2022

American Red Cross

Focused Updates and Guidelines

HEALTHCARE

American Red Cross
Training Services

The American Red Cross *Focused Updates and Guidelines 2022* 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 2020 to 2022* are consistent with the most current science and treatment recommendations from:

- The American Red Cross Scientific Advisory Council (ARCSAC)

- The International Liaison Committee on Resuscitation (ILCOR)

- Cardiac Arrest Registry to Enhance Survival (CARES)

- Centers for Disease Control and Prevention (CDC)

- The American Academy of Pediatrics (AAP)

- The American College of Emergency Physicians (ACEP)

- The American College of Obstetrics and Gynecology (ACOG)

- The American College of Surgeons (ACS)

- The American Society of Anesthesiologists (ASA)

- The Association of Women's Health, Obstetric and Neonatal Nurses (AWHONN)

- The Brain Trauma Foundation

- The Committee on Tactical Combat Casualty Care (Co-TCCC)

- The Society for Critical Care Medicine (SCCM)/American College of Critical Care Medicine (ACCM)

- The Stop the Bleed Campaign (STB)

- The Surviving Sepsis Campaign (SSC)

- The World Health Organization (WHO)

Dedication

The American Red Cross *Focused Updates and Guidelines 2022* is 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 2022* 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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American Red Cross Scientific Advisory Council

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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Table of Contents

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Training Services

Introduction

About *Focused Updates and Guidelines 2022*

Each chapter in the American Red Cross *Focused Updates and Guidelines 2022* is organized by topic and contains the following recurring sections:

Red Cross Guidelines include recommended actions for healthcare professionals and emergency responders, as appropriate. The American Red Cross *Focused Updates and Guidelines 2022* include those that are new, updated and reaffirmed:

- *New:* Guidelines are new for 2022.

- *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 have been determined to remain valid.

Evidence Summary highlights the most recent and important science, when available, to support the guidelines.

Insights and Implications provides ARCSAC expert guidance and decisions, related observations, reviewer opinions or important gaps in knowledge or research.

The American Red Cross *Focused Updates and Guidelines 2022* includes **infographics** that present key information in a visually compelling and understandable way. The following infographics are included:

- Minimizing Pauses During CPR

- Using Point-of-Care Ultrasound During Resuscitation from Cardiac Arrest

- Pediatric Early Warning Systems (PEWS)

- Routine Suctioning of Amniotic Fluid at Birth

- Retention of CPR Skills After Training

Summary of Reaffirmed Guidelines/Recommendations (Appendix B) provides a snapshot of guidelines that are not included in the *Focused Updates and Guidelines 2022* but have been reviewed and reaffirmed by the ARCSAC.

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, Triennial Reviews, 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 2022* and for providing expert opinion when evidence is lacking. The digital publication of the *Focused Updates and Guidelines 2022* will allow incorporation of critical new evidence or guidelines, as needed, where the science is rapidly evolving.

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Basic
Life Support

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Early Access

Public Access Defibrillation Programs for Adults

Bystander use of automated external defibrillators (AEDs) has been shown to improve the odds of survival to hospital discharge and favorable neurological outcome following out-of-hospital cardiac arrest (OHCA).[1] Despite this, public access defibrillators (PADs) are used in less than 3% of OHCAs prior to the arrival of emergency medical services (EMS).[2] Identifying barriers to the use of PADs can help generate novel strategies for public access to AEDs and for their deployment, thus allowing for earlier defibrillation and improved survival from OHCA.

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 2021 American Red Cross Scientific Advisory Council literature update of a scientific review[3] identified observational studies showing improved survival outcomes following use of PAD programs for OHCA. Other studies were identified evaluating strategies for placement of, and novel deployment of, public AEDs. A 2022 International Liaison Committee on Resuscitation (ILCOR) evidence update[4] identified one new randomized controlled trial (RCT)[5] showing an improved odds of favorable neurological outcomes following bystander defibrillation for witnessed OHCA at metropolitan railroad stations, compared with patients who received defibrillation by EMS, supporting previous recommendations for implementation of public access defibrillation programs for patients with OHCA.

Recently, a scientific statement from ILCOR sought to identify known barriers to PAD use and early defibrillation, to review current and new strategies to address barriers and to identify knowledge gaps to guide future research.[2] Suggestions made to improve PAD implementation centered on:

• Improving public awareness and willingness to use.

• Optimizing AED availability, reliability and usability.

• Automated external defibrillator signage, including design, visibility, location information and maintenance.

• Mobile device application use for crowdsourcing cardiopulmonary resuscitation (CPR) and early AED use.

• Use of mobile community health, fire and police personnel for early community AED deployment and defibrillation.

Insights and Implications

Survival to hospital discharge with a favorable neurologic outcome following OHCA remains low, at about 10% internationally.[6] Immediate CPR and AED use can greatly improve the odds of neurologically favorable survival. Public access defibrillator use bridges the temporal gap between OHCA and EMS arrival but continues to be underutilized. While AED proximity to OHCAs is key to bystander defibrillation, many other known and potential barriers exist. The ILCOR scientific statement can serve as a blueprint for future research and consideration in PAD program development.[2]

Public Access Defibrillation Programs for Infants, Children and Adolescents

Out-of-hospital cardiac arrest is rare in infants and children, and unlike adults, is less likely to be due to a primary cardiac event and more likely to be the result of a respiratory issue or trauma. Is there evidence to support the use of public access AEDs in pediatric OHCA?

Red Cross Guidelines

UPDATED

- Public access defibrillation may be used in infants, children, and adolescents, for out-of-hospital cardiac arrest. If available, pediatric-specific automated external defibrillator pads or electrical settings should be used for infants and children 8 years of age or younger or weighing 25 kilograms or less.

Evidence Summary

A 2022 systematic review[7] and Consensus on Science with Treatment Recommendations (CoSTR)[4,8] by ILCOR evaluated the evidence for the application of, or shock delivery from, an AED by lay rescuers to infants, children and adolescents with nontraumatic OHCA compared with standard care without AED application and use. Four observational studies were identified, including three from the Cardiac Arrest Registry to Enhance Survival (CARES) database.[9-11] Data from the CARES studies was used to calculate the relative risk of survival if an AED was applied and analyzed by age group for infants less than 1 year of age, children from 1 to 12 years of age and adolescents from 13 to 18 years of age. The relative risk of survival to hospital discharge with a Cerebral Performance Category (CPC) score of 1 to 2 was found to be significantly improved with AED application in all age groups except for the under 1 year age group.[8]

A weak recommendation was made by ILCOR suggesting the use of an AED by lay rescuers for all children over 1 year of age who have a nontraumatic OHCA. No recommendation was made for or against the use of an AED by lay rescuers for infants under 1 year of age with a nontraumatic OHCA. The authors noted the limited evidence available, including a small percentage of children (1.5%) from the CARES database who had an AED applied and a small percentage of children (3.7%) in the fourth observational study[12] who had a shock delivered. Only 12 patients in the under 1 year of age group had an AED applied, with 1 survival. Because this may result in a false negative result, a recommendation was not made by ILCOR for this age group.[8]

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Insights and Implications

Cardiac arrest in children is commonly preceded by a respiratory event and hypoxemia. As would be expected, ventilations with compressions have been shown to be vitally important for successful resuscitation.[13] The application of an AED may delay starting CPR or increase pauses in CPR, which could be potentially detrimental. The review authors acknowledge this but note the relative risk was still significantly in favor of AED application.[4,8] While OHCA is less common in infants and children than in adults, shockable rhythms do occur in this population. Despite the lack of evidence in the ILCOR review to support the public use of AEDs for infants with OHCA, there is no evidence to suggest harm from their use. Although the application of an AED may cause a slight pause in CPR, that determinant is outweighed by the lifesaving benefit in both infants and children with shockable rhythms.

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 CPR

Communication between dispatch centers and lay responders at the scene of a cardiac arrest are typically through an audio connection on a cell phone. The use of video-based dispatcher-assisted CPR instructions is a promising means for improving CPR instruction delivery and technique.

Red Cross Guidelines

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

Evidence Summary

A 2022 evidence update[4] to the 2021 ILCOR CoSTR[14] on this topic identified two new studies.[15,16] The first observational study, conducted in a large metropolitan area in Korea and enrolling 2,109 adult OHCA patients with dispatch-assisted CPR, reported that video-instructed dispatcher-assisted CPR was significantly associated with neurologic recovery (aOR, 2.11; 95% CI, 1.48–3.01) and survival to hospital discharge (aOR, 1.81; 95% CI, 1.33–2.46) compared with audio-instructed dispatcher-assisted CPR in adult patients after adjusting for age, gender, underlying diseases and CPR location.[15] The second study reported improved compression depth, hand position, compression rate and compression depth for bystanders with the use of live video-instructed dispatcher-assisted CPR instruction.[16]

Insights and Implications

Evidence reporting clinical outcomes from video-based dispatcher assisted CPR is limited but supports the existing Red Cross guidelines. Further clinical research is needed to confirm potential benefits or to identify harm associated with video-based dispatcher-assisted CPR.

Assessment

Pediatric Early Warning Systems

A significant percentage of in-hospital pediatric serious events and deaths have been shown to be associated with a failure to detect and respond to clinical deterioration.[17] This has led to the development of tools for use in the healthcare setting, including pediatric early warning systems (PEWS), to alert healthcare professionals to clinical deterioration through periodic observation of physiologic parameters, application of a scoring system and criteria for triggering communication and an appropriate response. Is there clinical evidence to support the use of PEWS?

Red Cross Guidelines

NEW

- Pediatric early warning systems may be used as part of a larger framework to reduce serious safety events by identifying and responding to hospitalized infants, children and adolescents who may either be at risk for deterioration or be deteriorating clinically.

Evidence Summary

A 2022 systematic review[18] and CoSTR[4,19] by ILCOR evaluated the use of PEWS, with or without rapid response teams or medical emergency teams, in hospitalized infants, children and adolescents compared with standard care without a scoring system. The review included a single RCT[20] and multiple cohort studies; the certainty of evidence was rated as very low across all outcomes due to very serious risk of bias and imprecision. No significant difference in mortality, cardiopulmonary arrest events and/or significant deterioration events was shown with the use of PEWS compared with no PEWS. However, there was a trend toward increased mortality in the pooled analysis for the no PEWS group and toward both increased cardiopulmonary arrests and increased significant clinical deterioration events with no PEWS. For the outcome of unplanned code events, a statistically significant increase in unplanned code events was demonstrated with no PEWS compared with the PEWS group (pooled IRR/RR, 1.73; 95% CI, 1.01–2.96). A weak recommendation by ILCOR suggests using PEWS to monitor hospitalized children, with the aim of identifying those who may be deteriorating.[4,19]

Pediatric Early Warning Systems (PEWS)

About PEWS

→ Tool to identify hospitalized children at increased risk of deterioration

→ Scoring system based on vital signs and clinical findings

→ Uses criteria to alert healthcare professionals and trigger response

→ Goal is to eliminate preventable codes

→ Many variations of PEWS in use

Research Findings*

→ Implementing a PEWS to monitor hospitalized children was associated with:

→ A reduction in unplanned code events

→ Reduced mortality

🔑 KEY POINT

PEWS should support, NOT replace, clinical judgement!

Used as part of a larger framework

To reduce serious safety events

By identifying/ responding to hospitalized children

Who maybe at risk for clinical deterioration

*Chong SL, Goh MSL, Ong GY, et al. Do paediatric early warning systems reduce mortality and critical deterioration events among children? A systematic review and meta-analysis. *Resusc Plus.* Sep 2022;11:100262. doi:10.1016/j.resplu.2022.100262

Insights and Implications

Pediatric early warning systems are one component of an organization strategy used in many hospitals to help healthcare professionals recognize infants, children and adolescents who are either at risk for clinical deterioration or who are clinically deteriorating, using established criteria, and to accelerate an urgent response through a clear communications plan. Pediatric early warning systems should support, but not be a replacement for, clinical judgement. Many variations of PEWS exist with a wide range of sensitivities and specificities for detecting clinical deterioration.[21] Other components of a rapid response system include having the necessary personnel and resources for response, such as a medical emergency team or rapid response team, that focuses on correcting the deteriorating child's physiology, a process-monitoring and improvement plan, and an administrative structure to implement and support the system.[22,23]

CPR Techniques and Sequence

CPR Quality During Transport

Prehospital healthcare professionals responding to OHCAs are sometimes faced with the decision to either continue CPR on-scene or to transport a patient to the hospital while continuing to provide CPR. Often, the decision is based on predetermined EMS transport criteria or termination of resuscitation rules. Is there evidence to support one approach versus another?

Red Cross Guidelines

NEW
- The decision to transport a patient following out-of-hospital cardiac arrest (OHCA) and while CPR is in progress should be made based on emergency medical services (EMS) protocols and/or in consultation with on-line medical control.

NEW
- Protocols to determine care on-scene versus during transport for OHCA should be evidence-based, and at a minimum, consider local resources, competency of providers and distances to hospital care.
   ◦ There should be separate protocols for adults and for infants and children.

NEW
- When transporting an OHCA patient to a hospital, prehospital healthcare professionals should strive to deliver high-quality CPR.

Evidence Summary

A 2022 systematic review and CoSTR[4,24] by ILCOR looked at the effect of transporting a patient following OHCA with ongoing CPR compared with completing CPR on the scene. Outcomes of interest included survival to hospital discharge, favorable neurological outcome, return of spontaneous circulation (ROSC), and quality of CPR metrics on-scene versus during transport.

No studies were identified evaluating the effect that CPR quality during transport had on patient outcomes. Both manikin studies and observational studies were included for evaluation of CPR quality metrics. Findings reported from the limited number of observational studies of CPR metrics during transport were varied, with some reporting no differences in chest compression rate and depth, CPR fraction or ventilation rate, while some studies

reported negative impacts on these metrics. Most studies reported a lower CPR fraction during transport. A single observational study enrolling 27,705 patients reported on the impact of transport while providing CPR on ROSC, survival to hospital discharge and hospital discharge with favorable neurologic outcome.[25] Fewer patients in the CPR during transport group were discharged with favorable neurologic outcome (RR, 0.39; 95% CI, 0.33–0.47; 2 patients fewer/1,000 [2 fewer to 3 fewer]), fewer survived to hospital discharge (RR, 0.46; 95% CI, 0.42–0.52; 5 patients fewer/1,000 [4 fewer to 5 fewer]), and fewer achieved ROSC (RR, 0.41; 95% CI, 0.39–0.43; 23 patients fewer/1,000 [22 fewer to 24 fewer]). Evidence was judged as very low certainty.[4,24]

A weak recommendation was made by ILCOR suggesting that providers deliver resuscitation at the scene rather than undertake ambulance transport with ongoing resuscitation unless there is an appropriate indication to justify transport. A strong recommendation was made that whenever transport is indicated, EMS providers should focus on the delivery of high-quality CPR throughout transport.[4,24]

Insights and Implications

Providing CPR in a moving vehicle can be challenging and thus findings for the CPR metric outcomes are not unexpected. Data for survival, survival with favorable neurologic outcome, and ROSC, however, are from a single study with very low-certainty evidence and therefore more difficult to interpret. The decision to transport and when or where to transport is complex and in some cases, multifactorial. Emergency medical services protocols should be followed, where available, and when questions arise, EMS Medical Command should be contacted for advice.

Barrier Devices During CPR

Barrier devices used during CPR include face masks, face shields and surgical masks. The coronavirus disease 2019 (COVID-19) pandemic led to a greater use of these devices to protect rescuers from infectious disease transmission. Is there additional evidence to show the efficacy of various barrier devices from transmitting infectious disease?

Red Cross Guidelines

REAFFIRMED Although the risk of harm while performing CPR is considered low, precautions should be taken to minimize the risk of transmission of infectious disease. This may include, but is not limited to:

- Using standard precautions to provide patient care in all settings including performance of hand hygiene and use of personal protective equipment (PPE), that is, 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.

Evidence Summary

A 2021 American Red Cross Scientific Advisory Council scientific review[26] evaluated the risk of infection during CPR and first aid. Case reports identified in this review document the transmission of a variety of infectious diseases during resuscitation. In most cases, PPE in the form of gloves or a barrier device for rescue breathing were not used. A 2022 evidence update[4] of a 2005 CoSTR[27] by ILCOR searched for evidence related to the use of barrier devices, compared with no use of barrier devices by rescuers performing CPR on adult or pediatric patients for OHCA and in-hospital cardiac arrest (IHCA). Outcomes of interest included lower infection rates and quality of ventilation. No new studies were identified that were specifically related to barrier devices during CPR since a previous 2020 ILCOR evidence update and a systematic review[28] of COVID-19 in cardiac arrest and infection risk to rescuers. The previous ILCOR treatment recommendation remains unchanged and recommends that providers should take appropriate safety precautions when feasible and when resources are available to do so, especially if a victim is known to have a serious infection (e.g., human immunodeficiency virus [HIV], tuberculosis, hepatitis B virus [HBV] or severe acute respiratory syndrome [SARS]).[4]

Insights and Implications

There are relatively few reports of infectious disease transmission following the provision of CPR. Despite the lack of evidence beyond case series 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 barrier devices.

Hand Positioning During Chest Compressions

The specific location on the chest for hand placement to provide chest compressions has been the topic of past research and systematic reviews, but studies reporting clinical outcomes, such as survival or ROSC, have been lacking.

Red Cross Guidelines

REAFFIRMED • For adults and children, chest compressions should be performed on the lower half of the sternum.

REAFFIRMED • For infants, chest compressions should be performed just below the inter-mammary line (middle of the chest).

REAFFIRMED • For adults, the two-hand technique should be used for chest compressions.

REAFFIRMED • For children, either a two-hand or one-hand technique should be used for chest compressions.

REAFFIRMED • For infants, the two-thumb/encircling hands technique should be used for chest compressions.

REAFFIRMED • For infants, the two-finger technique (two or three fingers placed in the middle of the chest) may be considered.

REAFFIRMED • For infants, if the required depth cannot be achieved with either the two-thumb/encircling hands technique or the or two-finger technique, a one-hand technique may be considered.

