

## Starting CPR (A-B-C versus C-A-B)

The question of how to begin CPR—with compressions first or with ventilations first—was the subject of a 2020 ARCSAC Answer[1] and a 2021 ARCSAC literature update.

### Red Cross Guidelines

REAFFIRMED • Once cardiac arrest is recognized, resuscitation should begin with compressions.

REAFFIRMED • Healthcare professionals may consider rescue breaths or manual ventilations first in pediatric patients with primary respiratory etiologies of cardiac arrest.

REAFFIRMED • For the drowning process resuscitation, once cardiac arrest is recognized, resuscitation should begin with rescue breaths or manual ventilations.

### Evidence Summary

A 2021 ARCSAC literature update did not lead to a change in the 2020 ARCSAC Answer,[20] which recommended to continue teaching the airway-breathing-circulation (A-B-C) approach for assessment in all emergencies and, for adult cardiac arrest and sudden pediatric arrest, to begin CPR with compressions followed by ventilations (compressions-airway-breathing [C-A-B]). A retrospective review in 2020 analyzed data from the Cardiac Arrest Registry for Enhanced Survival (CARES) between 2013 and 2016 from 548 cases of cardiac arrest following drowning on whom information was available on the type of CPR performed.[21] Compression-ventilation CPR (CV-CPR) in 5- to 15-year-olds was reported to be significantly associated with neurologically favorable survival (aOR, 2.68; 95% CI, 1.10–6.77; *P*=0.03) compared with CO-CPR, supporting the need for ventilations in hypoxic cardiac arrest.[21] This study informed the recommendation that for the drowning process, resuscitation should begin with ventilations/rescue breaths (A-B-C).

### Insights and Implications

For adult cardiac arrest and sudden pediatric cardiac arrest, the correct resuscitation sequence is compressions first, followed by ventilations. However, not every cardiac arrest is due to a primary cardiac etiology; many patients in cardiac arrest may have very low levels of oxygen in their blood at the time of arrest. The priority for these victims is to get oxygen to the vital organs, particularly in cases such as drowning or with infants and children, since cardiac arrest in this population is most commonly the result of a respiratory issue. For pediatric patients in cardiac arrest due to a respiratory issue, healthcare professionals may consider providing breaths first; for lay responders, uniformity of approach outweighs the slight delay in ventilations when using compressions first. For resuscitation from drowning, it is vital to begin with ventilations because of the unique pathological process associated with drowning.

## CPR Prior to Call for Help

Mobile phones with audio command and speaker capability now make it possible to call 9-1-1 while simultaneously beginning CPR.

## Red Cross Guidelines

REAFFIRMED
- A mobile phone with a speaker, if available, should be used to call 9-1-1, allowing activation of emergency medical services to occur parallel to the beginning of CPR and to facilitate dispatcher guidance and/or support of CPR.

## Evidence Summary

A 2021 ARCSAC literature update did not identify any new relevant studies, and guidelines remain unchanged.

This topic was last reviewed by ILCOR in 2020.[2] The review included a single large cohort study[22] of OHCA with CPR performed with dispatcher assistance identified from a national registry. Although a CPR-first strategy was not shown to improve survival to hospital discharge when compared with a call-first strategy, a subgroup analysis with adjusted data suggested a survival benefit with favorable neurological outcome using a CPR-first strategy, and a survival benefit with favorable neurological outcome was reported in patients under 20 years of age with use of a CPR-first strategy (aOR, 3.74; 95% CI, 1.46–9.61).[2]

## Insights and Implications

This guideline reflects the technological changes in cell phone design, their widespread use and the ability to simultaneously call 9-1-1 using voice command while beginning CPR. This shifts the focus to initiating CPR as quickly as possible and helps avoid the need to leave a cardiac arrest victim to call 9-1-1.

# Compression-Only CPR Versus Conventional CPR: EMS

What approach is recommended for EMS prehospital professionals to perform CPR that will minimize interruptions to chest compressions?

## Red Cross Guidelines

- For healthcare professionals:

UPDATED
  - A compression-to-ventilation (CV) ratio of 30:2 should be used in adults with cardiac arrest without an advanced airway.

REAFFIRMED
  - A CV ratio of 15:2 should be used in children and infants with cardiac arrest and with two healthcare or prehospital professionals trained in this technique.

REAFFIRMED
  - With an advanced airway in place, healthcare and prehospital professionals should not pause compressions for ventilations.

REAFFIRMED
  - Emergency medical services systems may consider alternative initial compression-only strategies for witnessed cardiac arrest.

## Evidence Summary

A 2021 ARCSAC literature update from 2017 forward did not identify relevant studies to indicate the need for a new systematic scientific review or change in the guidelines. The wording of one guideline has been updated for clarity to show that the CV ratio of 30:2 is for adults with cardiac arrest and without an advanced airway, as compared to continuous compressions when an advanced airway is present and there is no pause for ventilations.

The Red Cross guidelines were informed by a 2017 ILCOR review[18] that evaluated continuous chest compression CPR for OHCA combined with:

- Positive pressure ventilations (PPVs) using bag-mask ventilation at 10 breaths per minute.
- An endotracheal tube.
- A supraglottic airway.
- Passive oxygenation through an oropharyngeal airway and an oxygen mask.

The review included one RCT[23] that did not find an increase in favorable neurological function or survival to discharge for patients receiving continuous chest compressions plus PPV without pauses for compressions, as compared with patients receiving conventional CPR with a CV ratio of 30:2 and ventilations delivered with positive pressure during a pause in compressions. One cohort study[24] reported improved favorable neurological function with continuous chest compressions and passive ventilation for three cycles, when compared with conventional CPR with a CV of 15:2 or with the transition to a CV ratio of 30:2.

In a second included cohort study of patients with witnessed shockable cardiac arrest, a minimally interrupted approach using three cycles of 200 uninterrupted chest compressions, plus passive ventilation and before/after rhythm analysis delivering shocks as appropriate, was compared with conventional CPR (a mix of CV ratios of 15:2 and 30:2).[25] Although an increase in survival was reported with the minimally interrupted chest compression approach, improvement in favorable neurologic function rates were not associated with a minimally interrupted chest compression approach compared with conventional CPR. The ILCOR review recommended that EMS providers perform CPR with a CV ratio of 30:2 or continuous chest compressions with PPV delivered without pausing chest compressions until a tracheal tube or supraglottic device has been placed.[18]

## Insights and Implications

Many EMS systems now use a minimally interrupted cardiac resuscitation strategy as part of a bundle of care as an alternative to conventional CPR with a CV ratio of 30:2 for witnessed OHCA.

# Chest Compression Rate

Is there a chest compression rate during CPR that is associated with higher rates of survival to hospital discharge with or without good neurological outcome?

## Red Cross Guidelines

REAFFIRMED

- Chest compressions should be performed at a rate of 100 to 120 per minute for adults, children and infants.

## Evidence Summary

A 2021 ARCSAC literature update on chest compression rate during CPR did not identify new relevant studies since January 2020 and guidelines remain unchanged. Evidence for chest compression rates used in CPR was last reviewed systematically in 2015 by ILCOR,[27] followed by a scoping review in 2020.[2,28]

The 2015 systematic review included large observational studies showing an association between increasing chest compression rates and declining chest compression depth, and a decrease in survival to hospital discharge with compression rates above 140 per minute.[27] A strong treatment recommendation was made for a manual chest compression rate of 100 to 120 per minute. The more recent scoping review[2,28] of chest compression rate, depth and chest wall recoil identified additional observational studies and one RCT evaluating chest compression rate; some studies evaluated compression rate in isolation, and others in conjunction with compression depth. Several studies suggested confounding interactions and advised caution when evaluating any chest compression component in isolation. The review concluded that there was insufficient evidence to support a new systematic review or change to treatment recommendations.[2]

## Insights and Implications

The chest compression rate is defined as the rate used for each continuous period of chest compressions over 1 minute, excluding pauses.[27] Studies evaluating chest compression rate are primarily observational, from the OHCA setting, and do not account for potential interactions from compression depth, hand position and other components of chest compression. More recent studies of compression rate have focused on rescuer fatigue with compressions, use of automatic compression devices compared with manual compression, and real-time CPR feedback devices to help maintain correct compression rates and quality of chest compression.

# Chest Compression Depth

Is there a compression depth during CPR that is associated with higher rates of survival to discharge with or without good neurological outcome?

## Red Cross Guidelines

REAFFIRMED • During CPR, an adult chest should be compressed to a depth of at least 2 inches.

REAFFIRMED • During CPR, a child's and infant's chest should be compressed to a depth of at least one-third the anteroposterior diameter of the chest (about 2 inches for a child and about 1 1/2 inches for an infant).

## Evidence Summary

No new relevant studies of chest compression depth during CPR were identified by ARCSAC in a 2021 literature update, and the guidelines remain unchanged. Evidence for chest compression depth during CPR was last reviewed systematically in 2015 by ILCOR,[27] followed by a scoping review in 2020.[2,28]

The 2015 ILCOR systematic review[27] led to a strong treatment recommendation for a manual chest compression depth of approximately 2 inches (5 centimeters) in adults, and a weak recommendation was made for avoiding excessive chest compression depths (greater than 2.4 inches [6 centimeters] in an average adult). The upper limit for chest compression depth reflected evidence suggesting that a depth of more than 2.4 inches is associated with a higher rate of injuries in adults compared with a depth of 2 inches to 2.4 inches (5 centimeters to 6 centimeters).

The more recent scoping review[2,28] identified observational studies evaluating both chest compression rate and depth as well as one RCT and several observational studies evaluating depth alone. There was insufficient new evidence to support a systematic review or reconsideration of ILCOR treatment recommendations.[2]

## Insights and Implications

Studies evaluating compression depth in isolation are commonly confounded by many factors, including body and chest size, as well as chest wall compliance. Studies identified but excluded in the ARCSAC literature update focus on other factors that may impact compression depth including:

- Leaning on the chest.
- Kneeling on a bed to deliver compressions.
- Rescuer height and weight.
- Firmness of surfaces under a body.
- Use of mechanical compression devices versus manual compression.
- Compression cycle length.
- Use of real-time feedback devices.

Future guidance will likely reflect some of these factors as new studies emerge.

# Chest Wall Recoil

Chest wall recoil allows the chest to return to its normal position following a chest compression, allowing for venous return to the heart. Leaning on the chest wall between compressions restricts recoil and can increase intrathoracic pressure and reduce right heart filling and coronary perfusion pressure. Does maximizing chest wall recoil improve ROSC and clinical outcomes?

## Red Cross Guidelines

REAFFIRMED
- During compressions for adults, children and infants, the chest wall should be allowed to fully recoil, and compression and recoil times should be approximately equal.

## Evidence Summary

Evidence for chest wall recoil during CPR was the subject of a 2021 ARCSAC literature update and was last reviewed systematically in 2015 by ILCOR,[27] followed by a scoping review in 2020.[2,28] The 2021 ARCSAC literature update identified one recent randomized simulation trial that reported an association between rescuers' height and weight and the chest compression depth and recoil.[29] An older simulation study also reported an association between higher weight and body mass index (BMI), male sex and height, and a lower likelihood to achieve a complete chest wall recoil.[30] Other studies focus on the impact of real-time CPR feedback devices and rescuer physical fitness when providing CPR. These studies do not support a change in guidelines.

The 2015 systematic review[27] by ILCOR included evidence from two animal studies and one observational study in anesthetized children not in cardiac arrest, all reporting reduced coronary perfusion pressure with incomplete chest wall recoil. The pediatric study applied a force on the chest corresponding to 10% to 20% of body weight, with the finding of a proportional reduction in coronary perfusion pressure, but without effect on cardiac output.[27] The more recent scoping review[2,28] did not identify new studies related to chest wall leaning, highlighting an ongoing gap in research.

### Insights and Implications

The limited evidence supports full chest wall recoil between chest compressions to improve CPR quality. Studies of anthropomorphic variables on chest wall recoil have future implications for CPR instruction and skills training.

## Compression-to-Ventilation Ratios for CPR

The CPR compression-to-ventilation (CV) ratio for adults changed from 15:2 to 30:2 in 2005. Is there evidence to support an alternative CV ratio compared with 30:2 for CPR in adult cardiac arrest?

### Red Cross Guidelines

REAFFIRMED • A compression-to-ventilation (CV) ratio of 30:2 should be used for CPR in adults with cardiac arrest without an advanced airway.

REAFFIRMED • A CV ratio of 30:2 should be used for CPR in children and infants with cardiac arrest with one lay responder/ healthcare professional and without an advanced airway.

REAFFIRMED • A CV ratio of 15:2 should be used for CPR in children and infants with cardiac arrest and with two healthcare professionals trained in this technique.

REAFFIRMED • With an advanced airway in place, healthcare professionals trained in this technique should not pause compressions for ventilations during CPR.

### Evidence Summary

A 2021 ARCSAC literature update from 2017 forward did not identify new human studies evaluating alternative CV ratios for CPR in adults or children, and the guidelines remain unchanged. The Red Cross guidelines were informed by a 2017 ILCOR systematic review with meta-analyses, finding a benefit for favorable neurological function with a CV ratio of 30:2 compared with 15:2, and a higher survival rate with a 30:2 ratio.[18]

### Insights and Implications

Other CV ratios have been evaluated in the past, including a retrospective cohort study showing improved survival with a ratio of 50:2 compared with a 15:2 ratio.[26] Despite the very low-certainty of the evidence included in the 2017 ILCOR systematic review, the meta-analysis supports a CV ratio of 30:2 and there is no new evidence to support an updated review or change to the guidelines.

# Pulse Check During CPR

Chest compression fraction (CCF) is the amount of time during cardiac arrest in which chest compressions are administered and may be calculated manually or by AED analytic software that permits identification of all interruptions greater than 2 seconds. Any interruption in chest compressions during CPR, such as for a pulse check, can contribute to a reduced CCF. Does interruption of CPR to perform a pulse (circulation) check, compared with no interruption of CPR, change outcomes, including ROSC, survival or CCF?

## Red Cross Guidelines

REAFFIRMED
- When performing CPR, if signs of return of spontaneous circulation (ROSC) are observed:
  - Stop CPR and automated external defibrillator use.
  - Check for breathing and a carotid or femoral pulse.
  - Pauses should be minimized to less than 10 seconds.

REAFFIRMED
- Routine pulse checks without signs of ROSC are not recommended.

## Evidence Summary

A 2021 ARCSAC literature update did not identify studies to support routine pulse checks during CPR for basic life support. A 2015 ARCSAC scientific review[31] and a 2015 ILCOR systematic review[27] did not identify human studies specific to this question. The 2021 ARCSAC literature update identified studies in monitored situations related to the use of a doppler and end-tidal capnography and electrocardiogram (ECG) morphology as a means of confirming pulse or ROSC. While these technologies may be useful in identifying ROSC in a monitored, advanced life support setting, there continues to be no evidence to support routine pulse checks during CPR for basic life support.

## Insights and Implications

The value of a pulse check while CPR is in progress is uncertain, particularly in light of the difficulty in detecting a pulse despite training. Additionally, checking for a pulse during CPR has the potential to prolong pauses, leading to an associated reduction in CCF. If there are clinical, hemodynamic or end-tidal capnography signs of ROSC, it is reasonable to consider a pulse check if trained to do so.

# CPR Prior to Defibrillation

The optimal time to perform CPR prior to defibrillation is unclear.

## Red Cross Guidelines

REAFFIRMED
- CPR should be performed prior to the availability of an automated external defibrillator and analysis of rhythm.

# 5 Take-Home Messages for High-Quality CPR

## 1 Compress the chest at a rate of 100 to 120 per minute (adults, children and infants)

## 2 Compress the chest to a depth of:

- → At least 2 inches (5 cm) for adults.
- → About 2 inches (5 cm) for children.
- → About 1 ½ inches (3.8 cm) for infants.

## 3 Allow for full chest wall recoil after each compression

- → Compression and recoil times should be approximately equal.

## 4 Minimize interruptions in chest compressions


- → Minimize interruptions to less than 10 seconds.
- → After a shock is delivered, resume CPR immediately for about 2 minutes or until the AED is ready to analyze.
- → No routine pulse checks.
- → Pulse check if signs of ROSC.

## 5 Avoid excessive ventilation

- → **Without advanced airway:**
  - 2 ventilations each lasting about 1 second and making the chest begin to rise for **adults, children and infants**
- → **With advanced airway:**
  - 1 ventilation every 6 seconds with continuous chest compressions for adults
  - 1 ventilation every 2 to 3 seconds with continuous chest compressions for children and infants

## When to do a Pulse Check During CPR

PULSE CHECK **YES**

**Signs of return of spontaneous circulation (ROSC) observed:**

- → Stop CPR and automated external defibrillator use.
- → Check for breathing and a carotid or femoral pulse.
- → Minimize interruptions to less than 10 seconds.

PULSE CHECK **NO**

**No signs of ROSC observed:**

- → Do not perform routine pulse checks.

## Evidence Summary

A 2021 ARCSAC literature update did not identify any new human studies evaluating CPR intervals prior to defibrillation, and the guidelines remain unchanged. This topic was last reviewed systematically by ILCOR in 2020[2] without evidence of a clear survival benefit for OHCA following a prolonged period of CPR compared with a shorter period of CPR prior to defibrillation.

## Insights and Implications

The ideal time to perform CPR on adults and children with a shockable rhythm following OHCA remains a knowledge gap, but this time should not be extended beyond the arrival of an AED, turning the power on and applying the defibrillator pads.

# Optimal Surface for CPR

A firm surface is considered necessary to deliver chest compressions of adequate depth. What options for improving the firmness of a surface under a patient in cardiac arrest may be of benefit?

## Red Cross Guidelines

UPDATED
- It is reasonable to perform manual chest compressions on a firm surface when possible.

NEW
- It is suggested that a person in cardiac arrest in the hospital setting not be moved from their bed to the floor to improve chest compression depth.

NEW
- If a person in cardiac arrest is in a bed with CPR mode to increase mattress stiffness, it is reasonable to activate this mode.

## Evidence Summary

A 2021 ARCSAC literature update from 2020 forward identified a single new simulation study[32] of an inflated dynamic overlay mattress, and a systematic review[33] of backboard use in CPR. The systematic review[33] confirmed findings from a 2020 ILCOR systematic review[34] of optimal surfaces for CPR, with a meta-analysis of 15 studies showing that the use of backboards during CPR increases chest compression depth by only 1.46 millimeters in manikins; while statistically significant, this finding is of questionable potential clinical significance.

The 2020 ILCOR systematic review[34] evaluated compression depth using manikins on various surfaces and concluded that the use of a backboard marginally improved compression depth, while increasing mattress stiffness or moving the manikin from a bed to the floor did not improve compression depth. Studies were not identified simulating out-of-hospital settings in which mattresses are typically softer than hospital mattresses, and thus ILCOR recommendations were limited to the in-hospital setting.

## Insights and Implications

For in-hospital cardiac arrest (IHCA), patients are sometimes moved from the bed to the floor to improve the quality of CPR compressions. This action can be associated with potential injury to staff and patient and can delay starting CPR. The addition of a backboard in manikin studies appears to improve compression depth only marginally and can also delay starting CPR. However, if the patient is in a bed with CPR mode to increase mattress stiffness, this mode can be quickly activated. Previous studies have shown that compression depth can be adjusted to compensate for mattress compression;[35] feedback devices may also help healthcare professionals to achieve adequate compression depth during CPR on hospital mattresses.

# Head-Up CPR

Head-up CPR is a method shown in studies using cadaver and porcine models to improve cerebral blood flow and cerebral perfusion pressure when combined with active compression-decompression plus impedance threshold devices. Does the use of head-up CPR in humans compared with conventional (supine) CPR improve survival to hospital or survival to hospital discharge with good neurological outcomes?

