ILCOR Summary Statement

2024 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations

Summary From the Basic Life Support; Advanced Life Support; Pediatric Life Support; Neonatal Life Support; Education, Implementation, and Teams; and First Aid Task Forces

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Abstract

This is the eighth annual summary of the International Liaison Committee on Resuscitation International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations; a more comprehensive review was done in 2020. This latest summary addresses the most recent published resuscitation evidence reviewed by the International Liaison Committee on Resuscitation task force science experts. Members from 6 International Liaison Committee on Resuscitation task forces have assessed, discussed, and debated the quality of the evidence, using Grading of Recommendations Assessment, Development, and Evaluation criteria, and their statements include consensus treatment recommendations. Insights into the deliberations of the task forces are provided in the Justification and Evidence-to-Decision Framework Highlights sections. In addition, the task forces list priority knowledge gaps for further research.

Key Words: ILCOR, resuscitation, cardiac arrest, basic life support, advanced life support, neonatal, first aid

Abbreviation	**Definition**
AED	automated external defibrillation
ALS	advanced life support
BLS	basic life support
BMV	bag-mask ventilation
BP	blood pressure
CAC	cardiac arrest center
COPD	chronic obstructive pulmonary disease
CPR	cardiopulmonary resuscitation
ECLS	extracorporeal life support
ECMO	extracorporeal membrane oxygenation
ECPR	extracorporeal cardiopulmonary resuscitation

Abbreviation	**Definition**
EEG	electroencephalogram
EIT	Education, Implementation, and Teams
EMS	emergency medical services
GRADE	Grading of Recommendations Assessment, Development, and Evaluation
ICU	intensive care unit
IHCA	in-hospital cardiac arrest
ILCOR	International Liaison Committee on Resuscitation
IPD	individual patient data
IQR	interquartile range
MAP	mean arterial pressure
NLS	neonatal life support
NMA	network meta-analysis
NNT	number needed to treat
OHCA	out-of-hospital cardiac arrest
PEARLS	Promoting Excellence and Reflective Learning in Simulation
PICO	population, intervention, comparator, outcome
PICOST	population, intervention, comparator, outcome, study design, and time frame
PLS	pediatric life support
PROSPERO	Prospective Register of Systematic Reviews
RCDP	rapid cycle deliberate practice
RCT	randomized controlled trials
ROC	return of circulation
ROSC	return of spontaneous circulation
SGA	supraglottic airway
STEMI	ST-segment elevation myocardial infarction
TELSTAR	Treatment of Electroencephalographic Status Epilepticus After Cardiopulmonary Resuscitation

INTRODUCTION

This is the eighth in a series of annual International Liaison Committee on Resuscitation (ILCOR) International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations (CoSTR) summary publications summarizing the ILCOR task forces' analyses of published resuscitation evidence since ILCOR began the more continuous process of evidence evaluation in 2015. Summarizing the work from the 6 task forces over the past year, this year's review includes 19 systematic reviews (SysRevs) with new or updated treatment recommendations. Although only SysRevs can generate a full CoSTR and new treatment recommendations, 14 scoping reviews (ScopRevs) and 29 evidence updates (EvUps) are also included.

Draft CoSTRs for all topics evaluated with SysRevs were posted on a rolling basis between December 1, 2023, and January 24, 2024, on the ILCOR website.[1] Each draft CoSTR includes the data reviewed and draft treatment recommendations, with public comments accepted for 2 weeks after posting. In some cases, if requested, public comment was permitted for longer. Task forces considered public feedback and provided responses. The 33 draft CoSTR statements and ScopRevs were viewed ≈18,200 times, and 38 comments were provided. All CoSTRs are now available online, adding to the existing CoSTR statements.

This summary statement contains the final wording of the treatment recommendations and good practice statements as approved by the ILCOR task forces, but it differs in several respects from the online CoSTRs. The language used to describe the evidence is not restricted to standard Grading of Recommendations Assessment, Development, and Evaluation (GRADE) terminology,[2] making it more accessible to a wider audience, and in some cases only the high-priority outcomes are reported. The Justification and Evidence-to-Decision Framework

Highlights sections are generally shortened, but aim to provide a transparent rationale for treatment recommendations. The complete evidence-to-decision frameworks are provided in Appendix A. Finally, the task forces have prioritized knowledge gaps requiring future research studies. Links to the published reviews and full online CoSTRs are provided in the corresponding sections.

The CoSTRs are based on analysis of the data using the GRADE approach.[2] SysRevs are conducted by expert systematic reviewers or by task force members, always with the involvement of ILCOR content experts. The GRADE approach guides the rating of the certainty of evidence that supports the intervention effects (predefined by the population, intervention, comparator, outcome [PICO] question). Certainty is categorized as high, moderate, low, or very low. Randomized controlled trials (RCTs) begin the analysis as high-certainty evidence, and observational studies begin the analysis as low-certainty evidence. Certainty of evidence can be downgraded for risk of bias, inconsistency, indirectness, imprecision, or publication bias; it can be upgraded for a large effect, for a dose-response effect, or if any residual confounding would be thought to decrease the detected effect.

The format for outcome data reporting varies by the data available but ideally includes both relative risk and the absolute risk difference, both with 95% CI. The absolute risk difference enables a more clinically useful assessment of the magnitude of the effect of an intervention and enables calculation of the number needed to treat (NNT=1/RD). When the data do not enable absolute effect estimates, alternative measures of effect such as odds ratios (ORs) are reported. Treatment recommendations are generated by the task forces after evaluating the evidence and after discussion. The strength of a recommendation does not depend solely on the certainty of evidence but also on the likely clinical impact as determined by task force members.

ILCOR's goal is to review at least 20% of all PICO questions each year so that the CoSTRs reflect current and emerging science. Acknowledging that many PICO topics will not have sufficient new evidence to warrant a SysRev, ILCOR implemented 2 additional levels of evidence review in 2020. ScopRevs are undertaken when the amount and type of evidence on a broader topic is unclear. Search strategies are similar in rigor to those of SysRevs, but ScopRevs do not include bias assessments or meta-analyses. Although ILCOR does not create or alter treatment recommendations without a SysRev, if the topic of a ScopRev is thought to be of particular interest to the resuscitation community, good practice statements are often made. Good practice statements are not evidence-based recommendations but represent expert opinion in light of very limited data.

The third and least rigorous form of evidence evaluation is the evidence update (EvUp), in which a minimum of a PubMed search is carried out to screen for significant new data and assess whether there has been sufficient new science to warrant a more extensive review and updated CoSTR. EvUps can inform a decision about whether a SysRev should be undertaken but are not used to generate new or updated treatment recommendations because they do not include bias assessment, GRADE evidence evaluation, or meta-analysis. In this document, ScopRevs are summarized in the relevant Task Force section, with references to the more complete online review. EvUps are listed at the end of each task force section in table form, with information including the prior treatment recommendation(s) related to the PICO question, how many new studies were identified, key findings, and whether an updated SysRev is recommended. Complete EvUps are provided in Appendix B.

The following topics are addressed in this CoSTR summary:

Basic Life Support

- Optimal surface for performing cardiopulmonary resuscitation (CPR) (Basic Life Support [BLS] 2510: SysRev)
- Optimization of dispatcher-assisted recognition of out-of-hospital cardiac arrest (OHCA) (BLS 2102: ScopRev)
- Optimization of dispatcher-assisted CPR (BLS 2113: ScopRev)
- Optimization of dispatcher-assisted automated external defibrillation (AED) retrieval and use (BLS 2120: ScopRev)
- Feedback for CPR quality (BLS 2511: ScopRev)
- Ultraportable or pocket AEDs (BLS 2603: ScopRev)
- Compression-ventilation ratio (BLS 2202: EvUp)
- Hand positioning (BLS 2502: EvUp)
- CPR before defibrillation (BLS 2203: EvUp)
- Rhythm check during compressions (BLS 2211: EvUp)
- Head-up CPR (BLS 2503: EvUp)
- Public access defibrillation programs (BLS 2121: EvUp)

Advanced Life Support

- Post–cardiac arrest oxygenation and ventilation (Advanced Life Support [ALS] 3506 and 3516: SysRev)
- Post–cardiac arrest hemodynamics (ALS 3515: SysRev Adolopment)
- Post–cardiac arrest temperature control (ALS 3523, 3524, 3525: SysRev)
- Post–cardiac arrest seizure prophylaxis and management (ALS 3502 and 3503: SysRev)
- Extracorporeal CPR (ALS 3001: SysRev)

- Cardiac arrest during pregnancy (ALS 3401: ScopRev)
- Front of neck airway access (ALS 3606: ScopRev)
- Cardiac arrest related to asthma (ALS 3408: EvUp)
- Atropine for cardiac arrest (ALS 3206: EvUp)
- Use of advanced airway during cardiac arrest (ALS 3300, 3301, 3302, 3303, 3304: EvUp)
- CPR-induced consciousness (ALS 3004: EvUp)
- Antiarrhythmics during and after cardiac arrest (ALS 3201, 3514: EvUp)

Pediatric Life Support

- Blood pressure targets following return of circulation after cardiac arrest (Pediatric Life Support [PLS] 4190-01: SysRev)
- Effect of prophylactic antiseizure medication and treatment of seizures on outcome of pediatric patients following cardiac arrest (PLS 4210-02: SysRev)
- Advanced airway interventions in pediatric cardiac arrest (PLS 4060-01: SysRev)
- Ventilation rate with advanced airway during pediatric cardiac arrest (PLS 4120-02: SysRev)
- Management of pulmonary hypertension with cardiac arrest in infants and children in the hospital setting (PLS 4160-11: ScopRev)
- Prearrest care of pediatric dilated cardiomyopathy or myocarditis (PLS 4030-19: EvUp)
- Ventilation rate in pediatric respiratory arrest with a perfusing rhythm present (post–cardiac arrest) (PLS 4120-01: EvUp)

Neonatal Life Support

- Cord management at birth for preterm infants (Neonatal Life Support [NLS] 5051: SysRev)
- Effect of rewarming rate on outcomes for newborns who are unintentionally hypothermic after delivery (NLS 5700: SysRev)
- Therapeutic hypothermia in limited resource settings (NLS 5701: SysRev)

Education, Implementation and Teams

- Cardiac arrest centers (Education, Implementation and Teams [EIT] 6301: SysRev)
- Cognitive aids during resuscitation education (EIT 6400: SysRev)
- Immersive technologies for resuscitation teaching (EIT 6405: SysRev)
- Gamified learning compared with other forms of resuscitation learning (EIT 6412: SysRev)
- Rapid cycle deliberate practice in resuscitation training (EIT 6414: SysRev)
- Team competencies training for resuscitation (EIT 6415: SysRev)
- CPR education tailored to specific populations (EIT 6108: ScopRev)
- International facets of the Chain of Survival (EIT 6311: ScopRev)
- Provider workload and stress during resuscitation (EIT 6401: ScopRev)
- Scripted debriefing compared with nonscripted debriefing in resuscitation training (EIT 6413: ScopRev)
- Emergency medical services (EMS) experience and exposure (EIT 6104: EvUp)
- Patient outcomes of team members attending a CPR course (EIT 6106: EvUp)
- Willingness to provide CPR (EIT 6304: EvUp)
- Implementation of guidelines in communities (EIT 6306: EvUp)

- Debriefing of resuscitation performance (EIT 6307: EvUp)
- CPR feedback devices during training (EIT 6404: EvUp)
- Blended-learning approach for life support education (EIT 6409: EvUp)
- High-fidelity training for resuscitation (EIT 6410: EvUp)

First Aid

- Use of supplemental oxygen in first aid (First Aid [FA] 1649: ScopRev)
- Recognition of sepsis (FA 7180: ScopRev)
- Stroke recognition (FA 7170: EvUp)
- Oxygen in stroke (FA7031: EvUp)
- Dental avulsion (FA 7361: EvUp)
- Second dose of epinephrine for anaphylaxis (FA 7111: EvUp)
- Naloxone for opioid emergencies (FA 7442: EvUp)
- Exertion-related dehydration and rehydration (FA 7241: EvUp)
- Counter-pressure maneuvers for prevention of syncope (FA 7550: EvUp)
- Recovery position (FA 7040: EvUp)

Readers are encouraged to monitor the ILCOR website[3] to provide feedback on planned SysRevs and to provide comments when additional draft reviews are posted.

References

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BLS TASK FORCE

Optimal Surface for Performing CPR (BLS 2510: SysRev)

Rationale for Review

This topic was prioritized for review by the BLS Task Force because it had not been reviewed since 2019.[1,2] Since the last systematic review (SysRev) of this topic,[3] the task force was concerned that the practice of moving patients from the bed to the floor to improve the quality of CPR could delay CPR; thus, it was considered timely to update the SysRev completed for the 2020 CoSTR.[1,2] The SysRev was registered before initiation (International Prospective Register of Systematic Reviews [PROSPERO] CRD42017080475). The full online CoSTR can be found on the ILCOR website.[4]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: For adults or children in cardiac arrest (OHCA and in-hospital cardiac arrest [IHCA])
- Intervention: The performance of CPR using a hard surface (eg, backboard, floor, or deflatable or specialist mattress)
- Comparators: The performance of CPR on a regular mattress or other soft surface
- Outcomes: Survival with a favorable neurological outcome at hospital discharge/30 days (critical), survival at hospital discharge/30 days (critical), event survival (important), return of spontaneous circulation (ROSC) (important), CPR quality (eg, compression depth, compression rate, compression fraction) (important)
- Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) were excluded.

Randomized manikin simulation or cadaver studies were included only if insufficient human studies were identified. Studies were included regardless of language if an abstract in English was available.

- Time frame: The dates searched were September 17, 2019 (date of the search for the previous SysRev), to February 5, 2024.

Consensus on Science

In addition to the 11 manikin simulation RCTs[5-15] identified in the previous review,[3] we identified 1 small observational study[16] and 6 additional manikin RCTs[17-22] addressing this population, intervention, comparator, outcome, study design, and time frame (PICOST) question. The overall certainty of evidence was rated as very low to low due to risk of bias and serious indirectness. No studies reported patient outcomes. The included studies were grouped by surfaces studied: backboard versus hospital mattress, floor versus hospital mattress, floor versus firm home mattress, and floor versus other surface types. The small observational study that compared a backboard with a hospital mattress used a single accelerometer for measurement, and the results were considered unreliable.[16] Results of the meta-analysis of data from the manikin simulation studies are given in Table 1.

Table 1. Results of the Meta-Analysis of CPR Metrics From the Manikin Simulation Studies Examining Different Surfaces for CPR

Backboard compared with hospital mattress	
Compression depth	7 mannikin RCTs[7,8,10-12,14,20] Mean difference= 2.16 millimeters (95% CI 0.52 to 3.81)
Compression rate	5 mannikin RCTs[7,8,10,14,20] Mean difference= -0.11 (95%CI: -3.8 to 3.59)
Floor compared with hospital mattress	
Compression depth	2 mannikin RCTs[6,9] Mean difference = 5.36 millimeters (95% CI -1.59 to 12.32)
Compression rate	2 mannikin RCTs[6,9]

	No meta-analysis performed. No significant difference.
Floor compared with firm home mattress	
Compression depth	2 mannikin RCTs[15,22] Mean difference = 2.11 millimeters (95% CI -3.23 to 7.45)
Compression rate	2 mannikin RCTs[15,22] No meta-analysis performed. No significant difference.

CPR indicates cardiopulmonary resuscitation; and RCT, randomized controlled trial.

Prior Treatment Recommendations (2020[1,2])

We suggest performing chest compressions on a firm surface when possible (weak recommendation, very low–certainty evidence).

During in-hospital cardiac arrest, we suggest, where a bed has a CPR mode which increases mattress stiffness, it should be activated (weak recommendation, very low–certainty of evidence).

During in-hospital cardiac arrest, we suggest against moving a patient from a bed to floor to improve chest compression depth (weak recommendation, very low–certainty of evidence).

During in-hospital cardiac arrest, we suggest in favor of either a backboard or no-backboard strategy, to improve chest compression depth (conditional recommendation, very low–certainty of evidence).

2024 Treatment Recommendations

We suggest performing chest compressions on a firm surface when this is practical and does not significantly delay the commencement of chest compressions (weak recommendation, very low–certainty evidence).

We suggest against moving a patient from a firm mattress to the floor to improve chest compression depth (weak recommendation, very low–certainty of evidence).

We suggest activation of the CPR mode to increase mattress stiffness if available for in-hospital cardiac arrest (good practice statement).

For health care systems that have already incorporated backboards into routine use during resuscitations, the evidence was considered insufficient to suggest against their continued use (weak recommendation, very low–certainty of evidence).

For health care systems that have not introduced backboards, the limited improvement in compression depth and uncertainty about harms seemed insufficient to justify the costs of purchasing backboards and training staff in their use (weak recommendation, very low–certainty of evidence).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision framework is provided in Appendix A1.

When performing chest compressions on a patient lying on a mattress, the force of the chest compressions is dissipated through the compression of the chest and compression of the surface beneath the patient. Mattress compression can be as high as 57% of total compression depth, with greater compression seen in softer mattresses.[23-25] This can lead to reduced spinal-sternal displacement and a reduction in effective chest compression depth. It is known that effective compression depths can be achieved on soft surfaces if the CPR provider increases overall compression depth to compensate for mattress compression.[26-29] CPR feedback devices that account for mattress compression (eg, the use of dual, and not single, accelerometers or increasing compression depth targets) can help CPR providers to ensure adequate compression depth when CPR is performed on a mattress.[7,29-31]

In making these recommendations, the task force considered the importance of high-quality chest compressions and minimizing delays to the initiation of CPR and the lack of human data, including patient outcomes. Within the limitations of manikin studies, the available evidence indicates that using a backboard on a hospital mattress provides only a marginal depth benefit that is unlikely to be clinically significant. In considering whether to transfer a patient to the floor to improve compression depth, the task force considered the risks of harm (eg, interruption in CPR, risk of losing vascular access) to the patient and resuscitation team outweighed any small improvement in chest compression depth. The addition of 2 studies simulating out-of-hospital settings (where beds may be softer) and one where the CPR provider may be a single untrained rescuer led the task force to broaden the recommendations to include OHCA. The task force felt the indirect evidence on backboards was not sufficient to have backboards removed where they are currently used. However, users should be aware that mattress stiffness and backboard size and orientation influence the backboard's effectiveness.[32-35]

Knowledge Gaps

- Studies reporting clinical outcomes
- Studies examining the logistical aspects of backboard deployment or moving a patient from a bed to the floor
- Studies in both high- and low-resource settings where hospital bed or prehospital stretcher configurations may vary

Optimization of Dispatcher-Assisted Recognition of OHCA (BLS 2102: ScopRev)

Rationale for Review

The 2020 CoSTR on dispatcher-assisted diagnosis of cardiac arrest recommended dispatch centers look for ways to optimize sensitivity.[1,2] These interventions have not been reviewed by ILCOR before. A ScopRev was conducted to understand factors related to DA recognition and to review the current state of evidence for interventions aiming to optimize recognition to inform the development of a PICOST for a SysRev. The full online CoSTR can be found on the ILCOR website.[36]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adults and children who are in cardiac arrest outside of a hospital.
- Intervention: Factors and interventions that improve dispatcher-assisted recognition of cardiac arrest.
- Outcomes: Dispatcher-assisted recognition of cardiac arrest defined as initiation of cardiac arrest–specific actions, such as instructions to perform CPR.
- Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies, qualitative) were eligible for inclusion. All relevant studies with an abstract in English were included.
- Time frame: The search of Medline was performed on performed on June 2, 2023, from database inception to June 2, 2023.