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Evidence Summary

A 2020 American Red Cross Scientific Advisory Council systematic review with meta-analysis of data from simulation studies concluded that for CPR performed on a simulated infant manikin by a single rescuer, the two-thumb technique improves chest compression quality without compromising ventilation.[29] A 2022 evidence update by ILCOR[4] did not identify new studies addressing the delivery of chest compressions in adults and children over the lower half of the sternum compared with alternative locations for outcomes of survival, ROSC, cardiac output, harm and coronary perfusion pressure.

Insights and Implications

Hand position is an important component of chest compression effectiveness. A limited number of studies identified in a 2020 ILCOR systematic review showed improved peak arterial pressure during compression systole when compressions are performed over the lower third of the sternum for both adults and children compared with compressions over the center of the chest or in the middle of the sternum.[30] Despite this, the lower half of the sternum is considered easily identifiable by rescuers, and in the absence of clinical evidence to support a change in recommendations, the Red Cross guidelines continue to recommend that compressions be provided over the lower half of the sternum for both adults and children.

Fatigue with Chest-Compression-Only CPR

Red Cross guidelines allow for providing compression-only CPR (CO-CPR) as an alternative to conventional compression-ventilation CPR (CV-CPR) when a rescuer is unwilling or unable to provide ventilations. Does providing compression-only CPR to adult or pediatric patients in cardiac arrest compared with CV-CPR increase rescuer fatigue with a subsequent decrease in the quality of chest compressions?

Red Cross Guidelines

REAFFIRMED
- Compression-only CPR may be used as an alternative to CPR with compressions and ventilations when someone is unwilling or unable to provide ventilations.

REAFFIRMED
- Compression-only CPR should be continued unless it is no longer possible due to physical exhaustion.

Evidence Summary

A 2022 evidence update by ILCOR identified simulation studies with manikins investigating resting frequency during CO-CPR.[4] Results of these studies were not felt to warrant a change in guidelines, but it was suggested that subsequent to the COVID-19 pandemic and increase in CO-CPR, future studies evaluating rest duration and frequency during CO-CPR should be considered. ILCOR currently recommends that no modification be made to current CO-CPR guidelines for cardiac arrest to mitigate rescuer fatigue.

Insights and Implications

The relationship between rescuer fatigue during CO-CPR and chest compression quality continues to be a knowledge gap in need of future research. The Red Cross guideline for continuing CO-CPR unless it is no longer possible due to physical exhaustion is in addition to the standing guidance to continue CPR/AED until:

- The team leader tells you to stop.

- Other trained healthcare professionals arrive and relieve you.

- There are signs of life/return of spontaneous circulation (ROSC).

- You are presented with a valid do not resuscitate order.

- The situation becomes unsafe to continue.

Compression-to-Ventilation CPR Ratio for Adults: Healthcare Professionals

Compression-ventilation CPR is recommended for healthcare professionals in emergency medical services and in-hospital settings. Is there evidence to support the use of delayed ventilations or CO-CPR in these settings?

Red Cross Guidelines

For healthcare professionals:

REAFFIRMED • A compression-to-ventilation (CV) ratio of 30:2 should be used for 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 2022 evidence update[4] of a 2017 ILCOR systematic review[31] looked for studies of adults with OHCA who received chest compressions with delayed ventilation by EMS compared with chest compressions with early ventilations. The update identified a single observational study[32] providing indirect evidence for this review, showing that the tidal volume generated with chest compressions alone (20 milliliters [mL]; interquartile range, 13 to 28 mL) is inadequate to provide adequate alveolar ventilation. No new evidence was identified specific to the in-hospital setting for CPR provided after tracheal intubation or placement of a supraglottic airway device. The previous ILCOR treatment recommendations remain unchanged.

Insights and Implications

The single study identified in the ILCOR update[4] supports the need for manual ventilations to achieve adequate volumes for alveolar ventilation. The Red Cross guidelines recommending CV-CPR by healthcare professionals, including in the prehospital and in-hospital settings following advanced airway management, remain unchanged. An initial CO-CPR strategy may be considered by EMS for witnessed cardiac arrest.

Compression-to-Ventilation CPR Ratio for Infants and Children: Healthcare Professionals

Since 2015, it has been recommended by the Red Cross that lay responders and healthcare professionals provide rescue breaths and chest compressions for infants and children with IHCA and OHCA. It has also been a Red Cross guideline recommendation that if someone is unwilling or unable to provide ventilations (i.e., mouth-to-mouth, mouth-to-mask) for infants and children in cardiac arrest, they should at least perform chest compressions. Is there new evidence to support these recommendations?

Red Cross Guidelines

REAFFIRMED • For children and infants, a compression-to-ventilation ratio of 30:2 should be used by one healthcare professional and a ratio of 15:2 should be used by two healthcare professionals, while a ratio of 30:2 should be used by a lay responder.

REAFFIRMED • For children and infants with an advanced airway in place, healthcare professionals should deliver 1 ventilation every 2 to 3 seconds (20 to 30 breaths per minute) with continuous compressions.

REAFFIRMED • Compression-only CPR may be used as an alternative to CPR with compressions and ventilations when someone is unwilling or unable to provide ventilations.

Evidence Summary

An evidence update[4] of a 2017 ILCOR CoSTR[31] on CO-CPR in pediatric patients identified one relevant study. A retrospective review of data from the CARES database evaluated 13,060 pediatric (18 years of age or younger) nontraumatic OHCAs.[33] In multivariable analysis of the overall cohort, neurologically favorable survival was associated with rescue breathing CPR (RB-CPR) (aOR, 2.16; 95% CI, 1.78–2.62) and with CO-CPR (aOR, 1.61; 95% CI, 1.34–1.94) compared with no CPR. Rescue-breathing CPR (RB-CPR) was associated with higher odds of neurologically favorable survival compared with CO-CPR (aOR, 1.36; 95% CI, 1.10–1.68). Risk stratification by age group was also reported. For the comparison of RB-CPR with no CPR, adjusted OR for neurologically favorable survival was greater for infants less than 1 year old (aOR, 1.65; 95% CI, 1.19–2.3; $P<0.003$), children (1 to 11 years of age) (aOR, 2.73; 95% CI, 2.00–3.72; $P<0.001$) and adolescents (12 years of age or older) (aOR 2.12; 95% CI, 1.44–3.11; $P<0.001$). When comparing data for patients who received CO-CPR with data for patients with no CPR, CO-CPR was associated with better neurologically favorable survival in children (aOR 1.94; 95% CI, 1.41–2.68; $P<0.001$) and adolescents (aOR, 1.71; 95% CI, 1.23–2.37; $P<0.001$), but not for infants (aOR, 1.16; 95% CI, 0.083–1.62; $P=0.294$).[33]

The identified study was considered supportive of current ILCOR recommendations for providing rescue breathing with chest compressions in pediatric IHCA and OHCA and for providing CO-CPR when rescuers are unwilling or unable to provide rescue breathing. The evidence update authors noted that a previously identified study from 2010[34] found that CO-CPR for infants was not associated with a more favorable neurologic outcome compared with no CPR. Although the new study[33] also found that CO-CPR was not associated with better neurologically favorable survival for infants compared with no CPR, the ILCOR Pediatric Task Force continues to recommend CO-CPR for infants in cardiac arrest when rescuers are unwilling or unable to provide rescue breathing.[4]

Insights and Implications

The Red Cross guidelines for the use of CV-CPR in children and infants and for the use of CO-CPR when someone is unwilling or unable to provide ventilations are reaffirmed with this ILCOR evidence update. Further studies are needed to determine the benefit of CO-CPR for infants.

Mechanical Chest Compression Devices

Mechanical CPR (mCPR) devices are sometimes used for delivering chest compressions by trained EMS healthcare professionals. Use of these devices has been restricted in most circumstances due to the inherent delay in CPR during application of the device, the lack of superiority to manual CPR and evidence suggesting some worse outcomes.

Red Cross Guidelines

NEW • The routine use of mechanical CPR (mCPR) devices is not recommended.

UPDATED • Healthcare professionals may consider the use of mCPR devices if the response team is skilled with usage.

REAFFIRMED • Application of mCPR devices should not delay initiation of manual chest compressions.

Evidence Summary

A 2022 triennial review of an American Red Cross Scientific Advisory Council scientific review[35] identified six systematic reviews with meta-analyses or network meta-analysis[36-41] with no new evidence of improved survival with mCPR devices or superiority to manual CPR for routine use. While there was a suggestion of injury with use of the devices, in most cases the injury was not severe or life-threatening. The review concluded that there may be specific indications where it is challenging to provide high-quality manual chest compressions (e.g., limited personnel, infectious disease concerns, prolonged resuscitation) where it is reasonable for well-trained personnel to use mCPR devices.

Insights and Implications

Despite the lack of a survival benefit with the use of mCPR devices and evidence suggesting harm, the use of mCPR devices may be appropriate in some cases of OHCA, such as prolonged CPR and resuscitation associated with hypothermia, toxicologic and pulmonary embolism-induced cardiac arrest, and OHCA with prolonged transport times. Because pauses and delay in starting CPR contribute to lower survival, the previous 2020 time-limited recommendation for placement of a mCPR device has been revised to state that mCPR application should not delay the start of manual compressions.

Minimizing Pauses in Chest Compressions

Chest compression fraction (CCF) is the proportion of time spent providing chest compressions during CPR and is measured by dividing the cumulative time spent providing chest compressions by the total time taken for the entire resuscitation. The interruption of chest compressions during CPR to perform rescue breaths, rhythm analysis, pulse checks and defibrillation all reduce chest compression fraction, leading to decreased coronary and cerebral blood flow and the potential for decreased survival.[42] A CCF of greater than 80% is considered a high-quality CPR metric. This has led to efforts to minimize the frequency and duration of peri-shock pauses, to provide continuous chest compressions without pauses for ventilations and the development of artifact-filtering algorithms in AEDs. Is there new evidence to support efforts to minimize pauses in chest compressions?

Red Cross Guidelines

NEW
- Pauses during CPR, including peri-shock pauses, changing roles, and moving between ventilations and compressions for a single rescuer, should be as short as possible.

NEW
- Chest compression fraction should be as high as possible and at least 60%.

NEW
- Where system resources permit, monitoring of peri-shock pauses and chest compression fraction may be considered as part of a comprehensive quality improvement program.

Evidence Summary

A systematic review and CoSTR[4,43] by ILCOR updated in 2022 evaluated the evidence for minimizing pauses in chest compressions in adults in cardiac arrest in any setting (i.e., a higher CPR fraction or chest compression fraction, or shorter peri-shock pauses), compared with conventional CPR (with a lower CPR or chest compression fraction, or longer peri-shock pauses). The review included several observational studies and three RCTs.[44-46] The overall certainty of evidence across outcomes was rated as very low. Meta-analyses were not possible due to confounding and a high degree of heterogeneity. Of the included RCTs, one trial[44] using an experimental AED algorithm observed higher CCFs and shorter pre-shock and post-shock pauses, with no significant difference in survival to hospital admission or hospital discharge when compared to the control group. A second trial[46] observed a higher CCF in a continuous chest compression group compared with 30:2 CV-CPR, with lower survival to hospital admission but no difference in survival to hospital discharge. A third trial[45] using an experimental AED algorithm observed a higher CCF and shorter pre-shock and post-shock pauses compared with the control group, but no significant differences in survival to hospital admission or hospital discharge.[4,43]

Minimizing Pauses During CPR

Chest compression fraction (CCF):

→ Is the proportion of time spent doing chest compressions during resuscitation for cardiac arrest.

→ Is a component of high-quality CPR.

→ Should be as high as possible and at least 60%.

Pauses during chest compressions decrease the CCF and may occur:

→ Before, during and immediately after shock delivery.

→ While changing roles during CPR.

→ When switching from compressions to ventilations (single rescuer).

→ During delivery of ventilations with conventional CPR.

→ During airway management or rhythm analysis.

🔑 KEY POINT

Pauses during chest compressions should be kept as short as possible.

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The included observational studies evaluated outcomes following incremental changes in CPR quality metrics and outcomes over time, outcomes for patients treated in physician-staffed versus paramedic-staffed ambulances, and outcomes following training and feedback interventions. While increases in CCF and/or shorter peri-shock pauses were documented with these interventions, most studies reported no significant differences for survival to hospital discharge. One observational study[47] reported higher survival for cardiac arrest with a CCF greater than 80.4% compared with less than 80.4% in a subgroup with a 20-minute CPR duration. Two other studies reported higher adjusted odds ratio for survival with a lower CCF compared with higher CCFs while other studies reported no significant difference in outcomes.[4,43]

For peri-shock pauses, most observational studies reported higher survival in patients with shorter pre-shock pauses (less than 10 seconds) compared with longer pauses (greater than 10 to 20 seconds), and a few reported higher survival in patients with shorter peri-shock pauses (less than 20 seconds) compared with longer pauses (greater than 20 to 40 seconds). In adjusted analysis, the most recent study enrolling 15,568 patients did not report higher odds of survival with shorter pre-shock pauses (less than 10 seconds) compared with longer pauses (greater than 10 seconds).[48] Divergent results were reported in observational studies in which pauses in compressions were compared between survivors and nonsurvivors of OHCA.[4,43]

Insights and Implications

High-quality CPR is important for patient outcomes and includes the provision of chest compressions for at least 60% and up to or more than 80% of the entire resuscitation. To achieve this CCF, it is necessary to minimize pauses that can occur with interventions, such as intubation and peri-shock pauses. While this systematic review did not find strong evidence of a survival benefit with higher CCFs and decreased peri-shock pauses, the review authors noted that observational studies of pauses in compressions are challenging to interpret because short duration resuscitation efforts in patients with shockable rhythms tend to have better outcomes than long duration resuscitation efforts in patients with non-shockable rhythms. The cardiac rhythm and the duration of resuscitation will impact the number and duration of pauses. This makes it difficult to determine optimal pause duration or frequency for guidance, although it is unlikely that a reduction in the frequency and duration of pauses will produce harmful effects. Technological advances with the development of algorithms to automatically detect chest compression periods using an accelerometer may allow for future automated CCF calculations, monitoring and research.

Passive Ventilation Techniques During CPR

Passive ventilation or oxygen insufflation during resuscitation from OHCA offers an alternative to positive pressure ventilations (PPVs) and oxygen delivery. Initial passive ventilation has been reported to be associated with higher neurologically intact survival to hospital discharge when compared with initial bag-mask ventilation in EMS systems when combined with minimally interrupted cardiac resuscitation.[49]

Red Cross Guidelines

NEW

- The use of passive ventilation techniques may be considered by prehospital healthcare professionals as part of a bundle of care to include minimally interrupted cardiac resuscitation.

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Evidence Summary

A 2022 ILCOR systematic review and CoSTR[4,50] evaluated the use of any passive ventilation technique in addition to chest compressions, compared with conventional CV-CPR in adults and children with presumed cardiac arrest in any setting. Very low-certainty evidence from two RCTs, an observational study and a small pilot RCT were identified.[49,51-53] The two RCTs used intermittent PPV through a tracheal tube compared with continuous insufflation of oxygen using a modified (Boussignac) tracheal tube; an active compression-decompression device was used for chest compressions when available and may have contributed to passive ventilation. Results from the observational study[49] were considered difficult to interpret due to confounding from differing CPR protocols.[4,50] Overall, no benefit from passive ventilation was found for outcomes of survival to ICU discharge, survival to hospital admission and ROSC. The ILCOR treatment recommendation suggests against the routine use of passive ventilation techniques during conventional CPR.[4,50]

Insights and Implications

Passive ventilation techniques during chest compressions can be used with or without oxygen and include positioning of the body, opening the airway and using airway adjuncts, use of a passive oxygen administration and constant flow insufflation. Some EMS systems provide continuous chest compressions with passive ventilation using an oropharyngeal airway and oxygen delivery through a simple face mask. Whether chest compressions generate a sufficient tidal volume for gas exchange is uncertain and may vary with the duration of resuscitation. Despite the lack of evidence to support passive ventilation in the ILCOR review, a strategy by EMS systems that includes minimally interrupted CPR with passive ventilation is considered reasonable.

Drowning Process Resuscitation

CPR Start Sequence for Drowning Victims (C-A-B versus A-B-C)

The pathophysiology of the drowning process is unique and is a continuum of events that include laryngospasm and possible resultant asphyxia. As a result of the constellation of events, severe hypoxemia ensues, which leads to cardiac arrest. This process contrasts with cardiac arrest from primary cardiac etiologies. A 2021 American Red Cross Scientific Advisory Council scientific review led to the Red Cross guidelines recommending a ventilations-first approach to starting CPR.[54]

Red Cross Guidelines

REAFFIRMED
- For infants, children, adolescents and adults 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.

REAFFIRMED
- For lay persons, if compression-ventilation CPR is not possible or someone is unwilling to provide compression-ventilation CPR, compression-only CPR should be performed.

Evidence Summary

A systematic review by the American Red Cross Scientific Advisory Council in 2021[54] evaluated evidence for use of a ventilations-first approach to CPR in drowning victims with cardiac arrest, compared with a compressions-first CPR approach. Indirect evidence identified an association between ventilations with CPR in drowning victims and improved outcomes. One observational study reported a higher odds ratio for survival following cardiac arrest in drowning victims who received bystander ventilations compared with those who did not receive ventilations.[55] A retrospective analysis of cardiac arrest registry data, including drowning victims, reported improved neurologically favorable survival in patients aged 5 to 15 years and improved survival to hospital discharge in all age groups who received CV-CPR, compared with CPR without ventilations.[56]

A 2022 systematic review and CoSTR[4,57] by ILCOR reviewed evidence for a compression-first resuscitation strategy in adults and children in cardiac arrest following drowning compared with a ventilation-first strategy. No studies were identified that were considered relevant to the question. The authors reviewed consensus statements and literature to help inform good practice statements. One study noted was a 2004 retrospective analysis of 46 nonbreathing drowning victims rescued by lifeguards, of which 19 (41.3%) received in-water immediate resuscitation with ventilations, and 27 (58.7%) received delayed resuscitation after being brought to shore.[58] Survival was significantly higher in the group receiving in-water resuscitation with ventilations compared with the in-water resuscitation with no ventilations group (87.5% versus 25%, $P<0.001$). Survival with favorable functional outcome was also higher in the in-water resuscitation with ventilations group compared with the in-water resuscitation with no ventilations group (52.6% versus 7.4%).