## Red Cross Guidelines

NEW
- Head-up CPR should not be routinely used for cardiac arrest.

## Evidence Summary

A 2021 CoSTR[36] and systematic review[12,13] by ILCOR identified a single observational before-and-after clinical trial[37] of 1,835 adult OHCAs in a single prehospital system in the United States. Evidence from this trial was judged to be of very low certainty and at high risk of bias. Patients received either conventional (supine) CPR or head-up/torso-up CPR, both bundled with mechanical CPR and the use of an impedance threshold device. A "pit crew" approach was taken for rapid LUCAS® Chest Compression System placement, interrupting manual compressions for no more than 5 seconds. The head-up/torso-up CPR group underwent an initial priming period of supine CPR with oxygen administration but deferred positive pressure ventilations (PPV) for several minutes. Patients were then gradually placed in a reverse Trendelenburg position at approximately 20 degrees after placement of the mechanical CPR device and with simultaneous placement of an advanced airway connected to an impedance threshold device.

Data analysis from the systematic review[36] showed a higher rate of ROSC to hospital arrival for OHCA treated with approximately 20 degree head-up CPR compared with the group treated with supine CPR (RR, 1.90; 95% CI, 1.61–2.26; *P*<0.001; ARR, 16.1%; 95% CI, 20.0%–12.2%, or 161 more patients out of 1000 survived with the intervention [95% CI, 109 more patients out of 1000 to 225 more patients out of 1000 survived with the intervention]). In addition, the trial authors reported that there were no problems or physical complications observed or reported with the head-up/torso-up positioning group and angled mechanical CPR (n=1,489).[37] Improvements in ROSC were reported across all subgroups for demographics, presenting rhythm and provision of bystander CPR.

A weak treatment recommendation by ILCOR suggests against the routine use of head-up CPR and suggests that the usefulness of head-up CPR be assessed in clinical trials or research initiatives.[36]

## Insights and Implications

This review was limited to a single clinical study that suggests that augmented flow CPR through the addition of active compression decompression with the use of an impedance threshold device, deferred PPV, and gradual head and torso elevation may lead to improved short-term outcomes from cardiac arrest. Neurological status at hospital discharge was not obtained in all patients, and other limitations of the study impact the certainty of evidence. While promising, additional clinical trials are needed to assess if this bundled technique will lead to improved outcomes following OHCA, including longer term survival and functional outcomes.

# Alternative Cardiac Resuscitation Techniques

Alternative techniques have been described for converting a malignant cardiac rhythm or for maintaining cardiac output to support consciousness. These include the use of a precordial thump for ventricular tachycardia (VT), "cough CPR" (in conscious patients) for ventricular fibrillation (VF), asystole or high-grade atrioventricular block, and percussion pacing ("fist pacing") for asystole or bradycardia. Is there evidence to support the use of these alternative techniques?

## Red Cross Guidelines

REAFFIRMED • A precordial thump and percussion pacing should not be used for cardiac arrest.

REAFFIRMED • "Cough CPR" should not be used for cardiac arrest.

## Evidence Summary

A 2021 ARCSAC literature update did not identify new human studies related to "cough CPR," precordial thumps, and percussion ("fist") pacing for adults in cardiac arrest, and guidelines remain unchanged. A 2020 ILCOR CoSTR[2] and accompanying systematic review[38] evaluated the use of cough CPR, precordial thumps and percussion pacing on clinical outcomes following cardiac arrest. The evidence evaluated in this review suggests that there is no association between the use of a precordial thump and survival to hospital discharge. Evidence was not identified showing improved clinical outcomes following cardiac arrest with the use of either cough CPR or percussion pacing.[38]

## Insights and Implications

Studies of cough CPR are limited to a small cohort study of in-hospital patients with VT and case series from the cardiac catheterization laboratory and the coronary care unit. The evidence for percussion pacing was limited to case series. While there may be exceptional circumstances where these techniques are considered, such as for a witnessed IHCA in a monitored setting or catheterization laboratory, the Red Cross does not recommend their use for cardiac arrest.

# Tidal Volumes and Ventilation Rates

Guidelines for ventilation rates for children changed in 2020. For adults, guidelines for ventilation rates, tidal volumes and inspiratory rates have remained unchanged since 2010. Is there new science to suggest a need to reevaluate current guidelines?

## Red Cross Guidelines

REAFFIRMED • For adults with a pulse but insufficient respiratory effort, and during CPR with an advanced airway in place, 1 rescue breath/manual ventilation should be provided every 6 seconds.

REAFFIRMED • For children and infants with a pulse but insufficient respiratory effort, and during CPR with an advanced airway in place, 1 rescue breath/manual ventilation should be provided every 2 to 3 seconds.

REAFFIRMED • Rescue breaths and manual ventilations should be delivered over 1 second in adults, children and infants and with a volume that produces visible initiation of chest rise.

## Evidence Summary

A 2021 ARCSAC literature update did not identify new studies of inspiratory times, ventilation rates or tidal volumes for adults or children without advanced airways in place, and guidelines are unchanged.

Historically, guidelines for the inspiratory time to deliver mouth-to-mouth and bag-mask ventilations (BMV) in adults stem from a 2005 ILCOR CoSTR,[39] while guidelines for adult ventilatory rates and tidal volume reflect the treatment recommendations from a 2010 ILCOR review[40] of airway management. Guidelines for children and infants in respiratory arrest and cardiac arrest with an advanced airway in place changed in 2020 following publication of a large multicenter cohort study of ventilation in children receiving CPR with an advanced airway in place.[41] The recommended ventilatory rate was changed to 1 breath or ventilation every 2 to 3 seconds. This change reflects:

- A closer approximation with baseline physiologic pediatric respiratory rates.
- The likelihood of an underlying respiratory process preceding a cardiac event in children.
- The findings from the 2019 multicenter cohort study that evaluated ventilation rates during CPR performed in children with an advanced airway, showing that higher ventilation rates (at least 30 breaths/minute in infants and 25 or more breaths/minute in older children) were associated with higher odds of ROSC and survival to hospital discharge.[41]

For adults, evidence supporting the guidelines for delivery of a rescue breath or manual ventilation over 1 second includes a secondary analysis of case series[42,43] that included patients with advanced airways after OHCA. Ventilation rates above 10 per minute and inspiration times greater than 1 second were associated with no survival.[39] In addition, a 2005 study using a model of a simulated unprotected airway reported that a reduction of peak inspiratory time from 2 seconds to 1 second resulted in a significant increase in peak airway pressure and peak inspiratory flow rate, with no increase in stomach inflation.[44]

Evidence supporting guidelines for ventilatory rates and tidal volume in adults includes human studies showing that oxygenation and normocarbia were maintained in apneic adults who were ventilated with room air and tidal volumes of 600 ml, while supplemental oxygen was needed to reach adequate saturation levels when tidal volumes of 500 ml were used.[40]

### Insights and Implications

Excessive ventilation (rate and volume) can cause gastric insufflation with regurgitation and aspiration, increased intrathoracic pressure, and decreased cardiac venous return and output, and should be avoided. For patients with an advanced airway in place during CPR, the reduced cardiac output should support a lower minute ventilation and tidal volume of about 500 ml to 600 ml (6 ml/kg to 7 ml/kg). For patients without an advanced airway in place, this volume equates to seeing the initiation of chest rise. Delivering ventilations over 1 second instead of 2 also allows for higher chest compression rates without increased risk of gastric insufflation.

## Bag-Mask Ventilation Versus Mouth-to-Mask Ventilation

Are clinical outcomes improved when a lay responder/healthcare professional uses BMV as compared with mouth-to-mask ventilation?

### Red Cross Guidelines

REAFFIRMED
- A single person providing ventilations should use the mouth-to-mask technique rather than the bag-mask ventilation (BMV) technique.

REAFFIRMED
- Multiple healthcare professionals may use the two-person BMV technique if properly trained and experienced in this method.

## Evidence Summary

A 2021 updated scientific review by ARCSAC[45] sought evidence from January 2017 to January 2021 to support ventilation of a nonbreathing person with a BMV device compared with mouth-to-mask ventilation provided by a single person and when multiple trained lay responders or healthcare professionals are available. All clinical outcomes were considered. No studies met inclusion criteria, and guidelines remain unchanged.

This topic was previously reviewed by ARCSAC[46] in 2017 and included one narrative review, six observational manikin studies and one observational cadaver study. The evidence that was included was of low to very low certainty and suggested an association between the use of mouth-to-mask ventilation and improved ventilations, less interruptions of chest compressions and improved skill retention at 1 year when compared with the use of BMV. Hyperventilation was less common with mouth-to-mask or mouth-to-face shield ventilation and was more common with BMV. The review concluded that mouth-to-pocket mask remains the best technique to teach lay responders ventilation of nonbreathing patients. Bag-mask ventilation is a more difficult skill to learn and retain.

## Insights and Implications

Rescue breaths can be delivered by mouth-to-mouth (with or without a barrier device), or mouth-to-mask (with inline filter/one-way valve) while manual ventilations can be delivered with a bag-mask device. The mouth-to-mask technique appears easier to learn and remember than the BMV technique, has not been associated with any reported disease transmission, and allows for fewer interruptions in chest compressions than BMV technique by a single rescuer.

# Feedback for CPR Quality

Feedback devices are commonly used in training to improve the quality of compressions and ventilation rate during CPR. These devices may include audiovisual feedback with visual feedback and corrective audio prompts; audio and tactile feedback indicating adequate chest compression depth and release; and metronome guidance for chest compression rate. Quality metrics and measures, such as pauses in compression and CCF, can be recorded and feedback provided in summary form following a resuscitation. Alternatively, feedback can be provided in real time while CPR is underway. Is there clinical evidence to support the use of real-time CPR feedback devices during real-life cardiac arrest?

## Red Cross Guidelines

REAFFIRMED • Healthcare professionals may consider using feedback devices during real-time CPR performance.

REAFFIRMED • Instructors may choose to incorporate feedback devices during CPR training to improve CPR performance.

## Evidence Summary

A 2021 ARCSAC literature update sought to identify new studies evaluating the use of real-time CPR feedback devices during cardiac arrest. The identified studies support the current guidelines and include one new observational cohort study,[47] one RCT[48] and four systematic reviews,[49-52] including 3 meta-analyses.[49,50,52]

A prospective cohort study[47] of 292 OHCAs compared no-feedback with sensor-only feedback to collect compression depth data with real-time feedback for compression quality (depth, pauses and frequency). Real-time feedback was reported to not change compression depth significantly but did improve chest compression quality in terms of pauses in compressions and compression frequency.

A prospective RCT,[48] including 22 patients receiving chest compressions for IHCA, compared the use of standard manual chest compressions with compressions using a commercial feedback device. The study reported improved CPR quality and guidelines adherence scores with the feedback device, and a similar incidence of ROSC, survival to intensive care unit (ICU) discharge, and survival to hospital discharge with or without use of the feedback device.

A meta-analysis[52] of clinical RCTs with adult IHCA evaluated clinical outcomes following use of real-time chest compressions delivered without feedback compared with use of a free-standing audiovisual feedback device. Four trials were included, with three using the same brand of feedback device. The authors reported improvement in sustained ROSC (four studies), survival to hospital discharge (two studies), and survival to hospital discharge (three studies) with the use of audiovisual feedback compared with standard CPR.

A 2020 systematic review[49] evaluated the effect of real-time audiovisual CPR feedback device use for both OHCA and IHCA on ROSC, short-term survival and favorable neurological outcomes. Pooled results were reported to not confirm effectiveness of CPR feedback device use, and this was felt to reflect high heterogeneity that on subgroup analysis was due to the types of devices used. It was noted that outcomes were more favorable in studies using portable devices than in studies using AED-associated devices. The methodology, selection of studies and outcomes of this meta-analysis were the subject of a letter to the editor of the journal that published this review.[53]

A 2021 systematic review[50] sought evidence to determine if CPR with the use of either real-time or post-event feedback improves CPR quality or patient outcome compared with CPR without real-time or post-event feedback in OHCA. The authors reported that meta-analysis of studies of real-time feedback showed statistically improved compression depth and rate, but not CCF. For analysis of depth, this improvement was only seen after removing one of three studies because of heterogeneity. Post-event feedback improved depth and CCF. Patient outcomes (ROSC, survival to hospital, survival to hospital discharge) were not improved with real-time or post-event feedback. The authors concluded that based on limited and low-quality to very low-quality evidence, real-time and post-event feedback should be combined to improve CPR quality.

A second systematic review[51] from 2021 sought to assess the effectiveness of automated real-time feedback devices for improving CPR performance during training, simulation and real-life resuscitation in both adults and children. Three real-life CPR studies in adult patients were reported to demonstrate significant improvement with the use of feedback devices compared with CPR without the use of a feedback device.

Current guidelines are informed by a 2020 ILCOR systematic review and CoSTR,[2] which suggests the use of real-time audio-visual feedback and prompt devices during CPR in clinical practice as part of a comprehensive quality improvement program for cardiac arrest designed to ensure high-quality CPR delivery and resuscitation care across an EMS system. Although most studies in this review did not show a statistically significant association between the use of real-time feedback devices and improved clinical outcomes, there was no strong signal of harm associated with their use.[2]

## Insights and Implications

The number of new studies evaluating real-time CPR feedback devices in real-life are limited and the systematic review conclusions are conflicting. Future studies will hopefully focus on device-to-device comparisons, IHCA versus OHCA, and AED-associated versus free-standing feedback devices.

# Harm to Those Performing CPR

Harm related to the provision of CPR is uncommon and may be physical (injury or illness) or emotional. The coronavirus disease 2019 (COVID-19) pandemic has led to renewed interest in the risks of harm to oneself associated with performing CPR, particularly the potential for transmission of infectious disease. What evidence exists demonstrating harm to lay responders or healthcare professionals because of performing CPR?

## Red Cross Guidelines

UPDATED

- Although the risk of harm while performing CPR is considered low, precautions should be taken to minimize the risk of transmission of infectious disease or defibrillator-associated injury. This may include, but is not limited to:
  - Using standard precautions to provide patient care in all settings, to include performance of hand hygiene and use of personal protective equipment (PPE) (i.e., gloves, gown and a face mask) based on activities being performed and the risk assessment.
  - Using additional PPE, including an N95 or higher level respirator, and eye protection (goggles or face shield) for aerosol-generating procedures or resuscitation of patients. Disposable N95 respirators should be discarded after leaving the patient's room or care area.
  - Using an inline filter for mouth-to-mask or bag-mask ventilation.
  - Performing hand hygiene after removal and disposal of PPE or after providing CPR without PPE.
  - Avoiding touching a person in cardiac arrest when advised by automated external defibrillator prompts prior to the delivery of a shock.

## Evidence Summary

A 2021 ARCSAC scientific review[54] evaluated the risk of infection during CPR and first aid, while an ARCSAC literature update sought studies describing other forms of harm to individuals providing CPR.

The ARCSAC Review and literature update identified one systematic review[55] (updated in 2021)[12,13] evaluating the risk of COVID-19 transmission to rescuers performing chest compressions, defibrillation and CPR. Of the included cohort studies, case-control studies, case reports and manikin RCTs, 2 case reports and a cadaver study reported generation of aerosols during delivery of chest compressions, defibrillation or CPR. It was concluded that chest compressions and CPR have the potential to generate aerosols, and suggested that in the current COVID-19 pandemic, healthcare professionals use PPE for aerosol-generating procedures during resuscitation, although it is reasonable to consider defibrillation before donning PPE in situations where the benefits may exceed the risks. For children in need of CPR, it is suggested that lay responders who are willing, trained and able, consider providing rescue breaths in addition to chest compressions.[12,13,55]

The 2021 ARCSAC scientific review[54] evaluated the risk of transmission of infectious disease (not solely coronavirus). Eight case reports identified in this review document transmission of a variety of infectious disease during resuscitation. In most cases, PPE in the form of gloves or a barrier device for rescue breathing were not used. In one retrospective cohort study,[56] 72 healthcare workers with respiratory symptoms were followed for diagnosis of COVID-19. Thirty-three of these workers were classified as high risk based on their job location and

39 persons were classified as general risk based on their job location. The high-risk group had a 2.13 relative risk of developing COVID-19 compared with the general risk group. Suboptimal hand hygiene and improper PPE (undefined) were associated with an increased risk of contracting COVID-19 (RR, 3.10; 95% CI, 1.43–6.73; and RR, 2.43; 95% CI, 1.34–4.39, respectively). One case-control study[57] evaluated 51 SARS- infected healthcare workers (compared with 426 uninfected controls) who had self-reported exposure to SARS patients and reported that chest compressions were significantly associated with high risk for infection (OR, 4.52; 95% CI, 1.08–18.81; *P*=0.031). However, in multivariate analysis it was not possible to distinguish between chest compressions and intubation. Wearing protective goggles, gloves and protective gowns were all found to reduce the risk of infection (*P* values 0.046, 0.011, 0.052, respectively; raw data not provided). Not wearing a mask was found to be a risk for contracting SARS (*P*=0.002).

A search of the grey literature identified an investigative report[58] by The Guardian and Kaiser Health News documenting 3,607 United States healthcare worker deaths from COVID-19 between March 2020 and April 2021, of which 7% were medical first responders. A subset of 654 first responder cases documented if there were concerns expressed (by patient, family or colleagues) about having adequate amounts of PPE available. Within this subset, 145 cases had concerns about having adequate amounts of PPE, 165 did not have concerns and, in 344, it was unknown.

Harm to rescuers from CPR was last reviewed systematically by ILCOR in 2010,[59] followed by a scoping review[2] in 2020. The original 2010 ILCOR systematic review[59] was a multifaceted evaluation of the evidence for the safety of rescuers during training and clinical CPR performance and while using defibrillators, and for the impact of barrier device use on reducing infectious disease transmission. Evidence was sought for adverse physical effects, including injuries or fatigue, psychological effects and for infectious disease transmission. Treatment recommendations stemming from this review included consideration of changing rescuers after about 2 minutes of CPR to prevent rescuer fatigue, while minimizing interruptions to compressions, and pausing compressions during delivery of a shock. It was deemed reasonable to wear PPE while performing CPR. Although evidence was limited, the provision of CPR was felt to be safe for rescuers, with few reports of disease transmission or injury.[59]

The 2020 ILCOR scoping review[2] of this topic identified several additional experimental studies and a case report. The identified studies primarily evaluated the safety of hands-on defibrillation while using gloves during chest compression. This review also noted that evidence supporting rescuer safety during CPR is limited, with few reports of possible disease transmission following mouth-to-mouth resuscitation, and a low incidence of defibrillator-related injuries to rescuers. The overall body of evidence was felt insufficient to warrant a full systematic review.[2]

## Insights and Implications

In general, the provision of CPR is considered low risk to providers. Physical injuries, such as back or muscle strain, may occur, and fatigue is common. There are relatively few reports of infectious disease transmission following provision of CPR. Despite the lack of direct evidence showing an association between chest compressions or defibrillation and transmission of COVID-19 to rescuers, lay responders and healthcare professionals can proactively reduce any risk through the use of PPE, when available, including the use of face masks, eye protection, gowns and gloves, and with hand hygiene.

# Defibrillation

## Defibrillator Electrode Pad Size and Placement

Defibrillator electrode pads are typically greater than 8 centimeters in diameter for adults and applied in an anterolateral position on the chest (avoiding breast tissue), or in an anteroposterior position. Does any other specific pad size, orientation, or position change outcomes?

### Red Cross Guidelines

REAFFIRMED • Use adult defibrillator electrode pads and energy levels on adult patients. Defibrillator pad size and selection should be as recommended by the defibrillator manufacturer.

REAFFIRMED • Adult electrode pads should be applied per defibrillator manufacturer instructions in either an anterolateral or an anteroposterior position.

REAFFIRMED • Defibrillator electrode pads should not incorporate any breast tissue.