Summary of Evidence

This ScopRev identified 60 relevant papers.[37-96] The included manuscripts described 4 major categories and 18 subcategories: 2 major categories and 11 subcategories relate to factors found to influence DA recognition, and 2 major categories and 7 subcategories were interventions aiming to improve DA recognition (Table 2). The detailed findings within each theme are summarized in the full CoSTR on the ILCOR website.[36]

Table 2. Categories and Subcategories of Factors Influencing Dispatcher-Assisted Recognition of OHCA

Categories	Subcategories
Factors related to dispatcher-assisted recognition	
Communication between caller and dispatcher (n=16)	1. Caller’s emotional state 2. Caller’s proximity to OHCA patient 3. Effects of dispatcher behavior and communication with

Categories	Subcategories
	caller 4. Caller's status (health care professional compared with non–health care professional) 5. Effects of language barriers 6. Linguistic format of qualified breathing questions 7. Influence of callers "chief complaint" and use of trigger words
Symptoms and patient characteristics (n=19)	8. Agonal breathing 9. Patient status 10. Seizures 11. Patient demographics
Interventions to improve dispatcher-assisted recognition	
New technology to improve dispatcher recognition of OHCA (n= 7)	12. CCTV 13. Machine learning 14. Smart devices to detect agonal breathing
Quality improvement/implementation of new protocols to improve dispatcher recognition (n=26)	15. MPDS 16. Criterion-based dispatch 17. Breathing 18. Other quality improvement

CCTV indicates closed-circuit television; MPDS, medical priority dispatch system; and OHCA, out-of-hospital cardiac arrest.

Task Force Insights

- Most of the studies identified were retrospective, observational studies assessing the proportion of OHCAs recognized by dispatchers and factors associated with OHCA recognition. Only 1 study reported dispatcher-assisted recognition in pediatric arrests. There were no studies testing 2 different protocols in a randomized trial.
- The most pertinent challenge to dispatcher-assisted recognition of OHCA seems to be determining whether the patient is breathing normally. Several strategies were studied, including bypassing breathing in the initial assessment and asking the caller to put their

hand on the patient's stomach. No strategy showed better results than the commonly used 2-questions strategies. Although several strategies were tested, there were no RCTs comparing different strategies.

- The only randomized control trial in this review studied the effect of including an artificial intelligence model to improve recognition of OHCA. Although the model seemed to perform well, the study did not show an effect on dispatcher recognition of OHCA when using the model in the emergency dispatch center. The main problem appeared to be high false positive rates.
- Based on this ScopRev, there is insufficient evidence to pursue a new SysRev on this topic.

Knowledge Gaps

- Sensitivity, specificity, and positive predictive values of different factors to improve dispatcher-assisted recognition of OHCA, as well as how studied variables affect time to recognition
- How different protocols and strategies compare with each other in randomized trials
- When dispatchers should deviate from the script in the dispatch protocol. There is an expectation or necessity for dispatchers to follow and not deviate from a script. However, deviation may be necessary in certain cases, and continuation of the script in these cases could lead to worse communication, lower rates of recognition of OHCA, or longer time to recognition. Studies to identify which cases may benefit from deviation of script are warranted.
- How to optimize dispatcher-assisted recognition of pediatric OHCA

Optimization of Dispatcher-Assisted CPR (BLS 2113: ScopRev)

Rationale for Review

The 2020 SysRev recommends CPR instructions be provided by dispatchers during the emergency call.[1,2] Although the certainty of evidence was rated as very low at that time, dispatcher-assisted CPR (DA-CPR) has been implemented widely,[97-100] and the task force was aware of new evidence examining interventions aiming to optimize DA-CPR. A ScopRev was conducted to map this evidence and determine if it was sufficient to warrant a new SysRev of interventions to improve DA-CPR. Studies comparing compression-only CPR with standard CPR were excluded as this topic is covered in a separate ILCOR PICOST.[101,102] The full online CoSTR can be found on the ILCOR website.[103]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adults and children with out-of-hospital cardiac arrest where DA-CPR is implemented
- Intervention: Interventions used in addition to DA-CPR
- Comparators: Nonmodified DA-CPR
- Outcomes: Any outcomes
- Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols), editorials, commentaries, animal studies, and SysRevs were excluded. If there were insufficient studies from which to draw a conclusion, case series could be included in the initial search. All relevant studies with an abstract in English were included.

- Time frame: The search of Embase, Medline, Cumulative Index to Nursing and Allied Health Literature Database, and Cochrane Database of Systematic Reviews was performed on May 17, 2023, for the period 2000 to May 17, 2023.

Summary of Evidence

Thirty-one studies were included in this ScopRev: One was a nonrandomized implementation trial,[104] 16 were simulation studies (15 RCTs,[105-119] 1 nonrandomized comparison[120]) and 12 were observational studies reviewing real-world OHCAs from registries or collected data[75,120-130] or emergency call review.[131] Two included studies used qualitative[132] and mixed methods.[133] Only 1 study focused on pediatric cardiac arrest.[111] Complete details of the studies and findings are reported in the full CoSTR on the ILCOR website.

The interventions examined were advanced dispatcher training (n=3[121-123]), centralization of the dispatch center (n=2[124,125]), use of metronome or varied metronome rates (n=2[105,106]), change in CPR sequence and compression ratio (n=1[126]), an animated audiovisual recording (n=1[107]), prerecorded instructions compared with conversational live instructions (n=1[108]), implementation of novel DA-CPR protocols (n=4[75,104,109,127]), changes in terminology about compressions (n=6[110-112,120,128,131]; 1 pediatric), inclusion of "undress patient" instructions (n=1[113]), verbal encouragement (n=1[119]), and use of video at the scene (n=9[114-118,129,130,132,133]).

The implementation of novel DA-CPR protocols, prerecorded instructions, centralized dispatch, advanced dispatcher training, use of metronomes and varying metronome rates and instructions to undress the patient all have less than 3 papers published, and therefore, we are unable to make any comment on their effectiveness at this point.

The studies that focus on simplifying the compression instruction language (ie, "Push as hard as you can" versus "Push approximately 2 inches/5 cm") suggest an improvement in the quality of CPR.[111,112,120,128] The studies that examined adding video to the emergency call, compared with audio-only calls, suggest an improvement in CPR practice (eg, hand positioning) and quality (eg, compression depth and rate).[114-118,130]

Task Force Insights

The task force discussed the review findings and noted the following:

- The lack of high-quality evidence, studies in humans, and the significant heterogeneity between studies of the various interventions
- Terminology changes in instructions may not be generalizable to other languages.
- Almost half of the studies comparing video to audio were simulation studies.
- Based on this ScopRev, there is insufficient evidence to pursue a new SysRev on this topic.

Knowledge Gaps

- High-quality prospective research in humans
- Data on optimizing DA-CPR in pediatric cases

Optimization of Dispatcher-Assisted AED Retrieval and Use (BLS 2120: ScopRev)

Rationale for Review

Bystander use of AEDs is associated with high survival rates from OHCA,[134,135] but use is currently infrequent.[136] This topic was selected for review by the BLS Task Force because of the widespread use of dispatch instructions for the retrieval and use of an AED[100,137] and the need to optimize systems to improve the public's AED use.[138,139] Although there is no existing ILCOR treatment recommendation related to dispatcher-assisted AED (DA-AED) retrieval, the task force decided the current evidence required a ScopRev to fully explore the scope of the topic. The full online CoSTR can be found on the ILCOR website.[140]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adults and children with out-of-hospital cardiac arrest
- Intervention: DA-AED retrieval and use
- Outcomes: Any reported outcomes
- Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies), simulation studies, case series (>5 patients), trial protocols, and conference abstracts were included. All relevant studies with an abstract in English were included.
- Time frame: The search of Embase, Medline, and Cochrane Central was performed on April 14, 2023, from database inception to April 13, 2023.

Summary of Evidence

Sixteen studies were included in this ScopRev: 5 observational studies reviewing real-world OHCAs[141-145] and 11 simulation studies (6 RCTs,[146-151] 1 nonrandomized trial,[152] and 4 observational[153-156]).

There were no studies that examined patient outcomes. One observational study did report improvement in survival with favorable neurological outcome in 1132 (of 1606) OHCAs when a DA-CPR protocol included instructions to retrieve an AED, but the relative contribution of the DA-AED instruction could not be determined from the data provided.[143]

In systems using DA-AED retrieval and use, 5 observational studies reported low rates of AED retrieval (0.8%–5.8%[141,142,144]), pad application (0.4%–1.7% [142,144,145]), and shocks delivered (2.4%–11%[141,143]). In one study, rates of bystander defibrillation were greater with dispatcher instructions to retrieve an AED, compared with cases where no instructions were given (11% versus 5%, unadjusted $p<0.001$).[143] Another observational study reported confusion and delays in the emergency call following a 3-part instruction to retrieve an AED.[141] Callers often had to ask the dispatcher to repeat the instruction, or they asked clarifying questions.

In simulation studies, time to first shock, when measured from the time the AED arrived, was longer when dispatcher assistance was provided than when there was no assistance.[146,157] However, when time to retrieve an AED was factored in, time to first shock was shorter.[149,158]

AED competence scores were consistently higher with dispatcher assistance (or an analogous form of instruction).[146,151,157,159,160] In a simulation study, the use of video instruction enabled the correction of pad placement, which initially was done incorrectly by most bystanders.[160] In another study the use of mobile phone video resulted in better performance than verbal instruction alone,[146] but a second study demonstrated no difference.[159] The use of prerecorded video instruction was inferior to real-time (verbal) dispatcher instruction.[151] In 1 study, dispatchers facilitated the application of an AED in 5 out of 6 cases when the AED had been brought to the (simulated) patient's side, but the study participant did not attempt to use it unprompted.[161]

Task Force Insights

- There is limited published research in this area, particularly on the impact on patient outcomes.
- Given the majority of OHCAs occur in the home, public-access AEDs are likely to be in close proximity in only a minority of cases, and fewer still are likely able to be located, retrieved, and attached to a patient in a meaningful time frame.
- Research is emerging on the user-friendliness of different AED brands.[162,163]
- There is a risk that by implementing dispatcher instructions to retrieve and use public-access AEDs, other aspects of the community response (eg, time to CPR, delay to

dispatcher CPR instructions, reduced CPR efficacy due to distraction or interruptions) could be affected. These risks are likely to be greatest when there is a lone rescuer at the scene.

The studies reviewed in the present ScopRev suggest there is currently insufficient evidence to pursue a new SysRev on this topic. There were no previous treatment recommendations on this topic. Given the widespread adoption of this intervention and interest in this topic, the task force considered the available evidence and developed the following good practice statements.

2024 Treatment Recommendations

EMS implementing dispatcher-assisted public-access AED systems should monitor and evaluate the effectiveness of their system (good practice statement).

Once a cardiac arrest is recognized during the emergency call and CPR has been started, dispatchers should ask if there is an AED (or defibrillator) immediately available at the scene and ask the caller to update them when one arrives (good practice statement).

If an AED is not immediately available and if there is more than 1 rescuer present, dispatchers should offer instructions to locate and retrieve an AED. Retrieval instructions should be supported, where resources allow, by up-to-date registries about public-access AED locations and accessibility (good practice statement).

Once an AED is available, dispatchers should offer instructions on its use (good practice statement).

Task Force Knowledge Gaps

- High-quality evidence of the effect of dispatcher-assisted public-access AED use on critical and important clinical (patient) outcomes

- The risks associated with dispatcher instructions for public-access AED retrieval and use during an emergency call
- What contribution dispatcher instructions for public-access AED retrieval and use have in the overall community and EMS response to OHCA
- The barriers and facilitators to dispatcher instruction for public-access AED retrieval and use
- Which specific interventions will increase bystander retrieval and use of a public-access AED following dispatcher instructions
- Optimization of current systems: What is the optimal way to introduce and implement dispatcher instructions for public-access AED retrieval and use? How and where should AED retrieval integrate into current dispatch protocols/algorithms? What is the optimum phrasing to use? Do the AED's instructions complement or conflict with DA-CPR instructions? What is the potential role of using live-stream video or similar during dispatcher instruction? How best to use registries and associated technology so that dispatchers can best help bystanders locate and retrieve AEDs?

Feedback for CPR Quality (BLS 2511: ScopRev)

Rationale for Review

CPR feedback devices are intended to improve patient outcomes through improving the quality of CPR. The 2020 CoSTR on feedback for CPR quality recommended the use of real-time audiovisual feedback and prompt devices during CPR when used as part of a comprehensive quality improvement program.[1,2] There were challenges with the 2020 ILCOR review due to the exclusion of many studies because they combined the evaluation of feedback with other quality improvement activities (eg, debriefing). The task force decided to perform a

ScopRev to understand if the wider literature, including studies with other interventions, may provide further insights into the effectiveness of feedback and improve the existing PICOST question. Additionally, the task force concluded that this review should focus on the provision of CPR by health professionals responding in a professional capacity, rather than by bystanders or lay responders. The detailed results are provided on the ILCOR website.[164]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adults and children (excluding neonates) who are in cardiac arrest in any setting who are resuscitated by health professionals responding in a professional capacity
- Intervention: Real-time feedback and prompt devices regarding the mechanics of CPR quality (eg, rate and depth of compressions and/or ventilations)
- Comparators: No feedback or prompt devices, or alternative devices
- Outcomes: Any outcome or measure of CPR quality
- Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion
- Time frame: PubMed, Embase, Cochrane, and Cumulative Index to Nursing and Allied Health Literature were searched from database inception to July 18, 2023. A grey literature search was performed in the Google search engine (July 18, 2023). All relevant studies with an abstract in English were included.

Summary of Evidence

Of the 55 studies included, we identified 10 SysRevs,[165-174] 5 RCTs,[175-179] 37 observational studies,[180-215] 2 case series,[216,217] and 1 commentary.[218] The patients included varied widely between studies. Only 3 studies included children,[209,211,219] and most of the evidence consisted of before-and-after studies.

The use of metronomes was examined in 1 SysRev from 2014[174] and 6 observational studies (3 OHCA and 3 IHCA).[180-185] This evidence suggests an associated improvement in CPR quality, but there are few data on patient outcomes and what outcome data are reported are not adjusted for confounding (Table 3).

By including a wider range of published studies and studies examining audiovisual feedback with other system improvements, we identified 9 SysRevs,[165-173] 5 RCTs,[175-179] 31 observational studies,[186-215,219] and 2 case series.[216,217] Evidence examining key outcomes with a non-feedback comparator group suggests improved CPR quality, but most studies reporting improved patient outcomes beyond ROSC included other interventions, such as high-performance CPR and postevent debriefing (Table 4). This evidence aligns with ILCOR's current treatment recommendation that feedback devices should be used as part of a comprehensive quality improvement program.[1,2]

Task Force Insights

- As this was a ScopRev, no formal assessment of the quality of the literature was performed. However, the lack of RCTs was noted and many of the studies published since the last review continue to have methodological issues (eg, lack of adjustment for confounders, small sample sizes, no patient outcomes reported).
- EMS systems and hospitals in well-resourced settings have, or are implementing, quality improvement programs, including the use of feedback devices, to improve the quality of CPR. This implementation makes the study of isolated interventions, such as feedback devices, difficult to evaluate in observational research.
- While 59 studies were included in the narrative synthesis, there was insufficient new evidence to recommend a SysRev using the expanded PICOST question. An update of

the SysRev using the existing PICOST question is recommended, with subgroups based on the different devices and separate review for health care professionals and lay people.

- This ScopRev has revealed a substantial adjacent literature studying the implementation of high-performance CPR and quality improvement programs, but it was not possible to extract a specific association with real-time CPR feedback from these studies. It is suggested that a new PICOST question is developed that examines the impact of these programs on clinical outcomes for both OHCA and IHCA patients.