A second study of pediatric drowning cases reported worse functional outcomes in children with cardiac arrest compared with respiratory arrest alone (81% versus 0%, $P<0.001$), suggesting that early intervention with ventilations before cardiac arrest may improve outcomes.[59]

Insights and Implications

The studies included in the ILCOR systematic review are felt to provide additional indirect evidence supporting the 2021 American Red Cross Scientific Advisory Council systematic review and conclusions. The Red Cross guidelines recommending the use of a ventilations-first approach to CPR remain unchanged and reflect evidence suggesting that earlier ventilations may improve outcomes. For lay persons who are not trained or willing to provide CV-CPR, a CO-CPR approach continues to be recommended by the Red Cross.

Prehospital Oxygen in Drowning Process Resuscitation

A 2021 scoping review of the literature by ILCOR[14] searched for studies comparing the administration of oxygen to adults and children in cardiac arrest following drowning compared with no oxygen administration before hospital arrival. Evidence identified in this scoping review was used to inform the Red Cross guidelines. The ILCOR scoping review has led to a recent systematic review on this topic.[4,60]

Red Cross Guidelines

UPDATED
- If available, supplemental oxygen may be provided empirically by responders trained in its use to drowning victims who are conscious and with respiratory symptoms. Once pulse oximetry is available, supplemental oxygen therapy should be appropriately titrated.

UPDATED
- For the drowning victim in cardiopulmonary arrest, supplemental high-flow and high-concentration oxygen should be provided, if available, with ventilations by responders trained in its use.

Evidence Summary

A 2022 systematic review and CoSTR[4,60] by ILCOR sought to evaluate literature to answer the question, in adults and children in cardiac arrest following drowning, does oxygen administration before hospital arrival compared with no oxygen administration before hospital arrival change survival outcomes or ROSC? No direct evidence was identified that addressed the question. A good practice statement was made, that when available, ILCOR recommends trained providers use the highest possible inspired oxygen concentration during prehospital resuscitation for adults and children in cardiac arrest following drowning. In making this statement, the authors noted that hypoxemia is associated with worse outcomes; that prompt initiation of bystander CPR is associated with better outcomes in drowning; and that use of supplemental oxygen, when available during and after CPR, is an accepted practice in drowning resuscitation and other circumstances. However, there is evidence that prolonged administration of high-concentration oxygen may be harmful and there are no adult human studies comparing maximal inspired oxygen with another inspired oxygen concentration in CPR.[4,60] It was also noted that adding oxygen to resuscitation algorithms could increase their complexity, and it is recommended that oxygen use be limited to providers who are trained and practiced in its use during resuscitation. There is uncertainty about the effectiveness of oxygen in early stages after drowning, and the high-cost low-benefit balance does not favor the use of pulse oximetry during resuscitation. Finally, it was noted that following ROSC, recommendations should be followed for oxygen titration.[4,60]

Insights and Implications

The new ILCOR systematic review, while not identifying direct evidence, describes the rationale behind their good practice statement and has been used to inform the Red Cross guidelines. The Red Cross guidelines have been updated to reflect that responders who use oxygen must receive training in oxygen administration. ILCOR does not address the administration of oxygen to drowning victims not in cardiac arrest who have respiratory symptoms. The pathophysiology of the drowning process, including decreased oxygen diffusion capacities of the lungs following aspiration of water, provides a rationale for the administration of oxygen, when available, to drowning victims with respiratory symptomatology, with oxygen titration once pulse oximetry is available and a reliable reading can be obtained.

AED Use for Cardiac Arrest in Drowning Process Resuscitation

Out-of-hospital cardiac arrest with a shockable rhythm (ventricular fibrillation [VF]/ventricular tachycardia [VT]) attributed to drowning has been reported in only 2% to 14% of patients.[61,62] Although concerns have been expressed over the use of an AED on a drowning victim in cardiac arrest and in an aquatic environment, the use of AEDs in simulation studies appears feasible and safe.[30,31] The use of AEDs is recommended by the Red Cross after beginning CPR and once available, where feasible and safe. A recent systematic review by ILCOR sought to evaluate evidence for the use of an AED before CPR in cardiac arrest following drowning compared with providing CPR before AED use.

Red Cross Guidelines

REAFFIRMED • If an adult, adolescent, 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

The 2022 ILCOR systematic review and CoSTR[63] of AED use first versus CPR first in cardiac arrest following drowning did not identify any studies that addressed the question. Related literature was reviewed and discussed by the authors. It was noted that cardiac arrest following drowning is most commonly the result of the hypoxic drowning process but may be a primary cardiac event in adults and children.[63] While shockable rhythms are rare in cardiac arrest following drowning, they are slightly higher in children and witnessed events. However, there is conflicting data about improved outcomes when shockable rhythms are present. One study[64] discussed was a review of 336 drowning related OHCAs, finding 6% to be in a shockable rhythm and 79% in asystole and 13% in PEA (non-shockable rhythms). Improved outcomes were found to be associated with an initial shockable rhythm, with higher adjusted odds of survival to hospital discharge (aOR 48.70; 95% CI, 3.80–624.86). The ILCOR systematic review authors weighed the potential benefits versus risks and disadvantages of adding the use of an AED to CPR following drowning. A good practice statement by ILCOR recommends that when available, an AED be used in cardiac arrest following drowning in adults and children. CPR should be started first and continued until an AED has been obtained and is ready for use.[4,63]

Insights and Implications

The ILCOR good practice statement is consistent with the Red Cross guidelines and no changes to the guidelines are indicated based on this review.

American Red Cross
Training Services

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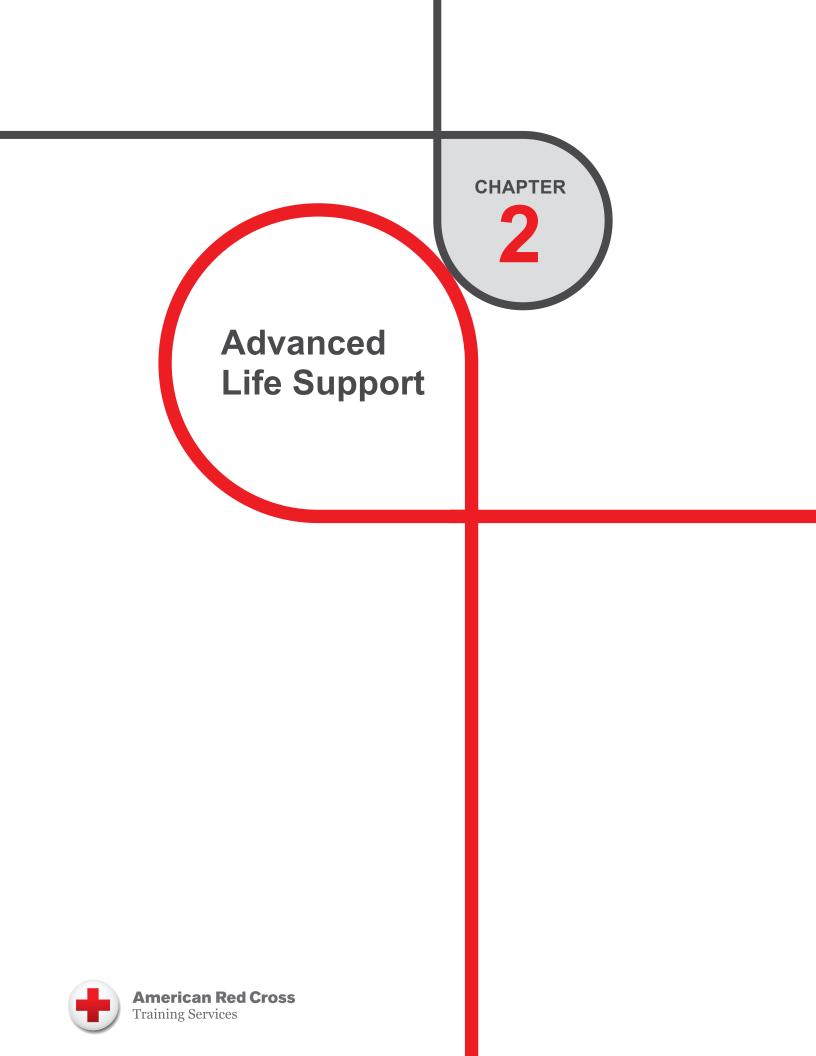
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Advanced Life Support

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Drug Therapy and Vascular Access

Vasopressin with Corticosteroids for Cardiac Arrest

The use of vasopressin with corticosteroids after epinephrine for in-hospital cardiac arrest (IHCA) has been the subject of several studies and systematic reviews, but evidence has not shown beneficial long-term outcomes. A systematic review[1] has been completed on this topic since the last American Red Cross Scientific Advisory Council review.

Red Cross Guidelines

REAFFIRMED
- There is insufficient evidence to recommend the combined use of vasopressin with corticosteroids for in-hospital cardiac arrest.

NEW
- The combined use of vasopressin with corticosteroids is not recommended for out-of-hospital cardiac arrest.

Evidence Summary

A 2021 American Red Cross Scientific Advisory Council Answer[2] on the combined use of vasopressin with corticosteroids for IHCA identified three randomized controlled trials[3-5] reporting higher rates of return of spontaneous circulation (ROSC) with the combined use of vasopressin with corticosteroids. The most recent randomized controlled trial (RCT), however, failed to show a benefit for survival to hospital discharge or for favorable functional outcome at hospital discharge. A recent systematic review[1] and ILCOR CoSTR[6,7] on this topic included all three RCTs for meta-analysis and concluded that while intra-arrest administration of vasopressin with corticosteroids improved ROSC, this was not shown for outcomes of survival to hospital discharge and favorable functional outcome at hospital discharge. There continues to be no evidence specific to cardiac arrest in the out-of-hospital setting. This systematic review has been through the adolopment process[8] by ILCOR and used to generate weak treatment recommendations that suggest against the combined use of vasopressin with corticosteroids in addition to the standard care for adult IHCA and out-of-hospital cardiac arrest (OHCA).[6,7]

Insights and Implications

The most recent systematic review[1,7] includes the studies identified in the 2021 American Red Cross Scientific Advisory Council[2] Answer. Additional studies are needed to determine if the increase in rates of ROSC reported with the combined use of vasopressin with corticosteroids for IHCA translate into long-term beneficial clinical outcomes. While the Red Cross guidelines continue to state that there is insufficient evidence to recommend the combined use of vasopressin with corticosteroids for IHCA, a new guideline clarifies that due to lack of evidence, the combined use of vasopressin with corticosteroids for OHCA is not recommended.

Vasopressor Use During Cardiac Arrest

Epinephrine use during cardiac arrest has been shown to improve rates of ROSC and survival. Vasopressor use during cardiac arrest continues to be an active area of research and was the focus of a recent ILCOR evidence update.

Red Cross Guidelines

REAFFIRMED • Epinephrine 1 milligram intravenous (IV) or intraosseous (IO) may be administered after initial defibrillation attempts are unsuccessful for cardiac arrest with a shockable rhythm and may be repeated every 3 to 5 minutes.

REAFFIRMED • For cardiac arrest with non-shockable rhythms, epinephrine should be administered at 1 milligram IV or IO as early as possible and repeated every 3 to 5 minutes.

REAFFIRMED • Vasopressin should not be used in place of epinephrine nor in addition to epinephrine for cardiac arrest.

Evidence Summary

The most recent ILCOR CoSTR[9] and systematic review[10] with meta-analysis of vasopressor use in cardiac arrest was completed in 2019 and used to inform the Red Cross guidelines. The systematic review[10] concluded that RCT data suggest that epinephrine use in cardiac arrest improves ROSC, survival to hospital discharge, and 3-month survival in OHCA, with more pronounced improvement in short-term outcomes for patients with non-shockable rhythms. Vasopressin with or without epinephrine was not shown to provide a benefit compared with epinephrine use alone. Most studies included in the review were of OHCA. A 2022 evidence update by ILCOR[7] identified multiple new relevant observational studies and secondary analyses of previous trials. The reviewers concluded that there is insufficient new data to pursue an update to the systematic review or to change current ILCOR treatment recommendations.[7]

Insights and Implications

The relevant studies identified in the evidence update are from different settings with varying inclusion criteria and interventions and do not change the strength or direction of existing ILCOR treatment directions. The current Red Cross guidelines for vasopressor use are reaffirmed.

Mannitol or Hypertonic Saline for Acute Major Traumatic Brain Injury

Mannitol and hypertonic saline are osmotic diuretics commonly used to treat cerebral edema and increased intracranial pressure (ICP) in patients with traumatic brain injury (TBI). The choice of which agent to use is frequently based on local protocol. Are clinical outcomes improved with the use of hypertonic saline compared with mannitol for patients with acute major TBI and elevated ICP?

Red Cross Guidelines

- Mannitol or hypertonic saline may be given to patients with:

  REAFFIRMED   ◦   Traumatic brain injury (TBI) who have a monitored elevation in intracranial pressure (ICP).

  REAFFIRMED   ◦   Signs of transtentorial herniation prior to ICP monitoring.

  UPDATED   ◦   Progressive neurological deterioration not due to extracranial causes.

REAFFIRMED   - Mannitol is effective for control of raised ICP at doses of 0.25 to 1 gram per kilogram of body weight (0.25 g/kg to 1 g/kg).

NEW   - Arterial hypotension (systolic blood pressure less than 90 mmHg) should be avoided in patients with intracranial hypertension.

- For pediatric patients with major TBI and acute intracranial hypertension:

  NEW   ◦   Hypertonic saline is preferred over mannitol to lower the ICP to less than 20 mmHg.

  NEW   ◦   A bolus of hypertonic saline (3%) is recommended at a dose between 2 and 5 milliliters per kilogram of body weight (2 mL/kg to 5 mL/kg) over 10 to 20 minutes.

  NEW   ◦   A continuous infusion of 3% hypertonic saline is suggested at a rate between 0.1 mL/kg and 1.0 mL/kg per hour. The minimum dose needed to maintain ICP less than 20 mmHg is suggested.

  NEW   ◦   A bolus of 23.4% hypertonic saline is suggested for refractory ICP. The suggested dose is 0.5 mL/kg with a maximum of 30 mL.

  NEW   ◦   A serum sodium level of greater than 170 milliequivalents per liter (mEq/L) for a sustained period (greater than 72 hours) should be avoided to preclude complications of thrombocytopenia and anemia, and a sustained serum sodium greater than 160 mEq/L should be avoided to preclude the complication of deep venous thrombosis.

  UPDATED   ◦   Mannitol may be considered to lower the ICP in situations where hypertonic saline cannot be used. A bolus of 0.25 g/kg to 1 g/kg over 10 minutes is suggested.

Evidence Summary

A 2022 triennial review of a 2019 American Red Cross Scientific Advisory Council scientific review[11] of this topic identified two systematic reviews[12,13] and two randomized trials of pediatric patients.[14,15]

The first systematic review from 2015 identified seven relevant manuscripts comparing hypertonic saline to mannitol in TBI.[12] The authors found that both agents were effective osmolar diuretics, however, there was heterogeneity between studies and the findings were inconclusive regarding which agent was more effective.

A 2020 Cochrane systematic review[13] included six trials with 91% of participants having severe TBI. Meta-analysis for outcomes of mortality at final follow-up and for a poor outcome was only possible for two trials but was challenged by a high loss to follow-up with survivors at 6 months. Based on calculated worst-case, best-case and per-protocol results, no difference in mortality at 6 months or for poor outcome based on Glasgow Outcome Scale was shown for hypertonic saline versus mannitol. Meta-analysis for the outcome of change in ICP was not possible due to heterogeneity between studies, including variation in modes of drug administration, follow-up times and ways of reporting changes in ICP. Results of trials were reported narratively. Both hypertonic saline and mannitol tended to be reported as effective in reducing elevated ICP, but greater benefits were noted in some studies with hypertonic saline. Rebound phenomenon following use of mannitol was reported in one trial, and no other adverse effects were reported in the remaining trials.

A randomized trial of 200 pediatric intensive care unit (PICU) patients with elevated ICP found that 3% sodium chloride decreased coma in patients compared to mannitol, however, without a mortality benefit.[14] Mannitol was associated with acute tubular necrosis in this trial.

A 2022 trial, Approaches and Decisions for Acute Pediatric TBI (ADAPT), compared the effect of bolus doses of 3% hypertonic saline versus mannitol on ICP and included data from 518 children with severe TBI. The data showed a statistically significant decrease in ICP and increase in cerebral perfusion pressure (CPP) with hypertonic saline bolus administration, while mannitol was observed to increase CPP.[15] Hypertonic saline was associated with a greater reduction in ICP compared with mannitol using unadjusted data, but after adjusting for confounders, associations of both agents with ICP and CPP were not different. During periods of increased ICP, greater improvements in outcomes were observed with 3% hypertonic saline than with mannitol. This difference persisted with adjusted data for an ICP greater than 25 mmHg.

The Brain Trauma Foundation Guidelines for the Management of Pediatric Severe TBI, published in 2019, is based on a systematic review and synthesis of the literature with evidence-based recommendations.[16] Recommendations include the use of a bolus dose of 3% hypertonic saline for acute intracranial hypertension, while a continuous infusion is suggested using the minimum dose needed to maintain an ICP less than 20 mmHg. No studies using mannitol were identified as meeting inclusion criteria in the development of the pediatric severe TBI guidelines.

Insights and Implications

The ADAPT trial is the first to compare a bolus of 3% hypertonic saline with mannitol in pediatric patients with severe TBI.[15] Results from this trial demonstrated a modest decrease in ICP and increase in CPP with hypertonic saline and increased CPP with mannitol. The Cochrane review[13] also noted that improved outcomes of ICP reduction were reported with hypertonic saline. Long-term clinical outcomes with treatment, however, are lacking except for mortality, which was not shown to be improved with hypertonic saline compared with mannitol.

When choosing an osmolar diuretic, one must consider that the hyperosmolar state induced by hypertonic saline can be associated with a higher risk of kidney injury, congestive heart failure, pulmonary edema and, after repeated doses, with hyperchloremic acidosis.[17] Mannitol was associated with acute tubular necrosis in one included study.[14] Hypertonic saline may thus be more appropriate in patients with decreased renal perfusion. Additional controlled trials are needed comparing hypertonic saline with mannitol to determine efficacy for lowering ICP, short- and long-term neurologic and survival outcomes, and adverse effects or limitations. Future studies that demonstrate a definitive improvement in outcomes or harmful effects may result in a change in recommendations.