### Evidence Summary

No new RCTs were identified in a 2021 ARCSAC literature update, and guidelines remain unchanged. A 2016 animal study[60] using a porcine model found that small variations in pad placement can significantly affect defibrillation shock efficacy.

This topic was last reviewed systematically by ILCOR in 2010[61] followed by a scoping review in 2020[2] with no new evidence identified that directly addressed the question. It is likely that the ideal electrode pad placement will vary with factors such as the type of underlying cardiac rhythm, body habitus, pregnancy and the presence of implanted pacemakers and defibrillators.

### Insights and Implications

Defibrillator models function differently and may require the use of electrode pads designed to work with the specific model. Manufacturers typically have their own proprietary means of attaching electrode pads to their defibrillator model, and they are not interchangeable. Manufacturer's directions should be followed for the defibrillator model in use, with adult pads used for adults. Additional safety considerations include:

- Avoiding placement of defibrillator pads directly over implanted pacemakers or defibrillators or over jewelry or body piercings.
- Removing transdermal medication patches and wiping away any residual medication.
- Quickly shaving the areas where pads will be placed if excess chest hair interferes with pad-to-skin contact.

# Opioid-Associated Emergencies

## Suspected Opioid-Associated Emergency Resuscitation

High-quality CPR and AED use are the most important interventions for cardiac arrest. When opioids are suspected in a cardiac arrest, how should the delivery of naloxone be timed?

### Red Cross Guidelines

REAFFIRMED • CPR and automated external defibrillator (AED) use remain the first interventions for cardiac arrest in opioid overdose and should not be delayed or interrupted.

REAFFIRMED • For suspected cardiac arrest due to opioids, naloxone should be administered as soon as possible without disrupting or delaying CPR and AED use.

### Evidence Summary

Naloxone administration during resuscitation was reviewed by ARCSAC[62] in 2017 and by ILCOR[2] in 2020. An ARCSAC 2021 literature update from January 2019 forward did not identify new studies to suggest a need for a repeat systematic review or possible change in guidance. Current guidelines are based on expert opinion due to lack of scientific evidence.

The 2020 ILCOR review[2] did not identify any studies in any setting comparing lay responder naloxone administration for suspected opioid-associated cardiac arrest in addition to standard CPR with providing standard CPR only and reporting outcomes of ROSC and survival to hospital discharge.

### Insights and Implications

The incidence of opioid-associated cardiac arrest may be underestimated and has spiked during the COVID-19 pandemic and post-pandemic period. A 2021 cohort study evaluated trends in 83.7 million patient encounters in 49 states that participate in the National EMS Information System.[63] Opioid-associated cardiac arrests in 2020 were compared with baseline values from 2019 and data compared with provisional total mortality in the Centers for Disease Control and Prevention records from rolling 12-month windows spanning from January 2019 to July 2020. Opioid-associated cardiac arrests rose 42% nationally in 2020, and there was high concordance with provisional total overdose mortality numbers for months in which both data sets were available.[63] Opioid overdose education and in-home naloxone administration are essential interventions to manage the physiologic effects of overdose, including hypoventilation, apnea, hypoxemia and systemic ischemia leading to cardiac arrest.

# Drowning Process Resuscitation

Drowning is a leading cause of unintentional injury-related deaths. The drowning process is a continuum of events beginning with airway and respiratory impairment from submersion or immersion in liquid.[64] If the process is not stopped, liquid enters the nose and/or mouth, triggering reflex swallowing, closure of the glottis, and laryngospasm and asphyxia. Hypoxemia ensues, laryngospasm subsides, and gasping will then lead to aspiration. Severe hypoxemia eventually leads to cardiac arrest which may include a period of ventricular

fibrillation. This unique pathophysiology of the drowning process contrasts with the pathophysiology associated with other etiologies of cardiac arrests, such as those due to a primary cardiac cause, and explains in part why early resuscitation beginning with ventilations followed by CV-CPR is particularly important.

One recent cross-sectional study of drowning patients using data from 1,859 encounters identified in a national emergency medical services data registry between January 2016 and July 2018 reported that pediatric patients (less than 18 years old) accounted for 50% (n=919; 95% CI, 47%–52%) of cases meeting inclusion criteria.[65] Cardiac arrest was reported in 29% (n=537; 95% CI, 27%–31%) and ROSC in 37% of those presenting with cardiac arrest (n=186; 95% CI, 32%–41%). Higher rates of ROSC were noted in pediatric patients. The prehospital fatality rate was reported to be 18% (n=341; 95% CI, 17%–20%).

The highest drowning rates are in children ages 1 to 4 years, with most drownings in this population taking place in swimming pools, while over half of the drownings in people 15 years and older occur in natural waters such as lakes, rivers or oceans.[66] The rescue and initial resuscitation of a drowning victim may begin with lay responders, such as family members of a small child, followed by prehospital healthcare professionals providing advanced life support. For drownings that take place in larger pool complexes or in natural waters, other specially trained aquatic responders and healthcare professionals may participate in rescue operations and resuscitation in water, at aquatic complexes or beaches, or on a boat.

## CPR for Drowning Process Resuscitation

Is there drowning-specific evidence to support the current recommended sequence and CV ratio for CPR in adults and children?

### Red Cross Guidelines

REAFFIRMED • Initiate compression-ventilation CPR (CV-CPR) for cardiac arrest following drowning in adults, children and infants. If CV-CPR is not possible, compression-only CPR should be performed.

REAFFIRMED • For adults, children, and infants with the drowning process and after determining the presence of cardiac arrest, resuscitation should start by opening the airway, providing 2 rescue breaths/manual ventilations, and then continuing CPR by providing cycles of 30 compressions followed by 2 rescue breaths/manual ventilations.

NEW • Trained lay responders and healthcare professionals may consider providing more than 2 initial breaths when starting resuscitation of a drowning victim. Five initial rescue breaths/manual ventilations are suggested based on current practice.

UPDATED • A CPR compression-to-ventilation ratio of 15:2 should be used for children and infants with the drowning process and cardiac arrest when two healthcare professionals or trained lay responders are available.

## Evidence Summary

A 2021 systematic review[67] by ARCSAC evaluated the sequence of actions and the CV ratio for cardiac arrest due to drowning. The literature search was updated from a previous 2015 ARCSAC review. Of 165 studies identified initially, four indirect observational studies were included in the qualitative synthesis, including:

- A 2018 retrospective study[68] of drowning cases in Singapore treated by EMS over a 2-year period found that of the 93 patients who received CPR, four were reported to regain consciousness with ventilations alone.
- One observational study[69] prospectively analyzed all drowning cardiac arrest patients reported to the French cardiac arrest registry. The patients who received bystander ventilations displayed a much higher rate of intact vital signs on hospital admission compared to those who did not. Additionally, they reported a statistically significant higher odds ratio for survival with bystander ventilations (OR, 6.742).
- An observational cohort study[70] analyzed all drowning cardiac arrest patients presenting to Japanese emergency departments over a 3-year span to compare the effect of bystander CO-CPR with bystander CPR, including compressions and ventilations. After analysis, it was reported by the authors that there was no difference in outcome when comparing these CPR modalities. However, over 90% of the study population was over the age of 18, with over 80% of the population aged 65 and over.
- A fourth study[21] retrospectively analyzed registry data from CARES, specifically including patients who were presumed to have experienced drowning and in whom the type of bystander CPR was reported. The authors reported that CPR with ventilations was associated with neurologically favorable survival in patients aged 5 years to 15 years and with survival to hospital discharge in all age groups. There was also a trend toward improved neurologically favorable survival in all age groups associated with CPR with ventilations.

While there is little evidence to suggest a need for change in ARCSAC guidelines, two of the studies in the ARCSAC systematic review[67] suggest an association between ventilations and improved outcomes. This includes an association between bystander ventilations without compressions and higher odds of survival, and an association between receiving CV-CPR compared with CO-CPR and neurologically favorable survival in patients aged 5 years to 15 years. The typical drowning victim is young, lacks underlying cardiac disease, and is often identified and rescued early in the drowning process, making them potentially at greater odds of survival through early ventilations and CPR with ventilations. No evidence was identified to strongly recommend a specific CV ratio for CPR in the drowning process resuscitation.

## Insights and Implications

Given the unique role of airway and respiratory pathophysiology in the drowning process, including laryngospasm and hypoxemia and the morbidity and mortality following drowning, ventilations should be a priority of treatment. The evidence provides support for either a 2-ventilation or 5-ventilation strategy. None of the studies were designed or sufficiently powered to discern which strategy is preferable and if there were sub-populations that would benefit more from a particular ventilation approach. Therefore, while a 2-ventilation strategy continues to be taught and is supported by increased retention with a single resuscitation technique across different etiologies and shorter time to compressions following the initial ventilations, an option for facilities and agencies is to have a protocol for healthcare providers or trained lay responders to provide 5 breaths at the start of resuscitation.

# Special Considerations in Drowning Process Resuscitation

Most drownings of young children take place in a home pool where rescue can be rapid, and resuscitation can be started immediately after removal from the pool. In older children and adults, drowning may take place in a lake, river, or ocean, creating potential delays in starting CPR or raising concern for use of an AED when close to the water and with wet skin. Is there evidence to support in-water resuscitation or resuscitation of a drowning victim on a boat? Does the wet environment or wet skin pose a hazard to use of an AED in a drowning victim?

## Red Cross Guidelines

REAFFIRMED • In-water resuscitation can be considered in cases where a responder has proper training in the in-water resuscitation technique and is comfortable performing it without causing an unsafe environment for the responder or the drowning victim.

REAFFIRMED • Though in-water resuscitation can be performed without the aid of additional equipment, floating and propelling equipment should be considered.

NEW • Resuscitation from drowning may be performed on a boat if conditions are safe and there are adequately trained responders to assist.

REAFFIRMED • If an adult, child or infant is in cardiac arrest following a drowning event, begin CPR and initiate automated external defibrillator use as soon as one is available and where feasible and safe.

## Evidence Summary

### In-Water Resuscitation

The topic of in-water resuscitation was most recently evaluated systematically by ARCSAC[71] in 2019. Scoping reviews by ILCOR in 2021 sought to identify literature related to in-water resuscitation,[12,13,72] resuscitation on a boat,[12,13,73] and use of an AED in drowning.[12,13,74] No evidence was identified to change the ARCSAC guidelines.

The ARCSAC scientific review[71] of in-water resuscitation focused on the technical feasibility and clinical outcomes. A single observational study was included[75] with 19 patients who received in-water resuscitation. Compared with the group of patients who did not receive in-water resuscitation, patients who received in-water resuscitation had significantly lower prehospital and hospital mortality. Other in-water resuscitation-specific studies used manikins in simulated rescue scenarios,[76-79] finding that:

- In-water resuscitation is feasible by mouth-to-mouth, BMV and laryngeal tube ventilation.
- In-water resuscitation increases the time and perceived difficulty of a rescue.
- In-water resuscitation increases the amount of measured water aspiration on the part of the patient.
- Lifeguards perform in-water resuscitation more effectively and efficiently than laypersons.

The ARCSAC review[71] concluded that although the evidence is limited, in-water resuscitation is feasible but difficult, and can be physically and metabolically taxing to a rescuer, particularly if the rescuer is not properly trained and physically fit. Physical and metabolic demands and rescue time can be decreased with the use of rescue equipment.

The 2021 scoping review[12,13,72] of in-water resuscitation by ILCOR concluded that in suitable water conditions, in-water resuscitation by highly trained rescue teams with water rescue equipment seems feasible.

### Resuscitation on a Boat

A 2021 scoping review by ILCOR searched for studies related to delivering resuscitation to adults and children on a boat following a submersion event, compared with delaying resuscitation until they were on dry land.[12,13,73] The review identified two case series and four manikin studies. The larger of the case series described resuscitation of 24 cases on a lifeboat or another ship by lifeboat crews. None of the patients who received resuscitation on a boat survived. In the second case series, there was one survivor (who was a month out from the submersion event) out of six resuscitations on a boat or lifeboat. Three of the manikin studies evaluated CPR performance by lifeguards and fishermen on inflatable rescue boats or traditional fishing boats and found that while feasible, boat speed or sea conditions impacted the quality of resuscitation and made CPR physically demanding.

### AED Use for Drowning

A 2021 scoping review by ILCOR[12,13,74] sought to identify literature evaluating the use of an AED for adults and children following submersion in water, compared with no AED use. Only indirect evidence was found from observational studies. Of note, among 14,920 patients in 12 studies, OHCA with a shockable rhythm (VF/VT) attributed to drowning was reported in only 2% to 14% of patients. One study[80] with 529 patients was described as showing, with multivariable analysis, an association between a shockable rhythm and increased 30-day survival.[12,13,74] Simulation studies included in this review were described as showing that AED use for cardiac arrest following drowning appears feasible and safe.

## Insights and Implications

Because airway and respiratory pathophysiology, including systemic hypoxemia, are the most significant insults and primary cause of morbidity and mortality in the drowning process, the earlier an intervention can be applied to reverse the insult and the drowning process, the greater the chances should be for survival. The limited evidence suggests that in-water resuscitation is feasible, is performed better with proper training and equipment, and the use of rescue equipment may decrease the physical demands.

Very limited evidence also suggests that resuscitation on a boat is feasible if conditions are safe and if the number of available crew and deck space permits it. High-quality CPR may be difficult to perform, and rescuer fatigue may be problematic.

The review of AED use for drowning confirms prior observations that the incidence of a shockable rhythm in cardiac arrest following drowning is lower than for cardiac arrest due to a primary cardiac etiology. Additional studies are needed to help identify which patients may be more likely to have a shockable rhythm following a submersion event and ways to increase the success of defibrillation while minimizing any risk of AED use in settings near water.

# Prehospital Oxygen in Drowning Process Resuscitation

The drowning process begins with airway and respiratory compromise leading to asphyxia, hypoxemia, global ischemia and eventual cardiac arrest. The use of oxygen in the prehospital setting is typically guided using empirical evidence, and when available, by pulse oximetry with the goal of avoiding both hypoxia and hyperoxia. Should oxygen be empirically provided to drowning victims?

## Red Cross Guidelines

NEW • If available, supplemental oxygen may be provided empirically to drowning victims who are conscious and with respiratory symptoms. Low-flow oxygen is suggested for those with mild symptoms and high-flow oxygen at 15 liters per minute through a face mask is suggested for severe symptoms. Once pulse oximetry is available, supplemental oxygen therapy should be appropriately titrated.

NEW • For the drowning victim in cardiopulmonary arrest, supplemental oxygen should be provided, if available, with ventilations.

## Evidence Summary

A 2021 scoping review by ILCOR[12,13,81] sought to identify literature demonstrating clinical and physiologic outcomes in drowning victims who receive prehospital oxygen compared with no prehospital oxygen administration.

Four observational studies were identified that provided indirect evidence for associations between hypoxemia, oxygen administration and worse outcomes.[12,13,81] No studies directly evaluated the prehospital use of oxygen in adults or children. Cohen et al.[82] performed a retrospective review over a 12-year period of 71 children presenting awake and without an advanced airway to a pediatric emergency department (ED) following a drowning event. Of the 26 children who were admitted, 81% (n=21) presented with an initial oxygen saturation ($SaO_2$) less than 92% at the scene or upon ED arrival, compared with 15 out of 45 (34%) children who were discharged. Cantu et al.[83] also performed a retrospective analysis of 90 children who were 18 years or younger who presented to an ED after accidental drowning. The findings of this analysis indicate that discharge from the ED was significantly more likely with normal oxygen saturations (96% or greater) in triage (aOR, 6.80) and no field intervention by a bystander or first responder at the scene of the submersion, including chest compressions, back/chest blows or rescue breaths (aOR, 5.10). Gregorakos et al.[84] performed a retrospective analysis of 43 hospitalized adults and children presenting to the ED following a seawater drowning event over an 8-year period. On presentation, a partial pressure of oxygen ($PaO_2$):fraction of inspired oxygen ($FiO_2$) ratio less than 300 mmHg was noted in 41 out of 43 patients, but no association was found between the $PaO_2$:$FiO_2$ ratio and duration of hospital stay.[81]

## Insights and Implications

In the prehospital setting, oxygen administration is typically provided using empirical guidance, and then once available, guided by pulse oximetry. In drowning victims, particularly following cold-water submersion, pulse oximetry can be unreliable. In addition, there is no direct evidence from the prehospital setting to support the administration of oxygen following drowning. However, the pathophysiology of the drowning process and hypoxemia suggests the need for supplemental oxygen.

CHAPTER 2

# Advanced Life Support

American Red Cross
Training Services

# Cardiopulmonary Resuscitation: Techniques and Process

## Rhythm Analysis During Chest Compressions

Interrupting chest compressions during CPR to check for the presence of a rhythm, or to determine if a rhythm has become shockable, can contribute to a reduced CCF, leading to decreased coronary and cerebral blood flow, which reduces the potential for survival.

### Red Cross Guidelines

REAFFIRMED • Immediately after a shock is delivered, CPR should be resumed for 2 minutes before pausing compressions to check for or analyze a rhythm.

REAFFIRMED • Based on the clinical situation, performing rhythm analysis after defibrillation may be considered by healthcare professionals.

REAFFIRMED • Compressions should be paused for rhythm analysis, even when using devices with artifact-filtering algorithms.

REAFFIRMED • After every 2 minutes of CPR, the rhythm should be reassessed (while minimizing interruptions to CPR for no more than 10 seconds).

REAFFIRMED • If there are physiologic signs of return of spontaneous circulation (ROSC), briefly pausing compressions for rhythm analysis may be considered.

### Evidence Summary

A 2021 ARCSAC literature update identified a single observational study enrolling 3,601 out-of-hospital cardiac arrests (OHCAs).[85] This study analyzed the frequency of interruptions greater than 1 second in chest compressions, the reasons for and the duration of interruption, and how they changed between 2007 and 2016. Most compression interruptions were associated with cardiac rhythm analysis. Manual ECG rhythm analysis and pulse checks accounted for 41.6% of total interruption time, with a median individual interruption time of 8 seconds. Automated external defibrillator rhythm analysis accounted for 13.7% of total interruption time (median 17 seconds) and manual rhythm analysis and shock delivery accounted for 8.0% of total interruption time (median 9 seconds).

While this study does not evaluate outcomes from chest compression interruptions, it demonstrates the extent of the interruption produced from rhythm analysis, both manual and with AED analysis, supporting the Red Cross guidelines to immediately resume chest compressions following defibrillation. Reducing chest compression interruption time remains paramount to improved CCF and improved outcomes. This topic was last reviewed systematically by ILCOR in 2020[2] with findings suggesting potential harm associated with an immediate check for cardiac rhythm following defibrillation. A previous ILCOR review[27] recommended against the routine use of artifact-filtering algorithms for analysis of electrocardiographic rhythm during CPR and recommended that their usefulness be assessed in clinical trials or research initiatives

## Insights and Implications

There may be unique situations where a rhythm analysis is warranted. As such, healthcare professionals may, in these cases, consider a rhythm analysis but should minimize the duration of the interruption in compressions.

# CPR and Defibrillation in the Prone Patient

The COVID-19 pandemic has led to the further use of the prone position to improve oxygenation, with and without advanced airway management. This has led to questions regarding the feasibility of performing CPR and defibrillation with the patient in the prone position and its effectiveness compared with resuscitation in the supine position.

## Red Cross Guidelines

- For patients in a prone position who develop cardiac arrest:
  - NEW If an advanced airway is not in place, the patient should be turned to a supine position as quickly as possible, and CPR initiated.
  - NEW If an advanced airway is in place and immediate supination is not feasible or poses a risk to the patient, CPR should begin while the patient is prone.
  - NEW If the patient cannot be immediately supinated, defibrillation should be attempted in the prone position.
  - NEW For patients with an advanced airway in place in the prone position while receiving CPR, the quality of CPR should be assessed with end-tidal carbon dioxide and arterial blood pressure monitoring, if feasible.