Knowledge Gaps

- High-quality evidence adequately powered to examine patient outcomes
- Studies examining the impact of ultrasound

Table 3. Human Studies on Metronome Rate Guidance During CPR

Studies	Design issues	Results with use of feedback
Survival to discharge/30 days		
Fletcher 2008[184] Bolstridge 2016[180]	Before/after study[180,184] Small sample size[180] Conference abstract[180] Unadjusted outcome[180,184]	*Significant increase:* 1 before/after OHCA study[184] *No change:* 1 before/after IHCA study[180]
ROSC		
Bolstridge 2016[180] Chiang 2005[183]	Before/after study[180,183] Small sample size[180,183] Conference abstract[180] Unadjusted outcome[180,183]	*No change:* 1 before/after IHCA study[180]; 1 before/after OHCA study[183]
CPR quality: compression rate		
Bolstridge 2016[180] Rainey 2021[182] Fletcher 2008[184] Kennedy 2023[185]	Before/after study[180-182,184,185] Small sample size[180,182]	*Significant increase:* 3 before/after IHCA studies[180-182]; 2 before/after OHCA study[184,185]
CPR quality: compression depth		
Bolstridge 2016[180]	Before/after study[180,181]	*Significant increase:* 2 before/after

Studies	Design issues	Results with use of feedback
Khorasani-Zadeh 2020[181]	Small sample size[180]	IHCA studies[180,181]
CPR quality: chest compression fraction		
Chiang 2005[183]	Before/after study[183] Small sample size[183]	*No change:* 1 before/after OHCA study[183]

Table 4. Human Studies Examining Real-Time Audiovisual Feedback With and Without Other Interventions

Studies	Design issues	Results with use of feedback
Favorable neurological outcome		
Bobrow 2013[191] Sainio 2013[193] Freese 2014[194] Couper 2015[187] Davis 2015[188]‡ Hopkins 2016[196]* Pearson 2016[203§] Riyapan 2019[197] Chandra 2022[190]†	Before/after or observational[187,188,190,191,193,194,196,197,203] Abstract only[190,194] Small sample size[197] Unadjusted outcomes[190,193,194,197]	*Significant increase:* 1 before/after IHCA study[188]; 2 before/after OHCA studies[191,196] *Significant decrease:* 1 observational OHCA study[203] *No change:* 4 before/after OHCA studies[187,190,194,197]; 1 observational[193]
Survival to discharge/30 days		
Kramer-Johansen 2006[189] Abella 2007[186] Bobrow 2013[191] Freese 2014[194] Couper 2015[187] Davis 2015[188]‡ Hopkins 2016[196]* Goharani 2019[178] Riyapan 2019[197] Vahedian-Azimi 2020[177]	Before/after[186-191,194,196,197,199,200] Small sample size[177,186,197] Unadjusted outcomes[177,190,194,197] Patients excluded postrandomization[178]	*Significant increase:* 1 IHCA RCT[178]; 1 before/after IHCA study[188]; 3 before/after OHCA studies[191,199,200] Significant decrease: *No change:* 1 cluster OHCA RCT[176]; 1 pilot RCT[177]; 2 before/after IHCA studies[186,187]; 4 before after

Studies	Design issues	Results with use of feedback
Nehme 2021[199]* Alqudah 2022[200]* Chandra 2022[190]†		OHCA studies[189,194,196,197]; 1 observational[193]
Event survival		
Hostler 2011[176] Sainio 2013[193] Freese 2014[194] Riyapan 2019[197] Lakomek 2020[198] Nehme 2021[199]* Alqudah 2022[200]*	Before/after or observational[193,194,197-200] Small sample size[197] Abstract only[194] Unadjusted outcomes[193,194,196-198]	*Significant increase:* 1 before/after OHCA study[199]; 1 observational study[193] *No change:* 1 cluster OHCA RCT[176]; 4 before/after OHCA studies[194,197,198,200]
ROSC		
Abella 2007[186] Hostler 2011[176] Leis 2013[192] Sainio 2013[193] Freese 2014[194] Couper 2015[187] Hopkins 2016[196]* Vahedian-Azimi 2016[179] Goharani 2019[178] Lakomek 2020[198] Vahedian-Azimi 2020[177] Nehme 2021[199]* Alqudah 2022[200]* Chandra 2022[190]†	Before/after or observational[186,187,190,192,194,198,199] Small sample size[177,186,190,192] Abstract only[190,194] Unadjusted outcomes[177,190,192-194,198]	*Significant increase:* 2 IHCA RCT[178,179]; 3 before after OHCA studies[194,196,199]; 1 observational[193] *No change:* 1 cluster OHCA RCT[176]; 1 pilot RCT[177]; 2 before/after IHCA studies[186,187]; 3 before/after OHCA studies[190,198,200]; 1 observational[192]
CPR quality: compression rate		
Kramer-Johansen 2006[189] Abella 2007[186] Hostler 2011[176]	Before/after study[186,189-191,195,197-199,201] Abstract only[190,201] Small sample size[195,197]	*Significant increase:* 5 before/after OHCA studies[189,191,197,198,201]

Studies	Design issues	Results with use of feedback
Bobrow 2013[191] Crowe 2015[195]† Riyapan 2019[197] Nehme 2021[199]* Chandra 2022[190]† Lyngby 2022[201]	Significant missing data[176,190]	*No change:* 1 cluster OHCA RCT[176]; 1 before/after IHCA study[186195]; 3 before/after OHCA studies[178,190,199]
CPR quality: compression depth		
Kramer-Johansen 2006[189] Abella 2007[186] Hostler 2011[176] Bobrow 2013[191] Crowe 2015[195]† Riyapan 2019[197] Nehme 2021[199]* Chandra 2022[190]† Lyngby 2022[201]	Before/after study[186,189-191,195,197-199,201] Abstract only[190,201] Small sample size[195,197] Significant missing data[176,190]	*Significant increase:* 1 cluster OHCA RCT[176]; 7 before/after OHCA studies[189-191,195,197,198,201] *No change:* 1 before/after IHCA study[186]
CPR quality: chest compression fraction		
Kramer-Johansen 2006[189] Hostler 2011[176] Crowe 2015[195]† Riyapan 2019[197] Lakomek 2020[198] Nehme 2021[199]* Chandra 2022[190]† Lyngby 2022[201]	Before/after study[189,190,195,197-199,201] Abstract only[190,201] Small sample size[195,197] Significant missing data[176,190]	*Significant increase:* 1 cluster OHCA RCT[176]; 3 before/after OHCA studies[190,199,201] *No change:* 4 before/after OHCA studies[189,195,197,198]

CPR indicates cardiopulmonary resuscitation; IHCA, in-hospital cardiac arrest; OHCA, out-of-hospital cardiac arrest; and RCT, randomized controlled trials.
*High-performance training (audiovisual feedback, scenario-based training, checklist, team leader, and debriefing
†Audiovisual feedback and debriefing
‡High-performance CPR education, audiovisual feedback, and debriefing
§High-performance CPR education and audiovisual feedback

Effectiveness of Ultraportable or Pocket AEDs (BLS 2603: ScopRev)

Rationale for Review

Early defibrillation is associated with a large increase in survival from OHCA.[220-223] If defibrillation occurs within 3 to 5 minutes of collapse, survival rates as high as 50% to 70% have been reported.[222,223] EMS response times rarely enable delivery of defibrillation in such a short time.[224] Recently, several companies have started advertising “ultraportable” or “pocket” AEDs for personal use or equipping community volunteer responders to improve AED availability. These devices may be limited in the number and the energy of the shocks they deliver (eg, restricted to up to 20 shocks and a maximum of 85 J). This topic has not been reviewed before, and given the interest in these devices, the task force thought a review of their effectiveness in practice was timely. The detailed results are provided on the ILCOR website.[225]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adults and children in OHCA
- Intervention: The use of an ultraportable or pocket AED
- Outcomes: All outcomes were accepted
- Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies, conference abstracts, and trial protocols) were eligible for inclusion. Studies that describe the use of mobile AEDs associated with drone technology were excluded. All studies with an abstract in English were included.
- Time frame: The search of Embase and Medline was performed on November 1, 2023, for the period January 1, 2012, to October 31, 2023.

Summary of Evidence

This review included 3 studies: a medico-economic simulation study,[226] a study protocol of a cluster RCT,[227] and an abstract with preliminary results of that cluster RCT.[228] Key findings from these studies are summarized in Table 5.

Table 5. Summary of Studies Reporting on Ultraportable or Pocket AEDs

First author and year, study design	Population	Intervention / comparator(s)	Findings
Shaker 2022[226]; economic analysis	600 000 simulated patients at low, moderate, and high risk for SCA	Small AED for rapid treatment of SCA (SMART) / No SMART strategy	At a 1.6% SCA annual risk, SMART strategy was associated with $95 251/QALY (societal perspective) and $100 797/QALY (health care perspective). At a 3.5% SCA annual risk, SMART strategy was associated with $53 925/QALY (societal perspective) and $59 672/QALY (health care perspective). SMART prevented 1762 fatalities across risk strata (1.59% fatality relative risk reduction across groups).
Todd 2023[227]; cluster RCT study protocol	Sample size calculation of 714 (357 per arm)	Community responder dispatched with GoodSAM app equipped with an ultraportable	Primary outcome: Survival to 30 days Aim to detect a 7% increase in survival (9%–16%)

First author and year, study design	Population	Intervention / comparator(s)	Findings
		AED (CellAED) / community responder not equipped with AED	
Todd 2023[228]; cluster RCT preliminary results (abstract)	1805 community responders recruited; 903 allocated to CellAED	Community responder dispatched with GoodSAM app equipped with an ultraportable AED (CellAED) / community responder not equipped with AED	Unfinished study; 1788 alerts to CellAED participants, 104 arriving before EMS

AED indicates automatic external defibrillator; EMS, emergency medical services; QALY, quality-adjusted life years; RCT, randomized controlled trial; SCA, sudden cardiac arrest; and SMART, small AED for rapid treatment of SCA.

Task Force Insights

- Ultraportable or pocket AEDs are a new generation of defibrillators characterized by small size, being lightweight and easy to carry on one's person, and affordable for personal and home use.
- We acknowledge that the development of ultraportable or pocket and more affordable AEDs offers the unique opportunity to develop more efficient public access defibrillation or community volunteer responder programs, increase home AED availability, and therefore improve outcomes.
- Device registration with regulatory authorities alone does not provide evidence of device performance in real-world settings. Because the success of defibrillation is related to several factors, including shock energy, transthoracic impedance, defibrillator pad size and anatomical location, diagnostic accuracy for shockable rhythms, and the duration the

person has been in cardiac arrest, further research is required to demonstrate the clinical efficacy of pocket/ultraportable AEDs.

- There is a lack of research in this area.

There is currently insufficient evidence to recommend progression to a formal SysRev.

2024 Treatment Recommendations (new)

There is currently insufficient evidence on the clinical effectiveness of ultraportable or pocket AEDs to make a treatment recommendation.

Knowledge Gaps

- The effect of ultraportable or pocket AED use on critical and important clinical outcomes
- A consensus on the definition of ultraportable AED
- The clinical efficacy (ie, whether the devices work in optimal settings) or clinical effectiveness (real-world settings) of ultraportable AEDs
- The performance of ultraportable AEDs compared with standard AEDs: Such research should address process measures (eg, time to defibrillation), evidence of efficacy (eg, termination of fibrillation, return of organized rhythm, ROSC) and clinical effectiveness (eg, survival with a favorable neurological outcome, survival to discharge).
- The cost-effectiveness of ultraportable defibrillators in different contexts (eg, at home, by community volunteer responder programs, and in public locations)
- How to best organize and maintain ultraportable defibrillators

Topics evaluated with EvUps are summarized in **Table 6**. The complete EvUps are provided in Appendix B1.

Table 6. BLS Topics Reviewed by Evidence Updates

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
PAD programs (BLS 2121)	2020	We recommend the implementation of public-access defibrillation programs for patients with OHCAs. (Strong recommendation, low-certainty evidence)	0	4	Four studies reported improved outcomes overall. Subgroup analysis in two studies showed benefits varied by age, sex and etiology.	Yes (include subgroup analysis)
CPR ratios (BLS 2202)	2017	We suggest a compression–ventilation ratio of 30:2 compared with any other compression–ventilation ratio in patients with cardiac arrest (weak recommendation, very low-quality evidence).	0	2	One study reported increased ventilation associated with improved outcomes. One study reported no association with ventilation rates and outcomes.	Yes (further studies identified in 2 SysRevs)
CPR prior to defibrillation	2019	We suggest a short period of CPR until the defibrillator is ready for	0	0	No new studies	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
(BLS 2203)		analysis and/or defibrillation in unmonitored cardiac arrest (weak recommendation, low-certainty evidence).				
Timing of rhythm check: during compressions (BLS 2211)	2019	We suggest against the routine use of artifact-filtering algorithms for analysis of electrocardiographic rhythm during CPR (weak recommendation, very-low-certainty evidence). We suggest that the usefulness of artifact-filtering algorithms for analysis of electrocardiographic rhythm during CPR be assessed in clinical trials or research initiatives (weak recommendation, very-low-certainty evidence).	0	4	None of the studies report on critical outcomes and only one considers the important outcome of CPR quality (chest compression fraction).	No
Hand positioning	2020	We suggest performing chest compressions on the lower half of	0	0	No new studies.	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
(BLS 2502)		the sternum on adults in cardiac arrest (weak recommendation, very low certainty evidence).				
Head-Up CPR (BLS 2503)	2021	We suggest against the routine use of head-up CPR during CPR (weak recommendation, very-low-certainty evidence). We suggest that the usefulness of head-up CPR during CPR be assessed in clinical trials or research initiatives (weak recommendation, very-low-certainty evidence).	0	2	High risk of bias. No difference in outcomes in propensity-matched cohort.	No

BLS indicates basic life support; CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; PAD, public access defibrillation, PICO, population, intervention, comparator, outcome; and RCT, randomized controlled trial.

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ADVANCED LIFE SUPPORT

Post–Cardiac Arrest Oxygenation and Ventilation (ALS 3506 and 3516: SysRev)

Rationale for Review

This review was conducted by the ALS Task Force in collaboration with the BLS Task Force. Oxygenation and ventilation are important components of post–cardiac arrest management. This topic was last updated with a SysRev for the 2020 CoSTR (PROSPERO registration CRD42022371007).[1-3] Since the last review of this topic, the task forces were aware of new clinical trials, prompting an update of the SysRev. The complete CoSTR can be found online.[4]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Unresponsive adults with sustained ROSC after cardiac arrest in any setting (in-hospital or out-of-hospital)
- Intervention: An oxygenation or ventilation strategy targeting a specific SpO_2, PaO_2, and/or $PaCO_2$
- Comparators: Treatment without specific targets or with an alternate target to the intervention
- Outcomes:
  - Critical: Survival or survival with a favorable neurological outcome at hospital discharge/30 days or longer
  - Other outcomes will depend on the available data and subsequent outcome prioritization by the ILCOR ALS Task Force
- Study designs: Controlled trials, including RCTs, and nonrandomized trials (eg, pseudorandomized trials) were included. Observational studies, animal studies,

ecological studies, case series, case reports, reviews, abstracts, editorials, comments, letters to the editor, and unpublished studies were excluded. All languages were included if there was an English abstract or full-text article.

- Time frame: From August 22, 2019 (date of search of the prior review), to June 30, 2023

Consensus on Science

Five new RCTs including adult patients were identified.[5-9] These studies add to the previous SysRev, which included 7 RCTs.[2,10-16] Studies used a variety of specific oxygen and carbon dioxide strategies or targets, as defined in Table 7.

Table 7. Specific Oxygenation and Ventilation Strategies or Targets, by Study

Study author, year	**Lower oxygen and higher carbon dioxide strategies**	**Higher oxygen and lower carbon dioxide strategies**
Kuisma, 2006[15]	2–4 L/min O_2	>10 L/min O_2
Bray, 2018[14]	O_2 saturation goal 90%–94%	O_2 saturation goal 98%–100%
Thomas, 2019[11]	O_2 saturation goal 94%–98%	100% FIO_2
Bernard, 2022[5]	O_2 saturation goal 90%–94%	O_2 saturation goal 98%–100%
Jakkula, 2018[10]	PaO_2 of 10–15 kPa (75–113 mm Hg)	PaO_2 20–25 kPa (150–188 mm Hg)
Young, 2020[13]	O_2 saturation goal 90%–97%	Standard care
Schmidt, 2022[8]	PaO_2 of 9–10 kPa (68–75 mm Hg)	PaO_2 13–15 kPa (98–105 mm Hg)
Semler, 2022[7]	O_2 saturation goal 88%–96%	O_2 saturation goal 96%–100%
Crescioli, 2023[9]	PaO_2 60 mm Hg (8 kPa)	PaO_2 90 mm Hg (12 kPa)
Jakkula, 2018[10]	$PaCO_2$ 5.8–6.0 kPa (44–45	$PaCO_2$ 4.5–4.7 kPa (34–35

Study author, year	Lower oxygen and higher carbon dioxide strategies	Higher oxygen and lower carbon dioxide strategies
	mm Hg)	mm Hg)
Eastwood, 2016[12] Eastwood, 2023[6]	Pa_{CO_2} 50–55 mm Hg (6.7–7.3 kPa)	Pa_{CO_2} 35–45 mm Hg (4.7–6.0 kPa)

Key results for both oxygen and carbon dioxide comparisons are presented in Table 8 and Table 9. Overall, there was no consistent evidence of benefit or harm from the different oxygen and carbon dioxide strategies investigated.

Table 8. Summary of Findings From Studies Comparing Higher Oxygen Values With Lower Oxygen Values

Outcome (importance)	Participants, n (studies)	Certainty of evidence, GRADE	RR (95% CI)	ARD (95% CI)
Higher compared with lower oxygen in the prehospital setting				
Survival to hospital discharge (critical)	549 (4 RCTs)[5,11,14,15]	Moderate	0.98 (0.70, 1.37)	34 fewer per 1000 patients (126 fewer to 88 more)
Survival to 3 months (critical)	35 (1 RCT)[11]	Very low	3.15 (1.04, 9.52)	379 more per 1000 patients (7 more to 1000 more)
Survival to 12 months (critical)	401 (1 RCT)[5]	Moderate	0.82 (0.64, 1.06)	76 fewer per 1000 patients (151 fewer to 25 more)
Survival with favorable neurological outcome at 12 months (critical)	389 (1 RCT)[5]	Moderate	0.85 (0.62, 1.17)	47 fewer per 1000 patients (118 fewer to 53 more)
Higher compared with lower oxygen in the ICU				

Outcome (importance)	Participants, n (studies)	Certainty of evidence, GRADE	RR (95% CI)	ARD (95% CI)
Survival to hospital discharge, 28 days, or 30 days (critical)	1409 (2 RCTs, 2 RCT subgroups)[7,8,10,13]	Low	1.10 (0.95, 1.27)	60 more per 1000 patients (30 fewer to 163 more)
Survival with favorable neurological outcome at discharge (critical)	789 (1 RCT)[8]	Moderate	1.03 (0.93, 1.14)	20 more per 1000 patients (46 fewer to 93 more)
Survival to 3 months or 6 months (critical)	1405 (2 RCTs, 2 RCT subgroups)[8-10,13]	Moderate	1.05 (0.92, 1.20)	29 more per 1000 patients (47 fewer to 116 more)
Survival with favorable neurological outcome at 3 or 6 months (critical)	1059 (2 RCTs, 1 RCT subgroup)[8,10,13]	Low	1.07 (0.96, 1.20)	43 more per 1000 patients (24 fewer to 122 more)

ARD indicates absolute risk difference; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; ICU, intensive care unit; RCT, randomized controlled trial; and RR, relative risk.

Table 9. Summary of Findings From Studies Comparing Higher Carbon Dioxide Values With Lower Carbon Dioxide Values

Outcome (importance)	Participants, n (studies)	Certainty of evidence, GRADE	RR (95% CI)	ARD (95% CI)
Moderate hypercapnia compared with normocapnia or low-normal Pa_{CO_2} after ROSC				
Survival to hospital discharge (critical)	1866 (3 RCTs)[6,10,12]	Moderate	0.95 (0.82, 1.10)	30 fewer per 1000 patients (108 fewer to 60 more)
Survival to 6 months (critical)	1648 (1 RCT)[6]	Moderate	0.96 (0.88, 1.05)	22 fewer per 1000 patients (65 fewer to 27 more)

Outcome (importance)	Participants, n (studies)	Certainty of evidence, GRADE	RR (95% CI)	ARD (95% CI)
Survival with favorable neurological outcome at 6 months (critical)	1751 (3 RCTs)[6,10,12]	Moderate	0.96 (0.85, 1.10)	19 fewer per 1000 patients (70 fewer to 46 more)

ARD indicates absolute risk difference; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; ROSC, return of spontaneous circulation; RCT, randomized controlled trial; and RR, relative risk.