The most recent (2019) Brain Trauma Foundation guidelines[16] were used to inform the Red Cross guidelines related to the use of hypertonic saline in pediatric severe TBI and for avoiding complications related to hypernatremia.

Intra-Cardiac Arrest Diagnostic Interventions

Intra-Cardiac Arrest Point-of-Care Diagnostic Ultrasound

Point-of-care ultrasound is sometimes used during cardiac arrest to search for a reversible cause of arrest. Previous reviews have determined that point-of-care ultrasound should not have a role in prognostication. However, is there evidence to support its use as a diagnostic tool?

Red Cross Guidelines

UPDATED
- Point-of-care ultrasonography may be considered by healthcare professionals competent in its performance as an additional diagnostic tool for assessment of suspected reversible etiologies of cardiac arrest but should not interfere with resuscitation or providing high-quality CPR.

REAFFIRMED
- Point-of-care ultrasonography should not have a role in prognostication for cardiac arrest.

Evidence Summary

For adults in cardiac arrest in any setting, is there any finding on point-of-care ultrasound during CPR, compared with any external confirmatory test, process or procedure other than the original point-of-care ultrasound, that accurately identifies a specific etiology of cardiac arrest? A 2022 ILCOR systematic review[18] and CoSTR[7,19] sought to evaluate evidence to answer this question. Data available from a subset of 31 patients from an observational study[20] with 48 IHCAs was used to estimate sensitivities and specificities of point-of-care ultrasound to identify cardiac tamponade (sensitivity, 1.00; 95% CI, 0.29–1.00; specificity, 1.00; 95% CI, 0.88–1.00), pulmonary embolism (sensitivity, 1.00; 95% CI, 0.16–1.00; specificity, 0.97; 95% CI, 0.82–0.99) and myocardial infarction (sensitivity, 0.86; 95% CI, 0.57–0.98; specificity, 0.94; 95% CI, 0.71–0.99).[18,19] Additional observational studies included in the review were used to estimate individual positive predictive values for cardiac tamponade, pericardial effusion, pulmonary embolism, myocardial infarction, aortic dissection and hypovolemia in small subsets of patients with cardiac arrest in any setting. The estimates of positive predictive value had very wide confidence intervals and were considered difficult to interpret. It was noted that all studies had a high risk of bias related to both selection bias and ascertainment bias, and most had verification bias. The authors also noted that there is evidence showing that point-of-care ultrasound may increase the length of pauses during chest compressions.[7,19]

American Red Cross
Training Services

Using Point-of-Care Ultrasound During Resuscitation from Cardiac Arrest

Q Research Findings*

Point-of-Care Ultrasound:

→ Shown to have variable predictive values for identifying reversible causes of cardiac arrest

→ Requires procedural skill and correct interpretation of results

→ Potential for increased pauses during CPR

KEY POINTS

Point-of-Care Ultrasound Use:

→ Should not be routinely used during CPR to diagnose reversible causes (i.e., tamponade).

→ Should not have a role in prognostication.

→ Should not interrupt high-quality CPR.

→ May be considered as an additional diagnostic tool to assess for suspected, reversible causes of cardiac arrest by healthcare professionals skilled in its use.

*Reynolds JC, Nicholson T, O'Neil B, Drennan IR, Issa M, Welsford M. Diagnostic test accuracy of point-of-care ultrasound during cardiopulmonary resuscitation to indicate the etiology of cardiac arrest: A systematic review. *Resuscitation.* Mar 2022;172:54-63. doi:10.1016/j.resuscitation.2022.01.006

Weak recommendations by ILCOR suggest against routine use of point-of-care ultrasound during CPR to diagnose reversible causes of cardiac arrest. However, the recommendations by ILCOR suggest that if point-of-care ultrasound can be performed by experienced personnel without interrupting CPR, it may be considered as an additional diagnostic tool when clinical suspicion for a specific reversible cause is present. A good practice statement was also made that any deployment of diagnostic point-of-care ultrasound during CPR should be carefully considered and weighed against the risks of interrupting chest compressions and misinterpreting the sonographic findings.[7,19]

Insights and Implications

A previous ILCOR systematic review assessed the prognostic use of point-of-care ultrasound during CPR to predict clinical outcomes in adults with nontraumatic IHCA or OHCA.[21] The included studies reported a wide range of sensitivities and specificities for cardiac motion in association with favorable clinical outcomes, informing the Red Cross guidelines against the use of point-of-care ultrasound during CPR for prognostication. The Red Cross guidelines have been updated for clarity and to note that use of point-of-care ultrasound should not interfere with resuscitation or providing high-quality CPR. The guideline recommendation against the use of point-of-care ultrasound for prognostication remains unchanged.

Special Circumstances

Interventions for Cardiac Arrest from Pulmonary Embolism

Fibrinolytic drugs are an option to consider for patients in cardiac arrest due to known or suspected pulmonary embolism. Evidence to support their use is limited, with most studies in a 2020 ILCOR systematic review not finding a difference in survival outcomes with the use of fibrinolytics compared with placebo during cardiac arrest.[21] Evidence to support the use of surgical embolectomy and percutaneous mechanical thrombectomy was limited to case series. Is there new evidence to support or change guidelines?

Red Cross Guidelines

UPDATED
- Fibrinolytic therapy, surgical embolectomy or percutaneous mechanical thrombectomy may be considered for cardiac arrest due to known or suspected pulmonary embolism.

Evidence Summary

An evidence update[7] of a 2020 ILCOR systematic review[21] on alterations in treatment algorithms for cardiac arrest due to pulmonary embolism or suspected pulmonary embolism identified relevant observational studies of thrombolysis with a limited number of patients and yielding divergent results. An update to the systematic review is unlikely to change current treatment recommendations.

Insights and Implications

The Red Cross guidelines have been updated to include the options of surgical embolectomy or percutaneous mechanical thrombectomy when pulmonary embolism is the known or suspected cause of cardiac arrest.

Interventions for Cardiac Arrest from Hyperthermia

Heat waves are associated with significant numbers of casualties. Both exertional hyperthermia and heatstroke can result in multi-organ failure, but in some cases, they present with cardiac arrest.

Red Cross Guidelines

- For cardiac arrest initiated by hyperthermia:

  UPDATED
  - Begin cardiac resuscitation as per standard approaches.

  REAFFIRMED
  - Initiate hyperthermic protocols for cooling, including environmental manipulation and evaporative cooling, if feasible, during resuscitation. Immersion during CPR is not recommended.

Evidence Summary

A 2022 triennial review of an American Red Cross Scientific Advisory Council scientific review[22] looked for evidence related to the management of hyperthermia-induced cardiac arrest. No relevant studies were identified in a literature search spanning from 2017 to 2022. The Resuscitation Subcouncil noted that it is not feasible to immerse a person in water and simultaneously provide CPR, and there is no role for an mCPR device as the device cannot be submerged. Observational studies from the previous 2017 American Red Cross Scientific Advisory Council review showed an association of higher ambient heat with higher mortality, but there were no intervention assessments.[23,24] There are studies indicating that effectiveness of CPR in hot environments is diminished.[25,26] The American Red Cross Scientific Advisory Council recommendations and guidelines remain unchanged apart from minor wording changes for clarity.

Insights and Implications

Climate change is impacting public health. A recent systematic review[27] with meta-analysis looked at the effects of heat exposure (high temperatures and heat waves) on cardiovascular disease outcomes, including mortality and morbidity. Results showed that a 1° C increase in temperature was positively associated with cardiovascular disease-related mortality, and the overall risk of cardiovascular disease-related mortality increased by 2.1% (RR, 1.021; 95% CI, 1.020–1.023). A 1° C temperature rise was associated with a significant increase in arrhythmias and cardiac arrest, while heat waves were significantly associated with an 11.7% increase in risk of mortality (RR 1.117; 95% CI, 1.083–1.141). The mortality risk increases with increasing heat wave intensity.[27] Future research is needed to evaluate clinical outcomes of cooling measures during resuscitation of patients with heatstroke-induced or exertional hyperthermia-induced cardiac arrest, including veno-arterial extracorporeal membrane oxygenation (ECMO).

Post-Cardiac Arrest Care

Post-Cardiac Arrest Coronary Angiography

A 2021 systematic review[28] and CoSTR[29,30] by ILCOR evaluated evidence to support early versus late coronary angiography following cardiac arrest of suspected cardiac etiology with ROSC, with or without ST-elevation on electrocardiogram (ECG). Results of this review informed the 2021 Red Cross guidelines. A new RCT[31] on this topic has since been identified, and for 2022, the CoSTR[7,32] has been updated with the search strategy restricted to RCTs published since the prior search was run.

Red Cross Guidelines

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

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

Evidence Summary

A 2021 ILCOR systematic review[30,33] of early versus late coronary angiography in comatose patients following cardiac arrest of suspected cardiac etiology with ROSC was updated[7,32] to include a single new RCT,[31] allowing additional meta-analyses of some outcomes for patients without ST-segment elevation on post-ROSC ECG. The overall results of the revised meta-analyses are unchanged, and the ILCOR treatment recommendations are unchanged.[7,32]

Insights and Implications

The Red Cross guideline wording reflects the finding that for post-cardiac arrest patients without ST-segment elevation on ECG, regardless of a shockable or non-shockable presenting cardiac arrest rhythm, there was insufficient evidence to show improved outcomes with early coronary angiography. Early coronary angiography is an accepted standard of care for ST-elevation myocardial infarction (STEMI) without cardiac arrest. No evidence was found in the ILCOR systematic review to alter this strategy for patients with ST-segment elevation following cardiac arrest with ROSC.
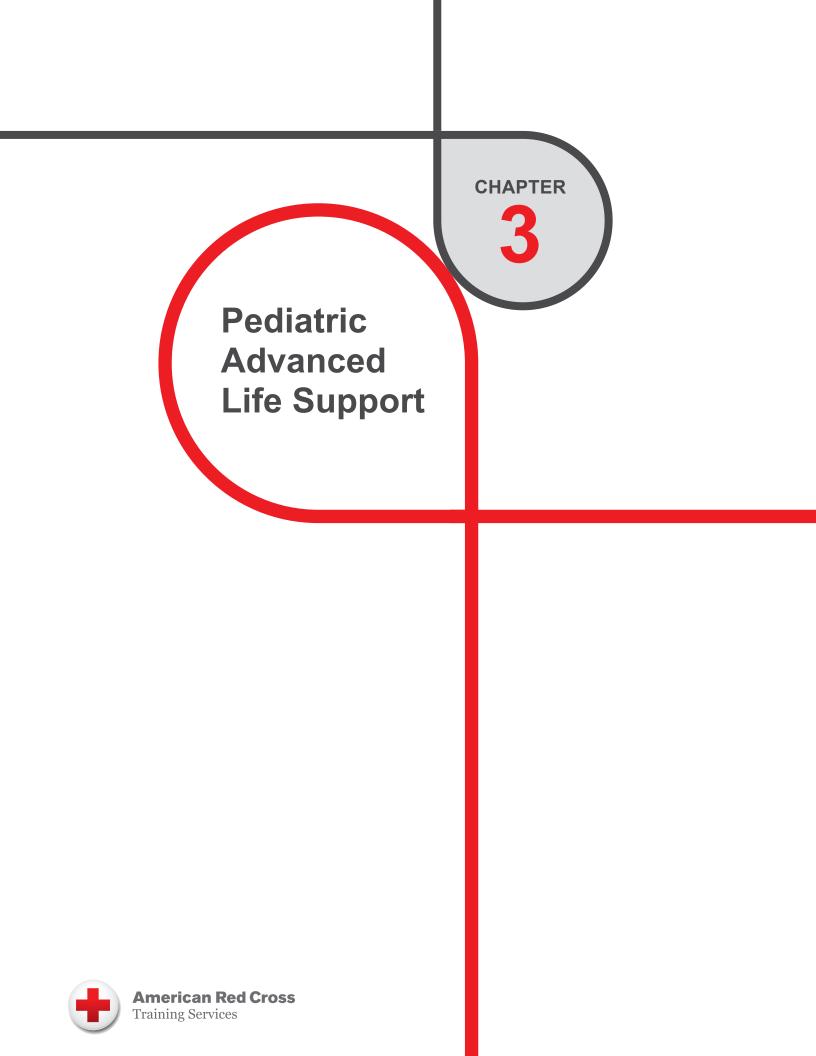
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Pediatric Advanced Life Support

American Red Cross
Training Services

Early Access

Public Access Defibrillation Programs for Infants, Children and Adolescents

Out-of-hospital cardiac arrest (OHCA) is rare in infants and children, and unlike adults, is less likely to be due to a primary cardiac event and more likely the result of a respiratory issue or trauma. Is there evidence to support the use of public access AEDs in pediatric OHCA?

Red Cross Guidelines

UPDATED

- Public access defibrillation may be used in infants, children and adolescents for out-of-hospital cardiac arrest. If available, pediatric-specific automated external defibrillator pads or electrical settings should be used for infants and children 8 years of age or younger or weighing 25 kilograms or less.

Evidence Summary

A 2022 systematic review[1] and Consensus on Science with Treatment Recommendations (CoSTR)[2,3] by the International Liaison Committee on Resuscitation (ILCOR) evaluated the evidence for the application of, or shock delivery from, an AED by lay rescuers to infants, children and adolescents with nontraumatic OHCA compared with standard care without AED application and use. Four observational studies were identified, including three[4-6] from the Cardiac Arrest Registry to Enhance Survival (CARES) database. Data from the CARES studies was used to calculate the relative risk of survival if an AED was applied and analyzed by age group for infants less than 1 year of age, children 1 to 12 years of age, and adolescents from 13 to 18 years of age. The relative risk of survival to hospital discharge with a Cerebral Performance Category (CPC) score of 1 to 2, and for survival to hospital discharge was found to be significantly improved with AED application in all age groups except for the under 1 year age group.[1,3]

A weak recommendation was made by ILCOR suggesting the use of an AED by lay rescuers for all children over 1 year of age who have a nontraumatic OHCA.[2,3] No recommendation was made for or against the use of an AED by lay rescuers for infants under 1 year of age with a nontraumatic OHCA. The authors noted the limited evidence available, including a small percentage of children (1.5%) from the CARES database who had an AED applied and a small percentage of children (3.7%) in the fourth observational study[7] who had a shock delivered. Only 12 patients in the under 1 year age group had an AED applied, with one survival. Because this may result in a false negative result, a recommendation was not made by ILCOR for this age group.

Insights and Implications

Cardiac arrest in children is commonly preceded by a respiratory event and hypoxemia. As would be expected, ventilations with compressions have been shown to be vitally important for successful resuscitation.[8] The application of an AED may delay starting CPR or increase pauses in CPR, which could be potentially detrimental. The review authors acknowledge this but note the relative risk was still significantly in favor of AED application.[2,3] While OHCA is less common in infants and children than in adults, shockable rhythms do occur in this population.

Despite the lack of evidence in the ILCOR review to support the public use of AEDs for infants with OHCA, there is no evidence to suggest harm from their use. Although the application of an AED may cause a slight pause in CPR, that determinant is outweighed by the lifesaving benefit in infants and children with shockable rhythms.

Pediatric Early Warning Systems

A significant percentage of in-hospital pediatric serious events and deaths have been shown to be associated with a failure to detect and respond to clinical deterioration.[9] This has led to the development of tools for use in the healthcare setting, including pediatric early warning systems (PEWS), to alert healthcare professionals to clinical deterioration through periodic observation of physiologic parameters, application of a scoring system and criteria for triggering communication and an appropriate response. Is there clinical evidence to support the use of PEWS?

Red Cross Guidelines

NEW

- Pediatric early warning systems may be used as part of a larger framework to reduce serious safety events by identifying and responding to hospitalized infants, children and adolescents who may either be at risk for deterioration or be deteriorating clinically.

Evidence Summary

A 2022 systematic review[10] and CoSTR[2,11] by ILCOR evaluated the use of PEWS, with or without rapid response teams or medical emergency teams, in hospitalized infants, children and adolescents compared with standard care without a scoring system. The review included a single randomized controlled trial (RCT)[12] and multiple cohort studies; the certainty of evidence was rated as very low across all outcomes due to very serious risk of bias and imprecision. No significant difference in mortality, cardiopulmonary arrest events or significant deterioration events was shown with the use of PEWS compared with no PEWS. However, there was a trend toward increased mortality in the pooled analysis for the no PEWS group and toward both increased cardiopulmonary arrests and increased significant clinical deterioration events with no PEWS. For the outcome of unplanned code events, a statistically significant increase in unplanned code events was demonstrated with no PEWS compared with the PEWS group (pooled IRR/RR, 1.73, 95% CI, 1.01–2.96). A weak recommendation by ILCOR suggests using PEWS to monitor hospitalized children with the aim of identifying those who may be deteriorating.[2,11]

Insights and Implications

Pediatric early warning systems are one component of an organization strategy used in many hospitals to help healthcare professionals recognize children who are either at risk for clinical deterioration or who are clinically deteriorating, using established criteria, and to accelerate an urgent response through a clear communication plan. Pediatric early warning systems should support, but not be a replacement for, clinical judgement. Many variations of PEWS exist, with a wide range of sensitivities and specificities for detecting clinical deterioration.[13] Other components of a rapid response system include having the necessary personnel and resources for response, such as a medical emergency team or rapid response team, that focuses on correcting the deteriorating child's physiology, a process-monitoring and improvement plan, and an administrative structure to implement and support the system.[14,15]

Pediatric Early Warning Systems (PEWS)

About PEWS

→ Tool to identify hospitalized children at increased risk of deterioration

→ Scoring system based on vital signs and clinical findings

→ Uses criteria to alert healthcare professionals and trigger response

→ Goal is to eliminate preventable codes

→ Many variations of PEWS in use

Research Findings*

→ Implementing a PEWS to monitor hospitalized children was associated with:

→ A reduction in unplanned code events

→ Reduced mortality

KEY POINT

PEWS should support, NOT replace, clinical judgement!