## Evidence Summary

A 2021 systematic review[86] and CoSTR[12,13] by ILCOR focused on CPR and defibrillation for cardiac arrest in adults and children in any setting when in the prone position, compared with turning the patient to the supine position prior to the initiation of CPR and/or defibrillation. Outcomes of interest included survival with/without favorable neurologic outcome, ROSC, $ETCO_2$ and arterial BP readings during CPR, and time to defibrillation.

The search included all years. Two prospective nonrandomized studies and two simulation studies were identified. An additional 20 adult case reports were included, of which 12 had CPR initiated while in a prone position, and the remaining cases were supinated before starting CPR. The operating room was the predominant setting for case reports.[86]

The majority of evidence included for this review was assessed to be of very low certainty and difficult to interpret. The authors of the review commented that each case may be unique and require weighing the potential risk of delayed CPR and defibrillation against the possible risk of less effective CPR and defibrillation while prone. It was noted that it may be difficult to supinate a patient who is prone and mechanically ventilated and with capnography and additional arterial lines in place. In addition, the etiology of the cardiac arrest may define the urgency of supination.[86]

## Performing CPR and Defibrillation in the Prone Patient

### Advanced Airway?

**NO**

→ Rapidly turn the patient to a supine position.

→ Begin CPR.

**YES**

**RAPID SUPINATION FEASIBLE:**

→ Turn the patient to a supine position.

→ Begin CPR.

**YES**

**RAPID SUPINATION NOT FEASIBLE:**

→ Begin CPR while prone.

→ Defibrillate while prone.

→ Assess quality of CPR with $ETCO_2$ and arterial BP, if feasible.

The treatment recommendations stemming from this review include several good practice statements, reflecting the lack of higher certainty evidence. A strong recommendation was made, for patients with cardiac arrest occurring while in the prone position without an advanced airway already in place, to turn that patient to the supine position as quickly as possible and begin CPR.[86] For patients with cardiac arrest while in the prone position with an advanced airway already in place, and where immediate supination is not feasible or poses a significant risk to the patient, initiating CPR while the patient is still prone may be a reasonable approach (good practice statement). Invasive blood pressure monitoring and continuous end-tidal carbon dioxide ($ETCO_2$) monitoring may be useful to ascertain whether or not prone compressions are meeting benchmarks for adequate perfusion, and this information could inform decision making on when to prioritize supination (good practice statement). For patients with cardiac arrest with a shockable rhythm who are in the prone position and cannot be supinated immediately, attempting defibrillation in the prone position is a reasonable approach (good practice statement).[86]

## Insights and Implications

Use of the prone position in the critical care of COVID-19 patients became commonplace over a short period of time, and the lack of comparative outcomes data makes it difficult to inform treatment recommendations. The ILCOR recommendations stem from a review of the best available evidence combined with task force discussion and expert consensus to create good practice statements that are reflected in the new Red Cross guidelines. Further research will be needed to address knowledge gaps, such as the time needed to supinate a patient with advanced airway in place, optimal hand and defibrillator pad placement while prone, and clinical outcomes following CPR or defibrillation while in the prone position.

# Consciousness During CPR

Consciousness of a person in cardiac arrest during CPR is occasionally described by rescuers. Some survivors of cardiac arrest also describe awareness during CPR, or describe near-death experiences with some degree of recall of the resuscitation event. Is any intervention indicated when consciousness is observed during CPR?

## Red Cross Guidelines

NEW • Sedatives and/or analgesics used in critical care may be considered in small doses for patients with possible consciousness during CPR.

## Evidence Summary

A 2021 scoping review[12,13,87] by ILCOR sought to identify published and unpublished studies, case reports and series, and grey literature related to the use of sedation, analgesia or another intervention to prevent consciousness in adults in any setting during CPR. Outcomes of interest included any clinical outcome, arrest outcomes and psychological well-being post-arrest. The review sought to describe specific cardiac arrest experiences and any interventions, such as the use of sedatives to prevent those experiences, while assessing the need for a future systematic review. Five observational studies were identified evaluating different aspects of sedation and consciousness, as well as case reports with a total of 31 patients.

A narrative summary of the evidence noted several important points.[87] First, based on two of the included observational studies[88,89] including 39,569 patients, the estimated true prevalence rate of CPR-induced consciousness is very low, between 0.23% and 0.7%. Increased rates of ROSC and survival to hospital admission and to discharge were noted in those with CPR-induced consciousness compared with patients without signs of CPR-induced consciousness. Sedation was rarely used in CPR-induced consciousness, and rescuer distress was found to be a common outcome. Pharmacological intervention rates ranged between studies from 11.5% to 39.7% for CPR-interfering consciousness. Dosing of sedatives or analgesics during resuscitation is unclear, and their use may negatively impact survival outcomes.

The ILCOR Advanced Life Support Task Force discussed the findings of this scoping review and made the following good practice statements:[12,13]

- In settings where it is feasible, rescuers may consider using sedative or analgesic drugs (or both) in very small doses to prevent pain and distress to patients who are conscious during CPR.
- Neuromuscular-blocking drugs alone should not be given to conscious patients.
- The optimal drug regimen for sedation and analgesia during CPR is uncertain. Regimens can be based on those used in critically ill patients and according to local protocols.

## Insights and Implications

Cardiac arrest experiences related by survivors are described differently and may include near-death experiences, out-of-body experiences, visual or auditory awareness, spiritual experiences or consciousness during CPR. Sedatives and analgesics have potential hemodynamic effects that may contribute negatively to survival outcomes and may potentially mask clinical signs of ROSC. These potential risks must be weighed against their benefit. The good practice statements by ILCOR provide reasonable suggestions for preventing pain and distress in patients who are conscious during CPR, but with the caveat of using local protocols and regimens in place for critical care patients.

# Oxygen Dose During CPR

The use of oxygen during CPR is recommended to help correct tissue hypoxia. Post-ROSC oxygen therapy is guided by oximetry and capnography, with a goal of preventing hypoxia while preventing hypereroxia. Is there a specific concentration of oxygen recommended during CPR?

## Red Cross Guidelines

UPDATED

- During resuscitation of cardiac arrest in adults and children, supplemental high-concentration oxygen should be administered, once available, by a pocket mask, a bag-mask device or an advanced airway.

## Evidence Summary

A 2021 ARCSAC literature update did not identify human studies addressing this topic since 2015, and guidelines remain unchanged. A systematic review[90] was last completed by ILCOR in 2015, evaluating evidence comparing the administration of a maximal oxygen concentration to adults in cardiac arrest in any setting with no supplementary oxygen or a reduced oxygen concentration. No direct comparative evidence was identified in the review, however, a single retrospective observational study[91] was described, enrolling 145 patients with an advanced airway who, during CPR, received 100% inspired oxygen and had a $PaO_2$ value measured. The study reported improved ROSC with higher $PaO_2$ measurements during CPR, while for the outcomes of survival to hospital discharge with favorable neurologic outcome, no difference was found between an intermediate $PaO^2$ and a low $PaO_2$ value during CPR. A weak recommendation was made by ILCOR suggesting the use of the highest possible inspired oxygen concentration during CPR.[90]

A 2020 ILCOR scoping review[92] of oxygen dosing during the provision of CPR in children and infants did not identify human studies (beyond the neonatal period). A previous treatment recommendation was restated that there is insufficient information to recommend for or against any specific inspired oxygen concentration during and immediately after resuscitation from cardiac arrest, and until additional evidence is published, they support healthcare providers' use of 100% oxygen during resuscitation, when available.

## Insights and Implications

The degree of tissue hypoxemia following cardiac arrest will vary depending on the etiology of the arrest and the time between onset of arrest and commencing CPR and advanced life support. For cardiac arrest precipitated by respiratory events, drowning or asphyxia, the use of maximal concentrations of oxygen during CPR is likely more important than for cardiac arrest of primary cardiac etiology and with immediate bystander response, but this remains a knowledge gap. The limited evidence available supports the administration of the highest concentration oxygen possible during CPR of adults and children.

# Double Sequence Defibrillation

Double sequence external defibrillation has been proposed as an option for patients who remain in refractory VF in OHCA. Is there evidence to support the use of double sequence external defibrillation compared with standard manual defibrillation for cardiac arrest with a shockable rhythm?

## Red Cross Guidelines

REAFFIRMED

- Standard defibrillation rather than double sequence external defibrillation should be used for cardiac arrest with a shockable rhythm.

## Evidence Summary

A 2021 ARCSAC literature update from January 2020 forward identified one additional case report,[93] one case series[94] and a pilot cluster randomized trial[95] with crossover enrolling 152 adults comparing continued resuscitation of OHCA in refractory VF/pulseless VT using one of three strategies after three standard defibrillation attempts:

1. Continued defibrillation therapy with pads in the anterolateral configuration
2. Vector change defibrillation with pads moved from the standard anterolateral position to the anteroposterior position as soon as possible during the 2-minute cycle of CPR after the third defibrillation attempt with minimal interruptions in CPR
3. Double sequence external defibrillation with pads from a second defibrillator placed in the anteroposterior position as soon as possible during the 2-minute CPR cycle following the third shock with minimal interruptions in CPR. Double sequence external defibrillation involved the use of defibrillators with the delivery of rapid sequential shocks for all subsequent defibrillation attempts. A different brand of defibrillator and initial shock energy was used by paramedics in different counties for this study.

Antiarrhythmics and epinephrine were given to all groups per local protocol. Cluster units defined by each EMS agency crossed over at 6 months to an alternate defibrillation strategy. The primary outcome was safety and feasibility for a full-scale RCT which is currently underway. Secondary outcomes included rates of VF termination

and ROSC for all three defibrillation strategies. Feasibility targets were met, and no safety concerns were identified, including defibrillator malfunction, skin burns or difficulty with pad placement. Rates of VF termination were 66.6% in the standard defibrillation group, 82.0% in the vector change group, and 76.3% in the double sequence external defibrillation group, while ROSC at any time occurred in 25.0% of the standard defibrillation group, 39.3% of the vector change group and 40.0% of the double sequence external defibrillation groups.[95]

The case reports and pilot RCT identified in the literature update are considered insufficient to warrant a systematic review at this time or a change in Red Cross guidelines. The topic of double sequence defibrillation was last reviewed systematically by ILCOR in 2020.[96,97] Individual study results, while not reported, were thought to show an association between double sequence external defibrillation and lower rates of survival and favorable neurological outcome. The limited evidence led to a weak recommendation against routine use of a double sequential defibrillation strategy compared with standard defibrillation for cardiac arrest with a shockable rhythm.[96]

### Insights and Implications

Survival from refractory VF during cardiac arrest is unlikely, and case reports of successful defibrillation and ROSC with double sequence external defibrillation and vector change are encouraging. The included pilot RCT[95] is the first to assess feasibility and clinical outcomes of vector change and double sequence external defibrillation compared with standard defibrillation strategies for refractory VF. While encouraging, there were fewer enrollees in the standard defibrillation group than either of the intervention groups; different defibrillator models and initial electricity doses were used; and critical outcomes, such as survival with favorable neurologic function, were not evaluated. The ongoing RCT will hopefully shed more light on this intervention for refractory VF.

## Steroids and Vasopressin for In-Hospital Cardiac Arrest

Recently, the use of vasopressin and corticosteroids after epinephrine for IHCA has been the subject of research and systematic reviews. The interaction of vasopressin, a potent vasoconstrictor, and steroids has been described for septic shock with a reduction of systematic inflammatory response syndrome and a reduced vasopressor requirement. In addition to impaired adrenal function, post-arrest patients often develop a sepsis-like state with a surge in proinflammatory cytokines accompanied by vasodilation. Providing intra-arrest steroids has garnered interest as a potential means to modulate an inflammatory response earlier in the course, while improving hemodynamic stability.[98]

### Red Cross Guidelines

NEW • There is insufficient evidence to recommend the use of steroids and vasopressin for in-hospital cardiac arrest.

### Evidence Summary

A 2021 ARCSAC Answer[99] on the use of steroids for IHCA identified three RCTs[100-102] and one systematic review[103] meeting inclusion criteria. The most recent study[100] was a multi-center, double-blind, randomized placebo-controlled trial of vasopressin and methylprednisolone during adult IHCA, conducted in Denmark in adults who received at least one dose of epinephrine during CPR. A total of 501 patients received either 20 international units (IU) of vasopressin after each dose of epinephrine (maximum of 80 IU) or placebo, regardless of initial

rhythm, and 40 milligrams (mg) of methylprednisolone or placebo after the first dose of epinephrine. The average patient age was 71 years and 90% of the patients had a non-shockable rhythm. For the primary outcome of ROSC, the group receiving vasopressin and methylprednisolone experienced ROSC in 42% of patients (100/237) compared with 33% (86/264) in the placebo group (RR, 1.30 [95% CI, 1.03–1.63]; RD, 9.5% [95% CI, 1.1–18.0]; *P*=0.03). No difference was found between the intervention group and the placebo group for the outcomes of survival at 30 days and favorable neurologic outcome.

The systematic review by Shah et al.[103] identified two RCTs[101,102] by the same authors from 2013 and 2009 that compared the use of vasopressin-corticosteroids-epinephrine (VSE) with epinephrine and placebo during cardiac arrest in patients who received one or more doses of epinephrine. Surviving patients in the intervention group with post-resuscitation shock received hydrocortisone (300 mg per day beginning at 4 hours after resuscitation and for up to 7 days followed by gradual tapering). Those with evidence of myocardial infarction received hydrocortisone for up to 3 days. The surviving patient in the control group received a saline placebo.

The 2009 RCT[102] included 100 patients with IHCA, while the 2013 RCT included 268 patients with IHCA. Patients in both studies received vasopressin 20 IU plus methylprednisolone 40 mg or placebo after the first dose of epinephrine, followed by vasopressin 20 IU after each epinephrine dose (maximum of 100 IU). If ROSC was achieved, hydrocortisone (200 mg per day) was given if the patient was in shock 4 hours post-arrest. Results reported in the 2009 RCT included improved ROSC with the intervention group compared with the placebo group, from 52% (27/52) with placebo to 81% (39/48) with the intervention, and improved survival to hospital discharge from 4% (2/52) with the placebo group to 19% (9/48) with the intervention group. Of patients with post-resuscitation shock, those in the VSE group had improved survival to hospital discharge compared with the epinephrine-placebo group (19% versus 4%; *P*=0.02).

The 2013 RCT[101] also reported improved ROSC with the intervention group compared with placebo group, from 66% (91/128) with the placebo group to 84% (109/130) with the intervention group, and improved survival to hospital discharge with favorable neurologic outcome (CPC of 1 to 2), from 5% (7/138) with the placebo group to 14% (18/130) with the intervention group. Of the patients with post-resuscitation shock, those in the initial VSE group had a higher odds ratio for survival to hospital discharge with favorable neurologic outcome (21.1%, 16/76) compared with the placebo group (8.2%, 7/73); (OR, 3.74; 95% CI, 1.20–11.62; *P*=0.02). The authors concluded that for patients with cardiac arrest requiring vasopressors, the use of vasopressin, epinephrine and methylprednisolone during CPR and the use of stress-dose hydrocortisone in post-resuscitation shock improved survival to hospital discharge with favorable neurological status as compared with the use of epinephrine with placebo.

## Insights and Implications

The evidence summary highlights studies that combine vasopressin, steroids and epinephrine. Vasopressin use during cardiac arrest has been previously reviewed and found to offer no advantage to epinephrine when administered in combination with epinephrine or as a substitute to epinephrine.[90] The use of corticosteroids as an adjunct during resuscitation of IHCA or OHCA was recently evaluated in a systematic review with meta-analysis.[103] A benefit was not found from use of corticosteroids as adjunct therapy for outcomes of favorable neurological outcome, survival to hospital discharge and survival to one year or more, or for secondary outcomes including ROSC; however evidence for this review was limited, subject to imprecision and a difference could not be ruled out.

The 2009 and 2013 RCTs of VSE by Mentzelopoulos et al. both reported higher rates of ROSC; the 2009 RCT reported higher rates of survival to hospital discharge, and for the 2013 RCT, higher odds of survival to hospital discharge with favorable neurologic outcome.[101,102] A meta-analysis of these two RCTs in the systematic review by Shah et al. reported similar positive outcomes.[103]

The most recent RCT by Andersen[100] adds to the literature reporting improved rates of ROSC for patients who received vasopressin and methylprednisolone. However, no difference was found between the intervention and control groups for 30-day survival or survival at 30 days with good neurologic function (Cerebral Performance Category [CPC] of 1 or 2). The lack of a survival benefit may possibly be attributed to the trial protocol, which did not include steroids in the post-resuscitation period, and to a higher percentage of patients with an initial non-shockable rhythm than in the other two RCTs; also, compared with the 2009 and 2013 RCTs, there was a temporal lag with delivery of the trial drugs (8 minutes, compared with 3 minutes or 5 minutes). Notably, no adverse events were reported in patients who received VSE in any of the three RCTs.

Vasopressin was removed from resuscitation algorithms in 2015[104] and is likely no longer carried in most code carts, making use of a VSE protocol potentially problematic. Future research is needed on this promising intervention to include continued use of steroids in the post-resuscitation period.

# Drowning Process Resuscitation

## Advanced Airway Management in Drowning Process Resuscitation

The drowning process results in asphyxia, hypoxemia and global ischemia, which if not reversed, will lead to cardiac arrest. Airway management and ventilatory and oxygenation support are key to successful resuscitation.

### Red Cross Guidelines

REAFFIRMED • For the drowning process resuscitation, once cardiac arrest is recognized, resuscitation should begin with ventilations.

NEW • Advanced airway management for victims of drowning with cardiac arrest should be by supraglottic airway or tracheal intubation, depending on local protocol or the skill/experience of the healthcare professional.

### Evidence Summary

A 2020 scoping review[12,13,105] by ILCOR searched for studies of adults and children who were submerged in water who received advanced airway management compared with no advanced airway management. No studies were identified that evaluated a single airway management strategy compared with another airway management strategy or with no airway management strategy for submerged adults and children. Five observational studies were identified that indirectly evaluated airway management following the drowning process, including one in both adults and children[69] and four in children.[106-109] These studies all described an association between severity of injury, including cardiac arrest, and intubation. Intubation was associated with worse outcomes in two studies,[107,108] which was felt by the review authors to be confounded by intubation being limited to more severe drowning.[105] No recommendations were made by ILCOR from this scoping review. Past ILCOR recommendations for airway management during cardiac arrest apply to drowning victims, including the use of a supraglottic airway for adults with OHCA in settings with a low tracheal intubation success rate, and supraglottic airway or tracheal intubation for adults with OHCA in settings with a high tracheal intubation success rate.[110]

## Insights and Implications

The unique pathophysiology of the drowning process and data from CARES highlight the need for early ventilatory support in drowning victims in cardiac arrest. The ideal advanced airway management strategy following drowning remains a research and knowledge gap and may be influenced by the setting (in water, on a boat or on land) and the experience/skill of the healthcare professional.

# Mechanical Ventilation in Drowning Process Resuscitation

Ventilation strategies for patients with lung injury following drowning can include noninvasive ventilation and invasive mechanical ventilation. Is there evidence to support the use of one strategy compared with the other?

## Red Cross Guidelines

NEW
- Healthcare professionals caring for adults and children with oxygenation or ventilation compromise following submersion or the drowning process may consider the use of noninvasive ventilation strategies (i.e., continuous positive airway pressure and bilevel positive airway pressure) or mechanical ventilation, based on clinical judgment.