Prior Treatment Recommendations (2020)[1,3]

We suggest the use of 100% inspired oxygen until the arterial oxygen saturation or the partial pressure of arterial oxygen can be measured reliably in adults with ROSC after cardiac arrest in any setting (weak recommendation, very low–certainty evidence).

We recommend avoiding hypoxemia in adults with ROSC after cardiac arrest in any setting (strong recommendation, very low–certainty evidence).

We suggest avoiding hyperoxemia in adults with ROSC after cardiac arrest in any setting (weak recommendation, low-certainty evidence).

There is insufficient evidence to suggest for or against targeting mild hypercapnia compared with normocapnia in adults with ROSC after cardiac arrest.

We suggest against routinely targeting hypocapnia in adults with ROSC after cardiac arrest (weak recommendation, low-certainty evidence).

2024 Treatment Recommendations

Oxygen Targets

We recommend the use of 100% inspired oxygen until the arterial oxygen saturation or the partial pressure of arterial oxygen can be measured reliably in adults with ROSC after cardiac arrest in the prehospital setting (strong recommendation, moderate-certainty evidence) and in-hospital setting (strong recommendation, low-certainty evidence).

We recommend avoiding hypoxemia in adults with ROSC after cardiac arrest in any setting (strong recommendation, very low–certainty evidence).

We suggest avoiding hyperoxemia in adults with ROSC after cardiac arrest in any setting (weak recommendation, low-certainty evidence).

Following reliable measurement of arterial oxygen values, we suggest targeting an oxygen saturation of 94% to 98% or a partial pressure of arterial oxygen of 75 to 100 mm Hg (≈10–13 kPa) in adults with ROSC after cardiac arrest in any setting (good practice statement).

When relying on pulse oximetry, health care professionals should be aware of the increased risk of inaccuracy that may conceal hypoxemia in patients with darker skin pigmentation (good practice statement).

Carbon Dioxide Targets

We suggest targeting normocapnia (a partial pressure of carbon dioxide of 35–45 mm Hg or ≈4.7–6.0 kPa) in adults with ROSC after cardiac arrest (weak recommendation, moderate-certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Appendix A2.

Oxygen Targets

- The task forces discussed that avoiding oxygen titration until blood oxygen values are accurately measured is especially important in the prehospital setting, where arterial blood gas analysis is rarely available and peripheral blood oxygen saturation may be difficult to obtain consistently. The largest RCT in the prehospital setting suggested that early titration to a lower oxygen target is harmful.[5] The task forces discussed whether the evidence favored avoiding any titration of oxygen in the out-of-hospital setting because most patients in the control arm of the EXACT trial (Reduction of Oxygen After Cardiac Arrest) received 100% oxygen without titration. However, most thought that once reliable measurement of oxygenation was available, the evidence only supported not titrating to a lower target range of 90% to 94%.

- In making the recommendation to avoid hypoxemia, the task forces concluded that the physiologic basis for hypoxia being harmful justifies its avoidance and that detection of hypoxemia may be the best surrogate for true hypoxia.
- The suggestion to avoid hyperoxemia is based on very low–certainty to moderate-certainty evidence that showed either harm (in observational studies included in the 2020 SysRev) or no benefit (in RCTs) from hyperoxemia. It is important to consider that the higher oxygen groups in RCTs generally did not reach the very high PaO_2 values (300–400 mm Hg) associated with harm in some observational studies.
- The variability in oxygenation targets across RCTs and observational studies makes it difficult to identify an evidence-based optimal range. However, the task forces recognized the need for more precise guidance than that provided previously and agreed that targeting an oxygen saturation of 94% to 98% or a PaO_2 target of 75 to 100 mm Hg (10–13 kPa) is reasonable.
- While studies evaluating the accuracy of pulse oximetry in people with different degrees of skin pigmentation were not part of this SysRev, the SysRev team and task forces were aware of and considered several such studies that have found a slightly higher risk of occult hypoxemia (pulse oximetry reading of >90% saturation, while arterial oxygen

saturation by blood gas is <88%) in people with dark skin.[17-19] While none of these studies were done in cardiac arrest patients, the task forces concluded that it was important to make medical professionals treating cardiac arrest patients aware of this issue because this knowledge could inform decision-making about whether to titrate supplemental oxygen. The task forces, therefore, provided a good practice statement to highlight this issue.

Carbon Dioxide Targets

- The evidence from RCTs and observational studies is inconsistent. RCTs have failed to show any effect from different CO_2 targets. Considering the lack of evidence for benefit or harm from targeting CO_2 values above or below the normal range, the task forces deemed it reasonable to target normocapnia, generally defined as a Pa_{CO_2} of 35 to 45 mm Hg, in both RCTs and observational studies. Notably, the task forces are aware of unpublished data from one RCT[5] as well observational studies not included in this review,[20-23] suggesting that $ETCO_2$ values may not accurately reflect Pa_{CO_2} values, which may be an important consideration in the prehospital setting. As with all critically ill patients, there may be specific scenarios in which CO_2 values may need to be higher or lower than normal to compensate for other illnesses (eg, severe lung injury or metabolic acidosis).
- The task forces discussed whether cardiac arrest patients with baseline chronic lung disease and chronic CO_2 retention might respond differently to different CO_2 targets; however, no evidence addressing this subgroup was found.

Knowledge Gaps

- The optimal oxygen target for post–cardiac arrest patients

- Whether there is a threshold at which hypoxemia and hyperoxemia become harmful
- The optimal duration for specific oxygen strategies
- The optimal CO_2 target for post–cardiac arrest patients
- Whether there is a threshold at which hypocapnia and hypercapnia become harmful
- The accurate correlation of $ETCO_2$ with $PaCO_2$ values
- The effects of manipulating $PaCO_2$ on cerebral blood flow in post–cardiac arrest patients
- How $PaCO_2$ targets should be adjusted in patients with chronic CO_2 retention
- Whether arterial blood gas analysis should be adjusted to 37 °C or to a patient's current temperature

Post–Cardiac Arrest Hemodynamics (ALS 3515: SysRev Adolopment)

Rationale for Review

The topic of hemodynamic goals after cardiac arrest was previously reviewed by the ALS Task Force in 2015,[24,25] and an EvUp was conducted in 2020.[1,3] In the previous recommendation, consideration of hemodynamic goals was suggested, but there was insufficient evidence to recommend a specific target. New RCTs have been published on this topic, and the task force decided a SysRev was warranted. A recently published SysRev with individual patient data meta-analysis, which included a meta-analysis of the effect of targeting a mean arterial pressure (MAP) higher or lower than 70 mm Hg, was identified; this review was deemed of sufficient quality to be used for adolopment.[26] The complete CoSTR can be found online.[27]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adults with sustained ROSC after cardiac arrest
- Intervention: Targeting a MAP of 71 mm Hg or higher
- Comparator: Targeting a MAP of 70 mm Hg or lower

- Outcomes:
  - Critical: Survival or good functional outcome defined as a modified Rankin Scale score of 1 to 3 or a score of 1 to 2 on the Cerebral Performance Category scale at 90 to 180 days
  - Important: Intensive care unit mortality, new arrhythmia resulting in hemodynamic compromise or cardiac arrest while in the intensive care unit (ICU)
- Study designs: RCTs were eligible for inclusion. All years and all languages were included as long as there was an English abstract. Observational studies and unpublished studies (eg, conference abstracts, trial protocols) were excluded.
- Time frame: The literature search was conducted in October 2022 and updated in August 2023.

Consensus on Science

The SysRev identified 4 RCTs of 1065 patients comparing lower and higher MAP targets after ROSC.[28-31] The included RCTs provided low-certainty evidence (downgraded for risk of bias and indirectness) of no benefit from a higher MAP compared with a lower MAP target for the critical outcomes of mortality at 180 days (relative risk [RR], 1.08 [95% CI, 0.92–1.26]) and good functional outcome at 180 days (RR, 0.99 [95% CI, 0.84–1.16]). Similarly, there was no benefit for the outcomes of ICU mortality (RR, 1.09 [95% CI, 0.81–1.46]) or new arrhythmia resulting in hemodynamic compromise or cardiac arrest during ICU stay (RR, 1.04 [95% CI, 0.77–1.40]).

Prior Treatment Recommendations (2015)[24,25]

We suggest hemodynamic goals (eg, MAP, systolic blood pressure) be considered during postresuscitation care and as part of any bundle of postresuscitation interventions (weak recommendation, low-certainty evidence).

There is insufficient evidence to recommend specific hemodynamic goals; such goals should be considered on an individual patient basis and are likely to be influenced by post–cardiac arrest status and pre-existing comorbidities (weak recommendation, low-certainty evidence).

2024 Treatment Recommendations

There is insufficient scientific evidence to recommend a specific blood pressure goal after cardiac arrest. Therefore, we suggest a mean arterial blood pressure of at least 60 to 65 mm Hg in patients after out-of-hospital (moderate-certainty to low-certainty evidence) and IHCA (low-certainty to very low–certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Appendix A2.

In making these updated recommendations, the ALS Task Force considered the following:

- The 4 RCTs conducted since the prior review provide significant new evidence but have not yet identified an optimal BP strategy.
- While no specific mean arterial BP strategy has been found to be beneficial in cardiac arrest trials, the task force thought it was important to provide more specific guidance than had been previously provided. The threshold of 65 mm Hg was agreed upon because this threshold is the accepted standard in other forms of critical illness, and there is no

evidence to deviate from that practice in postarrest patients. Observational data suggest that the lowest MAP not associated with a worse outcome after cardiac arrest is about 60 to 70 mm Hg,[32-34] and the “Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock” recommends targeting a MAP of >65 mm Hg in patients with septic shock.[35]

- No statistically significant benefit or harm from targeting a higher MAP was found for any critical outcome.
- All RCT studies conducted thus far focused on patients with a likely cardiac cause of the arrest and a high likelihood of a favorable outcome.
- Whether a higher MAP target, such as 80 to 100 mm Hg, may be beneficial for some patients has not been determined by trials to date. The task force acknowledged that this is part of clinical practice at some cardiac arrest centers. The current treatment recommendation purposefully does not prescribe an upper limit for MAP targets because it is unknown.

Knowledge Gaps

- Optimal BP management in patients with cardiac arrest of noncardiac etiology or with IHCA and who have thus far not been included in trials
- What blood pressure to target in the prehospital setting
- The current evidence can exclude a relative positive or negative treatment effect of targeting a higher MAP of higher than 25% but not lower; this difference may be unrealistic, and there may be a need for larger trials.
- Whether the effect of MAP on outcome is different in certain subgroups of patients, such as those with chronic hypertension

- Whether targeting a higher BP could be beneficial in patients with deranged cerebral autoregulation
- Whether increasing MAP influences cerebral or coronary blood flow
- Whether MAP, as opposed to some other proxy for organ perfusion (lactate clearance, urinary output, capillary refill), is the optimal bedside therapeutic target
- The optimal strategy to achieve a target MAP after cardiac arrest, which may include the use of intravenous fluids (fluid type and volume), specific vasopressors or combinations of vasopressors, and use of mechanical support

Post–Cardiac Arrest Temperature Control (ALS 3523, 3524, 3525: SysRev)

Rationale for Review

Since publication of the prior SysRev,[36] the task force has been aware of new clinical trials examining temperature control in comatose post–cardiac arrest patients and, therefore, updated the SysRev (PROSPERO registration of original review CRD42020217954). The SysRev covered the following 6 different aspects of temperature management: (1) use of hypothermic temperature control, (2) timing, (3) specific temperature, (4) duration of temperature control, (5) method of temperature control, and (6) rate of rewarming. The full CoSTR can be found online.[37]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adults with cardiac arrest in any setting (in-hospital or out-of-hospital)
- Interventions:
  - Intervention 1: Temperature control (temperature control studies targeting hypothermia at 32–34 °C in the SysRev)

- Intervention 2: Temperature control induction before a specific time point (eg, prehospital or intracardiac arrest)
- Intervention 3: Temperature control at a specific temperature (eg, 33 °C)
- Intervention 4: Temperature control for a specific duration (eg, 48 hours)
- Intervention 5: Temperature control with a specific method (eg, external)
- Intervention 6: Temperature control with a specific rewarming rate

● Comparators:
- Comparator 1: No temperature control (temperature control studies targeting normothermia or fever prevention included in the SysRev)
- Comparator 2: Temperature control induction after that specific time point
- Comparator 3: Temperature control at a different specific temperature (eg, 36 °C)
- Comparator 4: Temperature control at a different specific duration (eg, 24 hours)
- Comparator 5: Temperature control with a different specific method (eg, internal)
- Comparator 6: Temperature control with a different specific rewarming rate or no specific rewarming rate

● Outcomes:
- Critical: Survival and survival with a favorable neurological outcome at hospital discharge and 30 days and longer

● Study designs: Controlled trials in humans, including RCTs and nonrandomized trials (eg, pseudorandomized trials), were included. Observational studies, ecological studies, case series, case reports, reviews, abstracts, editorials, comments, letters to the editor, and unpublished studies were excluded. Studies assessing cost-effectiveness were included for a descriptive summary. Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All languages were included if there was an English abstract.

- Time frame: The original literature search was performed on October 30, 2020, and updated for clinical trials on June 17, 2021. The literature search was conducted on May 31, 2023, for the updated SysRev and on June 3, 2023, for ongoing clinical trials.

Consensus on Science

Note on Terminology

The term *targeted temperature management* has been updated as below for clarity.

- Hypothermic temperature control = active temperature control with the target temperature below the normal range
- Normothermic temperature control = active temperature control with the target temperature in the normal range
- Fever prevention temperature control = monitoring temperature and actively preventing and treating temperature above the normal range
- No temperature control = no protocolized active temperature control strategy

This updated search yielded 6 new trials investigating different aspects of post–cardiac arrest temperature control, adding to the 32 trials identified in the previous review. Comparisons included temperature control versus no temperature control, timing of temperature control, specific temperature targets, durations of temperature control, methods of temperature control, and rates of rewarming. Key results are summarized in Table 10. Overall, there was no difference between hypothermic temperature control and normothermic temperature control or between other specific temperatures studied or different durations or methods of temperature control.

1 **Table 10. Summary of Findings of Trials on Postarrest Temperature Control**

Outcome (importance)	Participants, n (studies)	Certainty of evidence, GRADE	RR (95% CI)	ARD (95% CI)
Hypothermia (32–34 °C) compared with normothermia or fever prevention				
Survival to hospital discharge (critical)	3074 (6 RCTs)[38-43]	Low	1.07 (0.91-1.25)	32 more per 1000 patients (41 fewer to 114 more)
Survival with favorable neurological outcome at hospital discharge or 30 days (critical)	2377 (4 RCTs)[38,39,42,43]	Low	1.16 (0.81-1.66)	59 more per 1000 patients (70 fewer to 243 more)
Survival to 90 or 180 days (critical)	3014 (6 RCTs)[39-44]	Low	1.06 (0.91, 1.23)	25 more per 1000 patients (38 fewer to 97 more)
Survival with favorable neurological outcome at 90 or 180 days (critical)	2991 (6 RCTs)[39-44]	Low	1.16 (0.92, 1.47)	57 more per 1000 patients (28 fewer to 166 more)
33 °C compared with 36 °C				
Survival with favorable neurological outcome at hospital discharge (critical)	938 (1 RCT)[45]	Low	0.96 (0.83, 1.11)	18 fewer per 1000 patients (78 fewer to 50 more)
Survival with favorable neurological	990 (2 RCTs)[45,46]	Low	1.01 (0.88, 1.15)	4 more per 1000 patients (42 fewer to 53 more)

Outcome (importance)	Participants, n (studies)	Certainty of evidence, GRADE	RR (95% CI)	ARD (95% CI)
outcome at 180 days (critical)				
Duration of cooling (12–24 h compared with 36 h of temperature control or 48 h compared with 24 h*)				
Survival at 1 month (critical)	173 (1 RCT)[47]	Very low	1.03 (0.89, 1.18)	24 more per 1000 patients (88 fewer to 145 more)
Favorable neurological outcome at 1 month (critical)	173 (1 RCT)[47]	Very low	0.95 (0.75, 1.21)	31 fewer per 1000 patients (156 fewer to 131 more)
*Survival at 6 months (critical)	351 (1 RCT)[48]	Low	1.10 (0.96, 1.27)	66 more per 1000 patients (26 fewer to 178 more)
*Favorable neurological outcome at 6 months (critical)	351 (1 RCT)[48]	Low	1.08 (0.93, 1.25)	51 more per 1000 patients (45 fewer to 159 more)
Method of temperature control (endovascular compared with surface cooling)				
Survival to hospital discharge or 28 days (critical)	523 (3 RCTs)[49-51]	Low	1.14 (0.93, 1.38)	56 more per 1000 patients (28 fewer to 152 more)
Favorable neurological outcome at hospital discharge or 28 days (critical)	523 (3 RCTs)[49-51]	Low	1.22 (0.95, 1.56)	64 more per 1000 patients (15 fewer to 163 more)
Rewarming rate (0.25 °C/h compared with 0.50 °C/h)				

Outcome (importance)	Participants, n (studies)	Certainty of evidence, GRADE	RR (95% CI)	ARD (95% CI)
Survival at 90 days (critical)	50 (1 RCT)[52]	Low	0.88 (0.56, 1.38)	77 fewer per 1000 patients (282 fewer to 243 more)
Favorable neurological outcome at 90 days	50 (1 RCT)[52]	Low	1.00 (0.59, 1.70)	0 fewer per 1000 patients (213 fewer to 364 more)
Duration of fever prevention after initial temperature control				
Survival at 90 days (critical)	789 (1 RCT)[53]	Low	0.99 (0.90, 1.08)	7 fewer per 1000 patients (80 fewer to 56 more)
Favorable neurological outcome at 90 days (critical)	789 (1 RCT)[53]	Low	0.98 (0.89, 1.08)	14 fewer per 1000 patients (74 fewer to 54 more)

ARD indicates absolute risk difference; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; RCT, randomized controlled trial; and RR, relative risk.

2024 Treatment Recommendations and Good Practice Statements (Unchanged)

We suggest actively preventing fever by targeting a temperature ≤37.5 °C for patients who remain comatose after ROSC from cardiac arrest (weak recommendation, low-certainty evidence).

Whether subpopulations of cardiac arrest patients may benefit from targeting hypothermia at 32 °C to 34 °C remains uncertain.