Used as part of a larger framework

To reduce serious safety events

By identifying/ responding to hospitalized children

Who maybe at risk for clinical deterioration

*Chong SL, Goh MSL, Ong GY, et al. Do paediatric early warning systems reduce mortality and critical deterioration events among children? A systematic review and meta-analysis. *Resusc Plus*. Sep 2022;11:100262. doi:10.1016/j.resplu.2022.100262

Pediatric CPR: Techniques and Process

Compression-to-Ventilation CPR Ratio for Infants and Children: Healthcare Professionals

Since 2015, it has been recommended by the Red Cross that lay responders and healthcare professionals provide rescue breaths and chest compressions for infants and children with IHCA and OHCA. It has also been a Red Cross guideline recommendation that if someone is unwilling or unable to provide ventilations (i.e., mouth-to-mouth, mouth-to-mask) for infants and children in cardiac arrest, they should at least perform chest compressions. Is there new evidence to support these recommendations?

Red Cross Guidelines

REAFFIRMED • For children and infants, a compression-to-ventilation ratio of 30:2 should be used by one healthcare professional and a ratio of 15:2 should be used by two healthcare professionals, while a ratio of 30:2 should be used by a lay responder.

REAFFIRMED • For children and infants with an advanced airway in place, healthcare professionals should deliver 1 ventilation every 2 to 3 seconds (20 to 30 breaths per minute) with continuous compressions.

REAFFIRMED • Compression-only CPR may be used as an alternative to CPR with compressions and ventilations when someone is unwilling or unable to provide ventilations.

Evidence Summary

An evidence update[2] of a 2017 ILCOR CoSTR[16] on compression-only CPR (CO-CPR) in pediatric patients identified one relevant study. A retrospective review of data from the CARES database evaluated 13,060 pediatric (18 years of age or younger) nontraumatic OHCAs.[17] In multivariable analysis of the overall cohort, neurologically favorable survival was associated with rescue breathing-CPR (RB-CPR) (aOR, 2.16; 95% CI, 1.78–2.62) and with CO-CPR (aOR, 1.61; 95% CI, 1.34–1.94) compared with no CPR. Rescue breathing CPR was associated with higher odds of neurologically favorable survival compared with CO-CPR (aOR, 1.36; 95% CI, 1.10–1.68). Risk stratification by age group was also reported. For the comparison of RB-CPR with no CPR, adjusted OR for neurologically favorable survival was greater for infants less than 1 year of age (aOR, 1.65; 95% CI, 1.19–2.3; P<0.003), children (1 to 11 years of age) (aOR, 2.73; 95% CI, 2.00–3.72; P<0.001) and adolescents (12 years of age or older) (aOR 2.12; 95% CI, 1.44–3.11; P<0.001). When comparing data for patients who received CO-CPR with data for patients with no CPR, CO-CPR was associated with better neurologically favorable survival in children (aOR 1.94; 95% CI, 1.41–2.68; P<0.001) and adolescents (aOR, 1.71; 95% CI, 1.23–2.37; P<0.001), but not for infants (aOR, 1.16; 95% CI, 0.083–1.62; P=0.294).[17]

The identified study was considered supportive of current ILCOR recommendations for providing rescue breathing with chest compressions in pediatric IHCA and OHCA, and to provide CO-CPR when rescuers are unwilling or unable to provide rescue breathing.[2] The evidence update authors noted that a previously identified study from 2010[18] found that CO-CPR for infants was not associated with a more favorable neurologic outcome compared with no CPR. Although the new study[17] also found that CO-CPR was not associated with better neurologically favorable survival for infants compared with no CPR, the ILCOR Pediatric Task Force continues to recommend CO-CPR for infants in cardiac arrest when rescuers are unwilling or unable to provide rescue breathing.[2]

Insights and Implications

The Red Cross guidelines for the use of conventional compression-ventilation CPR (CV-CPR) in children and infants and for the use of CO-CPR when someone is unwilling or unable to provide ventilations are reaffirmed with this ILCOR evidence update. Further studies are needed to determine the benefit of CO-CPR for infants.

Extracorporeal CPR for Cardiac Arrest

Extracorporeal CPR (ECPR) is a resuscitative technique that involves withdrawal and reperfusion of oxygenated blood back into the patient's body, with support of circulation through the addition of an external pump. By definition, ECPR occurs when extracorporeal membrane oxygenation (ECMO) flow is instituted during resuscitation to support perfusion or within 20 minutes of return of spontaneous circulation (ROSC) without ongoing compressions.[19] Patients cannulated after 20 minutes of sustained ROSC are considered to receive veno-arterial ECMO rather than ECPR. The goals of ECPR with ECMO during cardiopulmonary arrest are to deliver oxygen, support perfusion, remove carbon dioxide and decrease ischemic reperfusion injury. What evidence supports the use of ECPR for cardiac arrest?

Red Cross Guidelines

NEW

- Extracorporeal CPR, or cardiopulmonary resuscitation with extracorporeal membrane oxygenation, may be considered on a case-by-case basis for select populations (i.e., children with cardiac disease) with in-hospital cardiac arrest refractory to conventional resuscitation in settings where capability and defined protocols exist.

Evidence Summary

A 2022 evidence update[2] of a 2018 ILCOR systematic review[20] and CoSTR[21] sought evidence for children in cardiac arrest in any setting comparing the use of ECPR, including ECMO therapy or cardiopulmonary bypass during cardiac arrest, compared with conventional manual or mechanical CPR. Relevant publications identified included systematic reviews and RCTs published prior to the search timeline but with secondary analyses, and multiple observational studies including case series and analyses of registry data. The authors of the evidence update noted that reporting of studies using ECPR is heterogeneous and not standardized, and numerous knowledge gaps remain when comparing ECPR following a period of conventional CPR delivered with manual or mechanical compressions with conventional CPR alone. In addition, there are insufficient studies of pediatric OHCA and non-cardiac children with IHCA treated with ECPR to provide guidance for these populations.[2]

The ILCOR treatment recommendations remain unchanged and suggest that CPR with ECPR may be considered as an intervention for select infants and children (e.g., cardiac populations) with IHCA refractory to conventional CPR in settings where resuscitation systems allow ECPR to be well performed and implemented.[21] There continues to be insufficient evidence in pediatric OHCA to formulate a recommendation for the use of ECPR.

Insights and Implications

Survival to hospital discharge following ECPR in children has been reported to range from 37% to 44%.[22] Compared with adults, survival to hospital discharge is higher for children receiving ECPR.[19] The Red Cross guidelines for implementation of ECPR are informed by the 2019 ILCOR CoSTR[21] and 2022 evidence update.[2] The use of ECPR requires rapid deployment of a complex process involving a well-organized team, using a local protocol and coordination of multiple simultaneous tasks including patient selection, organizing the team and ECMO equipment, and provision of high-quality CPR while cannulating the patient. Resource requirements are high, and the process is typically limited to healthcare institutions with capability. More research is needed to determine which patients may benefit the most, long-term clinical outcomes, cost effectiveness, and to answer questions about the process and peri-procedure interventions.

Drug Therapy and Vascular Access

Mannitol or Hypertonic Saline for Acute Major Traumatic Brain Injury

Mannitol and hypertonic saline are osmotic diuretics commonly used to treat cerebral edema and increased intracranial pressure (ICP) in patients with traumatic brain injury (TBI). The choice of which agent to use is frequently based on local protocol. Are clinical outcomes improved with the use of hypertonic saline compared with mannitol for patients with acute major TBI and elevated ICP?

Red Cross Guidelines

- Mannitol or hypertonic saline may be given to patients with:

REAFFIRMED
  - Traumatic brain injury (TBI) who have a monitored elevation in intracranial pressure (ICP).

REAFFIRMED
  - Signs of transtentorial herniation prior to ICP monitoring.

UPDATED
  - Progressive neurological deterioration not due to extracranial causes.

NEW
- Arterial hypotension (systolic blood pressure less than 90 mmHg) should be avoided in patients with intracranial hypertension.

- For pediatric patients with major TBI and acute intracranial hypertension:

NEW
  - Hypertonic saline is preferred over mannitol to lower the ICP to less than 20 mmHg.

NEW
  - A bolus of hypertonic saline (3%) is recommended at a dose between 2 and 5 milliliters per kilogram of body weight (2 mL/kg to 5 mL/kg) over 10 to 20 minutes.

NEW
  - A continuous infusion of 3% hypertonic saline is suggested at a rate between 0.1 mL/kg and 1.0 mL/kg per hour. The minimum dose needed to maintain ICP less than 20 mmHg is suggested.

NEW
  - A bolus of 23.4% hypertonic saline is suggested for refractory ICP. The suggested dose is 0.5 mL/kg with a maximum of 30 mL.

NEW
  - A serum sodium level of greater than 170 milliequivalents per liter (mEq/L) for a sustained period (greater than 72 hours) should be avoided to preclude complications of thrombocytopenia and anemia, and a sustained serum sodium greater than 160 mEq/L should be avoided to preclude the complication of deep venous thrombosis.

UPDATED
  - Mannitol may be considered to lower the ICP in situations where hypertonic saline cannot be used. A bolus of 0.25 to 1 gram per kilogram of body weight (0.25 g/kg to 1 g/kg) over 10 minutes is suggested.

Evidence Summary

A 2022 triennial review of a 2019 American Red Cross Scientific Advisory Council scientific review[23] of this topic identified two systematic reviews[24,25] and two randomized trials of pediatric patients.[26,27] The first systematic review from 2015 included seven relevant manuscripts comparing hypertonic saline to mannitol in TBI.[24] The authors found that both agents were effective osmolar diuretics, however, there was heterogeneity between studies and the findings were inconclusive regarding which agent was more effective.

A 2020 Cochrane systematic review[25] included six trials with 91% of participants having severe TBI. Meta-analysis for outcomes of mortality at final follow-up and for a poor outcome was only possible for two trials but was challenged by a high loss to follow-up with survivors at 6 months. Based on calculated worst-case, best-case and per-protocol results, no difference in mortality at 6 months or for poor outcome based on Glasgow Outcome Scale was shown for hypertonic saline versus mannitol. Meta-analysis for the outcome of change in ICP was not possible due to heterogeneity between studies, including variation in modes of drug administration, follow-up times, and

ways of reporting changes in ICP. Results of trials were reported narratively. Both hypertonic saline and mannitol tended to be reported as effective in reducing elevated ICP, but greater benefits were noted in some studies with hypertonic saline. Rebound phenomenon following use of mannitol was reported in one trial, and no other adverse effects were reported in the remaining trials.

A randomized trial of 200 pediatric intensive care unit (PICU) patients with elevated ICP found that 3% sodium chloride decreased coma in patients compared to mannitol, however without a mortality benefit.[26] Mannitol was associated with acute tubular necrosis in this trial.

A 2022 trial, Approaches and Decisions for Acute Pediatric TBI (ADAPT) compared the effect of bolus doses of 3% hypertonic saline versus mannitol on ICP and included data from 518 children with severe TBI.[27] The data showed a statistically significant decrease in ICP and increase in cerebral perfusion pressure (CPP) with hypertonic saline bolus administration, while mannitol was observed to increase CPP. Hypertonic saline was associated with a greater reduction in ICP compared with mannitol using unadjusted data, but after adjusting for confounders, associations of both agents with ICP and CPP were not different. During periods of increased ICP, greater improvements in outcomes were observed with 3% hypertonic saline than with mannitol. This difference persisted with adjusted data for ICP greater than 25 mmHg.

The Brain Trauma Foundation Guidelines for the Management of Pediatric Severe TBI, published in 2019, is based on a systematic review and synthesis of the literature with evidence-based recommendations.[28] Recommendations include the use of a bolus dose of 3% hypertonic saline for acute intracranial hypertension, while a continuous infusion is suggested using the minimum dose needed to maintain an ICP of less than 20 mmHg. No studies using mannitol were identified as meeting inclusion criteria in the development of the pediatric severe TBI guidelines.

Insights and Implications

The ADAPT trial is the first to compare bolus 3% hypertonic saline with mannitol in pediatric patients with severe TBI.[27] Results from this trial demonstrated a modest decrease in ICP and increase in CPP with hypertonic saline and increased CPP with mannitol. The Cochrane review[25] also noted that improved outcomes of ICP reduction were reported with hypertonic saline. Long-term clinical outcomes with treatment, however, are lacking with the exception of mortality, which was not shown to be improved with hypertonic saline compared with mannitol.[26]

When choosing an osmolar diuretic, one must consider that the hyperosmolar state induced by hypertonic saline can be associated with a higher risk of kidney injury, congestive heart failure, pulmonary edema and, after repeated doses, with hyperchloremic acidosis.[29] Mannitol was associated with acute tubular necrosis in one included study.[26] Hypertonic saline may thus be more appropriate in patients with decreased renal perfusion. Additional controlled trials are needed comparing hypertonic saline with mannitol to determine efficacy for lowering ICP, short- and long-term neurologic and survival outcomes, and adverse effects or limitations. Future studies that demonstrate a definitive improvement in outcomes or harmful effects may result in a change in recommendations.

The most recent (2019) Brain Trauma Foundation guidelines[28] were used to inform Red Cross guidelines related to use of hypertonic saline in pediatric severe TBI and for avoiding complications related to hypernatremia.

Treatment of Bradycardia: Drugs and Transcutaneous Pacing

Sinus bradycardia with adequate perfusion typically does not require immediate intervention beyond supportive care and treatment of reversible causes. When bradycardia is accompanied by inadequate perfusion, a first step is to ensure that oxygenation and ventilation are adequate. When the heart rate is 60 beats per minute or less, chest compressions should be started. Epinephrine is the cornerstone of drug therapy when bradycardia with inadequate perfusion is present despite adequate oxygenation and ventilation, while transcutaneous or transvenous pacing may be needed for some types of bradycardias and/or if there is no response to drug therapy. Evidence updates were recently completed on these topics by ILCOR.[2]

Red Cross Guidelines

REAFFIRMED • For infants and children with bradycardia with inadequate perfusion, assurance of adequate oxygenation and ventilation must be the initial intervention.

REAFFIRMED • For infants and children with bradycardia with inadequate perfusion and a heart rate of 60 beats per minute or less despite adequate oxygenation and ventilation, chest compressions should be initiated.

REAFFIRMED • For infants and children with bradycardia with inadequate perfusion that is unresponsive to oxygenation and ventilation, drug therapy may begin with epinephrine.

REAFFIRMED • For infants and children with bradycardia with inadequate perfusion in the setting of increased vagal tone or atrioventricular (AV) block, or if there is no response to epinephrine, atropine may be considered.

REAFFIRMED • Transcutaneous pacing may be considered for some types of bradycardias, such as in the setting of complete AV block and/or if there is no response to drug therapy.

Evidence Summary

The topic of drugs for pediatric bradycardia with hemodynamic compromise was last reviewed by ILCOR in 2020,[30] with no new evidence to add to a 2010 CoSTR.[31] ILCOR treatment recommendations have been unchanged since 2010 and state:[31]

• Epinephrine may be used for infants and children with bradycardia and poor perfusion that is unresponsive to ventilation and oxygenation.

• It is reasonable to administer atropine for bradycardia caused by increased vagal tone or cholinergic drug toxicity.

• There is insufficient evidence to support or refute the routine use of atropine for pediatric cardiac arrest.

A 2022 ILCOR evidence update[2] on this topic identified three relevant observational retrospective studies.[32-34] Two studies[32,33] used the same population, with one[33] adding 2 more years of data analyzed with a time-dependent propensity score matching. An association was found between epinephrine use and a worse prognosis with the Holmberg study,[33] although it was noted by the evidence update authors that the study analysis was complex and there were many confounders. The third review[34] used a different population, reporting no differences in

epinephrine use between patients with bradycardia compared with patients with other rhythms. The ILCOR Pediatric Task Force discussed the evidence and concluded that the new evidence does not impact current recommendations or prompt a formal updated systematic review. ILCOR 2010 treatment recommendations for pharmacotherapy of bradycardia remain unchanged.[2]

A separate evidence update was completed by ILCOR on the topic of transcutaneous pacing for symptomatic bradycardia in pediatric patients.[2] No pediatric-specific literature was identified and treatment recommendations remain unchanged since a 2000 ILCOR and American Heart Association review[35] that noted in select cases of bradycardia caused by complete heart block or abnormal function of the sinus node, emergency transthoracic pacing may be lifesaving. Pacing is not helpful in children with bradycardia secondary to a post-arrest hypoxic/ischemic myocardial insult or respiratory failure. In addition, pacing was not shown to be effective in the treatment of asystole in children.[35]

Insights and Implications

The Red Cross guidelines for drug therapy and pacing of pediatric bradycardia with inadequate perfusion are informed by the ILCOR CoSTR.[30] With the latest evidence updates, the current guidelines are reaffirmed.

Sodium Bicarbonate Administration for Cardiac Arrest

Sodium bicarbonate was once proposed to reduce metabolic acidosis during CPR but has not been shown to improve outcomes with resuscitation. The routine use of sodium bicarbonate in the management of pediatric cardiac arrest has not been recommended since 2010. Evidence updates were completed by ILCOR most recently in 2020[30] and 2022.[2]

Red Cross Guidelines

REAFFIRMED • Routine use of sodium bicarbonate is not recommended in pediatric cardiac arrest.

REAFFIRMED • Administration of sodium bicarbonate may be considered in pediatric cardiac arrest associated with:

  ◦ Hyperkalemia or sodium channel blocker (i.e., tricyclic antidepressant) toxicity.

  ◦ Severe metabolic acidosis (pH less than 7.15), including after prolonged cardiac arrest/resuscitation, that persists despite adequate oxygenation and ventilation.

Evidence Summary

A 2022 evidence update[2] by ILCOR on the use of sodium bicarbonate for children in cardiac arrest did not identify new evidence since the previous update in 2020.[30] When first reviewed by ILCOR in 2010, no randomized controlled trials in infants and children evaluating the use of sodium bicarbonate in pediatric cardiac arrest were identified.[31]

A 2015 retrospective review[36] of sodium bicarbonate use during in-hospital pediatric cardiac arrest using data adjusted for confounders found that sodium bicarbonate was associated with decreased survival to hospital discharge; however, for patients with metabolic and electrolyte abnormalities, hyperkalemia, and toxic syndromes, sodium bicarbonate was not associated with decreased survival.