## Evidence Summary

A 2021 scoping review by ILCOR searched for literature related to the use of mechanical ventilation in adults and children who have been submerged in water, compared with no mechanical ventilation.[12,13] The review included a retrospective observational study[111] and three case series or reports, all describing ventilation strategies following drowning in a total of 93 adults and children. The observational study[111] compared 48 adult ICU patients treated for moderate to severe lung injury with noninvasive ventilation (continuous positive airway pressure or bilevel positive airway pressure) with patients treated with mechanical ventilation. The noninvasive ventilation group had a better initial Glasgow Coma Scale (GCS) score and MAP than the mechanical ventilation group. Both mechanical ventilation and noninvasive ventilation patients were reported to be associated with rapid (less than 6 hours) improvement of oxygenation and short ICU length of stay. The use of noninvasive ventilation was reported as successful in 92% of the patients with a 1.4-day average duration of ventilation.[12,13,112]

## Insights and Implications

The evidence identified in this scoping review is extremely limited but suggests that noninvasive ventilation is a viable treatment option for moderate to severe lung injury following drowning events in hemodynamically stable patients with a higher GCS score. Further prospective RCTs are needed to assess clinical outcomes and strategies for transition to mechanical ventilation.

# Extracorporeal Membrane Oxygenation in Drowning Process Resuscitation

The use of extracorporeal membrane oxygenation (ECMO) has been reported to treat drowning with refractory hypoxia and/or cardiac arrest. Is there evidence to support or guide the use of ECMO as part of the drowning process resuscitation?

## Red Cross Guidelines

NEW • Use of extracorporeal CPR may be considered by healthcare professionals as a rescue therapy for select patients in cardiac arrest secondary to drowning.

NEW • The use of extracorporeal membrane oxygenation may be considered by healthcare professionals in select patients with severe acute respiratory distress syndrome (ARDS), following drowning.

## Evidence Summary

A 2021 ILCOR scoping review[12,13,113] searched for literature related to the use of ECMO compared with no ECMO in adults and children following drowning. The review ultimately included two retrospective observational studies[114,115] and multiple case series enrolling a total of 658 adults and children that evaluated the use of ECMO following drowning.[12,13,113] The use of venous-arterial ECMO was reported by most studies for patients in cardiac arrest, and venous-venous ECMO use was reported in several studies for respiratory failure, with a duration of treatment between 2 hours and 260 hours. Survival rates that were reported ranged from 10% to 100%, with the highest survival to discharge rate (71.4%) among patients without a cardiac arrest.[12,13,113]

Data from an international extracorporeal life support registry[115] reported survival in 57.0% of patients requiring CPR prior to ECMO. Multiple factors were reported as associated with worse outcomes, such as hyperkalemia, asystole as an initial rhythm, submersion duration greater than 10 minutes, and a low blood pH, while a core body temperature less than 26° C (78.8° F) and normal serum potassium were reported as associated with good outcomes.[12,13,113] The review concluded that the use of ECMO to treat cardiac arrest or severe respiratory failure caused by drowning is feasible. The evidence also supports existing ILCOR treatment recommendations[113] for the use of extracorporeal CPR (ECPR) as a rescue therapy for select patients with cardiac arrest, as well as guidelines[116] suggesting the use of ECMO in select patients with severe ARDS.

## Insights and Implications

While ECMO and ECPR appear to be of use in select drowning victims with cardiac arrest or severe respiratory failure, the indications and optimal timing for starting ECMO and ECPR remain a knowledge gap.

# Criteria for Discharge in Patients Who Have Had a Drowning Event

The spectrum of signs and symptoms following a submersion event varies from asymptomatic to dyspnea, respiratory distress with hypoxemia, and respiratory or cardiac arrest. Not all drowning victims require hospitalization. Is there evidence to guide who can safely be discharged home from the emergency department?

## Red Cross Guidelines

- While the evidence does not support specific criteria, it is reasonable to consider discharge following a drowning event for patients under the age of 18 years who have not had an ongoing oxygen requirement and who have no alteration in mental status. For patients 18 years of age and older, it is reasonable to use clinical judgment to guide discharge decisions.

## Evidence Summary

A 2021 scoping review[12,13,117] by ILCOR searched for literature related to discharge criteria for adults and children following submersion.[117] The review ultimately included five retrospective observational studies for data abstraction, including a total of 834 patients, all under the age of 18. Various objective clinical findings, such as lung examination, room air oxygen saturation, vital signs, mental status, dyspnea, and need for airway support, were evaluated in the studies to determine what factors might predict the safe early discharge of a patient. Other findings evaluated in some studies included chest radiography and arterial blood gas results. In summary, the included studies found that for drowning patients under 18 years of age and presenting to an emergency department with normal mentation, an observation period of at least 6 hours appears to be sufficient to allow for any clinical deterioration to be observed.

The included studies reported that patients who maintain normal mentation without the need for supplemental oxygen and with normal age-adjusted vital signs can be considered for discharge following an observation period of at least 6 hours.[12,13] A future systematic review will be required for any recommendations by ILCOR.

## Insights and Implications

Limited studies identified by the scoping review report associations between various clinical findings and ancillary study results and the likelihood of hospital admission following drowning. Prospective studies are needed to confirm these associations and to develop and validate a clinical decision rule. None of the included studies evaluated discharge from the prehospital setting or scene of the submersion event.

# Post-Cardiac Arrest Care

## Early Coronary Angiography After Return of Spontaneous Circulation (ROSC)

Patients with an ST-elevation myocardial infarction (STEMI) without cardiac arrest are routinely taken directly to the cardiac catheterization laboratory for percutaneous coronary intervention (PCI), when indicated. For patients who remain unconscious with sustained ROSC following cardiac arrest of suspected cardiac origin and with ST-elevation on ECG, early coronary angiography with PCI, when indicated, has been advocated.[118] Less clear is the benefit from early coronary angiography in post-arrest patients without ST-elevation on an ECG and if a non-coronary cause of cardiac arrest is identified. What is the evidence to support early versus late coronary angiography following cardiac arrest of suspected cardiac etiology with ROSC, with or without ST-elevation on ECG?

### Red Cross Guidelines

NEW • An early or a delayed approach is reasonable for unresponsive post-arrest patients without ST-elevation when coronary angiography is being considered.

NEW • Early coronary angiography should be considered in comatose post-cardiac arrest patients with ST-elevation.

## Evidence Summary

A 2021 ILCOR systematic review[119] and CoSTR[12,13,120] sought to evaluate the impact of early (within 2 to 6 hours) versus delayed (greater than 6 hours after ROSC) or no coronary angiography with interventional PCI, if indicated, on clinical outcomes in patients who remain unresponsive after ROSC from cardiac arrest of presumed cardiac origin. The review included patients with both STEMI and non-ST-elevation myocardial infarction (NSTEMI) on ECG and all rhythms (shockable and non-shockable). Evidence was presented based on five cohorts:

1. Post-ROSC with no ST elevation and any initial rhythm

2. Post-ROSC with no ST elevation and an initial shockable rhythm

3. Post-ROSC with ST elevation

4. Post-ROSC with all ECG patterns and all initial rhythms

5. Post-ROSC with all ECG patterns and an initial shockable rhythm

Critical outcomes of interest for this review included both favorable neurologic outcome at ICU discharge (CPC 2 or less), survival and functional (CPC 1-2) survival at hospital discharge and at 30 days and 180 days at hospital discharge.

For the cohort of *post-ROSC without ST-elevation on ECG, and with any initial rhythm*, compared with no early coronary angiography, one RCT[121] enrolling 99 patients with ROSC reported on critical outcomes. No differences were found between early coronary angiography groups and no early coronary angiography groups for any outcomes.[12,13,120] A second RCT with 78 patients showed no improvement in 24-hour survival with early coronary angiography compared with late or no coronary angiography.[122]

For the cohort of *post-ROSC without ST elevation on ECG, and with an initial shockable rhythm on ECG*, one RCT[123] enrolling 538 patients was included. No benefit was found from early coronary angiography compared with late or no coronary angiography for critical outcomes.[120] One observational study[124] with 4029 patients showed benefit with early coronary angiography for the outcome of survival with favorable neurological outcome at hospital discharge (aOR, 1.60; 95% CI, 1.14–2.26), and a second observational study[125] with 203 patients show favorable neurological outcome at ICU discharge associated with early coronary angiography (aOR, 2.77; 95% CI, 1.31–5.85).[12,13,120]

For the cohort of *post-ROSC with ST-elevation on ECG*, a single observational study[125] of 112 patients found no effect (with adjusted effect estimates) with early coronary angiography compared with late/no coronary angiography for survival to hospital discharge and for the outcome of favorable neurologic outcome at hospital discharge.[120]

For the cohort of *post-ROSC with all ECG patterns and all initial rhythms*, one study[126] with 1,722 patients showed benefit for the outcome of survival at 30 days with the use of early coronary angiography compared with late/no coronary angiography (OR, 1.43; 95% CI, 1.12–1.83; 64 patients more out of 1000 survived with the intervention; 95% CI, 19 more patients out of 1000 to 116 more patients out of 1000 survived with the intervention).[12,13,120] The same study showed no benefit for survival at 1 to 3 years with early coronary angiography compared with late/no coronary angiography. Three observational studies[124,127,128] enrolling a total of 8,124 patients showed a benefit from early coronary angiography compared with late/no coronary angiography for the outcome of survival with favorable neurologic outcome at discharge (OR 1.93; 95% CI, 1.20–3.10). However, one observational study[129] with 544 patients reported no effect with early coronary angiography compared with late/no coronary angiography for the outcome of survival with favorable neurologic outcome at 3 to 6 months.[12,13,120]

For the cohort of *post-ROSC with all ECG patterns and an initial shockable rhythm*, one observational study[124] with 4,029 patients was identified. Early coronary angiography was reported to show a benefit for favorable neurologic outcome at hospital discharge when compared with late/no angiography (OR, 1.47; 95% CI, 1.36–1.72).[120]

The systematic review notes that for cardiac arrest patients post-ROSC with all ECG patterns regardless of initial rhythm, four observational studies included in the data synthesis indicated benefit associated with early coronary angiography, while higher certainty evidence from the included RCTs do not show benefit from early coronary angiography for critical survival outcomes.[119] Consistent evidence was not identified in the review in support of early coronary arteriography in undifferentiated patients, or in patients with or without ST elevation; however, the ECG post-ROSC may not be reliable for identifying myocardial infarction, and acute coronary artery lesions have been identified in up to 80% of patients with STEMI or new left bundle-branch block following ROSC, and in up to 35% of patients without ST elevation following ROSC.[130] Early coronary angiography is considered the standard of care for STEMI without cardiac arrest, and no evidence was found in the systematic review to alter this strategy for STEMI following cardiac arrest with ROSC.[120]

A weak recommendation was made by ILCOR that when coronary angiography is considered for comatose post-arrest patients without ST-segment elevation, it is suggested that either an early or a delayed approach for coronary angiography is reasonable. A good practice statement was made suggesting the use of early coronary angiography in comatose post-cardiac arrest patients with STEMI.[12,13,120]

### Insights and Implications

Insufficient evidence was identified in the ILCOR systematic review demonstrating improved outcomes with early coronary angiography for post-arrest patients with/without ST-elevation on EGG, regardless of a shockable or non-shockable initial rhythm. This topic remains a knowledge gap to target for future research.

## Post-Cardiac Arrest Temperature Control

The use of targeted temperature management (TTM) for adults with sustained ROSC following OHCA and who remain unconscious has been recommended to reduce global oxygen demand and improve outcomes after cardiac arrest. This is an active research topic with the recent publication of a large clinical trial[131] that has triggered a fresh look at the evidence for temperature management following OHCA with ROSC.

### Red Cross Guidelines

NEW
- For patients who remain unconscious after return of spontaneous circulation (ROSC) from cardiac arrest, it is reasonable to actively prevent fever and maintain a core temperature of 37.5° C (99.5° F) or less for at least 72 hours.

NEW
- While a normothermic temperature control approach is preferred, patients with mild hypothermia who remain unconscious after ROSC should not be actively warmed to achieve normothermia.

NEW
- Surface or endovascular temperature control techniques may be considered when temperature control is used in patients who remain unconscious after ROSC.

NEW
- Temperature control devices that include a feedback system based on continuous temperature monitoring are preferred to maintain a target temperature in post-cardiac arrest patients who remain unconscious after ROSC.

UPDATED
- Hypothermic temperature control may be considered in certain subpopulations of cardiac arrest patients who remain unconscious after ROSC.

NEW
- Rapid infusion of large volumes of cold intravenous fluid immediately after ROSC should not be used for prehospital cooling of post-cardiac arrest patients.

## Evidence Summary

A 2021 ARCSAC Answer[132] addressed a recently published large RCT[131] of TTM2 to determine if the study findings might change Red Cross guidelines. The TTM2 trial was an open-label RCT enrolling 1,850 patients comparing hypothermia (body temperature at 33° C [91.4° F]) to normothermia (body temperature less than 37.8° C (100.04° F); including, as needed, a reduction in fever).[131] Surface cooling was used in 70% of patients and intravascular cooling in 30%. Most patients had an initial shockable rhythm. Of the patients included, 50% of the hypothermia group died versus 48% of the normothermia group (RR, 1.04; 95% CI, 0.94–1.14; *P*=0.37). Both groups had a 55% rate of significant disability (Rankin Score greater than or equal to 4). Arrhythmia with hemodynamic compromise was more common in the hypothermia group (24% versus 17%; *P*<0.001).

In 2002, mild therapeutic hypothermia (32° C to 34° C [89.6° F to 93.2° F]) for 24 hours gained popularity following an investigation evaluating 75 patients who were cooled following VF arrest.[133] The authors demonstrated an improvement in neurologic outcome with TTM (CPC 1 to 2 = 55% versus 39%; RR, 1.4; 95% CI, 1.08–1.81; *P*=0.009), as well as a mortality benefit (RR, 0.74; 95% CI, 0.58–0.95; *P*=0.02). Bernard demonstrated similarly encouraging results on VF arrest with a similarly modest number of patients (n=77).[134] In that investigation, 49% of patients were discharged to home or rehabilitation following therapeutic hypothermia compared with 26% in the normothermia group (*P*=0.046). Notably, patients in the hypothermia group were not more likely to suffer hemodynamic instability or other adverse events.

More recent data with larger patient sets (n=939) and a more heterogeneous cohort (i.e., not all VF arrest) failed to replicate the encouraging work of previous investigations.[135] Nielsen et al.[135] found all-cause mortality to be no different between hypothermia (33° C [91.4° F]) and normothermia (36° C [96.8° F]). The hazard ratio for mortality was 1.06 (95% CI, 0.89–1.28; *P*=0.51), and follow up at 180 days showed a risk ratio for mortality and/or poor CPC of 1.02 (95% CI, 0.88–1.16; *P*=0.78).

A recent meta-analysis of targeted therapeutic hypothermia in critical illness evaluated 14 trials, including 2,670 patients looking specifically at traumatic brain injury, serious infection and stroke.[136] The analysis excluded intraoperative hypothermia, adult cardiac arrest and hypoxic-ischemic encephalopathy of newborns since they were regarded as being supported by international guidelines. Therapeutic hypothermia was associated with worsened mortality at follow up (31% versus 25%; RR, 1.24; 95% CI, 1.10–1.39; *P*=0.0004) and did not demonstrate an improvement in neurological favorable outcome among survivors (43% versus 46%; RR, 1.04; 95% CI, 0.97–1.12; *P*=0.27).[136]

The ARCSAC Answer concluded that, overall, survival remains poor after cardiac arrest and the data may support TTM following cardiac arrest of certain etiologies; however, broadly applied, TTM is not currently supported by the literature, and the emphasis should instead be on avoidance of fever.

A 2021 systematic review[137] and CoSTR[138] by ILCOR evaluated the use of TTM (hypothermia, 32° C to 34° C [89.6° F to 93.2° F]) in adults in any setting compared with no use of TTM (normothermia or fever prevention). Other variables evaluated were timing of the intervention (i.e., prehospital), the specific temperature targeted, the duration of temperature management and the method of TTM. The systematic review included 32 randomized and nonrandomized trials between 2001 and 2021. Most studies included only OHCA patients, limiting the conclusions to that population. Meta-analysis was completed using data from six trials that compared hypothermia at 32° C to 34° C (89.6° F to 93.2° F) for 12 to 24 hours with normothermia. The overall certainty of evidence was rated as low. No statistically significant improvement was shown for outcomes of survival (RR, 1.08; 95% CI, 0.89–1.30) or favorable neurologic outcome (RR, 1.21; 95% CI, 0.91–1.61) at 90 to 189 days after the cardiac arrest. Other temperature targets (33° C [91.4° F] versus 36° C [96.8° F], 32° C [89.6° F] and 33° C [91.4° F] versus 34° C [93.2° F]) were assessed by three trials, again with no difference in outcomes.[137]

For the comparison of prehospital versus no prehospital cooling, meta-analysis did not show improved survival to hospital discharge (RR, 1.01; 95% CI, 0.92–1.11) or survival to hospital discharge with favorable neurologic outcome (RR, 1.00; 95% CI, 0.90–1.11). Results for subgroups of shockable and non-shockable initial rhythm were similar. For endovascular cooling compared with surface cooling, meta-analysis of data from three trials did not show a statistically significant improvement in survival to hospital discharge or 28 days or for survival with a favorable neurologic outcome. For duration of TTM, only one trial with 355 patients was included, finding no difference in outcomes with TTM at 32° C to 34° C (89.6° F to 93.2° F) for 48 hours compared with 24 hours. The review concluded that for adults with cardiac arrest, the use of TTM at 32° C to 34° C (89.6° F to 93.2° F) compared with normothermia was not shown in meta-analysis to improve outcomes, and there was no effect from initiating TTM before hospital arrival.[137]

The accompanying ILCOR CoSTR[138] made a good practice statement that suggests active prevention of fever for at least 72 hours in post-cardiac arrest patients who remain comatose. The systematic review only included a single trial of TTM at 32° C (89.6° F) to 35° C (95° F) and found no difference in outcomes for a TTM duration of 48 hours compared with 24 hours. The good practice statement, however, was based on trials with temperature control for at least 72 hours in patients who remained sedated or comatose.[138]

The ILCOR systematic review[100] and CoSTR[138] support the findings of the ARCSAC review and updated/new Red Cross guidelines for use of post-cardiac arrest temperature management, with an emphasis on avoidance of fever.

## Insights and Implications

Reviewed studies appear to support maintaining patient temperature at or below 37.5° C (99.5° F) with conservative and pharmacologic interventions and initiating active surface or endovascular cooling if temperature reaches 37.8° C (100.4° F) or higher, but the data do not show a benefit for targeted hypothermia at 33° C (91.4° F). Ongoing trials, including the Influence of Cooling Duration on Efficacy in Cardiac Arrest Patients (ICECAP) being run by the SIREN Network, may provide further guidance once completed.

With the emergence of new evidence, the Red Cross has modified the guidelines to recommend an approach of active fever control and maintaining normothermia for cardiac arrest patients with ROSC and persistent unconsciousness, while hypothermic temperature control may be considered for certain sub-populations based on the clinical situation. Of note, most cardiac arrest cases included in the TTM1 and TTM2 trials were due to a primary cardiac etiology, and thus results may not be generalizable to all cardiac arrest populations. In addition, most RCTs have not used a rapid cooling time (2 hours post-ROSC) to a targeted temperature. Whether cardiac arrest etiologies and rapid cooling time post-ROSC might impact outcomes from hypothermic temperature control remain major research and knowledge gaps. Guidance recommending against prehospital cooling using a rapid infusion of large volume of cold intravenous (IV) fluids is informed by ILCOR[138] and based on a 2014 trial[139] showing increased rates of rearrest and pulmonary edema.