Comatose patients with mild hypothermia after ROSC should not be actively warmed to achieve normothermia (good practice statement).

We recommend against the routine use of prehospital cooling with rapid infusion of large volumes of cold intravenous fluid immediately after ROSC (strong recommendation, moderate-certainty evidence).

We suggest surface or endovascular temperature control techniques when temperature control is used in comatose patients after ROSC (weak recommendation, low-certainty evidence).

When a cooling device is used, we suggest using a temperature control device that includes a feedback system based on continuous temperature monitoring to maintain the target temperature (good practice statement).

Prior Good Practice Statement on Duration of Fever Prevention (2022[54,55])

We suggest active prevention of fever for at least 72 hours in post–cardiac arrest patients who remain comatose (good practice statement).

2024 Good Practice Statement on Duration of Fever Prevention

We suggest active prevention of fever for 36 to 72 hours in post–cardiac arrest patients who remain comatose (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Appendix A2.

Hypothermia Compared With Normothermia or Prevention of Fever

- All members of the task force agreed to continue to recommend active temperature control in post–cardiac arrest patients, although the evidence for this is limited.
- The task force acknowledged that the SysRev found no difference in overall outcomes between patients treated with hypothermia and normothermia or fever prevention.

- The majority of the task force favored fever prevention temperature control for comatose patients after ROSC as opposed to hypothermic temperature control, on the basis of the SysRevs and because this intervention requires fewer resources and had fewer side effects than hypothermic temperature control. Several members, however, wanted to leave open the option to use hypothermic temperature control (33 °C). Reasons for this include findings of a single trial suggesting benefit in those with a nonshockable initial rhythm[41] and the relatively few data in patients with cardiac arrest of a noncardiac etiology.
- The task force discussed the possibility that earlier cooling and achieving the target temperature sooner might still be beneficial. Trials to date have largely not been able to achieve this.
- Although there was no direct evidence in our SysRevs, the task force maintained the existing good practice statement supporting the avoidance of active warming of patients who have passively become mildly hypothermic after ROSC (eg, 32–36 °C) because there was concern that this may be a harmful intervention.

Prehospital Cooling

- Our treatment recommendation for prehospital cooling is unchanged from our 2015 recommendation. No new studies were identified.
- We found no evidence that any method of prehospital cooling improved outcomes, and the rapid infusion of large amounts of cold fluid immediately after achieving ROSC in the prehospital setting could be harmful. Any potential harm from this therapy may relate specifically to the prehospital setting, where there may be less control over the environment, fewer personnel, and reduced monitoring capabilities.

- We have not made a treatment recommendation about intra-arrest cooling for OHCA.

Cooling Devices

- There was consensus that temperature should be continually monitored by the cooling device, when such a device is used, so that a stable temperature is maintained.
- Two SysRevs conflict on whether surface or endovascular cooling is preferable. One showed that intravascular cooling is associated with improved neurological outcome,[56] while the other found no association with survival or neurological outcomes.[57]

Duration of Temperature Control

- Our previous treatment recommendation was a good practice statement based on trials controlling temperature for at least 72 hours in those patients who remained sedated or comatose. One trial showed no difference between 24 and 48 hours of hypothermia,[48] and another found no difference between 12 to 24 and 36 hours of hypothermia.[47]
- This updated review includes an additional trial comparing temperature control for a total duration of 36 hours versus 72 hours that found no difference in outcomes.[53] The same trial included temperature control with a surface cooling device at one site and an intravenous cooling device at the other site. Whether results are applicable to temperature control without a device or different cooling devices is unknown.
- The task force was not able to reach consensus on a treatment recommendation on duration of temperature control or fever prevention. After discussion about the lack of consistency in the interventions and comparators across the available studies, the task force agreed that there was not enough trial evidence to support a recommendation specifically on how long to prevent fever. All task force members agreed on the good

practice statement, which accommodates a range of duration that is supported by the limited data and by expert opinion.

Rewarming

- The task force discussed that, although there is no evidence that active rewarming is harmful, expert opinion is that it is generally unwarranted and can be avoided.

Knowledge Gaps

- Data on no temperature control versus fever prevention temperature control (little data available)
- The effect of temperature control after extracorporeal cardiopulmonary resuscitation (ECPR)
- The effect of temperature control after IHCA (only 1 trial and one trial subgroup available)
- Whether there is a therapeutic window within which hypothermic temperature control is effective in the clinical setting
- If a therapeutic window exists, whether there are clinically feasible cooling strategies that can rapidly achieve therapeutic target temperatures within the therapeutic window
- Whether the clinical effectiveness of hypothermia is dependent on providing the appropriate dose (target temperature and duration) based on the severity of brain injury
- Whether there are unidentified subsets of post–cardiac arrest patients who would benefit from hypothermic temperature control as currently practiced
- Whether temperature control using a cooling device with feedback is more effective than temperature control without a feedback-controlled cooling device

Post–Cardiac Arrest Seizure Prophylaxis and Treatment (ALS 3502 and 3503: SysRev)

Rationale for Review

This topic was last updated in 2020.[1,3] This was a nodal SysRev between the ALS and Pediatric Life Support Task Forces based on the knowledge of new evidence examining the treatment of seizures after cardiac arrest. The nodal review included both adults and children. Readers should refer to the pediatric life support section for pediatric-specific recommendations on this topic. The SysRev was registered on PROSPERO (CRD42023460746 and CRD42023463581), and the full CoSTR can be found online.[58]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adults or children in any setting (in-hospital or out-of-hospital) with cardiac arrest and ROSC
- Intervention: One strategy for prophylactic antiseizure medication or seizure treatment
- Comparators: Another strategy or no prophylactic antiseizure medication or seizure treatment
- Outcomes:
  - Critical: Survival or survival with favorable neurological/functional outcome at discharge, 30 days, 60 days, 180 days, or 1 year
- Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All relevant publications in any language were included if there was an English abstract.
- Time frame: All years; search conducted on September 11, 2023

Consensus on Science

Prophylactic Antiseizure Medication

No new studies were identified since the prior review. For the critical outcome of survival with favorable neurological outcome at discharge, 30 days, or longer, 2 RCTs including 562 patients investigated prophylactic antiseizure medication and provided very low–certainty evidence of no benefit for survival or neurologic outcome.[59,60] Agents used for prophylaxis included thiopentone,[59] magnesium, diazepam, and the combination of magnesium and diazepam,[60] all compared with placebo. A nonrandomized clinical trial of 107 patients provided very low–certainty evidence of no improvement in neurological outcome at hospital discharge or survival with thiopentone compared with historic controls.[61]

Treatment of Seizures

No RCTs or nonrandomized studies addressed the effect of treatment of clinical seizures in post–cardiac arrest patients compared with no seizure treatment. One RCT provided low-certainty evidence on the effect of treatment of rhythmic and periodic electroencephalogram (EEG) patterns in comatose patients after cardiac arrest, compared with no treatment, finding no difference in favorable neurological outcome (Cerebral Performance Category 1–2) at 3 months with administration of antiseizure medications compared with standard care (RR, 1.23 [95% CI, 0.48–3.15]; or 19 more per 1000 patients, [95% CI, from 43 fewer to 179 more]).[62] There was also no difference in survival.

Prior Treatment Recommendations (2020)

We suggest against seizure prophylaxis in adult post–cardiac arrest survivors (weak recommendation, very low–certainty evidence).

We suggest treatment of seizures in adult post–cardiac arrest survivors (weak recommendation, very low–certainty evidence).[1,3]

2024 Treatment Recommendations

We suggest against the use of prophylactic antiseizure medication in post–cardiac arrest adults (weak recommendation, very low–certainty evidence).

We suggest treatment of clinically apparent and electrographic (EEG) seizures in post–cardiac arrest adults (good practice statement).

We suggest treatment of rhythmic and periodic EEG patterns that are on the ictal-interictal continuum in comatose post–cardiac arrest adults (weak recommendation, low-certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Appendix A2.

Prophylactic Antiseizure Medication

No new evidence has emerged on this topic since the prior review. The task force decided to clarify the language slightly but saw no reason for substantive change. The task force considered the evidence that the administration of prophylactic antiseizure medication in other forms of acute brain injury is not associated with improved outcomes and that most prophylactic antiseizure medications can have significant side effects. Finally, the task force acknowledged that most comatose post–cardiac arrest patients routinely receive sedatives like propofol or benzodiazepines, which are known to have antiseizure effects. However, the task force identified no controlled studies that examined whether different sedation strategies or choices of sedation drugs had an impact on the incidence of post–cardiac arrest seizures.

Seizure Treatment

The task force discussed the importance of consistent definitions when investigating this topic and creating treatment recommendations. Terms and definitions established by the American Clinical Neurophysiology Society are used in the discussion below and should be employed consistently in trials (Table 11).[63]

Table 11. ACNS Standardized Critical Care EEG Terminology 2021 for Electrographic and Electroclinical Seizures

Category	Definition
Electrographic seizure	• Epileptiform discharges averaging >2.5 Hz for ≥10 s (>25 discharges in 10 s) *or* • Any pattern with definite evolution as defined above and lasting ≥10 s
Electroclinical seizure	Any EEG pattern with either • Definite clinical correlate time-locked to the pattern (of any duration) *or* • EEG **and** clinical improvement with a parenteral (typically IV) antiseizure medication
Electroclinical status epilepticus	An electroclinical seizure for • ≥10 continuous min *or* • A total duration of ≥20% of any 60-min period of recording *or* • ≥5 continuous min if the seizure is convulsive (ie, with bilateral tonic clonic motor activity; in any other clinical

Category	Definition
	situation, the minimum duration to qualify as status epilepticus is >10 min *Possible ECSE:* A pattern on the ictal-interictal continuum that is present for ≥10 continuous min or for a total duration of >20% of any 60-min period of recording, which shows EEG improvement with a parenteral antiseizure medication **but** without clinical improvement
Ictal-interictal continuum	● Any PD or SW pattern that averages >1.0 Hz and <2.5 Hz over 10 s (>10 and <25 discharges in 10 s) *or* ● Any PD or SW pattern that averages >0.5 Hz and <1 Hz over 10 s (>5 and <10 discharges in 10 s) and has a plus modifier or fluctuation *or* ● Any lateralized RDA averaging >1 Hz for at least 10 s (at least 10 waves in 10 s) with a plus modifier or fluctuation *and* ● Does not qualify as an electrographic seizure or electroclinical status epilepticus

ACNS indicates American Clinical Neurophysiology Society; ECSE, electroclinical status epilepticus; EEG, electroencephalogram; IV, intravenous; PD, periodic discharge; RDA, rhythmic delta activity; SE, status epilepticus; and SW, spike wave.

Other points of discussion included

- Correct categorization of EEG findings requires the skilled interpretation of video EEG.

- Untreated clinical seizure activity may cause additional brain injury, and, thus, treatment of clinical seizures is recommended despite the lack of high-certainty evidence.
- Rhythmic and periodic EEG patterns that do not meet criteria for electrographic seizures are of unclear significance in patients who are comatose after cardiac arrest. It is not clear if they represent a marker of an injured brain or if treatment may improve outcomes.
- In the TELSTAR trial (Treatment of Electroencephalographic Status Epilepticus After Cardiopulmonary Resuscitation), the majority (≈80%) of the EEG patterns were generalized periodic discharges of 0.5 to 2.5 Hz without evolution. Whether such EEG patterns deserve treatment is unknown, and no difference was seen in the trial. Post hoc subgroup analysis of TELSTAR suggested a possible beneficial effect in the small subgroup with electrographic seizures but not for treatment of periodic discharges.[62]
- Indirect evidence from case series suggests sedatives such as propofol are effective in suppressing clinical seizures and electrographic seizures. A retrospective study provides some evidence that conventional antiseizure medications (specifically valproate and levetiracetam) also have an effect in suppressing epileptiform activity in the EEG.[64]
- There is no direct evidence of undesirable effects of antiseizure medications in comatose post–cardiac arrest patients, although use of sedating agents may delay awakening.
- The benefit of continuous EEG compared with intermittent EEG was not specifically reviewed. Continuous EEG monitoring is labor intensive and likely to add significant cost to patient care. The cost-effectiveness of this approach is controversial and may depend substantially on the setting. The CERTA study (Continuous EEG Randomized Trial in Adults) evaluated continuous versus intermittent EEG in critically ill adults with impaired consciousness, and approximately one third of the subjects had been

resuscitated from cardiac arrest.[65] No difference was found in outcome (6-month mortality), although more seizures were detected and more frequent changes to antiseizure medications were made in the continuous EEG group.

Knowledge Gaps

- Whether antiseizure medications affect the outcome of post–cardiac arrest patients with either rhythmic and periodic EEG patterns or clinical seizures
- The optimal timing, duration, dosing, and choice of antiseizure medications for seizure treatment in comatose post–cardiac arrest patients
- The utility and cost-effectiveness of continuous EEG versus intermittent EEG monitoring in the diagnosis and treatment of seizures in comatose postarrest patients
- The threshold for treating rhythmic and periodic EEG activity
- The value of using volatile anesthetics to treat refractory status epilepticus in post–cardiac arrest patients

Extracorporeal Cardiopulmonary Resuscitation (ALS 3001: SysRev)

Rationale for Review

The task force was aware of new research published on the use of ECPR, and the decision was made to update our previous SysRev (PROSPERO registration CRD42022341077).[66,67] This SysRev update was a joint effort between the ALS and Pediatric Life Support Task Forces. For evidence related to pediatric cardiac arrest, refer to the Pediatric Life Support section of this summary. The full CoSTR can be found online.[68]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adults (>18 years) with cardiac arrest in any setting (out-of-hospital or in-hospital)

- Intervention: ECPR, including extracorporeal membrane oxygenation or cardiopulmonary bypass during cardiac arrest
- Comparators: Manual or mechanical cardiopulmonary resuscitation
- Outcome: Any clinical outcome
- Study designs: RCTs were included. Observational studies, animal studies, ecological studies, case series, case reports, reviews, abstracts, editorials, comments, letters to the editor, and unpublished studies were excluded. Studies assessing cost-effectiveness were included for a descriptive overview. Studies exclusively assessing the use of extracorporeal life support for cardiac or respiratory failure after sustained ROSC were excluded. Studies assessing extracorporeal circulation for deep hypothermia (or other conditions) were included only if cardiac arrest was documented. All languages were included if there was an English abstract or an English full-text article.
- Time frame: From June 21, 2022 (date of the search for the previous review), to May 10, 2023

Consensus on Science

A single new RCT was identified.[69] This adds to the 3 RCTs identified in the previous review.[67,70-72] Given the existence of 4 RCTs and the critical risk of bias of the observational studies identified in prior reviews, only evidence from RCTs was considered.

The overall certainty of evidence was rated as low for OHCA and as very low for IHCA (downgraded further because all evidence was in OHCA) for all outcomes. Because of a high degree of heterogeneity between the randomized trials, no meta-analyses were performed. Key results are summarized in Table 12.

Table 12. Key Outcomes by Treatment Group and ARD for Patients Treated With an ECPR Strategy, Compared With Standard Care

Author, year	n	Survival to discharge/30 d, n (%)		ARD (95% CI), %	Favorable functional outcome* at discharge/30 d, n (%)		ARD (95% CI), %	Favorable functional outcome* at 6 mo, n (%)		ARD (95% CI), %
		ECPR strategy	Standard care		ECPR strategy	Standard care		ECPR strategy	Standard care	
Yannopoulos, 2020[70]	30	6/14 (43)	1/15 (7)	36 (7.4 to 65)	3/14 (21)	0	21 (0 to 43)	6/14 (43)	0	43 (17 to 69)
Hsu, 2021[71]	15	0	1/3 (33)	−33 (−87 to 20)	0	0	0	NA	NA	NA
Belohlavek, 2022[72]	264	52/124 (42)	43/132 (33)	9.4 (−2.4 to 21)	38/124 (31)	24/132 (18)	13 (2 to 23)	39/124 (32)	29/132 (22)	10 (−1.3 to 20)
Suverein, 2023[69]	134	14/70 (20)	13/64 (20)	−0.3 (−14 to 13)	14/70 (20)	10/62 (16)	3.9 (−9.2 to 17)	14/70 (20)	10/63 (16)	4.1 (−8.9 to 17)

*Favorable functional outcome defined as mRS score of 0 to 3 or CPC score of 1 to 2.
ARD indicates absolute risk difference; CPC, Cerebral Performance Category; ECPR, extracorporeal cardiopulmonary resuscitation; mRS, modified Rankin Scale; and NA, not applicable.

Prior Treatment Recommendations (2023)

We suggest that ECPR may be considered as a rescue therapy for selected patients with OHCA when conventional CPR is failing to restore spontaneous circulation in settings in which this can be implemented (weak recommendation, low-certainty evidence).

We suggest that ECPR may be considered as a rescue therapy for selected patients with IHCA when conventional CPR is failing to restore spontaneous circulation in settings in which this can be implemented (weak recommendation, very low–certainty evidence).

2024 Treatment Recommendations

We suggest that extracorporeal cardiopulmonary resuscitation (ECPR) may be considered as a rescue therapy for selected adults with out-of-hospital cardiac arrest when conventional cardiopulmonary resuscitation is failing to restore spontaneous circulation in settings where this can be implemented (weak recommendation, low-certainty evidence).

We suggest extracorporeal cardiopulmonary resuscitation (ECPR) may be considered as a rescue therapy for selected adults with in-hospital cardiac arrest when conventional cardiopulmonary resuscitation is failing to restore spontaneous circulation in settings where this can be implemented (weak recommendation, very low–certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Appendix A2.

- In making this weak recommendation, we note that this patient population (ie, patients in whom conventional CPR is failing during cardiac arrest) has an extremely high mortality rate, particularly when refractory to standard advanced cardiac life support. Therefore, the potential for benefit and value of this intervention remains despite the overall low certainty of the evidence.

- The published randomized trials use highly selected patients for ECPR and not the general population of all cardiac arrest cases. The trial by Yannopoulos et al[70] enrolled OHCA patients with an initial shockable rhythm and randomized patients upon hospital arrival, whereas the trials by Hsu et al[71] and Belohlavek et al[72] enrolled OHCAs with any initial rhythm and randomized patients in the prehospital setting. The trial by Suverein et al[69] enrolled OHCA patients with an initial shockable rhythm and randomized most patients in the prehospital setting (63% in the ECPR group and 66% in the conventional CPR group). Guidelines for clinical practice should ideally apply to similar populations, although the optimal population remains undefined. For this reason, the findings of individual trials should be interpreted cautiously in the context of the trial setting and population.
- We acknowledge that ECPR is a complex intervention that requires considerable resources and training that are not universally available but also acknowledge the value of an intervention that may be successful in individuals for whom usual CPR techniques have failed. In addition, ECPR can sustain perfusion while another intervention, such as coronary angiography or percutaneous coronary intervention, can be performed.