The 2022 evidence update identified an American Heart Association guideline noting observational studies that reported that sodium bicarbonate administration during IHCA and OHCA was associated with worse survival outcomes.[37] The guideline noted that sodium bicarbonate may be indicated in cardiac arrest with special circumstances, such as hyperkalemia and sodium channel blocker toxicity. A 2021 systematic review with meta-analysis of non-randomized studies between 2006 and 2018 evaluated sodium bicarbonate administration during 4,877 pediatric IHCAs, finding decreased survival to hospital discharge (OR, 0.40; 95% CI, 0.25–0.63, *P*=0.0003).[38] The authors of the current ILCOR Evidence Update concluded that this study supports current guidelines.

Insights and Implications

While routine administration of sodium bicarbonate is not recommended by the Red Cross for pediatric cardiac arrest, it is recognized that there may be situations in which sodium bicarbonate may be considered, despite a lack of significant evidence. This includes cardiac arrest associated with hyperkalemia and sodium channel (i.e., tricyclic antidepressant) toxicity and with severe metabolic acidosis, including after prolonged cardiac arrest/resuscitation, that persists despite adequate oxygenation and ventilation.

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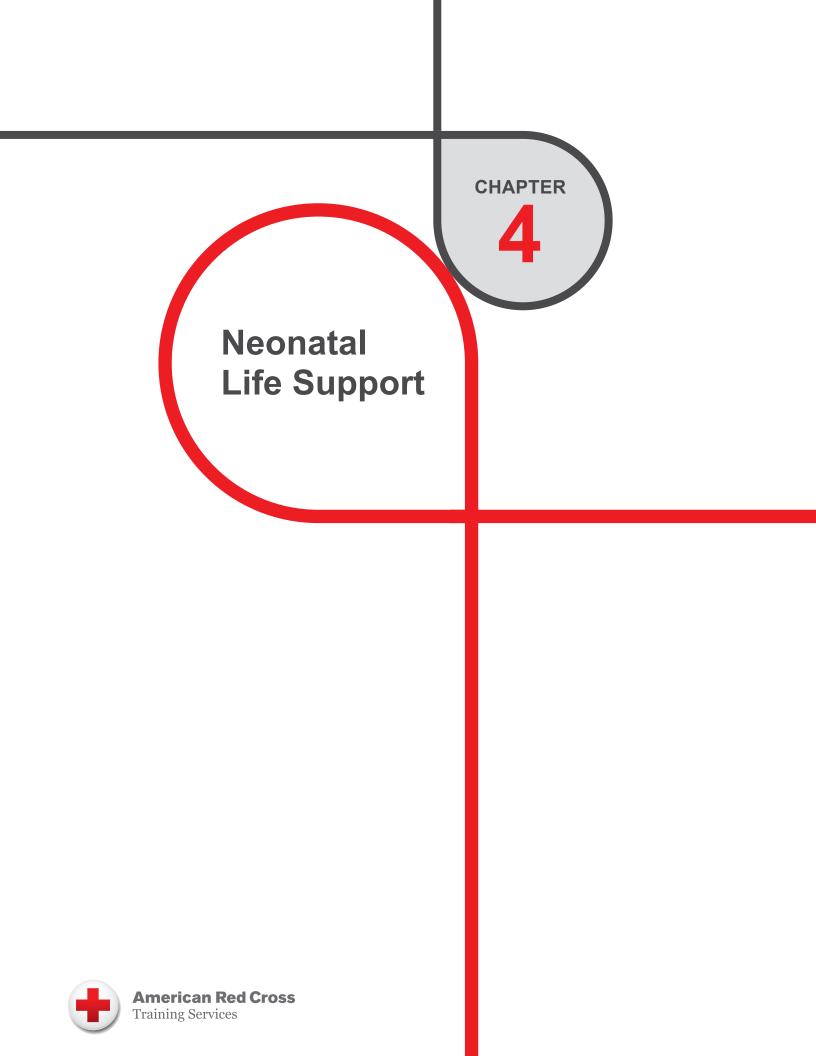
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Neonatal Life Support

American Red Cross
Training Services

Neonatal Resuscitation

Suctioning Clear Amniotic Fluid at Birth

Suctioning of the mouth and nose in newborn infants has been a common practice intended to clear the upper airway of amniotic fluid and to support breathing. Evidence identified in a 2010 International Liaison Committee on Resuscitation (ILCOR) Consensus on Science with Treatment Recommendations (CoSTR) suggested that routine suctioning of healthy neonates is associated with cardiorespiratory complications.[1] Routine suctioning of newborns with clear or meconium-stained amniotic fluid has not been recommended since that time. Other guidelines have recommended the use of suctioning for suspected airway obstruction or when positive pressure ventilations (PPVs) are needed.[2] Is there evidence of benefit or harm from suctioning the mouth and nose of newborns?

Red Cross Guidelines

NEW
- The routine suctioning of clear amniotic fluid from the mouth and nose of newborn infants immediately after birth is not indicated.

UPDATED
- For suspected airway obstruction, immediate airway repositioning is indicated and suctioning should be considered. Suctioning should be brief and begin with the mouth before the nose.

Evidence Summary

A 2022 ILCOR systematic review[3] and CoSTR[4,5] of newborn infants born through clear amniotic fluid sought evidence comparing the initial suctioning of the mouth and nose compared with no initial suctioning. The review identified nine randomized controlled trials (RCTs) and two observational studies of primarily full-term infants.[3] Clinical benefit or harm could not be excluded in this review for the primary outcomes of receiving assisted ventilation and receiving advanced resuscitation and stabilization interventions (intubation, chest compressions and epinephrine in the delivery room). In addition, clinical benefit or harm could not be excluded for secondary outcomes of receipt and duration of oxygen supplementation, heart rate at 5 minutes, respiratory rate greater than 60 breaths per minute in the first 24 hours and multiple other secondary outcomes. The authors of the review concluded that no benefit from routine suctioning of clear amniotic fluid was found.[4,5] A consistent trend of lower oxygen saturations with suctioning in the first few minutes of life was noted on graphical displays in some studies. This was supported by studies showing that the time needed to achieve target oxygen saturations was longer for infants who received suctioning at birth. A good practice statement was made that airway positioning and suctioning should be considered if airway obstruction is suspected.[4,5]

Routine Suctioning of Amniotic Fluid at Birth

→ Was once a common practice to clear amniotic fluid from upper airway

→ Not recommended because of possible association with cardiorespiratory complications

→ May stimulate vagally-mediated bradycardia

→ May delay start of ventilations in nonbreathing newborn

🔍 Research Findings*

→ No clinical benefit from suctioning clear amniotic fluid following birth

→ Some suggestion of oxygen desaturation with suctioning

🔑 KEY POINTS

→ Routine suctioning of clear amniotic fluid from the mouth and nose of newborns immediately after birth is not indicated.

→ For suspected airway obstruction, immediately reposition the airway and consider a brief trial of suctioning beginning with the mouth before the nose.

*Fawke J, Wyllie J, Udaeta E, et al. Suctioning of clear amniotic fluid at birth: A systematic review. *Resusc Plus.* Dec 2022;12:100298. doi:10.1016/j.resplu.2022.100298

Insights and Implications

While a benefit was not found with routine suctioning of the mouth and nose of infants born through non-meconium-stained amniotic fluid, there are concerns for potential harm. Suctioning the mouth and nose of infants born through clear, non-meconium-stained amniotic fluid has the potential to stimulate vagally mediated bradycardia and to delay the start of ventilations in nonbreathing infants. When airway obstruction is suspected, airway repositioning is indicated, and suctioning should be considered. Suctioning should be brief to avoid potential mucosal damage, prolonged hypoxia and vagally mediated bradycardia.

Tactile Stimulation for Resuscitation Immediately After Birth

Tactile stimulation has been recommended for decades for the initial management of infants with inadequate respiratory effort at birth. Forms of stimulation vary and may include rubbing the chest, sternum, back, or soles of the feet, and flicking the soles of the feet. This intervention has never been reviewed systematically to determine its effectiveness.

Red Cross Guidelines

NEW
- For newborn infants greater than 32 weeks' gestation with absent, intermittent or shallow respirations immediately after birth, it is reasonable to use tactile stimulation in addition to initial care including drying, stimulation and additional care to maintain temperature.

NEW
- Tactile stimulation should not delay the initiation of positive pressure ventilations for newborn infants who continue to have inadequate respiratory effort after birth despite initial care.

Evidence Summary

A 2022 ILCOR systematic review[6] and CoSTR[5,7] sought to compare the effectiveness of tactile stimulation with routine handling in newly born term and preterm infants. Eligible studies identified included two observational studies, but one was excluded from data analysis due to critical risk of bias. The remaining study[8] included 245 preterm infants on continuous positive airway pressure (CPAP) with clinical indications for tactile stimulation. Analysis of data from this study showed a reduction in tracheal intubation in infants who received tactile stimulation compared with no tactile stimulation (RR, 0.41; 95% CI, 0.20–0.85).[7] Anticipated absolute effects were risk with routine handling only (177 per 1,000) and risk difference with tactile stimulation in addition to routine handline, 105 fewer per 1,000 infants (95% CI, 142 fewer to 27 fewer). A weak recommendation was made by ILCOR suggesting that it is reasonable to apply tactile stimulation in addition to routine handling with measures to maintain temperature in newborn infants with absent, intermittent or shallow respirations during resuscitation immediately after birth. A good practice statement was made that tactile stimulation should not delay the initiation of PPV for newborn infants who continue to have absent, intermittent or shallow respirations after birth.[5,7]

In task force discussion, it was noted that the certainty of evidence from this single study is very low and results should be analyzed with caution because of indirectness (all infants were started on CPAP before tactile stimulation), possible selection bias and confounding.[7] Observational studies not included in the review due to lack of a control group reported that infants who received tactile stimulation responded with crying, grimacing and body movements. Other studies not included in the review included a comparison of back rubbing to foot

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flicking, reporting no difference between both techniques in achieving crying to prevent the need for PPV. One randomized controlled trial (RCT) commented on in the ILCOR CoSTR compared single versus repetitive tactile stimulation in newborn and preterm infants immediately after birth. Compared with the single tactile stimulation group, infants in the repetitive stimulation group had higher oxygen saturation levels and lower oxygen requirements at the start of transport to the neonatal intensive care unit.[5,7]

Insights and Implications

The Red Cross Scientific Advisory Council has expressed concern for the risk of intraventricular hemorrhage among preterm infants with a gestational age less than 32 weeks. The ILCOR systematic review included a single observational study[8] of 245 preterm newborn infants less than 32 weeks' of gestational age. This study showed tactile stimulation to be associated with a decreased need for tracheal intubation, but the evidence was deemed to be of very low certainty due to indirectness, possible selection bias, and confounding (retrospective analysis of tactile stimulation which could not be determined in 34% of the tactile stimulation episodes). No data was reported in this study for the outcome of intraventricular hemorrhage. Due to these concerns, the Red Cross guidelines limit the use of tactile stimulation to newborns at greater than 32 weeks' gestational age. Further research is needed to determine if tactile stimulation at birth has clinical benefits, which patients may benefit and the efficacy of different methods of tactile stimulation. The optimal duration for applying tactile stimulation is unknown, and there are concerns that tactile stimulation may delay initiation of ventilation after birth and compromise resuscitation or that it may cause soft tissue trauma.

Continuous Positive Airway Pressure for Term Infant Respiratory Distress in the Delivery Room

The use of CPAP has been found to be helpful for spontaneously breathing preterm newborn infants with breathing difficulty after birth or after resuscitation and is less invasive than intubation and PPV. The initial use of CPAP rather than intubation and intermittent PPV is suggested by ILCOR for spontaneously breathing preterm newborn infants with respiratory distress requiring respiratory support in the delivery room.[9] Since the incorporation of CPAP as a consideration into neonatal resuscitation program algorithms, an increase in pneumothorax has been reported in late preterm and term newborns who received CPAP in the delivery room, raising concerns over the safety of CPAP in this population.[10] The use of CPAP for preterm and term infants with respiratory distress in the delivery room has not been reviewed systematically until recently.

Red Cross Guidelines

NEW

- There is insufficient evidence to suggest for or against the routine use of continuous positive airway pressure (CPAP) compared with no CPAP for spontaneously breathing late preterm and term newborn infants in the delivery room with respiratory distress.

Evidence Summary

A 2022 ILCOR systematic review and CoSTR[5,11] compared the application of CPAP (with or without supplemental oxygen) to no application of CPAP (with or without supplemental oxygen) in spontaneously breathing newly born infants (34 weeks' gestation or more) with respiratory distress and/or low oxygen saturations during transition after

birth. Two RCTs[12,13] with 323 newborn infants and three observational studies[14-16] with 8,476 infants were included. Meta-analysis of the three observational studies showed a higher risk of air leak syndrome development in late preterm and term newborn infants with the use of CPAP (RR, 4.92; 95% CI, 4.13–5.87).[11] Meta-analysis of data from the two RCTs showed fewer neonatal intensive care unit (NICU) admissions, fewer infants needing NICU respiratory support and fewer deaths before hospital discharge when CPAP was used. Of note, all subjects in the two RCTs were delivered by cesarean section, and one RCT used prophylactic CPAP. There was not enough data to perform prespecified subgroup analyses, including later preterm, term and post term infants. The certainty of evidence across all outcomes was rated as very low. The CoSTR authors determined that there was insufficient evidence to suggest for or against the routine use of CPAP compared with no CPAP for spontaneously breathing late preterm and term newborn infants in the delivery room with respiratory distress.[5,11]

Insights and Implications

By not suggesting for or against the routine use of CPAP compared with no CPAP for spontaneously breathing late preterm and term newborn infants in the delivery room with respiratory distress, the Red Cross Scientific Advisory Council acknowledges the potential harm identified in the observational studies with the association between CPAP use and presence of air leak syndromes. This is balanced by the potential benefit shown in reduced NICU admissions of infants born by cesarean section. Additional large RCTs are needed to assess the use of CPAP in the population of interest, and studies need to include infants delivered vaginally. As such, the Red Cross Scientific Advisory Council feels that the choice to implement CPAP should be individualized, balancing risks and benefits, and should be made by the clinician caring for the patient.

Supraglottic Airways for Neonatal Resuscitation

Positive pressure ventilation (PPV) is used for the initial resuscitation of newborn infants and may be delivered by face mask, supraglottic airway (SGA) or endotracheal intubation. Supraglottic airways are devices inserted into the pharynx, above the glottis, for ventilation and oxygenation. These devices include laryngeal masks with either an air-filled or gel cuff.[17] While helping to maintain an airway for ventilation, supraglottic airway devices are not considered definitive airways. A 2015 ILCOR review compared the use of a laryngeal mask (first generation air-filled cuff) as a primary or secondary device with face mask ventilation or endotracheal intubation.[18] This review led to a weak recommendation in newborns (34 weeks' gestation or more) for a laryngeal mask to be used as an alternative to endotracheal intubation if ventilation through a face mask is unsuccessful. For the same patient population, a strong recommendation also supported the use of a laryngeal mask when endotracheal intubation is not feasible after failed PPV. Is there evidence to support the initial (primary) use of an SGA compared with a face mask for PPV in newborns during resuscitation immediately after birth?

Red Cross Guidelines

NEW

- Supraglottic airways (i.e., air-filled or gel cuff laryngeal masks) may be considered for newborn infants with a gestational age of 34 weeks' or more receiving intermittent positive pressure ventilation during resuscitation immediately after birth if unable to ventilate effectively with a face mask and healthcare professionals are present who are competent in their use.

Evidence Summary

A 2022 systematic review[19] and CoSTR[20] by ILCOR focused on the use of an SGA compared with a face mask for providing PPV to newborn infants 34 0/7 weeks' gestation or more during resuscitation immediately after birth. Five RCTs and one quasi-RCT[21-26] with a total of 1,857 newborn infants allowed for meta-analysis of data for multiple outcomes. Of note, a strong inverse association was found between the use of an SGA compared with a face mask for the outcome of risk of endotracheal intubation (RR, 0.34; 95% CI, 0.20–0.56; P<0.001; RD, 41 fewer per 1,000 infants had endotracheal intubation during resuscitation when an SGA was used [95% CI, 49 fewer to 27 fewer]). The authors commented that this may reflect a greater likelihood of achieving effective ventilation with an SGA, but there were biases in the studies that need to be considered. An inverse relationship was found between the use of an SGA compared with a face mask for the outcome of failure to improve with device (RR, 0.24; 95% CI, 0.17–0.36; RD, 105 fewer per 1,000 infants [95% CI, 114 fewer to 88 fewer] had failure to improve when an SGA was used). The duration of PPV was found to be a mean of 62 seconds, with a mean difference of 18 seconds lower (95% CI, 24 seconds lower to 36 seconds lower) when an SGA was used. Meta-analyses could not exclude benefit or harm from use of an SGA compared with a face mask for PPV for outcomes of chest compressions during resuscitation, epinephrine administration during resuscitation, air leak during initial hospital stay, soft tissue injury and survival to hospital discharge.[5,20]

Of note, data was not reported to allow subgroup analysis by gestational age (term versus late preterm). Subgroup analysis based on device design (air-filled cuff or gel cuff) showed no evidence of an interaction for the outcome of failure to improve with the device (P=0.29, I^2 = 10%). However, there was insufficient data to perform subgroup analysis based on device design for other outcomes.[5,20]

A weak treatment recommendation by ILCOR suggests that where resources and training permit, an SGA may be used in place of a face mask for newborn infants 34 0/7 weeks' gestation or more receiving intermittent PPV during resuscitation immediately after birth.[5,20]

Insights and Implications

The Red Cross guidelines are informed by this ILCOR systematic review. The authors of the review note that an optimal information size was not achieved for any of the critical or important prespecified outcomes except for duration of PPV. In addition, while the trials included in this review used both air-filled and gel cuff laryngeal masks, there was insufficient data to perform a subgroup analysis of air-filled cuff versus gel cuff laryngeal masks except for the outcome of failure to improve with the device. A small number of adverse events were reported across all studies in this review. Additional trials are needed before stronger recommendations can be made regarding the use of SGAs as the initial device for PPV in resuscitation of newborns immediately after birth and the specific device design. It is also important to consider the potential disadvantages to the initial use of SGAs for PPV. This may include the need for training, cost requirements, cost effectiveness and potential adverse events.