# Initial Management of Sepsis and Septic Shock in Adults

Sepsis is a significant healthcare problem accounting for an estimated 6% of hospitalizations in adults and resulting in a considerable economic burden.[140] Mortality varies with severity from 5.6% to as high as 34% for septic shock. The early recognition and management of sepsis is key to improved outcomes. The Surviving Sepsis Campaign (SSC) is an international collaboration committed to reducing the mortality and morbidity associated with sepsis and septic shock through evidence-based guidelines, best practice statements and recommendations for treatment. Updated adult sepsis guidelines were published in October 2021 by the SSC.[141] Guidelines for the care of pediatric sepsis and septic shock were published by the SSC in 2020.[142] Red Cross guidelines for the initial management of adult and pediatric sepsis and septic shock are informed by the SSC guidelines.

# Initial Resuscitation of Adults with Sepsis and Septic Shock

## Red Cross Guidelines

- Adult patients with sepsis and septic shock should be treated immediately and resuscitated, to include:

NEW
  - Administering at least 30 ml/kg of intravenous crystalloid fluid within the first 3 hours of resuscitation of patients with sepsis-induced hypoperfusion or septic shock.

NEW
  - Use of dynamic parameters, such as response to passive leg raise or fluid bolus, stroke volume variation or pulse pressure variation over static parameters or physical examination alone to guide fluid resuscitation.

NEW
  - Using capillary refill time as an adjunct to other measures of perfusion to help guide resuscitation. Use of capillary refill time to guide resuscitation should be accompanied by frequent and repeated comprehensive patient evaluation to predict or improve early recognition of fluid overload.

NEW
  - Using a decrease in serum lactate to help guide fluid resuscitation of patients with an elevated lactate level.

NEW
  - Using an initial target mean arterial pressure of 65 mmHg for septic shock requiring vasopressors.

## Evidence Summary

A review of the evidence was completed by the SSC on topics related to the initial resuscitation of a patient with sepsis or septic shock, to include the choice and volume of IV fluids, use of dynamic measures to assess fluid responsiveness, use of capillary refill to assess tissue perfusion and initial resuscitation targets for mean arterial pressure (MAP).[141]

The recommended minimum volume of IV crystalloids for initial fluid resuscitation is based on observational studies, with one retrospective study[143] of adults with sepsis or septic shock in an emergency department setting showing an association between failure to receive 30 ml/kg of crystalloid fluids within 3 hours of sepsis onset and an increased length of ICU stay.

An association between an elevated serum lactate level and the likelihood of sepsis is established and part of the definition of septic shock.[144] Other studies have evaluated the use of lactate as a means of screening for sepsis in adults with clinically suspected sepsis.[145-147] However, the SSC notes that a serum lactate level alone is neither sensitive nor specific enough for diagnosing sepsis and should be interpreted based on the clinical context and with consideration for other causes of an elevated lactate level. For these reasons, a weak recommendation is made for measurement of serum lactate levels in adults suspected of having sepsis.[141]

Beyond the initial 30 ml/kg initial fluid resuscitation, dynamic measures, such as response to passive leg raising combined with cardiac output measurement, and response to fluid challenges with stroke volume, stroke volume variation, pulse pressure variation or echocardiography can be used to predict fluid responsiveness as compared with static measures such as heart rate, central venous pressure and systolic blood pressure. A systematic review with meta-analysis showed that the use of dynamic assessment to guide fluid therapy was associated with reduced mortality (RR, 0.59; 95% CI, 0.42–0.83), ICU length of stay, and duration of mechanical ventilation.[148] In settings with limited resources, fluid responsiveness can be predicted by a greater than15% increase in pulse pressure with passive leg raise testing.[149]

# Initial Resuscitation of Sepsis and Septic Shock in Adults


**Initial resuscitation**

→ Begin treatment and resuscitation immediately.


**Within first 3 hours for sepsis-induced hypoperfusion or septic shock**

→ Intravenous crystalloids fluids 30 ml/kg

## Antibiotics


| SEPSIS | SEPTIC SHOCK | ANTIMICROBIAL TIMING |
|---|---|---|
| Definite or Probable | Present or Absent | Immediately, ideally within 1 hour of recognition of septic shock |
| Possible | Present | Immediately, ideally within 1 hour of recognition of septic shock |


| SEPSIS | SEPTIC SHOCK | ANTIMICROBIAL TIMING |
|---|---|---|
| Possible | Absent | Rapid evaluation, and if concern for infection persists, it is reasonable to administer antimicrobials within 3 hours from the time when sepsis was first recognized |

## Measuring Response to Therapy

### Dynamic parameters

(response to passive leg raise or fluid bolus, stroke volume variation, pulse pressure variation)

→ May help guide resuscitation over static parameters or physical examination alone

### Capillary refill time

→ May be used as an adjunct to other measures of perfusion to help guide resuscitation

→ Should be accompanied by frequent and repeated comprehensive patient evaluation to predict or improve early recognition of fluid overload

### Change in serum lactate

→ May help guide resuscitation of patients with an elevated serum lactate level

### Mean arterial pressure

→ Use an initial target MAP of 65 mmHg for septic shock requiring vasopressors

Capillary refill time has been shown to reflect tissue perfusion.[150,151] When a normal capillary refill time target is used as a resuscitation strategy, it has been found to be more effective than a strategy targeting normalized or 20% reduction of lactate in the first 8 hours of septic shock.[152] The SSC cautions, however, that an approach using capillary refill time to guide fluid resuscitation should be augmented by repeated and comprehensive patient evaluation to predict or promote early recognition of fluid overload.[141]

The recommendation for an initial target MAP of 65 mmHg is unchanged from previous SSC guidelines and reflects evidence from an RCT that showed no difference in mortality between patients given vasopressors with a target MAP of 65 mmHg to 70 mmHg compared with a target MAP of 80 mmHg to 85 mmHg, but showed a higher risk of atrial fibrillation in the high target MAP group.[153]

A more recent RCT[154,155] compared permissive hypotension (mean arterial pressure, 66.7 mmHg) with "usual care" with vasopressors and a MAP target set by the treating physician (mean arterial pressure, 72.6 mmHg) in septic shock patients aged 65 years and older. The intervention group had significantly less exposure to vasopressors and a 90-day mortality rate similar to the comparison group. The SSC recommendation for a target MAP of 65 mmHg reflects the lack of advantage associated with higher MAP targets and the lack of harm among elderly patients with lower MAP targets of 60 mmHg to 65 mmHg.[141]

In summary, the SSC recommends, as a best practice statement, the immediate treatment and resuscitation of adults with sepsis and septic shock, to include:[141]

- Using crystalloids as first-line fluid for resuscitation (strong recommendation), with a suggestion to use balanced crystalloid instead of normal saline, a suggestion against the use of gelatin and a recommendation against the use of starches for resuscitation.
- Administering at least 30 ml/kg of crystalloid fluid within the first 3 hours of resuscitation for sepsis-induced hypoperfusion or septic shock (weak recommendation).
- Guiding resuscitation to decrease serum lactate in patients with elevated lactate levels over not using serum lactate (weak recommendation).
- Using dynamic measures to guide fluid resuscitation (i.e., response to passive leg raise or a fluid bolus; stroke volume, stroke volume variation, pulse pressure variation or echocardiography) over physical examination or static parameters alone (weak recommendation).
- Using capillary refill time to guide resuscitation as an adjunct to other measures of perfusion (weak recommendation).
- Using an initial target MAP of 65 mmHg over higher MAP targets in the initial resuscitation of adults with septic shock requiring vasopressors (strong recommendation).

## Insights and Implications

The SCC guidelines for the initial resuscitation of a patient with sepsis and septic shock are unchanged from 2016, except for the addition of a best practice statement recommendation that treatment and resuscitation for sepsis and septic shock begin immediately, and a downgrading of evidence from strong to weak for the administration of crystalloid fluids, at least 30 ml/kg within the first 3 hours of resuscitation.

# Timing of Antimicrobial Administration for Sepsis and Septic Shock

Antibiotics are critical for reducing the mortality from sepsis and septic shock. Previous recommendations from the SCC advised starting antibiotics as soon as possible after recognition of sepsis and septic shock, and within 1 hour for both. For 2021, the SCC strongly recommends that for adults with possible septic shock or a high likelihood for sepsis, antimicrobials be administered immediately, ideally within 1 hour of recognition. What evidence supports this change?

## Red Cross Guidelines

NEW • For adults with a high likelihood of sepsis, with or without shock, antimicrobials should be administered immediately, ideally within 1 hour of recognition of septic shock.

NEW • For adults with shock and possible sepsis, antimicrobials should be administered immediately, ideally within 1 hour of recognition.

NEW • For adults with possible sepsis without shock, it is reasonable to rapidly evaluate the patient and if concern for infection persists, administer antimicrobials within 3 hours from the time when sepsis was first recognized.

NEW • For adults with sepsis or septic shock who are at high risk for methicillin-resistant *Staphylococcus aureus* (MRSA), empiric antimicrobials with coverage for MRSA should be initiated.

NEW • For adults with sepsis or septic shock who are at low risk for MRSA, it is reasonable to not include empiric antimicrobial coverage for MRSA.

NEW • For adults with sepsis or septic shock who are at high risk of multidrug resistant (MDR) organisms, use two antimicrobials with gram-negative coverage for empiric treatment.

NEW • For adults with sepsis or septic shock who are at low risk of MDR organisms, use one gram-negative antimicrobial for empiric treatment.

## Evidence Summary

Several large studies[156-158] have reported a strong association between each hour delay in time from emergency department arrival to administration of antimicrobials and in-hospital mortality with septic shock, while other observational studies at risk of bias and with design limitations have not observed an association between timing of antimicrobial administration and mortality.[141] For sepsis without shock, the association between time to antimicrobial administration and mortality is inconsistent but suggests an increase in mortality with interval times to antimicrobial administration exceeding 3 to 5 hours from hospital arrival and/or sepsis recognition. Thus, for adults with possible sepsis without shock, a time-limited course of rapid investigation is suggested, and if concern for infection persists, antimicrobials should be administered within 3 hours from the time when sepsis was first recognized.[141]

Outcomes from studies of antibiotic coverage for documented MRSA infection vary, with some showing that delays of greater than 24 to 48 hours to antibiotic administration being associated with increased mortality, and other studies not finding this association. The use of broad-spectrum antibiotics against MRSA in undifferentiated patients with pneumonia or sepsis has been shown to be associated with higher mortality.[141] The decision for use of antimicrobials active against MRSA depends on the likelihood of MRSA causing an infection, the risk of harm from withholding treatment when a patient has MRSA and the risk of harm from MRSA treatment when MRSA is absent. When adults with sepsis or septic shock are at high risk of MRSA, it is recommended to use empiric antimicrobials with MRSA coverage, while, conversely, it is suggested against using empiric antimicrobials with MRSA coverage for those at low risk of MRSA.

## Insights and Implications

In summary, when sepsis is definite or probable and regardless of the presence or absence of shock, antimicrobials should be administered immediately and ideally within 1 hour of recognition. In a patient with shock and possible sepsis, antimicrobials should also be administered immediately and ideally within 1 hour of recognition. If sepsis is possible and shock is absent, then the patient should be rapidly assessed for an infectious versus a noninfectious cause of acute illness, including obtaining a history and physical examination, testing for infectious and noninfectious causes of acute illness, and treating acute conditions that can mimic sepsis. Ideally, assessment should be completed within 3 hours of presentation and antimicrobials should be administered within that time if the likelihood of infection is thought to be high.

# Vasoactive Agents for Adults with Septic Shock

Patients with septic shock who do not respond to fluid resuscitation will require support with vasopressors. Is there scientific evidence to support the choice of one initial vasopressor over another? What alternatives or additional vasopressors should be considered? Should other vasopressors be selected for patients with septic shock and cardiac dysfunction?

## Red Cross Guidelines

NEW • Adults with septic shock should have vasopressors begun through peripheral access to improve mean arterial pressure (MAP) rather than waiting for central access.

NEW • Norepinephrine should be used as the first-line vasopressor agent in adults with septic shock unresponsive to IV fluid resuscitation.

NEW • Adults with septic shock should be treated initially with norepinephrine over other vasopressors.

NEW • It is reasonable to use epinephrine or dopamine for adults with septic shock when norepinephrine is not available.

NEW • For adults with septic shock and persistent MAP less than 65 mmHg on norepinephrine, consider adding vasopressin rather than increasing the dose of norepinephrine.

NEW • For adults with septic shock and persistent MAP less than 65 mmHg on norepinephrine and vasopressin, consider adding epinephrine.

NEW • For adults with septic shock and cardiac dysfunction, add dobutamine to norepinephrine or use epinephrine alone.

NEW • For adults with septic shock, consider invasive arterial blood pressure monitoring as soon as practical and if resources are available.

## Evidence Summary

Norepinephrine is an alpha-1 (α-1) and beta-1 (β-1) adrenergic receptor agonist with more potent vasoconstrictor effects than dopamine, resulting in increased MAP without a significant effect on heart rate. Meta-analysis of RCTs in a 2000 systematic review showed a lower mortality (RR, 0.89; 95% CI, 0.81–0.98) and risk of arrhythmia (RR, 0.48; 95% CI, 0.40–0.58) with use of norepinephrine compared with dopamine.[159]

# Vasoactive Agents Pathway for Adults in Septic Shock*

## For patients in septic shock:

- → Use norepinephrine as the first-line vasopressor.
- → Consider using epinephrine or dopamine when norepinephrine is not available.
- → Consider initiating invasive arterial blood pressure monitoring.

## If central access has not been obtained:

- → Consider starting vasopressors peripherally in a vein in or proximal to the antecubital fossa until central access is secured.

## For patients in septic shock on norepinephrine with persistent MAP less than 65 mmHg:

- → Consider adding vasopressin rather than increasing the dose of norepinephrine.

## For patients in septic shock with persistent MAP less than 65 mmHg on norepinephrine and vasopressin:

- → Consider adding epinephrine.

## For patients in septic shock with cardiac dysfunction and persistent hypoperfusion despite adequate volume status and arterial blood pressure:

- → Consider adding dobutamine to norepinephrine or use epinephrine alone.

*Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock 2021

Epinephrine at higher doses produces increased cardiac output and systematic vascular resistance, but its use may be limited by adverse effects, such as arrhythmias and splanchnic ischemia, and it may increase lactate production. Despite these challenges, a recent RCT found no difference in 90-day mortality and vasopressor-free days with epinephrine use in patients with shock compared with norepinephrine.[160]

Vasopressin, an endogenous peptide hormone, produces vasoconstrictor effects from multiple mechanisms. A fixed dose of 0.03 units per minute is typically used for septic shock; higher doses may be associated with adverse effects, such as cardiac ischemia. Previous studies have shown improved survival for a subgroup of patients with less severe shock who received norepinephrine plus vasopressin[161] and a catecholamine-sparing effect from vasopressin.[161,162]

A systematic review of 10 RCTs by the SSC showed reduced mortality with the use of vasopressin with norepinephrine as compared with norepinephrine alone (RR, 0.91; 95% CI, 0.83–0.99) and no difference in risks of digital ischemia or arrhythmias.[141]

A new weak recommendation from the SCC suggests that for adults with septic shock, vasopressors should be started by peripheral IV access to restore MAP rather than delaying initiation until a central venous access is secured. The SSC guidelines otherwise remain essentially unchanged for the hemodynamic management of adults with septic shock using vasoactive agents, with a strong recommendation to use norepinephrine as the first-line agent.

Alternatives to norepinephrine, if not available, include epinephrine or dopamine. If MAP levels remain inadequate despite norepinephrine, it is suggested to add vasopressin rather than escalating the dose of norepinephrine. If MAP levels remain inadequate despite norepinephrine and vasopressin, it is suggested to add epinephrine. For septic shock and cardiac dysfunction with persistent hypoperfusion despite adequate volume status and arterial blood pressure, the SCC suggests adding either dobutamine to norepinephrine or using epinephrine alone, while a new weak recommendation suggests against using levosimendan.[141]

### Insights and Implications

The desirable and undesirable or potential harm from vasopressors were considered by the SSC in making the recommendation to use norepinephrine rather than dopamine, vasopressin, epinephrine and other vasopressors as a first-line agent for septic shock. Additional considerations were the higher cost of vasopressin and limited availability. In summary, norepinephrine should be used as a first-line vasopressor. If not available, epinephrine and dopamine remain alternative vasopressors. A MAP of 65 mmHg should be targeted for patients with septic shock receiving vasopressors. Healthcare professionals may consider initiating invasive monitoring of arterial blood pressure monitoring, and if central access has not been obtained, consider starting vasopressors peripherally. Should MAP targets not be met despite low-to-moderate dose norepinephrine, healthcare professionals may consider adding vasopressin. The usual dose range for norepinephrine is 0.25 to 0.5 micrograms per kilogram per minute. If the MAP remains inadequate, healthcare professionals may consider adding epinephrine.

## Oxygenation and Ventilatory Management of Sepsis with Respiratory Failure

What oxygenation and ventilatory management strategy is recommended for patients with sepsis-induced hypoxemic respiratory failure, with or without acute respiratory distress syndrome (ARDS)?

## Red Cross Guidelines

NEW • For adults with sepsis-induced hypoxemic respiratory failure, it is reasonable to use high-flow nasal oxygen, when tolerated. Consider the use of noninvasive ventilation based on clinical judgment.

NEW • For mechanically ventilated adults with sepsis-induced acute respiratory distress syndrome (ARDS) and for sepsis-induced respiratory failure without ARDS, use a low-tidal volume strategy over a high-tidal volume strategy.

NEW • For mechanically ventilated adults with sepsis-induced severe ARDS, target an upper limit goal of 30 mmHg for plateau pressure.

NEW • For adults with moderate to severe sepsis-induced ARDS, use a prone position for greater than 12 hours per day.

## Evidence Summary

Sepsis with pneumonia or other infections can cause acute hypoxemic respiratory failure. In the absence of hypercapnia, hypoxia is managed initially with high-concentration oxygen through a nasal cannula, face mask or Venturi mask. As hypoxia worsens, noninvasive ventilation or high-flow oxygen may improve gas exchange and help reduce the work of breathing, avoiding potential complications of intubation and mechanical ventilation. High-flow nasal cannula therapy allows for airflows up to 60 liters per minute ($FiO_2$, 95% to 100%) but is less effective than noninvasive ventilation at reducing the work of breathing and providing greater positive end-expiratory pressure (PEEP).[163]

One large RCT evaluated ventilation strategies for acute hypoxemic respiratory failure despite the use of conventional oxygen.[164] For a strategy of noninvasive ventilation compared with high-flow nasal cannula therapy, no difference in intubation rate at 28 days was reported, but improved 90-day survival was reported with the use of high-flow nasal cannula compared with noninvasive ventilation (OR, 0.42; 95% CI, 0.2–0.85). Analysis of patients with severe hypoxemia reported a 35% intubation rate with high-flow nasal cannula therapy compared with noninvasive ventilation (58%).

A new recommendation from the SSC suggests the use of high-flow nasal oxygen over noninvasive ventilation for adults with sepsis-induced hypoxemic respiratory failure. There was insufficient evidence to make a recommendation on the use of conservative oxygen targets. Unchanged strong recommendations include using a low-tidal volume ventilation strategy (6 ml/kg) over a high-tidal volume strategy (less than 10 ml/kg) for adults with sepsis-induced ARDS and an upper limit goal for plateau pressures of 30 centimeters $H_2O$, and in those with moderate to severe ARDS using prone ventilation for greater than 12 hours a day. For sepsis-induced respiratory failure without ARDS, a low-tidal volume is suggested compared with high-tidal volume ventilation.[141]

## Insights and Implications

While high-flow nasal cannula therapy appears to be beneficial for sepsis patients with progressive hypoxia without hypercapnia, these patients are at high risk of needing intubation and require close monitoring for ventilatory failure. There was insufficient evidence to make a recommendation on the use of conservative oxygen targets in adults with sepsis-induced hypoxemic respiratory failure, but several trials are currently underway. Similarly, there was insufficient evidence to make a recommendation on the use of noninvasive ventilation compared with invasive ventilation for adults with sepsis-induced hypoxemic respiratory failure.