Knowledge Gaps

- There are few, and no large, randomized trials of ECPR versus standard care
- The optimal patient population who may benefit from ECPR
- The optimal time to initiate ECPR in cases of refractory cardiac arrest
- Whether ECPR for OHCA should be initiated in the prehospital or in-hospital setting
- The optimal techniques for providing safe and timely ECPR
- The optimal post–cardiac arrest care strategy for patients resuscitated using ECPR

- Whether there are population-specific differences in performing ECPR for in-hospital cardiac arrest and OHCA
- Whether there are differences in quality of life between survivors of ECPR and standard CPR
- The cost-effectiveness of ECPR

Cardiac Arrest During Pregnancy (ALS 3401: ScopRev)

Rationale for Review

Cardiac arrest during pregnancy is a rare but catastrophic event. Physiologic changes during pregnancy and concerns about both maternal and fetal survival bring additional considerations to resuscitation of a pregnant patient. The task force was aware that the evidence available was insufficient for a SysRev and meta-analysis to be possible but thought a review of this topic was a high priority, and this ScopRev was thus completed. The full report of this ScopRev, including detailed tables describing the individual studies, can be found online.[73]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Pregnant or up to 1-year postpartum patients in cardiac arrest in any setting (in-hospital or out-of-hospital)
- Intervention: Any specific intervention(s)
- Comparators: Standard care or usual resuscitation practice
- Outcomes:
- Maternal
  Critical: Survival and favorable functional outcome at hospital discharge, 30 days, 60 days, 180 days, or 1 year
  Important: ROSC

  - Neonatal

    Critical: Survival and favorable functional outcome at hospital discharge, 30 days, 60 days, 180 days, or 1 year

    Important: ROSC

- Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies, simulation/manikin and animal studies), case series with ≥20 patients, and descriptive studies without a comparator group were eligible for inclusion. Gray literature, social media, and non–peer-reviewed studies, unpublished studies, conference abstracts, and trial protocols were eligible for inclusion. All languages were included if there was an English abstract or an English full-text article.
- Time frame: From August 2014 (date of prior review) to September 2023

Summary of Evidence

This ScopRev identified 8 heterogeneous studies describing several interventions for cardiac arrest during pregnancy.[74-81] The studies are substantially limited by lack of granularity, small sample sizes, indirect measures of interventional effects, and high degrees of bias and confounding.

Studies are described in detail in the data tables in the online ScopRev.[73] The studies identified concentrated on 3 interventions: (1) left-lateral uterine displacement with supine positioning for resuscitation, (2) perimortem or resuscitative delivery, and (3) extracorporeal life support.

Indirect data from a porcine model demonstrated significantly higher coronary perfusion pressures during resuscitation with supine positioning with left-lateral uterine displacement compared with left-lateral tilt positioning (perfusion pressure of 20 mm Hg compared with 5 mm Hg, $P<0.05$).[76] Five observational studies reported data supporting performing perimortem cesarean or resuscitative delivery when ROSC does not occur early during resuscitation of cardiac arrest in a pregnant person with a uterine size ≥20 weeks' gestation.[77-81] The median number of minutes from collapse to cesarean delivery in survivors and nonsurvivors varied across studies, but shorter times from arrest to delivery were associated with improved maternal and neonatal outcomes. Two studies suggested that extracorporeal life support may improve pregnancy and peripartum outcomes for both the pregnant person and fetus in the setting of cardiac arrest, despite the potential of bleeding and clotting complications.[74,75]

Task Force Insights

The task force prioritized this topic because of the ongoing burden of mortality during pregnancy (estimated at 287 000 deaths globally in 2020, with mortality increasing in some countries, such as the United States).[82,83] The prevalence of cardiac arrest during hospitalizations for delivery in the United States from 2017 to 2019 rose to 1/9000, previously reported as 1/12 000 in 2014 using the US National Inpatient Sample database.[84] Cardiac arrest is the final common pathway of several pathophysiologic conditions leading to death during pregnancy, including hemorrhage, cardiomyopathy, hypertensive complications, embolic events, and sepsis. Management of cardiac arrest is complex because it requires accommodation of the physiological changes of pregnancy. Randomized trials are challenging to perform during pregnancy, and the evidence on this topic is limited. For these reasons, the task force decided to summarize the emerging research and identify specific knowledge gaps. The limited data did not support a full SysRev or making any changes to existing treatment recommendations, but 2 good practice statements were made.

2024 Treatment Recommendations (Unchanged) and Good Practice Statements (New)

We suggest delivery of the fetus by perimortem cesarean delivery for women in cardiac arrest in the second half of pregnancy (weak recommendation, very low–certainty evidence).

There is insufficient evidence to define a specific time interval by which delivery should begin.

High-quality usual resuscitation care and therapeutic interventions that target the most likely cause(s) of cardiac arrest remain important in this population.

There is insufficient evidence to make a recommendation about the use of left-lateral tilt and/or uterine displacement during CPR in the pregnant patient.

ECPR may be considered as a rescue therapy for selected cardiac arrest patients during pregnancy or in the postpartum period when conventional CPR fails and in settings in which it can be implemented (good practice statement).

This good practice statement does not replace the ALS treatment recommendation for use of ECPR in general.

Institution readiness and resuscitation education are required to accommodate the unique physiologic challenges of cardiac arrest during pregnancy (good practice statement).

Knowledge Gaps

- How to improve outcomes of cardiac arrest during pregnancy
- Optimal approach to airway management in cardiac arrest in pregnancy, including placement of an advanced airway, tracheal intubation, and use of video laryngoscopy
- Optimal management of OHCA during pregnancy, including issues of transport and consequent delays in perimortem or resuscitative delivery
- How to select patients most likely to benefit from, and not be harmed by, ECPR

Emergency Front of Neck Airway Access During Cardiac Arrest (ALS 3606: ScopRev)

Rationale for Review

This topic was selected for review by the ALS Task Force due to ongoing uncertainty regarding optimal strategies for emergency airway management in cardiac arrest when standard approaches to basic and advanced airway management fail. The full report of this ScopRev can be found online.[85]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adult patients in cardiac arrest in any setting in which adequate ventilation cannot be rapidly achieved by using basic or advanced airway management strategies
- Intervention: Front-of-neck airway access attempt
- Comparators: Ongoing attempts at basic or advanced airway management strategies
- Outcome: Any clinical outcome
- Study designs: RCTs, nonrandomized studies (eg, interrupted time series, controlled before-and-after studies and cohort studies), and case series with at least 5 patients were included. Animal studies, case series or reports with fewer than 5 patients, editorials, protocols, review papers, and letters were excluded.
- Time frame: From inception to November 2, 2023

Summary of Evidence

Our search identified a single RCT[86] and 68 observational studies from prehospital, in-hospital, and military settings.[87-154] No studies specifically focused on cardiac arrest.

The RCT compared emergency cricothyrotomy and emergency percutaneous dilational tracheostomy in 169 patients (9 with cardiac arrest) with failed airway management in the emergency department.[86] The success rate of percutaneous cricothyrotomy (95.3%) was similar to that of percutaneous dilational tracheostomy (97.6%) (*P*=0.45).

The observational studies documented a median 11.4 front-of-neck access attempts per study (interquartile range [IQR], 2.9-31.5). Most studies were trauma specific or a mix of trauma and medical emergencies and occurred in a mix of prehospital, in-hospital, and military settings. The most common emergency front-of-neck airway intervention was surgical cricothyroidotomy.

Incidence of front-of-neck airway access attempts varied markedly across studies, from 0.06 to 436 attempts per 1000 patients. The variability was predominantly driven by the denominator chosen in each study (eg, all intubation attempts or all cases of failed intubation). Success rates were typically high, with most studies reporting success rates of >70%. Outcomes varied markedly across studies. In cardiac arrest patients, rates of ROSC ranged from 0% to 64%. The evidence on complications was challenging to interpret because reporting was inconsistent.

Task Force Insights

The task force discussed the review findings and noted the following:

- None of the available evidence directly addressed the review question.
- There were no studies that specifically examined patients in cardiac arrest, such that the incidence of front-of-neck airway access attempts in the cardiac arrest population is uncertain.
- The success rate of emergency front-of-neck airway access attempts was generally high.
- Clinical outcomes across studies varied markedly.
- The available evidence does not enable the task force to make comparisons across different front-of-neck airway access strategies.

- The context of cardiac arrest (eg, ongoing chest compressions, unreliability of pulse oximetry or other strategies to monitor oxygenation) may make it particularly challenging to rapidly identify a failure to achieve adequate ventilation and adequate oxygenation.
- The task force recognized that the generation of high-quality data that directly address the review question would be challenging.

2024 Good Practice Statement (New)

In adults in cardiac arrest, when standard airway management strategies (eg, oropharyngeal airway and bag-mask, supraglottic airway, or tracheal tube) have failed, it is reasonable for appropriately trained rescuers to attempt front-of-neck airway access using a cricothyroidotomy technique (good practice statement).

Knowledge Gaps

- The incidence or success rate of emergency front-of-neck airway access attempts in the adult cardiac arrest population
- The optimal timing for emergency front-of-neck airway access in adults in cardiac arrest
- Clinical outcomes of adults in cardiac arrest for whom emergency front-of-neck airway access is attempted
- The optimal technique for achieving front-of-neck airway access

ALS Topics Reviewed by EvUps

ALS topics reviewed by EvUps are summarized in Table 13. Complete EvUps can be found in Appendix B2.

1 **Table 13. ALS Topics Reviewed With EvUps**

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
Use of atropine in cardiac arrest (ALS 3206)	2010	There is insufficient evidence to support or refute the use of atropine in cardiac arrest to improve survival to hospital discharge.	0	3	Administration of atropine was not associated with improved survival to hospital discharge or longer-term survival/ neurological outcomes.	No
Airway management during cardiac arrest (ALS 3300–3304)	2019	We suggest using bag-mask ventilation or an advanced airway strategy during CPR for adult cardiac arrest in any setting (weak recommendation, low-certainty to moderate-certainty evidence). If an advanced airway is used, we suggest a supraglottic airway for adults with OHCA in settings with a low tracheal intubation success rate (weak recommendation, low-certainty evidence). If an advanced airway is used, we	2 and 9 RCT subanalyses	50	One cluster RCT found no significant difference between tracheal tube and iGel. Five observational studies compared video with direct laryngoscopy. In all 5 studies, video laryngoscopy was associated with either better or equivalent outcomes (outcomes ranging from glottic view	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		suggest a supraglottic airway or tracheal intubation for adults with out-of-hospital cardiac arrest in settings with a high tracheal intubation success rate (weak recommendation, very low–certainty evidence). If an advanced airway is used, we suggest a supraglottic airway or tracheal intubation for adults with in-hospital cardiac arrest (weak recommendation, very low–certainty evidence).			to hospital survival). Two randomized trials compared proprietary laryngoscopy tools against direct laryngoscopy in small cohorts. In general, findings favored the proprietary tools over direct laryngoscopy. Seven observational studies, all limited by risk of bias, found an association between early advanced airway placement and better outcomes (patients who did not receive an advanced airway were excluded).	

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
CPR-induced consciousness (ALS 3004)	2021	In settings in which it is feasible, rescuers may consider using sedative or analgesic drugs (or both) in very small doses to prevent pain and distress to patients who are conscious during CPR (good practice statement). Neuromuscular-blocking drugs alone should not be given to conscious patients (good practice statement). The optimal drug regimen for sedation and analgesia during CPR is uncertain. Regimens can be based on those used in critically ill patients and according to local protocols (good practice statement).	0	5	Incidence of CPRIC appears to be high, with 57% of UK paramedics witnessing CPRIC. CPRIC is associated with memory and awareness of events and may have longer-lasting psychological sequelae (depression, anxiety, PTSD). It is unclear how to best treat CPRIC or whether treatment improves patient care and outcomes.	No
Cardiac arrest	2010	There is insufficient evidence to suggest any routine change to	0	1 guideline paper		No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
associated with asthma (ALS 3408)		cardiac arrest resuscitation treatment algorithms for patients with cardiac arrest caused by asthma.				
Antiarrhythmics during and after cardiac arrest (ALS 3201, 3514)	2018	We suggest the use of amiodarone or lidocaine in adults with shock refractory VF/pVT (weak recommendation, low-quality evidence). We suggest against the routine use of magnesium in adults with shock-refractory VF/pVT (weak recommendation, very low-quality evidence). The confidence in effect estimates is currently too low to support an ALS Task Force recommendation	0 6 secondary analyses of ROC-ALPS RCT	20	Observational studies and the secondary analyses of prior RCTs generally favor amiodarone or lidocaine over placebo, supporting the current treatment recommendations. Studies supported early administration of antiarrhythmics during cardiac arrest as survival decreased with longer times to drug	Yes for beta blockers and procainamide; No for other agents

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		about the use of bretylium, nifekalant, or sotalol in the treatment of adults in cardiac arrest with shock-refractory VF/pVT. The confidence in effect estimates is currently too low to support an ALS Task Force recommendation about the use of prophylactic antiarrhythmic drugs immediately after ROSC in adults with VF/pVT cardiac arrest.			administration. Recent observational data suggests intra-arrest beta blockers or procainamide might be beneficial.	

ALS indicates advanced life support; CPR, cardiopulmonary resuscitation; CPRIC, CPR-induced consciousness; EvUp, evidence update; mCPR, mechanical CPR; PICO, population, intervention, comparator, outcome; PTSD, posttraumatic stress disorder; RCT, randomized controlled trial; and SysRev, systematic review.

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PEDIATRIC LIFE SUPPORT

Blood Pressure Targets Following Return of Circulation After Pediatric Cardiac Arrest (PLS 4190-01: SysRev)

Rationale for Review

Determining the optimal BP targets in infants and children following cardiac arrest after ROSC, or after return of circulation (ROC) on mechanical support, poses a significant challenge due to lack of evidence. Clinical practice in this area is based on a few pediatric studies, extrapolation from studies conducted in adults, or expert consensus recommendations. While individual studies in infants and children suggest there is an association between hypotension post-ROSC or post-ROC and poor outcomes, these studies are small and it is unclear if the association is causal or a surrogate marker of more severe postresuscitation syndrome. To answer this knowledge gap, a systematic review aimed to evaluate the literature on the effects of BP targets on outcomes post-ROSC/ROC in infants and children (PROSPERO registration CRD42023483865). The full CoSTR can be found online.[1]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Infants and children in any setting (in-hospital or out-of-hospital cardiac arrest) after ROC
- Intervention: A specific BP target
- Comparator: No BP target or a different BP target
- Outcome
  - Critical: Survival/survival with favorable neurological outcome as per Pediatric Core Outcome Set for Cardiac Arrest[2]

- Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All languages were included if there was an English abstract.
- Time frame: All years were included. The initial search was done on January 25, 2023, and updated on November 3, 2023.

Consensus on Science

Six studies were identified.[3-8] All 6 were nonrandomized observational cohort studies, with 5 being secondary analyses. We identified significant variation in BP target definitions (eg, systolic, mean, and diastolic BP and >5th, >10th, and >50th percentile for age) and time frames for measurement (<20 minutes, 0–6 hours, within 24 hours, and 0–72 hours). In our final analysis, we included 4 studies[4,5,7,8] examining the BP targets of systolic BP >5th percentile for age compared with systolic BP ≤5th percentile within the first 6 hours after ROC. The pooled sample included 463/930 (49.8%) patients following IHCA and 467/930 (50.2%) after OHCA. We also included 1 study[3] that enrolled 693 infants and children after IHCA (excluding patients who required extracorporeal life support [ECLS]). This study compared systolic BP >10th percentile with systolic BP ≤10th percentile within the first 6 hours after ROC. The systolic BP cutoff at the 10th percentile was generated from receiver operator characteristic curves and spline curves created from the study data.

Results from included pediatric studies are included in Table 14. A random effects model was chosen for meta-analysis to better account for study heterogeneity.

Table 14. Studies Comparing BP Targets Post–Cardiac Arrest

Outcomes (importance)	Study type, participants, n (studies, n)	Certainty of evidence (GRADE)	aRR (95% CI)	ARD with intervention
Exposure: ≤5th percentile versus >5th percentile for age systolic BP within 6 h post-ROC				
Survival	Nonrandomized, 931 (4)[4,5,7,8]	Very low	1.34 (1.07–1.52)	143 more patients per 1000 survived with the intervention (95% CI, 30 more patients per 1000 to 219 more patients per 1000 survived with the intervention)
Survival with favorable neurologic outcome (critical)	Nonrandomized, 584 (2)[4,5]	Very low	1.30 (1.06–1.60)	156 more patients per 1000 survived with the intervention (95% CI, 31 more patients per 1000 to 312 more patients per 1000 survived with the intervention)
Exposure: ≤10th percentile versus >10th percentile for age systolic BP within 6 h post-ROC				
Survival	Nonrandomized, 693 (1)[3]	Very low	1.21 (1.00–1.33); $P<0.01$	138 more patients per 1000 survived with the intervention (95% CI, 66 more patients per 1000 to 213 more patients per 1000 survived with the intervention)
Survival with favorable neurologic outcome (critical)	Nonrandomized, 693 (1)[3]	Very low	1.22 (1.10–1.35); $P<0.01$	134 more patients per 1000 survived with the intervention (95% CI, 61 more patients per 1000 to 213 more patients per 1000 survived with the intervention)

ARD indicates absolute risk difference; aRR, adjusted risk ratio; BP, blood pressure; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; ROC, return of circulation.

Prior Treatment Recommendation (2020)

We recommend that for infants and children after ROSC, parenteral fluids and/or inotropes or vasopressors should be used to maintain a systolic blood pressure of at least greater than the fifth percentile for age (strong recommendation, very low–certainty evidence).[9]

2024 Treatment Recommendations

We suggest in infants and children with return of circulation following an IHCA or OHCA that a systolic BP >10th percentile for age should be targeted (weak recommendation, very low–certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Appendix A3.

- The PLS Task Force considered that the measurement and treatment of BP is a standard component of the postresuscitation bundle of care after cardiac arrest. However, current post–cardiac arrest BP targets and thresholds for treatment have been suggested through expert consensus and evidence extrapolated from individual studies.
- Measurement of BP is a low-cost intervention and available in nearly all resource settings. However, the PLS Task Force did not compare the cost-effectiveness of intermittent noninvasive BP measurement with invasive arterial or continuous BP measurement.
- There were no randomized controlled studies comparing 2 treatment approaches or 2 BP targets following cardiac arrest. The available evidence consisted of observational data demonstrating the impact of exposure to 2 different BP thresholds on clinically important outcomes. However, the BP thresholds were chosen either a priori by investigators as a clinically important threshold (eg, <fifth percentile) or the cutoff value was derived

statistically from the population data as the most significant inflection point (<10th percentile). The PLS Task Force focused on the impact of hypotension on clinical outcome and did not include studies assessing normotension or hypertension on outcomes. This will form part of future assessments.