Monitoring at Birth

Respiratory Function Monitoring During Neonatal Resuscitation at Birth

Respiratory function monitors are devices that continuously measure and display ventilatory parameters, such as respiratory rate, airway pressures, tidal volume, peak inspiratory pressure, mask leak and end-tidal carbon dioxide during ventilation. Respiratory function monitors are commonly used in NICU but have the potential for monitoring the effectiveness of ventilation for newborns in the delivery room who require respiratory support. A respiratory function monitor could help neonatal resuscitation teams avoid excessive tidal volume delivery that can lead to lung injury as well as inadequate tidal volumes resulting from mask leak, airway obstruction or insufficient ventilation pressures. Respiratory function monitor use in newborn resuscitation in the delivery room has been the subject of several recent trials.

Red Cross Guidelines

- No recommendation: Additional research is needed to determine if there is a clinical benefit from use of a respiratory function monitor in newborn infants receiving respiratory support at birth.

Evidence Summary

A 2022 ILCOR systematic review and CoSTR[5,27] aimed to compare the use of a respiratory function monitor device with no respiratory function monitor in the delivery room for newborn infants receiving respiratory support at birth. This systematic review was an update of a 2015 ILCOR review[18] on the same topic that identified one eligible study and that led to weak recommendations suggesting against the routine use of flow and volume monitoring as well as capnography for babies who receive PPV at birth.

The 2022 review[27] identified three RCTs[28-30] involving 443 newborns. Meta-analyses of data from the RCTs could not exclude clinical benefit or harm from displaying a respiratory function monitor compared with not displaying a respiratory function monitor for outcomes of intubation in the delivery room, achieving desired tidal volumes in the delivery room, pneumothorax, death before hospital discharge, severe intraventricular hemorrhage (grades 3 or 4) and bronchopulmonary dysplasia/chronic lung disease.[27] A possible clinical benefit was suggested with displaying a respiratory function monitor for the outcome of intraventricular hemorrhage (all grades). The CoSTR authors noted that it is uncertain if the difference in intraventricular hemorrhage between groups in the two RCTs was attributable to the respiratory function monitor or a chance finding.[5,27]

The ILCOR review concluded that there is insufficient evidence to make a recommendation for or against the use of a respiratory function monitor in newborn infants receiving respiratory support at birth.[5,27]

Insights and Implications

The systematic review found a lack of clinical benefit with respiratory function monitor use in newborns receiving respiratory support with the possible exception of all grades of intraventricular hemorrhage. Many research questions remain, including cost effectiveness, training requirements, and the ability of respiratory function monitoring during resuscitation to change the proportion of time spent delivering a target tidal volume.

Delivery Room Heart Rate Monitoring to Improve Outcomes for Newborns

Heart rate is a critical indicator of a newborn infant's clinical status at birth. Common methods to determine heart rate at birth include:

- Auscultating heart sounds over the left lower sternal border with a stethoscope.

- Evaluating pulse oximetry readings.

Additional modalities include electrocardiogram (ECG) monitoring, the use of doppler ultrasound and video, or photoplethysmography. Determination of heart rate in newborns in the delivery room should be rapid and accurate, but is there evidence that alternative techniques, such as ECG or photoplethysmography, are associated with better clinical outcomes than auscultation or pulse oximetry?

Red Cross Guidelines

NEW
- Where feasible, in addition to auscultation, it is reasonable to use an electrocardiogram (ECG) for heart rate assessment in newborn infants requiring resuscitation in the delivery room.

NEW
- Auscultation, with or without pulse oximetry, is a reasonable alternative for heart rate assessment of a newborn infant and should also be used to confirm the heart rate when pulseless electrical activity is suspected.

Evidence Summary

A 2022 ILCOR systematic review and CoSTR[5,31] aimed to evaluate outcomes from heart rate monitoring of newborn infants in the delivery room using an ECG, doppler device, digital stethoscope, photoplethysmography and video plethysmography, and other modalities compared with heart rate monitoring by:

- Pulse oximetry with or without auscultation.

- Auscultation alone.

- Between intervention comparison.

For the comparison of an ECG with auscultation plus a pulse oximeter during resuscitation of newborn infants, two RCTs[32,33] with 91 newborn infants and one cohort study[34] were identified. All meta-analyses and reports from individual studies are for this comparison. Studies of other modalities, besides ECG, compared with pulse oximetry and/or auscultation were not identified. No studies were identified for between intervention comparisons.[5,31]

The evidence identified could not exclude a benefit or harm from use of an ECG compared with use of auscultation plus a pulse oximeter for heart rate assessment in the delivery room for multiple outcomes including duration of PPV, time from birth to heart rate of 100 or greater beats per minute, use of epinephrine in the delivery room and death before discharge.[5,31]

Evidence from meta-analysis of RCTs similarly was not able to exclude benefit or harm from the use of an ECG compared with the use of auscultation plus a pulse oximeter for heart rate assessment for the outcomes of chest compressions and tracheal intubation.

Evidence from the one identified cohort study suggests that the use of an ECG compared with use of auscultation plus a pulse oximeter for heart rate assessment may reduce intubations in the delivery room (RR, 9.75; 95% CI, 0.62–0.90; ARD, 119 fewer delivery room intubations per 1,000 with ECG). Evidence from the same cohort study suggests that the use of an ECG compared with auscultation plus a pulse oximeter for heart rate assessment may increase or have little to no effect on the number of infants receiving chest compressions in the delivery room.[5,31]

A weak recommendation was made by ILCOR suggesting that where resources permit, the use of an ECG for heart rate assessment of a newly born infant requiring resuscitation in the delivery room is reasonable. Where an ECG is not available, auscultation with pulse oximetry is a reasonable alternative for heart rate assessment, but the limitations of these modalities should be kept in mind. A good practice point was made that auscultation with or without pulse oximetry should be used to confirm the heart rate when an ECG is unavailable, not functioning or when pulseless electrical activity is suspected.[5,31]

Insights and Implications

The Red Cross guidelines are informed by the 2022 ILCOR systematic review. While an ECG may provide a more rapid and accurate assessment of heart rate in the delivery room than the alternative modalities, it is not clear if this impacts clinical outcomes for newborn infants. The cost of ECG monitoring may be prohibitive in some settings, and it is unclear if subgroups, such as vigorous infants compared with non-vigorous infants, benefit from ECG monitoring of heart rate. An ECG can provide a measured heart rate but does not assure there is mechanical activity or sufficient mechanical activity for cardiac output. When using an ECG to monitor heart rate, if a newborn infant is not improving, auscultate heart sounds to ensure that pulseless electrical activity is not present.

Maintenance of Normal Body Temperature Immediately After Birth

Newborn infants are at a greater risk of heat loss immediately after birth due to their large surface area to body mass ratio, decreased subcutaneous fat and other characteristics. Body temperature may fall by 2° C to 4° C in the first 10 to 20 minutes after birth.[35] Hypothermia in newborns puts them at risk for several potentially life-threatening complications including hypoxia, metabolic acidosis, cardiovascular complications and hypoglycemia, and it is an independent predictor[36] of neonatal mortality. While definitions for normothermia and hypothermia in the newly born may vary, it is agreed that the temperature of newly born infants should be maintained between 36.5° C and 37.5° C immediately after birth and through to hospital admission.[36] The World Health Organization

recommends a "warm chain" of interlinked procedures at birth to minimize heat loss in all newborns, beginning with immediate drying using a warm towel or cloth and placing the newborn on the mother's chest or abdomen (skin-to-skin contact) while drying the newborn.[37] Other recommended interventions in the warm chain include placing a cap on the head and covering the newborn with a second towel. Is there evidence to support other interventions besides drying to maintain a normal temperature immediately after birth in late preterm and term infants?

Red Cross Guidelines

NEW
- Where feasible, a room temperature of 23° C is suggested compared with 20° C at birth for late preterm and term newborn infants (34 weeks' gestation or more) to maintain normothermia.

NEW
- Skin-to-skin care with a parent is encouraged immediately after birth to maintain normothermia in late preterm and term newborn infants (34 weeks' gestation or more) who are at low risk of needing resuscitation. Skin-to-skin care can be done with initial care (i.e., drying and stimulation).

NEW
- The use of a plastic bag or wrap and other measures may be considered in situations where skin-to-skin care, maintaining temperature under a radiant warmer or a room temperature at 23° C is not feasible.

Evidence Summary

A 2022 systematic review and CoSTR[5,38] aimed to compare various methods to maintain normal temperature immediately after birth in late preterm and term infants with maintaining normal temperature by drying alone. Methods searched for included increased room temperature of 23° C or higher, thermal mattress, plastic bag or wrap, hat, heating and humidification of gases used for resuscitation, radiant warmer (with or without servo control), early monitoring of temperature, warm bags of fluid, warmed swaddling/clothing, skin-to-skin care with a parent, or any combination of these interventions. The evidence that was identified allowed for several comparisons. All RCTs included in the review had exclusion criteria for infants at high risk of needing resuscitation or who received resuscitation, and no studies included out-of-hospital births. No evidence from RCTs was found for heating and humidification of gases used for resuscitation, use of a radiant warmer, warm bags of fluid, or warmed swaddling/clothing compared with standard care or any other intervention.[5,38]

For the comparison of increased room temperature versus no increased room temperature, evidence from one cluster RCT[39] with 825 late preterm and term newborn infants was identified, all born by caesarean section in an operating room, comparing outcomes at a temperature of 23° C with 20° C. For infants born when room temperature was 23° C compared with 20° C, mean temperatures on admission were 0.3° C higher, which was considered to be clinically significant. More infants were normothermic with a room temperature of 23° C compared with 20° C (RR, 1.25; 95% CI, 1.11–1.42; 130 more infants per 1,000 [95% CI, 55 more to 209 more]), and fewer infants had moderate hypothermia (less than 36° C) (RR, 0.26; 95% CI, 0.16–0.42; 140 fewer infants per 1,000 [95% CI, 158 fewer to 109 fewer]).[5,38]

For the comparison of skin-to-skin care with a parent versus no skin-to-skin care, the mean temperature on admission was 36.6° C (MD, 0.32° C higher with skin-to-skin care; 95% CI, 0.1° C higher to 0.54° C higher), and more infants were normothermic with skin-to-skin care (RR, 1.39; 95% CI, 0.91–2.12; 239 more infants per 1,000 [95% CI, 55 fewer to 688 more]). Fewer infants developed hypoglycemia with skin-to-skin care versus

no skin-to-skin care (RR, 0.16; 95% CI, 0.05–0.53; 273 fewer infants per 1,000 [95% CI, 309 fewer to 153 fewer]), and fewer infants were admitted to the NICU (RR, 0.34; 95% CI, 0.14–0.83; 46 fewer infants per 1,000 [95% CI, 60 fewer to 12 fewer]).[5,38]

For the comparison of using a plastic bag or wrap versus no plastic bag or wrap, studies were included where infants had been dried or not dried before use of the plastic bag or wrap. The mean temperature on admission was 36.3° C (MD, 0.29° C higher with use of a plastic bag; 95% CI, 0.2° C higher to 0.37° C higher). Meta-analysis of data showed that fewer infants died (i.e., greater survival to hospital discharge) when a plastic bag or wrap was used (RR, 0.95; 95% CI, 0.60–1.51; 49 fewer infants per 1,000 died with use of a plastic bag/wrap [95% CI, 392 fewer to 500 more]), and more infants were normothermic on admission (RR, 1.50; 95% CI, 1.20–1.89; 203 more infants per 1,000 [81 more to 3,629 more were normothermic]).[5,38]

For the comparison of plastic bag or wrap use combined with skin-to-sin care versus skin-to-skin care alone, the mean body temperature was 36° C (MD, 0.2° C higher when a plastic bag or wrap was added to skin-to-skin care [95% CI, 0.1° C higher to 0.3° C higher]). More infants were normothermic on admission with the combined intervention (RR, 1.39; 95% CI, 1.08–1.79; 86 more infants per 1,000 more were normothermic when a plastic bag/wrap was added to skin-to-skin care [95% CI, 18 more to 174 more per 1000]), and fewer infants were admitted to a NICU or special care unit (RR, 0.26; 95% CI, 0.03–2.26; 21 fewer infants per 1,000 [95% CI, 28 fewer to 36 more per 1,000]).[5,38]

Several comparisons had limited and very low-certainty evidence, and/or lacked statistical and/or clinical significance for outcomes, and are not reported here, including:

- Thermal mattresses versus no thermal mattress.

- Plastic bag or wrap versus drying compared with plastic bag or wrap without drying.

- Plastic bag or wrap without drying compared with a thermal nest.

- Early versus later skin-to-skin care.

- Continuously active warming blankets plus skin-to-skin care compared with standard care.

- Skin-to-skin care compared with a plastic bag or wrap.

ILCOR treatment recommendations stemming from this complex review for late preterm and term newborn infants (34 weeks' gestation or more) suggest the use of room temperatures of 23° C compared with 20° C at birth to maintain normothermia, and for infants at low risk of needing resuscitation, the use of skin-to-skin care with a parent immediately after birth. If skin-to-skin care is not possible, it is reasonable to consider the use of a plastic bag or wrap, among other measures, to maintain normal temperature.[5,38]

Insights and Implications

The complex systematic review by ILCOR identified evidence to support three interventions without evidence of adverse effects. This review has been used to inform the Red Cross guidelines, with additional considerations. Not all delivery and operating rooms have the capability to alter room temperatures, and not all deliveries occur in a delivery or operating room. Additional research is needed to determine if the use of plastic bags or wraps may cause harm and to evaluate alternative methods for maintaining normothermia such as use of a thermal mattress or other conductive heat sources (pre-warmed clothing and hats, etc.).

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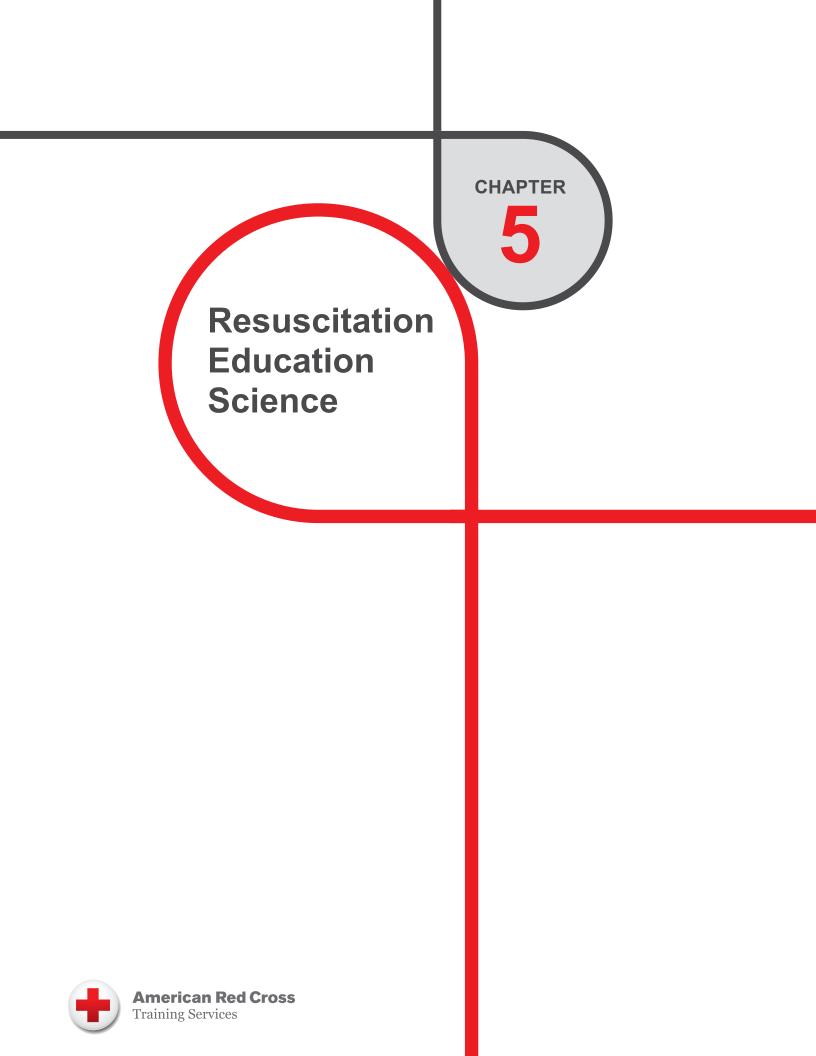
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Resuscitation Education Science

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Prearrest Prediction of Survival Following In-Hospital Cardiac Arrest

The ability to use a clinical decision tool to predict which patients may survive to hospital discharge following in-hospital cardiac arrest (IHCA) could help healthcare professionals understand which patients will benefit from CPR and which patients will not. A clinical decision tool could guide discussions between caregivers, patients, and their families and could guide decision-making for starting or abstaining from CPR (i.e., do-not-attempt-CPR). Many different scoring systems have been designed to predict survival or nonsurvival in IHCA. Is there evidence that any prediction rule is more accurate than others?

Red Cross Guidelines

NEW

- Prearrest prediction rules should not be used as the sole reason to not resuscitate an adult with in-hospital cardiac arrest.

Evidence Summary

A 2022 ILCOR systematic review[1] and CoSTR[2,3] focused on the use of prearrest clinical prediction rules for survival following IHCA of adults and children. Included studies investigated 13 different prearrest prediction rules for survival after IHCA. Meta-analyses were not performed as all included studies were based on retrospective cohort studies and judged at very high risk of bias. Several studies investigated a prearrest morbidity score, the prognosis after resuscitation score (which aims to predict survival to hospital discharge) and the Good Outcome Following Attempted Resuscitation (GO-FAR) score (which aims to predict survival with a Cerebral Performance Category [CPC] score of 1). Other smaller studies reported prediction of survival to hospital discharge with various rules. The review concluded that none of the scores were able to reliably predict survival to hospital discharge or to 30 days and favorable neurological outcome on the basis of patient factors before an IHCA, and none were able to reliably predict no chance of survival or chance of survival or favorable neurological outcome.[1-3]

ILCOR recommends against using any currently available prearrest prediction rule as a sole reason to not resuscitate an adult with IHCA and is unable to make a recommendation about using prearrest prediction rules to facilitate do-not-attempt-CPR discussions with adult patients or pediatric patients or their surrogate decision-maker. No studies with pediatric patients were identified.[2,3]

Insights and Implications

No prospective studies were identified in the systematic review on clinical implementation of a prearrest prediction model, and thus it remains unknown whether use of any of these prediction rules would impact outcomes, such as initiating do-not-attempt-CPR discussions and orders, patient or family perspectives, survival and CPC scores.