CHAPTER 3

# Pediatric Advanced Life Support

American Red Cross
Training Services

# Pediatric Cardiopulmonary Resuscitation: Techniques and Process

## CPR and Defibrillation in the Prone Patient

The COVID-19 pandemic has led to the further use of the prone position to improve oxygenation, with and without advanced airway management. This has led to questions regarding the feasibility of performing CPR and defibrillation with the patient in the prone position and its effectiveness compared with resuscitation in the supine position.

## Red Cross Guidelines

- For patients in a prone position who develop cardiac arrest:
  - NEW ◦ If an advanced airway is not in place, the patient should be turned to a supine position as quickly as possible, and CPR initiated.
  - NEW ◦ If an advanced airway is in place and immediate supination is not feasible or poses a risk to the patient, CPR should begin while the patient is prone.
  - NEW ◦ If the patient cannot be immediately supinated, defibrillation should be attempted in the prone position.
  - NEW ◦ For patients with an advanced airway in place in the prone position while receiving CPR, the quality of CPR should be assessed with end-tidal carbon dioxide and arterial blood pressure monitoring, if feasible.

## Evidence Summary

A 2021 CoSTR and systematic review[12,13,86] by ILCOR focused on cardiopulmonary resuscitation and defibrillation for cardiac arrest in adults and children in any setting when in the prone position, compared with turning the patient to the supine position prior to the initiation of CPR and/or defibrillation. Outcomes of interest included survival with/without favorable neurologic outcome, ROSC, $ETCO_2$ and arterial BP readings during CPR, and time to defibrillation.

The search included all years. Twelve pediatric case reports were included, of which 11 had CPR initiated while prone, and one patient was supinated before starting CPR.[86] All pediatric cases occurred in an operating room setting, with head fixation or devices that impeded the rapid and safe repositioning to a supine position. Of the pediatric cases reporting the outcome of ROSC, 10 out of 11 cases in which CPR was started while the patient was prone achieved ROSC. The single case in which a prone child was placed in a supine position before starting CPR, also achieved ROSC. Survival to hospital discharge was reported in 7 out of 10 cases in which CPR was started in the prone position and in the one case where the patient was placed supine prior to CPR.[12,13,86]

The authors of the review noted that each case may be unique and require weighing the potential risk of delayed CPR and defibrillation against the possible risk of less effective CPR and defibrillation while prone. It was also noted that it may be difficult to supinate a patient who is prone and mechanically ventilated and with capnography and arterial lines in place; in addition, the etiology of the cardiac arrest may define the urgency of supination.[86]

The treatment recommendations stemming from this review include good practice statements, reflecting the lack of higher-certainty evidence. A strong recommendation was made by ILCOR for patients with cardiac arrest occurring while in the prone position without an advanced airway already in place to turn that patient to the supine position as quickly as possible and begin CPR.[86] For patients with cardiac arrest while in the prone position with an advanced airway already in place and where immediate supination is not feasible or poses a significant risk to the patient, initiating CPR while the patient is still prone may be a reasonable approach (good practice statement). Invasive blood pressure monitoring and continuous $ETCO_2$ monitoring may be useful to ascertain whether prone compressions are meeting benchmarks for adequate perfusion. This information could also inform decision making on when to prioritize supination (good practice statement). For patients with cardiac arrest with a shockable rhythm who are in the prone position and cannot be supinated immediately, attempting defibrillation in the prone position is a reasonable approach (good practice statement).[12,13,86]

### Insights and Implications

Use of the prone position in the critical care of COVID-19 patients became commonplace over a short period of time, and the lack of comparative outcomes data makes it difficult to form treatment recommendations. The ILCOR recommendations stem from a review of the best available evidence combined with task force discussion and expert consensus to create good practice statements that are reflected in the Red Cross guidelines.

## Post-Cardiac Arrest Temperature Control in Children and Infants

Recent studies in adults who remain unconscious after ROSC from cardiac arrest have failed to show a benefit with the use of targeted hypothermic temperature control compared with normothermia. Cardiac arrest in children and infants tends to be of hypoxemic origin compared with primary cardiac etiologies in adults, and pediatric cardiac arrest tends to occur in a younger age range. Thus, results of studies of targeted temperature management performed in adults may not apply to children. Are there pediatric-specific studies of post-cardiac arrest hypothermic temperature control to inform guidelines?

### Red Cross Guidelines

NEW • For children and infants who remain unconscious after return of spontaneous circulation (ROSC) from cardiac arrest, it is reasonable to actively prevent fever and maintain a core temperature of 37.5° C (99.5° F) or less.

NEW • While a normothermic approach is preferred, patients with mild hypothermia who remain unconscious after ROSC should not be actively warmed to achieve normothermia.

NEW • Surface or endovascular temperature control techniques may be considered when temperature control is used in patients who remain unconscious after ROSC.

NEW • Temperature control devices that include a feedback system based on continuous temperature monitoring are preferred to maintain a target temperature in post-cardiac arrest patients who remain unconscious after ROSC.

NEW • Hypothermic temperature control may be considered in certain clinical presentations for children and infants after out-of-hospital and in-hospital (IHCA) cardiac arrest and who remain unconscious after ROSC.

NEW • Rapid infusion of large volumes of cold intravenous fluid immediately after ROSC should not be used for prehospital cooling of post-cardiac arrest patients.

## Evidence Summary

A systematic review of adult and pediatric targeted temperature management post-cardiac arrest with ROSC was completed by ILCOR in 2019[165] with a separate CoSTR[110] for children and infants. A weak recommendation was made based on evidence from two RCTs and eight observational studies, suggesting that for infants and children who remain comatose following ROSC from OHCA and IHCA, TTM be used to maintain a central temperature of 37.5° C (99.5° F) or less. There was inconclusive evidence to support or refute the use of TTM at 32° C to 34° C (89.6° F to 99.5° F) compared with TTM at 36° C to 37.5° C (96.8° F to 99.5° F) or an alternative temperature.[110]

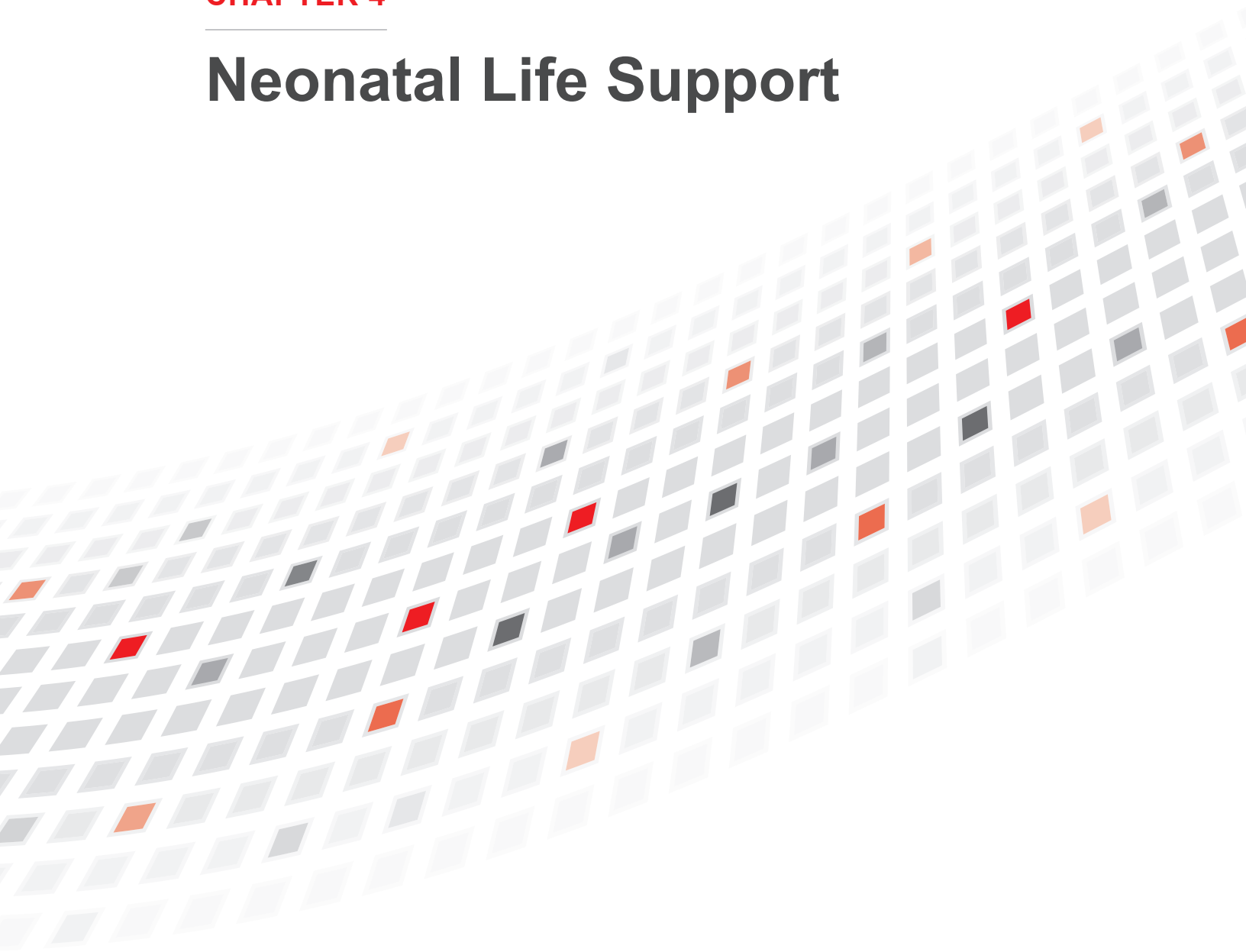
A 2021 Evidence Update[166] by ILCOR identified eight new studies, including seven that were secondary analyses of subgroups from the Therapeutic Hypothermia After Pediatric Cardiac Arrest (THAPCA) randomized trial[167,168] The secondary analysis data was reported to show no difference between treatment groups of 32° C to 34° (89.6° F to 99.5° F) and 36° C to 37.5° C (96.8° F to 99.5° F) for multiple subgroups. One retrospective cohort study[169] found no difference in survival following treatment with induced hypothermia to less than 35° C compared with normothermia (36° C to 37.5° C) [96.8° F to 99.5° F] but did report improved quality of life measures. Treatment recommendations by ILCOR regarding pediatric post-cardiac arrest temperature management remain unchanged other than for a minor wording change from “targeted temperature management” to “active control of temperature”.[166]

## Insights and Implications

Results from studies of hypothermic temperature control in pediatric patients with ROSC following cardiac arrest suggest clinical equipoise, highlighting an urgent need for additional well-designed trials. Most cardiac arrest cases included in the TTM1 and TTM2 trials were due to a primary cardiac etiology, and thus results may not be generalizable to all pediatric cardiac arrest populations. In addition, most RCTs to date have not used a rapid cooling time (2 hours post-ROSC) to a targeted temperature. These remain research and knowledge gaps. An approach with active fever control and maintaining normothermia is reasonable for pediatric cardiac arrest patients with ROSC who remain unconscious. The guidelines option to consider the use of hypothermic temperature control for certain pediatric post-cardiac arrest patients who remain unconscious following ROSC reflects clinical equipoise with the potential benefit from hypothermic temperature control in certain pediatric patients and settings. Guidance recommending against prehospital cooling using a rapid infusion of large volume of cold IV fluids is informed by ILCOR[138] and based on a 2014 trial[139] showing increased rates of rearrest and pulmonary edema.

CHAPTER 4

# Neonatal Life Support



American Red Cross
Training Services

# Neonatal Resuscitation

## Preterm Cord Management

Traditionally, an infant's umbilical cord has been clamped immediately after birth. However, clamping the umbilical cord at birth triggers cardiovascular physiologic changes that vary with apnea and hypoxia at birth. This has led to many studies comparing different cord management strategies for preterm infants.

## Red Cross Guidelines

NEW • Delayed umbilical cord clamping for at least 30 seconds is suggested for preterm infants born at less than 34+0 weeks' gestation not requiring immediate resuscitation after birth.

NEW • For infants born at 28+0 weeks' to 33+6 weeks' gestation who do not require immediate resuscitation after birth, intact cord milking is a reasonable alternative to deferred cord clamping.

NEW • For infants born at less than 28+0 weeks' gestation, intact cord milking is not advised.

## Evidence Summary

Red Cross guidelines are informed by a 2021 ILCOR systematic review[170] and CoSTR[171] that sought to evaluate the use of delayed cord clamping, intact cord milking and cut cord milking in preterm infants less than 34+0 weeks' gestation, compared with:

- Early cord clamping (less than 30 seconds after birth).
- Between-intervention comparisons.
- Delayed cord clamping at 30 seconds or more to less than 60 seconds compared with 60 seconds or more.
- Delayed cord clamping based on time since birth compared with physiologic approach to cord clamping (until cessation of pulsation or based on vital signs monitoring).

Outcomes of interest focused on both maternal and neonatal aspects:

- Survival to discharge.
- Survival without moderate to severe neurodevelopmental impairment in early childhood.
- Severe intraventricular hemorrhage.
- Maternal post-partum hemorrhage.
- Inpatient morbidities.
- Hematologic and cardiovascular status.
- Hyperbilirubinemia treated with phototherapy.
- Maternal complications.
- Need for resuscitation.

Detailed results of all outcome measures, comparisons and subgroup analyses are available in the CoSTR[12,13,171] and systematic review.[170]

For the comparison of delayed cord clamping (30 seconds of more) compared with early cord clamping (less than 30 seconds), 23 trials were identified enrolling a total of 3,515 infants, with most studies including infants under 34+0 weeks' gestation.[170] For the outcome of survival to discharge, meta-analysis of evidence of moderate certainty from 2,988 infants suggests either a slight benefit or no effect (RR, 1.02; 95% CI, 1.00–1.04). Other important hematologic and hemodynamic beneficial outcomes suggested from delayed cord clamping included a higher hemoglobin concentration and hematocrit within 24 hours after birth, a lower number of infants receiving inotropic support for hypotension within 24 hours after birth, and fewer infants receiving any blood transfusions.[170]

For the comparison of intact cord milking compared with early cord clamping, meta-analysis of data from 945 infants suggests a slight improvement in survival with intact cord milking (RR, 1.02; 95% CI, 0.98–1.06). An association with improved hematologic outcomes was suggested similar to those reported for delayed cord clamping.[170]

For the comparison of cut cord milking compared with early cord clamping, very low-certainty evidence from a single study could not exclude benefit or harm from any included outcomes, with the exception of a suggested benefit for hematocrit in the first 24 hours after birth.[170]

For the comparison of intact cord milking compared with delayed cord clamping, meta-analysis of data could not exclude a survival benefit or harm from delayed cord clamping. Of note, a signal for harm from intact cord milking was noted in the CoSTR for infants born at less than 28+0 weeks' gestation from data of a single large study. Similar inconclusive results were found for all other outcomes with this comparison.[170]

For all other planned comparisons, no studies were identified meeting inclusion criteria. The systematic review concluded that the ideal cord management strategy for preterm infants remains unknown, but that early clamping may be harmful. Delayed cord clamping appears to be associated with some benefit for infants born at less than 34+0 weeks' gestation, while cord milking needs additional evidence to determine potential benefits or harm.[170] Several ILCOR treatment recommendations were made based on the results of the CoSTR, including:[171]

- A weak recommendation suggests deferral of cord clamping for at least 30 seconds for infants born at less than 34+0 weeks' gestational age who do not require immediate resuscitation after birth.
- A weak recommendation suggests intact cord milking as a reasonable alternative to deferred cord clamping for infants born at 28+0 weeks' to 33+6 weeks' gestational age who do not require immediate resuscitation after birth.
- A weak recommendation suggests against intact cord milking for infants born at less than 28+0 weeks' gestation.
- There is insufficient evidence to make a recommendation for cord management in infants born at less than 34+0 weeks' gestation who require immediate resuscitation.
- There is insufficient evidence to make a recommendation for cord management for conditions such as multiple fetuses, congenital anomalies, placental abnormalities, alloimmunization, and/or fetal anemia, fetal compromise and maternal illness. A weak recommendation suggests that in these situations, individualized decisions be based on the severity of the condition and assessment of maternal and neonatal risk.[171]

## Insights and Implications

Despite the multitude of RCTs evaluating different strategies for cord management in preterm infants, the ideal cord management for preterm infants remains elusive, although there appears to be some benefit associated with delayed cord clamping in infants less than 34+0 weeks' gestation. Varying results were noted for studies from higher income countries compared with low- or medium-income countries, which may stem from variable resources available to participating hospitals. Several research studies related to umbilical cord management are underway and this topic is likely to be revisited in the future.

# Term Cord Management

How the umbilical cord is managed at birth can potentially impact a newborn's initial cardiovascular transition with the onset of breathing, as well as the volume of placental transfusion to the infant, with implications for development of iron deficiency anemia. Research into cord management has focused on immediate cord clamping, delayed cord clamping for up to 60 seconds or more, clamping with the onset of respirations, and milking or stripping of the intact or cut cord. Which cord management strategy is currently supported by the literature?

## Red Cross Guidelines

NEW

- It is reasonable to delay clamping of the cord for 60 or more seconds for term and late preterm infants born at 34+0 weeks' or more gestation and who are vigorous or considered to not require immediate resuscitation at birth.

## Evidence Summary

Red Cross guidelines are informed by a 2021 ILCOR systematic review[172] and CoSTR[173] that sought to evaluate the use of delayed cord clamping for 30 or more seconds, intact cord milking and cut cord milking in term and late preterm infants (34+0 weeks' or more gestation) compared with:

- Early clamping of the cord (less than 30 seconds after birth) without cord milking or initiation of respiratory support and compared to each of the above interventions.
- Between-intervention comparisons.
- Delayed cord clamping at less than 60 seconds compared with 60 seconds or greater.
- Delayed cord clamping based on time since birth compared with physiologic approach to cord clamping (until cessation of pulsation or based on vital signs monitoring/initiation of breathing).