- The PLS Task Force considered the exposure overlap of the 2 thresholds, <5th percentile and <10th percentile. It was not statistically possible to perform meta-regression to compare the 2 treatment targets. The consensus of the task force was that the higher threshold target (<10th percentile) included the population included in the <5th percentile group. Acknowledging the low certainty of evidence, the target of >10th percentile systolic BP was the more acceptable systolic BP goal and ensured avoidance of the 5th to 10th BP percentiles that were associated with worse outcome in the larger study.[3]
- The PLS Task Force concluded that although the effect size from the pooled studies is small, the value of the outcome is high and the potential impact on infant and child survivors globally is, therefore, large.

Knowledge Gaps

- There are no interventional RCTs comparing benefit or harm of targeting specific BP targets.
- The impact of prehospital BP measurement or treatment for OHCA
- Whether specific subgroups of pediatric patients after ROC require different BP targets. Observational data demonstrate an association between exposure to lower BP targets and worse outcome; however, more data are required to demonstrate a causal relationship between treatment interventions to achieve higher BP targets and improved outcomes.

The task force was unable to assess the benefits or harm of exposure to hypertension in the period after cardiac arrest.

- Whether patients receiving targeted temperature management (eg, 33°C) require different BP targets
- We encourage consistent reporting of BP monitoring definitions (eg, site, repeated measurement, component of BP [systolic, diastolic, mean BP]) and definitions of exposure to hypotension (eg, single episode versus percentage of time).
- Most studies report exposure to BP thresholds within 6 hours; impact of BP interventions outside this time frame is important.
- Which strategy is optimal to achieve a BP above the threshold level (eg, fluids, vasopressor support, mechanical support)
- Whether a BP target or another marker of end organ perfusion is the most appropriate target
- Optimal BP targets during ECLS post–cardiac arrest. Some patients on ECLS may lack heart pulsatility, which also limits use of systolic BP targets in this patient group.
- The optimal strategy to use when cerebral autoregulation is impaired

Effect of Prophylactic Antiseizure Medication and/or Treatment of Seizures on Outcome of Children Following Cardiac Arrest (PLS 4210-02: SysRevs)

Rationale for Review

Cardiac arrest in children is relatively uncommon and has a very high mortality rate, with hypoxic-ischemic brain injury being a common cause of death. Seizures including suspected clinical, electroclinical, and electrographic seizures with EEG correlation are common manifestations of post–cardiac arrest brain injury in children, with an incidence of approximately

10% to 40%.[10-12] Seizures and abnormalities on EEG post–cardiac arrest are associated with poor neurologic outcome in children.[12-15] It is unclear if prophylactic antiseizure medication to prevent seizures and/or treatment of seizures when they are identified improves outcome. There are no existing ILCOR recommendations for children, and this SysRev was thus undertaken (PROSPERO registrations CRD42023460746 and CRD42023463581). The full CoSTR can be found online.[16]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adults or pediatric patients in any setting (IHCA or OHCA) with ROC
- Intervention: One strategy for prophylactic antiseizure medication *or* seizure treatment
- Comparator: Another strategy or no prophylactic antiseizure medication *or* seizure treatment
- Outcome
  - Critical: Survival or survival with favorable neurological outcome as per Pediatric Core Outcome Set for Cardiac Arrest[2]
- Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All relevant publications in any language were included if there was an English abstract.
- Time frame: Literature search includes all years up to September 11, 2023.

Consensus on Science

Prophylactic Antiseizure Medication

For the critical outcome of survival with favorable neurological outcome at discharge/30 days or longer, no pediatric RCTs nor nonrandomized comparative studies were identified.

Indirect evidence from adult studies was identified and included (Table 15). We identified 2 randomized studies[17,18] and a single nonrandomized study[19] enrolling adult patients only. No studies reported improvement in survival with favorable neurological outcome or survival with prophylactic antiseizure medication.

Table 15. Adult Studies of Prophylactic Antiseizure Medication Post–Cardiac Arrest

Outcomes (importance)	Participants, n (studies, n/study type)	Investigation	Certainty of evidence (GRADE)	RR (95% CI)	ARD with intervention
			Adult studies		
Survival with favorable neurologic outcome (critical)	262 (1 RCT)[17]	Thiopentone versus standard care	Very low	1.3 (0.76–2.21)	46 more adult survivors per 1000 patients (95% CI, from 37 fewer to 185 more)
	300 (1 RCT)[18]	IV magnesium versus placebo	Very low	1.37 (0.83–2.25)	94 more adult survivors per 1000 patients (95% CI, from 43 fewer to 317 more)
	300 (1 RCT)[18]	IV diazepam versus placebo	Very low	0.68 (0.36–1.28)	81 fewer adult survivors per 1000 patients (95% CI, from 162 fewer to 71 more)
	300 (1 RCT)[18]	IV magnesium and diazepam versus placebo	Very low	0.68 (0.36–1.28)	81 fewer adult survivors per 1000 patients (95% CI, from 162 fewer to 71 more)
	107 (1 nonrandomized study)[19]	Bolus and continuous infusion of thiopentone and phenobarbital compared with historic controls	Very low	1.41 (0.88–2.27)	137 more adult survivors per 1000 adults (95% CI, from 40 fewer to 423 more)
Survival to	107 (1	Bolus and	Very low	1.40 (0.83–	119 more adult survivors per 1000 patients

Outcomes (importance)	Participants, n (studies, n/study type)	Investigation	Certainty of evidence (GRADE)	RR (95% CI)	ARD with intervention
hospital discharge	nonrandomized study)[19]	continuous infusion of thiopentone and phenobarbital compared with historic controls		2.36)	(95% CI, from 50 fewer to 403 more)

1 ARD indicates absolute risk difference; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; RCT, randomized controlled trial;
2 RR, risk ratio.

Treatment of Seizures

For the critical outcome of survival with favorable neurological outcome at discharge/30 days or longer, no pediatric RCTs or nonrandomized comparative studies were identified.

Indirect evidence from adult studies was identified and included. We identified a single randomized study[20] of 172 patients, assessing the effect of treatment of rhythmic and periodic discharges with antiseizure medication on the critical outcome of survival with favorable neurologic outcome at 3 months and finding no benefit (RR, 1.23 [95% CI, 0.48–3.15], or 19 more per 1000 patients [95% CI, from 43 fewer to 179 more]). There was also no difference in survival (RR, 1.14 [95% CI, 0.62–2.12], or 27 more survivors per 1000 patients [95% CI, from 68 fewer to 200 more]).

2024 Good Practice Statements—New

Prophylactic Antiseizure Medication

We suggest against the routine use of prophylactic antiseizure medication in children post–cardiac arrest (good practice statement).

Seizure Treatment

We suggest the treatment of seizures in children post–cardiac arrest (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Appendix A3.

Prophylactic Antiseizure Medication

- Due to the lack of direct evidence in children post–cardiac arrest and very low certainty of indirect evidence from adults, the PLS Task Force was unable to make a treatment recommendation. The task force's decision to provide a good practice statement suggesting against post–cardiac arrest prophylactic antiseizure medication was based on the absence of indirect evidence from adult comatose cardiac arrest survivors that prophylactic therapy with antiseizure medication prevents seizures or improves important outcomes. However, the PLS Task Force recognized the low certainty of the evidence from RCTs. The PLS Task Force also considered that the administration of prophylactic antiseizure medication in other forms of acute brain injury (eg, neonatal hypoxic-ischemic encephalopathy)[21] is not associated with improved long-term outcomes. Although prophylactic antiseizure medication is recommended following traumatic brain injury in children,[22] the evidence of benefit for early seizure prevention is of very low certainty and there is no evidence of improved long-term outcomes.[23]

- The medications used for antiseizure prophylaxis in the included adult trials (eg, barbiturates) can have significant side effects, although the cardiac side effects seen in adults may be less common in children. The PLS Task Force acknowledged that newer antiseizure medications have not been evaluated and that their efficacy and side effect profile may differ. Further evaluation is encouraged.

Seizure Treatment

- No direct pediatric evidence of the effects of treating seizures in children after cardiac arrest was identified, and the PLS Task Force could not make a treatment recommendation.
- The PLS Task Force chose to make the good practice statement based on the knowledge that high seizure burden in children has been associated with poor neurological outcome.[24,25] There are safe and effective antiseizure medications that can reduce seizure

burden in children with status epilepticus, which, in turn, may benefit longer-term outcomes.[26-28]

- The PLS Task Force acknowledges the challenge of seizure diagnosis and the important role of confirmatory EEG in addition to clinical signs of seizure to increase certainty of diagnosis. The potential risk of treating suspected seizures in settings without access to EEG confirmation needs to be balanced with potential harm of antiseizure medications. EEG confirmation remains the reference standard approach for seizure diagnosis; however, EEG may not be available in many clinical settings because it requires significant resources, including neurophysiology equipment, training, and expertise. Continuous EEG monitoring is labor intensive and likely to add significant cost to patient care. The cost-effectiveness of this approach is controversial and may depend on the setting. The relative benefit of continuous EEG compared with intermittent EEG monitoring was not reviewed.
- There is insufficient evidence to suggest for or against the treatment of rhythmic and periodic EEG patterns in children post–cardiac arrest. One RCT in adults[20] did not find a difference in the primary outcome with 1 therapeutic approach to treatment of rhythmic and periodic EEG patterns. However, no significant harm was noted in adults assigned to the treatment or control arm. Further research is required in children to evaluate the impact on treating specific EEG patterns and electrographic seizures.

- Medication for sedation (eg, benzodiazepines and propofol) and use of hypothermic temperature control after cardiac arrest may also affect seizure burden, timing, and detection. Evaluation of the use of prophylactic antiseizure medication and seizure treatment in the context of these therapies is important.

Knowledge Gaps

- Whether prophylactic antiseizure medication impacts outcomes in children post–cardiac arrest
- Whether use of antiseizure medications to treat seizures impacts important clinical outcomes in children post–cardiac arrest
- Indications for and cost-effectiveness of continuous EEG, quantitative EEG, and intermittent EEG post–cardiac arrest
- Impact of prophylactic antiseizure medication and seizure treatment on seizure burden and timing and detection in the context of medication for sedation and hypothermic temperature control

Advanced Airway Interventions in Pediatric Cardiac Arrest (PLS 4060-01: SysRevs)

Rationale for Review

Airway management is vital in pediatric resuscitation, especially since respiratory conditions are frequently the primary cause of pediatric cardiac arrest. Maintaining an open airway and delivering sustained effective ventilations using a bag-mask device can be difficult, even in skilled hands. Placement of an advanced airway device, such as a supraglottic airway (SGA) or tracheal tube, may facilitate more effective resuscitation than bag-mask ventilation (BMV). Both require skilled personnel, and the time taken to perform either procedure may interfere with other vital components of resuscitation (eg, chest compressions).

Since the last review of this topic,[29] the PLS Task Force was aware of new data, prompting this updated SysRev (PROSPERO registration CRD42023482459). The full CoSTR can be found online.[30]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Infants and children who received CPR after OHCA or IHCA (excluding newborn children)
- Intervention: Placement of an advanced airway device
- Comparator: BMV alone or non–advanced airway interventions (primary) or another advanced airway device (secondary)
- Outcome
  - Critical: Survival to hospital discharge with favorable neurological outcome and survival to hospital discharge
  - Important: ROSC[2]
- Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All relevant publications in any language were included if there was an English abstract.
- Time frame: The previous SysRev included studies up to September 24, 2018. The updated search included studies from June 2018 through August 15, 2023.

Consensus on Science

The PLS Task Force reviewed the evidence for the following comparisons: tracheal intubation (TI) compared with BMV, SGA compared with BMV, and TI compared with SGA during pediatric cardiac arrest.

Nineteen studies were included. Only 1 study provided clinical trial data.[31] Five studies provided propensity-adjusted cohort data.[32-36] Nine other studies provided retrospective cohort data amenable to meta-analysis.[37-45] Four studies provided retrospective cohort data in adjusted form only, not amenable to meta-analysis.[46-49] One study[50] that was included in the original SysRev[29] was excluded from this updated SysRev because it overlapped with a newer study.[36] Summative results from 15 of the studies are included in Table 16; the 4 cohort studies with results not amenable to meta-analysis were excluded.

A random effects model was chosen for meta-analysis to better account for study heterogeneity. The results suggest that resuscitation with TI is not superior to BMV-based resuscitation for cardiac arrest in children for the critically important outcomes of survival with favorable neurological outcome and survival to hospital discharge (with low to very low certainty). Some very low–certainty evidence suggests the use of TI may be associated with harm.

1 **Table 16. Summative Results of Studies Used in the Pediatric Airway SysRev for Each Comparison, Grouped by Outcome**

Outcomes (importance)	Participants, n (studies, n/study type)	Certainty of evidence, GRADE	RR (95% CI)	Absolute risk with comparator	ARD with intervention
TI (I) compared with BMV (C)					
Survival with favorable neurologic outcome (critical)	591 (1 RCT)[31]	Low	0.69 (0.32–1.52)	50/1000	15 fewer per 1000 (from 34 fewer to 26 more)
	4093 (5 propensity-matched observational studies)[32-36]	Very low	0.54 (0.29–1.00)	146/1000	67 fewer per 1000 (from 104 fewer to 0 fewer)
	372 (2 observational studies)[40,45]	Very low	0.76 (0.61–0.95)	544/1000	131 fewer per 1000 (from 212 fewer to 27 fewer)
Survival to hospital discharge (critical)	591 (1 RCT)[31]	Low	1.04 (0.60–1.79)	80/1000	3 more per 1000 (from 32 fewer to 63 more)
	4393 (5 propensity-matched observational studies)[32-36]	Very low	0.72 (0.48–1.07)	262/1000	73 fewer per 1000 (from 136 fewer to 18 more)
	7392 (8 observational studies)[37-39,41-45]	Very low	0.85 (0.40–1.78)	196/1000	29 fewer per 1000 (from 118 fewer to 153 more)
SGA (I) compared with BMV (C)					
Survival with favorable	3123 (4 propensity-matched	Very low	0.57 (0.26–1.23)	76/1000	33 fewer per 1000 (from 56 fewer to 18 more)

Outcomes (importance)	Participants, n (studies, n/study type)	Certainty of evidence, GRADE	RR (95% CI)	Absolute risk with comparator	ARD with intervention
neurologic outcome (critical)	observational) [33-36]				
Survival to hospital discharge (critical)	3123 (4 propensity-matched observational studies)[33-36]	Very low	0.89 (0.54–1.46)	126/1000	14 fewer per 1000 (from 58 fewer to 58 more)
	3085 (2 observational studies)[37,43]	Very low	0.53 (0.21–1.34)	90/1000	43 fewer per 1000 (from 71 fewer to 31 more)
TI (I) compared with SGA (C)					
Survival with favorable neurologic outcome (critical)	1514 (3 propensity-matched observational studies)[33,34,51]	Very low	0.80 (0.44–1.43)	40/1000	8 fewer per 1000 (from 23 fewer to 17 more)
	452 (1 observational studies)[36]	Very low	2.75 (0.67–11.27)	13/1000	24 more per 1000 (from 4 fewer to 138 more)
Survival to hospital discharge (critical)	1514 (3 propensity-matched observational studies)[33,34,51]	Very low	0.80 (0.55–1.15)	126/1000	25 fewer per 1000 (from 57 fewer to 19 more)
	1007 (3 observational	Very low	1.35 (0.82–	67/1000	24 more per 1000 (from 12

Outcomes (importance)	Participants, n (studies, n/study type)	Certainty of evidence, GRADE	RR (95% CI)	Absolute risk with comparator	ARD with intervention
	studies)[36,37,43]		2.22)		fewer to 82 more)

ARD indicates absolute risk difference; BMV, bag-mask ventilation; C, comparator; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; I, intervention; RCT, randomized controlled trial; RR, risk ratio; SGA, supraglottic airway; SysRev, systematic review; TI, tracheal intubation.

IHCA Versus OHCA

Separate analyses of studies of IHCA and OHCA produced similar results. However, the body of evidence for IHCA is particularly small (consisting of 1 propensity-matched cohort study and 3 other cohort studies) and provides very low–certainty evidence.[32,40-42] The studies are very heterogenous and showed inconsistent results.

Prior Treatment Recommendations (2019)

We suggest the use of BMV rather than TI or SGA in the management of children during cardiac arrest in the out-of-hospital setting (weak recommendation, very low–certainty evidence).

There is insufficient evidence to support any recommendation about the use of TI or SGA in the management of children with cardiac arrest in the in-hospital setting.

2024 Treatment Recommendations

We suggest the use of bag-mask ventilation rather than tracheal intubation or supraglottic airway in the management of children during cardiac arrest in the out-of-hospital setting (weak recommendation, very low–certainty evidence).

There is insufficient quality evidence to support any recommendation for or against the use of the bag-mask ventilation compared with tracheal intubation or supraglottic airway for in-hospital cardiac arrest.

The main goal of cardiopulmonary resuscitation is effective ventilation and oxygenation, by whatever means, without compromising the quality of chest compressions. We suggest that clinicians consider transitioning to an advanced airway intervention (supraglottic airway or tracheal intubation) when the team has sufficient expertise, resources, and equipment to enable placement to occur with minimal interruptions to chest compressions or when bag-valve-mask is not providing adequate oxygenation and ventilation (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Appendix A3.

- Advanced airway interventions, particularly TI, are long-established components of the advanced life support bundle of care in children. As a result of inherent limitations in their design and data sources, the available studies, though individually well conducted, can provide only very low–certainty evidence about whether attempting advanced airway placement before ROSC improves resuscitation outcomes.
- Most of the available data were obtained from registries, and an unknown proportion of events labeled as BMV resuscitation may have had failed intubation and/or SGA attempts (which would bias against BMV). Conversely, most of the included studies are susceptible to resuscitation-time bias, ie, the longer the child is in cardiac arrest, the more likely they will receive interventions but the less likely they will survive (which should bias against TI/SGA).
- The best available data show no benefit from these advanced airway interventions, and some suggest association with harm, for the critical outcomes of survival with favorable neurological outcome and survival to hospital discharge.
- Effective BMV, TI, and SGA are difficult skills that require initial training, retraining, and quality assurance to be done consistently, safely, and effectively. Pediatric advanced airway programs require a moderate investment in equipment and a significant investment in training, skills maintenance, and quality control programs to be successful.
- The decision on choice of airway management technique in the setting of pediatric cardiac arrest is complex because the benefit or harm may differ depending on setting, age of the child, cause of arrest, and experience of the resuscitation team. Importantly, the

available data do not inform the questions of whether better outcomes might be achieved by different airway strategies in long transport times or in prolonged resuscitation situations with highly experienced airway operators. The analyzed data are only relevant to advanced airway interventions during CPR and do not pertain to airway management in other critical situations or once ROSC is achieved.