Basic Life Support Training for High-Risk Populations

More than 356,000 out-of-hospital cardiac arrests (OHCAs) occur annually in the United States, with most occurring at home or at a residence (73.9%).[4] Layperson-initiated CPR occurs in 40.8% of OHCAs. Overall survival to hospital discharge for 2021 using Cardiac Arrest Registry to Enhance Survival (CARES) data was 9.1%, and with layperson CPR, 11.0%.[5] For patients identified at high risk for OHCA, does the targeted training of family members or caregivers in basic life support lead to improved patient or educational outcomes?

Red Cross Guidelines

NEW

- Family and caregivers of patients at high risk for out-of-hospital cardiac arrest should be trained in, or encouraged to be trained in, basic life support.

Evidence Summary

A 2022 systematic review and CoSTR [3,6] by ILCOR focused on basic life support (BLS) training of likely rescuers, such as family members or caregivers, for adults and children at high risk of OHCA, compared with no training. This review was an update of a 2015 review[7,8] that examined the evidence for effectiveness of providing BLS training to family members of high-risk cardiac patients. New studies identified since the 2015 review included likely rescuers of patients with cardiac disease, drug use disorder, pulmonary disease or an acute life-threatening event. Meta-analysis of outcomes was not possible due to heterogeneity in BLS training methods, control groups and outcome assessment. Few studies evaluated patient outcomes from targeted BLS training for family members, and the limited number of witnessed OHCAs and the loss to follow-up limited the certainty of the evidence identified.[3,6]

For studies that assessed educational outcomes, improvement in BLS skills and knowledge immediately after training were found in most studies. For long-term outcomes, although there was some degradation of some BLS skills, there was an improvement in skills and knowledge compared with baseline. Basic life support training was also found to increase willingness and confidence to provide CPR and to share training with other family members and friends[3,6]

ILCOR recommends BLS training for likely rescuers of populations at high risk of OHCA. A good practice statement was made recommending that healthcare professionals encourage and direct likely rescuers of populations at high risk of cardiac arrest to attend BLS training.[3,6]

Insights and Implications

A large percentage of OHCAs take place in the home or a residence. This review confirms positive outcomes with BLS training, including competency in skills and improved confidence and willingness to provide CPR, and it supports guidelines recommending BLS training for family members or caregivers of patients at high risk for OHCA.

Retention of CPR Skills After Training

Bystander CPR is associated with increased rates of survival following cardiac arrest. Past reviews have shown skill decay within 3 months of training and recommendations have been made for retraining at 1 to 2 years. Is there new evidence to suggest an ideal period for refreshing CPR skills after initial training?

Red Cross Guidelines

REAFFIRMED
- CPR skills must be refreshed periodically but not less than 12 months from initial training.

UPDATED
- More frequent CPR refresher intervals are suggested for healthcare professionals with low frequency use of CPR skills. Interval timing should be tailored to competency, scope of practice and clinical exposure.

Evidence Summary

A 2022 triennial review of an American Red Cross Scientific Advisory Council scientific review[9] aimed to look for evidence to determine how long after training or retraining in CPR is the ability retained to perform effective CPR. Studies of CPR skill retention that were identified are heterogeneous due to the many types of training, the multiple modes of teaching and the varying levels of trainees. Many forms of primary instruction were equally associated with CPR performance degradation and no form of primary instruction was shown to be superior in preventing degradation of skills. The authors of the review note that given the heterogeneity of the published research and the lack of standardized testing of skill retention, it is difficult to say with certainty what the optimal retraining schedule should be. However, more frequent refresher intervals are suggested and may be accomplished by establishing periodic personalized scheduling of performance training and assessment in the clinical environments, or through spaced learning with initial training.

Insights and Implications

There continues to be insufficient evidence to recommend the optimum interval or method for BLS retraining for laypersons. Because there is evidence of skills decay within 3 to 12 months after BLS training as well as evidence that frequent training improves CPR skills, the Red Cross suggests that individuals who encounter cardiac arrest less often consider more frequent training.

Retention of CPR Skills After Training

Bystander CPR Can Be Lifesaving!

🔍 Research Findings

→ CPR skills degrade within 3 to 12 months after training.

→ Optimum retraining interval is uncertain but frequent training improves CPR skills.

→ Different modes of CPR training/instruction show equal CPR skills degradation.

🔑 KEY POINTS

→ CPR skills must be refreshed periodically, but not less than 12 months from initial training.

→ Timing should be tailored to competency, scope of practice and clinical exposure.

→ More frequent refresher intervals are needed for those who encounter cardiac arrest infrequently.

Patient Outcome and Resuscitation Team Members Attending Advanced Life Support Courses

Advanced life support (ALS) courses are offered internationally for healthcare professionals caring for patients of all ages needing resuscitation and life support following a medical or trauma event. A team approach to resuscitation is commonly used in the in-hospital setting. A previous systematic review by ILCOR led to a recommendation for accredited adult ALS training for healthcare providers. Is there evidence to support the same recommendation for healthcare provider training in pediatric advanced life support (PALS) courses, neonatal life support and/or other ALS courses?

Red Cross Guidelines

NEW

- Healthcare professionals who provide resuscitation and life support for adults, adolescents, children, infants or neonates should receive accredited training in resuscitation and life support for their respective discipline(s).

Evidence Summary

A 2022 ILCOR systematic review and CoSTR[3,10] focused on the prior participation of one or more members of the resuscitation team in an accredited ALS course on clinical outcomes of patients of any age requiring resuscitation from an IHCA. Studies were identified for adult ALS, neonatal resuscitation training courses and the Helping Babies Breathe course.

For adult ALS courses, an evidence update of the previous systematic review[11] identified a single retrospective descriptive study[12] that supported conclusions from the previous 2020 CoSTR.[13]

For neonatal resuscitation training, a systematic review[14] of neonatal resuscitation training approaches was identified and used for data extraction and analysis of hospital-based studies. Included studies for this review were pre- and post-intervention studies from low- to middle-resource settings and changes were significant in all outcomes (fresh stillbirths, neonatal mortality at 1-day, 7-day, 28-day and perinatal mortality) except 28-day neonatal mortality. The authors reported statistical and clinical heterogeneity in all outcomes except for all still births but showed a consistent treatment effect with improved outcomes with neonatal resuscitation training. A systematic review[15] of the Helping Babies Breathe course was identified and evidence was incorporated into the ILCOR review. This review identified moderate certainty evidence for a decrease in intrapartum-related stillbirth and 1-day neonatal mortality after implementing the Helping Babies Breathe course.[3,10]

The ILCOR treatment recommendations stemming from the CoSTR include strong recommendations for the provision of accredited ALS training for healthcare providers who provide ALS care for adults and for the provision of accredited courses in neonatal resuscitation training and Helping Babies Breathe for healthcare providers who provide ALS care for newborns and babies.[3,10]

Insights and Implications

The evidence identified was considered very low certainty but showed a consistent treatment effect with the potential for saving many lives. The review did not identify evidence related to participation in PALS courses or comment on this, and the population of interest was restricted to patients requiring resuscitation from IHCA, although resuscitation of OHCA by emergency medical services responders typically involves teams with training in ALS.

Blended Learning for Basic, Advanced and Trauma Life Support Education

Blended learning uses self-directed online sessions to gain knowledge and understanding of information combined with an in-person, instructor-led skill session with manikin practice and feedback or with an automated manikin skill practice session with feedback for skills training. Self-directed, digital-based learning has been popular among students of BLS courses during the COVID-19 pandemic and has been shown to result in comparable educational outcomes for most CPR skills and knowledge when compared with traditional instructor-led training.

Red Cross Guidelines

REAFFIRMED
- Basic life support course content and skills may be offered to adults 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 or virtual automated manikin skill practice session with feedback.

    ▪ A self-directed online session to gain knowledge and understanding of the information and an in-person, instructor-led session skill practice session with manikin practice and feedback.

NEW
  ◦ Blended learning may be considered for advanced life support education and training where resources and accessibility permit.

Evidence Summary

A 2022 ILCOR systematic review[16] and CoSTR[3,17] sought to compare a blended learning approach for participants taking an accredited life support course (e.g., BLS, ALS, PALS, advanced trauma life support [ATLS]) with a non-blended learning approach (stratified to subgroups of online-only and face-to-face-only). Outcomes of interest included knowledge acquisition, skill acquisition, participant satisfaction, patient survival and implementation outcomes. A previous 2021 ILCOR CoSTR[18] led to a strong treatment recommendation for use of instructor-led training (with manikin practice with feedback device) or the use of self-directed training with video kits, including manikin practice with feedback device, for the acquisition of CPR theory and skills in lay adults and high school age children

Most of the studies identified in the current review used face-to-face-only training only as the control group. Results from BLS studies for outcomes of BLS knowledge and skills were reported as mixed, with some finding a benefit from blended learning and some finding no difference.[3,17] A financial benefit was identified from a single study for teaching BLS with a blended learning approach.[19]

For adult ALS, most studies reported no significant difference in knowledge and skills (post-course) between blended learning and non-blended learning approaches.[3,17]

For advanced trauma life support (ATLS), a single study[20] was identified and reported that a blended learning approach that substituted elements of didactic material with online learning was better than an in-person-only approach for knowledge outcomes.[3,17]

On the basis of the ILCOR CoSTR, a strong recommendation was made for a blended learning as opposed to a non-blended learning approach for life support training where resources and accessibility permit implementation.[3,17]

Insights and Implications

This review found that a blended learning approach results in similar educational outcomes for participants as does a non-blended learning approach and may have a financial benefit. There was evidence of positive attitudes to all forms of training for BLS, while ALS course participants were divided over preference for blended learning versus face-to-face. Blended learning allows training on the participants' own time and training in remote locations but requires resources including Internet or video access. Future studies are needed to determine if blended learning for life support education results in better patient outcomes. The Red Cross guidelines for use of blended learning with BLS courses remain unchanged, while a new guideline provides the option for ALS coursework, where feasible.

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Appendix A: Abbreviations in Focused Updates and Guidelines 2022

Commonly Used Abbreviations

A-B-C	airway-breathing-circulation
AED	automated external defibrillator
ALS	advanced life support
ARCSAC	American Red Cross Scientific Advisory Council
BLS	basic life support
CARES	Cardiac Arrest Registry to Enhance 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
CPP	cerebral perfusion pressure
CPR	cardiopulmonary resuscitation
CV	compression-to-ventilation
CV-CPR	compression-ventilation CPR
ECG	electrocardiogram
ECMO	extracorporeal membrane oxygenation
ECPR	extracorporeal CPR
EMS	emergency medical services
GO-FAR	Good Outcome Following Attempted Resuscitation
ICP	intracranial pressure
IHCA	in-hospital cardiac arrest
ILCOR	International Liaison Committee on Resuscitation

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mEQ/L   milliequivalents per liter

mCPR   mechanical CPR

NICU   neonatal intensive care unit

OHCA   out-of-hospital cardiac arrest

PAD   public access defibrillation

PALS   pediatric advanced life support

PCI   percutaneous coronary intervention

PICU   pediatric intensive care unit

PPE   personal protective equipment

PPV   positive pressure ventilation

RB-CPR   rescue breathing CPR

ROSC   return of spontaneous circulation

SGA   supraglottic airway

STEMI   ST-segment myocardial infarction

TBI   traumatic brain injury

VF   ventricular fibrillation

VT   ventricular tachycardia

Abbreviations in Statistical Analyses

aOR   adjusted odds ratio

ARD   adjusted rate difference

CI   confidence interval

I^2 measure of heterogeneity

IRR   incidence rate ratio

MD   mean difference

P   probability

RR   relative risk

RD   risk difference

RCT   randomized controlled trial

Appendix B: Summary of Reaffirmed Guidelines/Recommendations

Basic Life Support		
Topic	**Red Cross Guidelines**	**Last Review or Update**
DISPATCHER/TELECOMMUNICATOR-ASSISTED CPR		
Dispatcher Recognition of Cardiac Arrest	• Dispatch centers should employ standardized and evidence-based protocols for recognition of cardiac arrest. (Reaffirmed) • Dispatch centers should monitor the diagnostic accuracy of recognition of cardiac arrest from use of any specific dispatch criteria or algorithms. (Reaffirmed)	2022

Harm to Those Performing CPR	• 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: (Reaffirmed)
	  ◦ Using standard precautions to provide patient care in all settings, to include performance of hand hygiene and use of personal protective equipment (PPE), that is, 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.
		2022

Dispatcher-Assisted Compression-Only CPR Versus Conventional CPR	• 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. (Reaffirmed) • 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. (Reaffirmed)	2022
CPR TECHNIQUES AND SEQUENCE		
CPR Start Sequence (A-B-C versus C-A-B) (Adult and Pediatric)	• 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. (Reaffirmed)	2022

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Appendix B: Summary of Reaffirmed Guidelines/Recommendations

	Basic Life Support	
Topic	**Red Cross Guidelines**	**Last Review or Update**
CPR TECHNIQUES AND SEQUENCE *(continued)*		
Chest Compression-Only CPR Versus Compression-Ventilation CPR: Lay Responders	• Compression-only CPR (CO-CPR) may be used as an alternative to CPR with compressions and ventilations when a lay responder is unwilling or unable to provide ventilations. (Reaffirmed)	2022
Chest Compression Rate	• Chest compressions should be performed at a rate of 100 to 120 per minute for adults, children and infants. (Reaffirmed)	2022
Chest Compression Depth	• 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 1½ inches for an infant). (Reaffirmed)	2022
Chest Wall Recoil	• 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. (Reaffirmed)	2022

Pulse Check During CPR	• When performing CPR, if signs of return of spontaneous circulation (ROSC) are observed: (Reaffirmed)
	  ° 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.
	• Routine pulse checks without signs of ROSC are not recommended. (Reaffirmed)
		2022

CPR Prior to Defibrillation	• CPR should be performed prior to the availability of an automated external defibrillator and analysis of rhythm. (Reaffirmed)	2022
Rhythm Check Timing	• Immediately after a shock is delivered, CPR should be resumed for 2 minutes before pausing compressions to conduct a rhythm check. (Reaffirmed) • Based on the clinical situation, performing rhythm analysis after defibrillation may be considered by healthcare professionals. (Reaffirmed) • After every 2 minutes of CPR, the rhythm should be reassessed (while minimizing interruptions to CPR). (Reaffirmed) • If there are physiologic signs of ROSC, briefly pausing compressions for rhythm analysis may be considered. (Reaffirmed)	2022
Optimal Surface for CPR	• It is reasonable to perform manual chest compressions on a firm surface when possible. (Reaffirmed) • 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. (Reaffirmed) • If a person in cardiac arrest is in a bed with CPR mode to increase mattress stiffness, it is reasonable to activate this mode. (Reaffirmed)	2022
Head-Up CPR	• Head-up CPR should not be routinely used for cardiac arrest. (Reaffirmed)	2022

Appendix B: Summary of Reaffirmed Guidelines/Recommendations

	Basic Life Support	
Topic	**Red Cross Guidelines**	**Last Review or Update**
CPR TECHNIQUES AND SEQUENCE *(continued)*		
Alternative Cardiac Resuscitation Techniques (cough, precordial thump, fist pacing)	• A precordial thump and percussion pacing should not be used for cardiac arrest. (Reaffirmed) • "Cough CPR" should not be used for cardiac arrest. (Reaffirmed)	2022
Tidal Volumes and Ventilation Rates	• 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. (Reaffirmed)	2022
Harm from CPR to Persons Not in Cardiac Arrest	• Dispatchers should provide guidance to bystanders to begin CPR based on their assessment and without concern for harm to persons not in cardiac arrest. (Reaffirmed)	2022
DEFIBRILLATION		
Defibrillator Electrode Pad Size and Placement	• 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. (Reaffirmed)	2022
OPIOID-ASSOCIATED EMERGENCIES		
Suspected Opioid-Associated Emergency Resuscitation	• 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. (Reaffirmed)	2022

Appendix B: Summary of Reaffirmed Guidelines/Recommendations

Advanced Life Support		
Topic	**Red Cross Guidelines**	**Last Review or Update**
CARDIOPULMONARY RESUSCITATION: TECHNIQUES AND PROCESS		
Rhythm Analysis During Chest Compressions	• 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. (Reaffirmed)	2022
POST-CARDIAC ARREST CARE		
Post Cardiac Arrest Temperature Control	• 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. (Reaffirmed) • 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. (Reaffirmed) • Surface or endovascular temperature control techniques may be considered when temperature control is used in patients who remain unconscious after ROSC. (Reaffirmed) • 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. (Reaffirmed) • Hypothermic temperature control may be considered in certain subpopulations of cardiac arrest patients who remain unconscious after ROSC. (Reaffirmed) • Rapid infusion of large volumes of cold intravenous fluid immediately after ROSC should not be used for prehospital cooling of post-cardiac arrest patients. (Reaffirmed)	2022

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Appendix B: Summary of Reaffirmed Guidelines/Recommendations

	Pediatric Advanced Life Support	
Topic	**Red Cross Guidelines**	**Last Review or Update**
DRUG THERAPY AND VASCULAR ACCESS		
Intravenous Versus Intraosseous Administration of Drugs During Cardiac Arrest	• Intraosseous access may be considered as an acceptable alternative to intravenous access in children and infants. (Reaffirmed)	2022
POST-CARDIAC ARREST CARE		
Post-Cardiac Arrest Temperature Control	• 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. (Reaffirmed) • While a normothermic approach is preferred, patients with mild hypothermia who remain unconscious after ROSC should not be actively warmed to achieve normothermia. (Reaffirmed) • Surface or endovascular temperature control techniques may be considered when temperature control is used in patients who remain unconscious after ROSC. (Reaffirmed) • 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. (Reaffirmed) • Hypothermic temperature control may be considered in certain clinical presentations for children and infants after out-of-hospital and in-hospital cardiac arrest and who remain unconscious after ROSC. (Reaffirmed) • Rapid infusion of large volumes of cold intravenous fluid immediately after ROSC should not be used for prehospital cooling of post-cardiac arrest patients. (Reaffirmed)	2022