Primary outcomes included survival without moderate to severe neurodevelopmental impairment in early childhood, anemia by 4 to 6 months after delivery or maternal postpartum hemorrhage (estimated blood loss of greater than or equal to 500 ml). Secondary outcomes included neonatal mortality, moderate to severe hypoxic ischemic encephalopathy, resuscitation and numerous others described in the online CoSTR publication.[173]

For the comparison of delayed cord clamping at 30 or more seconds compared with early cord clamping at less than 30 seconds after birth, very low-certainty evidence from four trials including 537 infants evaluated the critical outcome of neonatal mortality.[172] Meta-analysis was not able to demonstrate an impact on neonatal mortality (RR, 2.54; 95% CI, 0.50–12.74), the need for resuscitation (RR, 5.08; 95% CI, 0.25–103.58) or admission to the

neonatal intensive care unit (NICU) (RR, 1.16; 95% CI, 0.69–1.95). The review noted that compared to early cord clamping, delayed cord clamping greater than or equal to 30 seconds may improve hematologic measures within 24 hours after birth and 7 days after birth but may make little to no difference to maternal postpartum hemorrhage greater than or equal to 500 ml.[172]

A single study reported on the comparison of intact cord milking compared with early cord clamping, reporting no effect from intact cord milking on admission to the NICU, clinical jaundice or exchange transfusion. Intact cord milking in this study may improve hemoglobin and hematocrit values within the first 7 days after birth compared with early cord clamping (MD, 2.20; 95% CI, 0.48–3.92; and MD, 7.50; 95% CI, 2.30–12.70, respectively).[172]

For the comparison of cut cord milking with early cord clamping, a single study was included; no impact of cut cord milking was shown for NICU admission, neonatal mortality or hyperbilirubinemia requiring phototherapy. Cut cord milking compared with early cord clamping was reported to possibly improve hematologic measures at 24 and 72 hours after birth.[172]

For the comparison of intact cord milking versus delayed cord clamping 30 or more seconds, a single study with 388 infants was included; no impact was shown for neonatal mortality.[172]

For the comparison of cut cord milking versus delayed cord clamping, no differences were observed in neonatal mortality (one study, 300 infants), NICU admission (one study, 200 infants) or phototherapy for hyperbilirubinemia (two studies, 500 infants). Lower hematologic measures were seen at 24 hours and 7 days after birth (two studies, 500 infants) with delayed cord clamping compared with cut cord milking.[172]

For the comparison of delayed cord clamping 60 or more seconds compared with less than 60 seconds, little or no difference was shown for neonatal mortality (one trial, 231 infants), resuscitation (one trial, 60 infants), NICU admission (two studies, 291 infants), moderate-to-severe hypoxic ischemic encephalopathy or respiratory support (one study, 60 infants).[172]

The systematic review concludes that delayed cord clamping or cord milking increases hemoglobin and hematocrit immediately after birth in infants at 34 or more weeks' gestation when compared with early cord clamping.[172] A weak recommendation by ILCOR suggests delayed clamping of the cord at 60 or more seconds for term and late preterm infants born at 34 or more weeks' gestation who are vigorous or deemed not to require immediate resuscitation at birth.[12,13,173]

## Insights and Implications

Definitions for delayed clamping varied among the included studies from 30 seconds to more than 3 minutes, while early clamping ranged from within 5 seconds to within 30 seconds. While there may had been some overlap between the early and delayed groups, most of the included studies for this review that compared delayed cord clamping with early cord clamping used a delay of 60 or more seconds.

The finding that delayed cord clamping or cord milking increases hemoglobin and hematocrit immediately after birth in infants 34 or more weeks' gestation when compared with early cord clamping is important since anemia during infancy may contribute to childhood neurodevelopmental delay. However, none of the included studies reported on the primary outcome of survival without moderate to severe neurodevelopmental impairment. It was noted that a single study reported better childhood neurodevelopment scores in the 60 seconds or greater delayed clamping group.[172,173]

# Positive Pressure Ventilations at Birth

Approximately 5% of term infants require respiratory support at birth with PPVs. Most commonly, support is provided with a flow-inflating bag, a self-inflating bag or a T-piece resuscitator. The choice of which device to use has previously been supported by bench and animal studies, but recent publications may help inform the Red Cross guidelines.

## Red Cross Guidelines

NEW

- For newborns requiring positive pressure ventilation at birth, a T-piece resuscitator should be used. If a T-piece resuscitator is unavailable or staff are untrained/not competent in its use, a self-inflating bag, with or without a positive end-expiratory pressure valve, can be used.

## Evidence Summary

Red Cross guidelines were informed by a 2021 ILCOR systematic review[174] and CoSTR[12,13,175] that compared the use of different devices for administering positive pressure ventilations (PPV) to infants at birth. Comparisons that were searched for included:

- T-piece resuscitator versus self-inflating bag.
- T-piece resuscitator versus flow-inflating bag.
- Flow-inflating bag versus self-inflating bag.
- Self-inflating bag with positive end-expiratory pressure (PEEP) versus self-inflating bag.

The primary outcome of interest was in-hospital mortality. Multiple secondary outcomes were selected. A total of six studies were ultimately included in the systematic review and meta-analysis, including five RCTs, and one prospective cohort study that enrolled only preterm newborns. Risk of bias was judged high for the RCTs included in the completed comparisons, and moderate for the observational study. Certainty of evidence was rated as very low or low for relevant outcomes due to serious risk of bias and imprecision.[174]

For the comparison of T-piece resuscitator versus self-inflating bag, meta-analysis of data from the four RCTs (1257 infants) did not find a difference between the treatment groups for in-hospital mortality, while for the observational study, a reduction of in-hospital mortality was associated with the use of a T-piece resuscitator compared with a self-inflating bag (RR, 0.71; 95% CI, 0.63–0.80; RD, -0.13).[174] The observational study also found that use of a T-piece resuscitator was associated with a reduced risk of intraventricular hemorrhage, severe intraventricular hemorrhage and intubation in the delivery room. A reduction in the probability of bronchopulmonary dysplasia was shown with meta-analysis for T-piece resuscitator use compared with a self-inflating bag use (RR, 0.64; 95% CI, 0.43–0.95; RD, -0.03), and a small reduction in the duration of PPV was shown with the use of a T-piece resuscitator (MD, -19.8 seconds; 95% CI, -27.7 to -12.0 seconds).[174]

For the comparison of self-inflating bag with a PEEP valve versus a self-inflating bag without a PEEP valve, meta-analysis of two RCTs (933 infants) did not find a difference between groups for the outcome of in-hospital mortality. Duration of hospital stay was slightly increased with self-inflating bag with a PEEP valve (MD, 0.14 days; 95% CI, 0.01–0.27 days).[174] No eligible studies were identified comparing a T-piece resuscitator with a flow-inflating bag or comparing a flow-inflating bag with a self-inflating bag.

The review concludes that there is no significant difference in the risk of in-hospital mortality with T-piece resuscitator use compared with self-inflating bag use; however, resuscitation with a T-piece resuscitator compared with a self-inflating bag reduces the duration of PPV and risk of bronchopulmonary dysplasia. There is insufficient evidence to determine the effectiveness of PEEP valves when used with self-inflating bags.[174] The ILCOR treatment recommendations state that where resources permit, the use of a T-piece resuscitator is suggested over the use of a self-inflating bag (with or without a PEEP valve) in infants receiving PPV at birth.[12,13] It was noted that a self-inflating bag should be available as a backup device for the T-piece resuscitation in case of gas supply failure.

## Insights and Implications

Mechanical advantages of T-piece resuscitators previously shown in bench experiments include a more precise peak inflation pressure, lower probability of unintended high-pressure inflations and the ability to apply continuous PEEP.[174] These advantages are consistent with the findings in this systematic review of a reduction of bronchopulmonary dysplasia in the T-piece resuscitator group. This may be of particular benefit in very preterm infants, although subgroup analysis by gestation was not possible in this review and future studies are needed. But, there are providers who are not familiar/competent in T-piece resuscitator use. For these individuals, it is preferable to use a self-inflating bag versus the risk for inadequate ventilation or overventilation.

While a T-piece resuscitator is a preferred method for providing respiratory support to newborns requiring PPV, many prehospital professionals and healthcare professionals who provide initial care may not have this device available. Care should not be delayed while obtaining a T-piece resuscitator. In this situation, prehospital professionals and healthcare professionals should begin respiratory support to newborns needing PPV with a self-inflating bag.

# Family Presence During Neonatal Resuscitation

Many hospitals now have policies and protocols for allowing family presence during CPR. At birth, the mother is always present, and other family members are frequently present. What evidence supports policies and protocols that allow family presence during the resuscitation of children and infants?

## Red Cross Guidelines

NEW

- It is reasonable for parents to be present, if they desire, during the resuscitation of neonates and where resources permit.

## Evidence Summary

Red Cross guidelines are informed by a systematic review[176] and CoSTR[12,13,177] by ILCOR that sought to evaluate published evidence related to family presence during pediatric and neonatal resuscitation in any setting, compared with no family presence during resuscitation. Outcomes included short- and long-term patient outcomes, short- and long-term family-centered outcomes (including perception of the resuscitation), and healthcare provider-centered outcomes (such as perception of the resuscitation and psychological stress). Thirty-six studies were included for review, including seven involving family presence during neonatal resuscitation, with all eligible studies being either a survey design or an interview design, or a combination of both survey and interview designs.[176] Meta-analysis was not possible and a narrative review was completed. Included studies focused on parental or family opinion of being present or absent during their child's resuscitation, and on healthcare provider experience or opinion of family presence during resuscitation.

Findings from studies of parental or family opinion of their presence during resuscitation reflect opinions that their presence during the resuscitation experience was very helpful, brought their child comfort and helped them with adjusting to the loss of their child.[176] Prominent themes included the parents' desire to be present and to understand what was happening, a need for physical contact with their child, and that their presence helped them to know that all had been done for their child. In over 80% of the included studies measuring hypothetical opinion of parents/families, parents believed it should be their decision whether to be present or not for the resuscitation of their child.[176]

Results of studies including healthcare providers with experience having parental/family present during resuscitation were mixed. The overall agreement with family presence was higher among clinically senior healthcare providers and those experienced with family presence. Overall, agreement was found to range from 85% disagreement to greater than 60% acceptance with family presence during resuscitation. Surveys of healthcare providers who disagreed with family presence described concern for psychological trauma for the parents, risk of interference with medical management, and potential stress on the care team, such as anxiety related to performance.[176]

Studies specifically related to family presence during immediate neonatal resuscitation were limited to six qualitative and one survey study.[176] The focus of the papers was on the experience of fathers during their infant's resuscitation, the experience of both parents, provider opinion, and one paper focused on both parent and provider opinions. In summary, the studies found:[176]

- A father's experience is unique. At the time of the resuscitation, fathers/partners focus on their partner.
- Although parents reported reservations about the emotional toll of their presence during resuscitation, they felt that their presence provided reassurance and the opportunity to be involved and to communicate.
- Education and training are needed for healthcare and nonhealthcare providers assigned to support family presence during resuscitation.
- Parental presence at birth was described as intense and ranged from desperation to immediately see their baby to the opposite end of the spectrum with fear of observing a situation involving their baby that they would prefer to have avoided.

The systematic review concludes that parents wish to be offered the opportunity to be present during resuscitation of their child, but perspectives on family presence vary greatly among healthcare providers.[176] The ILCOR treatment recommendation suggests it is reasonable for mothers/father/partners to be present during the resuscitation of neonates where circumstances, facilities and parental inclination allow (weak recommendation based on very low-certainty evidence).[12,13,177]

## Insights and Implications

While this review offers parental and healthcare provider perspectives on the topic of family presence during resuscitation, most of the included studies were surveys, using investigator-designed tools. Well-designed comparative studies are needed to measure the impact of family presence on patient-, family- or provider-centered outcomes. In addition, the included studies were conducted in multiple countries without consideration for cultural differences regarding family presence during resuscitation. Aspects that may influence parental and healthcare provider acceptance need further research, such as the impact of having trained support staff as part of an organized approach to family presence. Parents from some cultures may not feel comfortable with being present during resuscitation. In practice, parental presence, if offered, needs to be the choice or personal preference of the parent.

CHAPTER 5

# Education Science

American Red Cross
Training Services

# Self-Directed Digital Basic Life Support Training

The Red Cross has been a pioneer over the last decade in bringing quality resuscitation courses in digital format to the market. The courses offer learner-centered experiences and the use of visuals, including photos and videos. Self-directed, digital-based learning has been particularly popular among students during the COVID-19 pandemic to complete course work without the risk of disease transmission. To maintain a perspective on the value of self-directed digital education and training, it is important to compare them to instructor-led courses and training.

## Red Cross Guidelines

NEW

- Basic life support (BLS) course content and skills may be offered to adult and high-school aged children through:
  - Instructor-led training, including manikin practice.
  - Blended learning as:
    - A self-directed online session to gain knowledge and understanding of the information and an in-person automated manikin practice session with feedback for skill training
    - A self-directed online session to gain knowledge and understanding of the information and an in-person, instructor-led session for skill practice with manikin practice and feedback.

## Evidence Summary

A 2021 systematic review and CoSTR[12,13,178] by ILCOR compared self-directed digital-based BLS training for adults and children with traditional instructor-led training.

Patient-centered outcomes that were sought included good neurological outcome at hospital discharge or 30 days, survival at hospital discharge or 30 days, return of spontaneous circulation (ROSC), rates of bystander CPR, bystander CPR quality during OHCA, and rates of AED use.

Educational outcomes that were sought at the end of training and within 12 months included CPR quality and AED competency, CPR and AED knowledge, and confidence and willingness to perform CPR. Self-directed, digital-based BLS training included any form of digital education or training for BLS that can be completed without an instructor, except for mass media campaigns, such as videos with or without self-directed manikin practice, phone application-based, internet-based, game-based learning, virtual reality and augmented reality.

The reviewers included a total of 41 studies; overall certainty of evidence was very low to moderate across outcomes due primarily to risk of bias. A narrative synthesis of findings per outcome and by digital training medium (e.g., video or interactive computer programs with manikin practice) was reported. The reader is referred to the CoSTR for full details of this thorough, multifaceted review.[12,13,178]

In summary, the ILCOR CoSTR[178] reported that:

- Comparable educational outcomes were shown for most CPR skills and knowledge gained immediately following training and up to 1 year with both instructor-led training and digital training using video or interactive computer programs with manikin practice.

- Comparable educational outcomes were shown for most CPR skills and knowledge gained immediately following training and up to 1 year, and overall CPR competency and knowledge immediately for both instructor-led training and digital training using video only.
- Instructor-led training for AED skills may be more effective immediately following training, but not in the long term.
- For most studies, there was no difference between instructor-led and digital-based instruction for outcomes of mean compression depth and proportion of compressions with correct depth, chest compression fraction, complete chest recoil, ventilation rate and hand position during compressions. For overall CPR skill competency judged by instructors, results were mixed, although more studies found no difference between instructor-led training and digital training.
- For AED competency, most studies reported instructor-led training to be superior; failures in the digital groups included failure to “clear during analysis and shock” or to activate the AED.
- For CPR knowledge, AED knowledge, confidence and willingness to perform CPR, most studies reported that there was no difference between instructor-led and digital training groups.
- For long-term CPR and AED knowledge and skills that were measured between 2 months and 12 months, the majority of studies reported no differences between groups for chest compression rates and depth.
- Use of videos with self-directed manikin practice was the most commonly used mode of instruction and was comparable to instructor-led training for most educational outcomes. Limited evidence for video-only training and outcomes of overall CPR competence and knowledge immediately after training favored instructor-led training or showed no difference between training modes.[178]

The ILCOR Consensus on Science[12,13,178] led to strong treatment recommendations for use of instructor-led training (with manikin practice with feedback device) or the use of self-directed training with video kits (instructional video and manikin practice with feedback device) for the acquisition of CPR theory and skills in lay adults and high-school aged (older than 10 years) children. In addition, a strong recommendation was made for instructor-led training (with AED scenario and practice) or the use of self-directed video kits (instructional video with AED scenario) for the acquisition of AED theory and skills in lay adults and high-school aged (older than 10 years) children. A weak recommendation was made suggesting the use of BLS video education (without manikin practice) when instructor-led training or self-directed training with video kits (instructional video plus manikin with feedback device) are not accessible, or when quantity over quality of BLS training is needed in adults and children.

## Insights and Implications

Digital-based training for BLS gained popularity during the COVID-19 pandemic and demand for this mode of education remains strong. Although instructor-led training may be superior to digital training for some AED skills, the reviewers considered the significant improvement in AED skills attained with both methods compared with groups without training to be of greater importance because of voice prompts found on newer AEDs. Several important limitations of this review are acknowledged in the online CoSTR, such as variability in manikins used in the included studies and their technical specifications.

With its popularity among learners, digital training will likely be an active research topic going forward. In addition, the comparison of blended learning techniques that include instructor-led practice versus automated manikins requires further study.

# Opioid Overdose First Aid Education

A 2020 position statement[179] by the Red Cross recognizes the declaration by the United States Department of Health and Human Services of the opioid epidemic as a public health emergency. The Red Cross supports the availability of community opioid education and naloxone distribution programs to reduce mortality from opioid overdose and to reduce the burden on society.

## Red Cross Guidelines

REAFFIRMED • Overdose education programs and naloxone distribution programs should be widely available to the community.

REAFFIRMED • Overdose education programs should include training on naloxone administration, the potential complications of naloxone administration and the management of these complications.

## Evidence Summary

A 2021 scoping review by ILCOR[180] sought literature related to education of first aid providers on the response and care of an individual with an opioid overdose emergency, as compared with nonspecialized first aid education. Outcomes that were sought included any clinical or educational outcomes. From the initial 2,089 records identified, 59 studies were included in an observational synthesis and eight studies were included in meta-analysis. Most of the studies were of a one-group pretest/posttest design that did not allow data extraction for comparisons between studies. Key findings from the review include:[180]

- Improved learning outcomes were reported in more studies that were without skill practice compared with studies that had skill practice. For clinical outcomes, more studies reported improved results with skill practice compared with studies without skill practice. However, it was noted that all clinical outcomes were self-reported and unverified.
- Training times varied from less than or equal to 15 minutes (brief) to 16 to 60 minutes for stand-alone programs and more than 60 minutes for opioid education embedded in other programs. There was not a consistent relationship identified between overdose education and naloxone distribution training duration and educational outcomes.
- In two studies enrolling 173 participants, no statistical difference was found between training versus no training among those lay persons who reported providing first aid interventions.

The scoping review concludes that results show that lay responders are engaged and able to learn to recognize opioid overdose, provide first aid and to summon advanced medical care appropriately.[180]

## Insights and Implications

Although there was no evidence that overdose education and naloxone distribution education improved the odds of receiving naloxone, this may simply reflect the ease of access to naloxone post-education. A significant number of knowledge gaps were identified in the scoping review that will require further research to strengthen first aid education guidelines.

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# Appendix A: Abbreviations in Focused Updates and Guidelines 2021

## Commonly Used Abbreviations

| | |
|---|---|
| A-B-C | Airway-Breathing-Circulation |
| AED | automated external defibrillator |
| ARCSAC | American Red Cross Scientific Advisory Council |
| BiPAP | bilevel positive airway pressure |
| BMI | body mass index |
| BMV | bag-mask ventilation |
| CARES | Cardiac Arrest Registry for Enhanced Survival |
| CCF | chest compression fraction |
| C | Celsius |
| CO-CPR | compression-only CPR |
| CoSTR | Consensus on Science with Treatment Recommendations |
| COVID-19 | coronavirus disease 2019 |
| CPAP | continuous positive airway pressure |
| CPC | Cerebral Performance Category |
| CPR | cardiopulmonary resuscitation |
| CV | compression-to-ventilation |
| CV-CPR | compression-ventilation CPR |
| ECG | electrocardiogram |
| ECMO | extracorporeal membrane oxygenation |
| ED | emergency department |
| EMS | emergency medical services |
| $ETCO_2$ | end-tidal carbon dioxide |
| $FiO_2$ | fraction of inspired air |
| ICU | intensive care unit |
| IHCA | in-hospital cardiac arrest |

| | |
|---|---|
| ILCOR | International Liaison Committee on Resuscitation |
| NICU | neonatal intensive care unit |
| NSTEMI | non-ST elevation myocardial infarction |
| OHCA | out-of-hospital cardiac arrest |
| $PaO_2$ | partial pressure of oxygen |
| PEEP | positive end-expiratory pressure |
| PCI | percutaneous coronary intervention |
| PPE | personal protective equipment |
| PPV | positive pressure ventilation |
| ROSC | return of spontaneous circulation |
| SSC | Surviving Sepsis Campaign |
| $SaO_2$ | oxygen saturation |
| STEMI | ST-elevation myocardial infarction |
| TTM | targeted temperature management |
| VF | ventricular fibrillation |
| VSE | vasopressin-steroids-epinephrine |
| VT | ventricular tachycardia |

## Abbreviations in Statistical Analyses

| | |
|---|---|
| aOR | adjusted odds ratio |
| ARR | absolute risk reduction |
| CI | confidence interval |
| MD | mean difference |
| n | sample size |
| OR | odds ratio |
| *P* | probability |
| RR | relative risk |
| RD | risk difference |
| RCT | randomized controlled trial |