Knowledge Gaps

- Prehospital, emergency department-based, and in-hospital studies comparing TI, SGA, and BMV with planned subgroup analyses based on patient age and etiology of arrest (trauma versus nontrauma)
- The benefit of advanced airway interventions in particular settings (including in patients with poor pulmonary compliance and long transport times)
- The efficacy and speed of placement of advanced airways using newer technologies, such as video-assisted laryngoscopy (compared with regular laryngoscopy)
- Studies including measures of quality of ventilation (and cardiac metrics), timing of airway intervention, duration of CPR, and measures of the training and experience of the clinicians performing the interventions

Ventilation Rates in Pediatric CPR With an Advanced Airway (PLS 4120-02: SysRevs)

Rationale for Review

Ventilation is a major component of CPR for children and infants in cardiac arrest. During CPR, an adequate ventilation rate is an important element of ventilation.[52,53] However, the appropriate ventilatory rate for children and infants during CPR remains a topic of ongoing debate and investigation.[54] In 2010, the PLS Task Force reviewed the evidence about optimal minute ventilation (product of tidal volume and respiratory rate per minute) after the placement of an advanced airway during CPR in infants or children.[52] The minute ventilation recommended in the 2010 CoSTR was based on expert consensus. In 2020, an EvUp was completed to identify any evidence published after 2010 that might indicate the need for a new SysRev. The EvUp identified a single-center observational paper that reported an association between ventilatory rate during IHCA >12 to 20 breaths per minute and improved outcomes.[55] Since this EvUp, the task force was aware of new evidence that led the task force to conduct a SysRev (PROSPERO registration CRD42023480925). The full CoSTR can be found online.[56]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Infants and children (excluding newborn infants) with OHCA or IHCA and an advanced airway
- Intervention: Use of any specific ventilatory rate
- Comparator: Use of a ventilatory rate of 8 to 10 breaths per minute
- Outcome:
  - Critical: Survival with favorable neurological outcome as per Pediatric Core Outcome Set for Cardiac Arrest[2]
- Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All relevant publications in any language were included if there was an English abstract.
- Time frame: Literature search includes all years up to June 1, 2023.

Consensus on Science

No studies were identified that compared the ventilatory rate of 8 to 10 breaths per minute with any other specific ventilatory rate.

Prior Treatment Recommendations (2020)

After placement of a secure airway, avoid hyperventilation of infants and children during resuscitation from cardiac arrest, whether asphyxial or arrhythmic in origin. A reduction in minute ventilation to less than baseline for age is reasonable to provide sufficient ventilation to maintain adequate ventilation-to-perfusion ratio during CPR while avoiding the harmful effects of hyperventilation. There are insufficient data to identify the optimal tidal volume or respiratory rate.[55]

2024 Treatment Recommendations

There is currently no supporting evidence to make a treatment recommendation on a specific ventilatory rate in pediatric cardiopulmonary resuscitation with an advanced airway.

For cardiac arrest that occurs with an advanced airway in place, the use of ventilatory rates >10 breaths per minute may be reasonable. The PLS Task Force suggests using ventilatory rates close to age-appropriate respiratory rates with avoidance of hypoventilation and hyperventilation (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

- The PLS Task Force discussed that no study met inclusion in this SysRev because none specifically addressed the ventilation rate comparison of 8 to 10 breaths per minute that had been defined in the PICOST.
- The PLS Task Force discussed that the previous treatment recommendations of ventilation rates of 10 breaths per minute during cardiac arrest were derived from adult data. More recent adult studies suggest that ventilation rates of 10 breaths per minute during cardiac arrest were not associated with improved outcomes in adults. A ventilation

rate of 10 breaths per minute could cause hypoventilation in infants and children, and no pediatric data to support this ventilation rate were identified.

Knowledge Gaps

- The optimal ventilation rate during continuous chest compressions in children with an advanced airway
- The optimal minute ventilation and other ventilation measurements, including peak pressure, positive end-expiratory pressure, capnography, and blood gas analysis and their impact on oxygenation and ventilation during CPR
- The influence of hypocarbia and hypercarbia on outcomes
- The optimal ventilation rate according to cardiac arrest etiology

Management of Pulmonary Hypertension With Cardiac Arrest in Infants and Children in the Hospital Setting (PLS 4160-11: ScopRev)

Rationale for Review

This topic, with a new PICOST, was chosen by the PLS Task Force with input from the Neonatal Life Support Task Force because of the concern that children with pulmonary hypertension who are hospitalized are reported to be at higher risk of death following a cardiopulmonary arrest.[57]

In 2015, the American Heart Association and the American Thoracic Society published a guideline on the management of pediatric pulmonary hypertension.[58] In 2018, the American Heart Association published a statement on the management of CPR in infants and children with cardiac disease that included a section on pulmonary hypertension.[59] In 2018, the American Heart Association published a statement on right-sided heart failure and its management, but this statement focused on adults and did not include content for children.[60] The 2019 ILCOR EvUps provided guidance on the acute treatment of pulmonary hypertension.

Faced with these children at high risk of cardiopulmonary arrest, we formulated the new PICOST and conducted a ScopRev to better understand if evidence for new specific therapies to treat cardiopulmonary arrest had been published. The full report of this ScopRev can be found online.[61]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Infants and children with pulmonary hypertension at high risk of pulmonary hypertensive crises with a cardiac arrest in the in-hospital setting, including postoperatively
- Intervention: Specific management strategies included (1) respiratory management and monitoring to avoid hypoxia and acidosis; (2) use of opioids, sedatives, and neuromuscular blocking agents; and (3) pulmonary arterial hypertension–specific targeted therapy, like (a) phosphodiesterase-5 inhibitors, endothelin receptor antagonists, inhaled pulmonary vasodilators (eg, inhaled nitric oxide or prostaglandin) or (b) drugs that enhance the nitric oxide–cyclic guanosine monophosphate biological pathway (eg, sildenafil, tadalafil, or riociguat), prostacyclin pathway agonists (eg, epoprostenol or treprostinil), or endothelin pathway antagonists (eg, bosentan or ambrisentan).
- Comparator: Standard care without specific management strategies for pulmonary hypertensive crisis
- Outcome
  - Critical: All, including survival to hospital discharge with favorable neurological outcome and survival to hospital discharge

- Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) and case series with >5 cases were included. Gray literature, social media, and non–peer-reviewed studies, unpublished studies, and conference abstracts were excluded. Trial protocols were eligible if they informed the question. All languages were included if there was an English abstract.
- Time frame: The literature search was completed, and the selection focused on the most recent decade—from January 1, 2012, to December 22, 2023

Summary of Evidence

We included 19 studies in the ScopRev; 16 provided foundational background literature on the acute management of children with pulmonary hypertension,[57-59,62-74] and 3 presented data on the management of cardiac arrest in children with pulmonary hypertension.[75-77] Most did not report patient-level data in children with pulmonary hypertension and cardiac arrest. These articles collectively highlight the increased risk of death in children with pulmonary hypertension and the results of recent international efforts in establishing a pediatric pulmonary hypertension classification to support future international and multisite research and general therapeutic management.

Definition and Classification of Pediatric Pulmonary Hypertension

During the 6th World Symposium on Pulmonary Hypertension, the hemodynamic definition for pulmonary hypertension in children was aligned with the adult definition as a mean pulmonary artery pressure of >20 mm Hg[78-80] from being previously ≥25 mm Hg.[58] Five large clinical groups were updated—(1) pulmonary arterial hypertension, which includes pulmonary hypertension associated with congenital heart disease and persistent pulmonary hypertension of the newborn syndrome (the most frequent cause of transient pulmonary hypertension)[79]; (2)

pulmonary hypertension due to left heart disease; (3) pulmonary hypertension owing to lung diseases and or hypoxia; (4) pulmonary hypertension due to pulmonary artery obstructions; and (5) pulmonary hypertension with unclear multifactorial mechanism.

Risk of Death and Intensive Care Hospitalizations

To promote the study of children with pulmonary hypertension, the term clinical worsening is emerging as a meaningful composite endpoint for interventional trials. In a recent multicenter study from the Pediatric Cardiac Critical Care Consortium from 2014 to 2019, the risk of death for children with pulmonary hypertension was higher compared with all other medical cardiac admissions (10% versus 3.9%). Importantly, 6.1% of these admissions with pulmonary hypertension experienced a CPR event. Among this cohort, the receipt of mechanical ventilation and vasoactive therapies within the first 2 days of ICU admission were associated with increased mortality.[67]

A study using the Virtual Pediatric Intensive Care Unit database included over 160 ICUs, focused on children with an IHCA, and compared patients with and without pulmonary hypertension. Using propensity matching, the study showed that patients with pulmonary hypertension were less likely to survive to hospital discharge (adjusted OR, 0.83 [95% CI, 0.72–0.95; *P*=0.01]). The pulmonary hypertension group with an IHCA had a predicted survival rate of 59.1% (56.5%–61.8%) compared with 61.6% (60.0%–63.2%) in the group without pulmonary hypertension with an IHCA.[57]

More recently, an analysis of 1129 pediatric IHCA events from the prospective multicenter ICU-RESUS (Improving Outcomes from Pediatric Cardiac Arrest—the ICU-Resuscitation Project) study, where 16% of children had preexisting pulmonary hypertension, concluded that pre-arrest pulmonary hypertension was not associated with statistically significant differences in survival or intra-arrest physiologic measures.[81]

ECLS Technologies, Extracorporeal Membrane Oxygenation, and Pediatric Pulmonary Hypertension

Before a cardiac arrest, extracorporeal membrane oxygenation (ECMO) may be used to stabilize infants with persistent pulmonary hypertension of the newborn or congenital diaphragmatic hernia or in the postoperative period of congenital heart disease when inhaled nitric oxide and mechanical ventilation with general measures are insufficient.[58]

Pulmonary Hypertensive–Specific Therapies and Interventions for the Treatment of Cardiac Arrest

Only 3 articles presented data on the management of cardiac arrest in children with pulmonary hypertension (Table 17).[75-77] Two of these studies included ECMO cannulation as intervention.[75,77]

1 **Table 17. Reports of Studies Including Patient-Level Data With Pulmonary Hypertension and Cardiac Arrest**

Study, y	Country, study design	Population included	Age group	Exclusion criteria	Patients analyzed, n (events, N)	Total patients with PH and CA	Treatment exposure	Overall study sample survival (%)	Survival in patients with PH and CA (%)
Boudjemline, 2017[5]	France, case series	Drug-resistant PAH who underwent Potts shunt	5.9–17.9 y	Not described	6	2	ECMO provided to cardiac arrest events	4/6 (67%)	0/2 (0%)
Morell, 2020[77]	United States, retrospective multicenter registry study	Cannulated to ECMO with previous PH	28 d to 18 y	<28 d	605 (634 ECMO runs)	106 (ECPR)	PH with ECMO	48.70%	ECPR survival (27.4%)
Li, 2022[76]	China, retrospective single-center study	PAH who underwent RHC	<18 y	Cardiac shunts or other complex CHD Patients with left heart disease, lung disease, and other types of PH	147 (163 RHC)	5	PH with RHC	146/147 (99.3%)	4/5 (80%)

2 CA indicates cardiac arrest; CHD, congenital heart disease; ECMO, extracorporeal membrane oxygenation; ECPR, extracorporeal cardiopulmonary
3 resuscitation; PAH, pulmonary arterial hypertension; PH, pulmonary hypertension; RHC, right heart catheterization.

Task Force Insights

General approaches to improving cardiopulmonary physiology in the context of a pulmonary hypertension crisis or cardiac arrest are important. Children hospitalized with pulmonary hypertension are at higher risk of cardiac arrest than other children. The next steps should focus on generating original evidence in pulmonary hypertension disease groups characterized using contemporary classification systems and definitions. This disease remains relatively rare, which suggests that future research will require multicenter studies or large registry-based comparative studies to better understand the value of one intervention over another for treatment of cardiac arrest.

The PLS Task Force discussed the importance of using the classification of 5 groups and diagnoses detailed in the most recent international guidelines on pediatric pulmonary hypertension when studying the risk of cardiopulmonary arrest or interventions to treat cardiopulmonary arrest.[58,80,82]

Good Practice Statements

In children, including neonates, with pulmonary hypertension hospitalized for a clinical worsening event, we propose avoiding factors that may increase pulmonary vascular resistance while treating the aggravating condition to decrease the risk of cardiac arrest. Management strategies include avoiding hypoxia; hypercapnia; acidosis; stressors, such as pain, agitation, dehydration, or fluid overload; anemia; infection; or arrhythmias. Pulmonary hypertension–specific treatments—eg, inhaled nitric oxide, L-arginine, phosphodiesterase inhibitors (eg, milrinone, sildenafil), or endothelin-1 inhibitors (eg, bosentan)—may be considered (good practice statement).

In children who develop signs of pulmonary hypertensive crisis, low cardiac output, or right ventricular failure despite optimal medical therapy, ECMO may be considered before cardiac arrest or for refractory cardiac arrest as a bridge to recovery or as a bridge to the evaluation for organ replacement and transplantation in very select cases (good practice statement).

Knowledge Gaps

- Specific resuscitation management approaches for infants or children with pulmonary hypertension at high risk of cardiopulmonary arrest during cardiac arrest and after resuscitation
- Optimal approaches to mechanical ventilation during the resuscitation of children with pulmonary hypertension (eg, timing of the advanced airway; the use of oxygen therapy in cyanotic and noncyanotic heart disease or in the context of an atrial septostomy; the use of positive end-expiratory pressure, of peak inspiratory pressure, of minute ventilation [normal ventilation or hyperventilation], or of inhaled nitric oxide; or modes of mechanical ventilation during the post–cardiac arrest care period to best support the right and left ventricles and minimize harmful cardiopulmonary interactions)
- The dose or type of inotrope or vasopressor that could be delivered during a cardiopulmonary arrest event and the physiologic endpoints to target during the intra-arrest period, such as the optimal target in end-tidal capnography value
- Whether children with pulmonary hypertension with known right heart catheterization data should receive personalized resuscitation measures instead of standard measures

- The timing of transitioning from high-quality CPR to extracorporeal CPR in pediatric patients with severe pulmonary hypertension (eg, pulmonary hypertension listed for lung transplantation, pulmonary hypertension after atrial septostomy)[83]
- Optimal diagnostic and severity classification systems to improve knowledge of pediatric pulmonary hypertension patients who suffer cardiopulmonary arrest[82]
- Risk factors for cardiac arrest in children with pulmonary hypertension in the context of (1) anesthesia (for diagnostic catheterization or for other procedures), (2) postoperative period,[67] (3) hospitalizations with deteriorations associated with clinical worsening events.[84] We propose adding "cardiopulmonary arrest events" as a study variable among clinical worsening endpoints in longitudinal epidemiological registries; this would serve as a first step to measure the burden of this problem.

Topics reviewed by EvUps are summarized in Table 18. Complete EvUps can be found in Appendix B3.

1 **Table 18. Summary of Pediatric Life Support EvUps**

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
Prearrest care of the infant or child with dilated cardiomyopathy or myocarditis (PLS 4.030.19)	2020	2020 unchanged from 2015: The confidence in effect estimates is so low that the panel decided a specific recommendation was too speculative.	0	3	3 observational studies indirectly evaluated pre-arrest stabilization and intubation in patients with dilated cardiomyopathy or myocarditis.[85-87] Key findings: (1) Use of ketamine was associated with fewer adverse events (aOR, 0.74; 95% CI, 0.58–0.95).[85] (2) Given the high risk of cardiac arrest in children with acute myocarditis who demonstrate high-risk ECG changes (arrhythmias, heart block, ST segment changes) and/or low cardiac output, there should be early transfer to higher level of care for monitoring and therapy. (3) Where resources permit, pre-arrest use of ECLS may be beneficial. (4) Where resources permit, if cardiac arrest occurs, ECPR may be beneficial.	No
Ventilation rate when a perfusing rhythm is present (PLS 4.120.01)	2020	None	0	0	There was a SysRev in 2020 including 6 pediatric observational studies that examined oxygenation and ventilation targets, but not ventilation rate, after cardiac arrest.[88] For oxygenation, there was no association between hyperoxia and survival to hospital	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
					discharge or survival with favorable neurological outcome. For carbon dioxide levels, a single observational study rated as having less than critical risk of bias found both hypocapnia (OR, 2.71; 95% CI, 1.04–7.05) and hypercapnia (OR, 3.27; 95% CI, 1.62–6.61) to be associated with worse survival to hospital discharge compared with normocapnia. There remains insufficient evidence to make a recommendation on ventilation rates when a perfusing rhythm is present.	

aOR indicates adjusted odds ratio; ECG, electrocardiogram; ECLS, extracorporeal life support; ECPR, extracorporeal cardiopulmonary resuscitation; EvUps, evidence updates; PICO, population, intervention, comparator, outcome; RCTs, randomized controlled trials; SysRev, systematic review; TR, treatment recommendation.

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NEONATAL LIFE SUPPORT

Cord Management at Birth for Preterm Infants (NLS 5051: SysRev)

Rationale for Review

Adaptation to air breathing immediately after birth requires that several critical interdependent physiologic events occur rapidly.[1] Air breathing reduces pulmonary vascular resistance, which increases pulmonary blood flow. If the umbilical cord is clamped immediately, the increased pulmonary flow is initially from the aorta via the ductus arteriosus. If cord clamping occurs after the onset of breathing, the increased pulmonary blood flow can come from the placenta via the umbilical vein and ductus venosus, thereby maintaining left ventricular filling and output (vital for coronary and cerebral perfusion).[2] Both milking the intact (not clamped or cut) umbilical cord and milking a long segment of clamped and cut cord have been proposed as alternatives to deferring clamping of the umbilical cord. Decisions about umbilical cord management can critically influence the cardiorespiratory adaptation after birth,[3,4] how and when other resuscitation interventions are provided, and mortality during subsequent hospitalization, particularly among preterm infants.[5]

The topic was last reviewed in by ILCOR in 2021.[6,7] Since then, additional RCTs have been completed and compiled into a very large pairwise individual patient data (IPD) meta-analysis and network meta-analysis (NMA), the “individual participant data on cord management at preterm birth” (iCOMP) study,[8] which provided higher-certainty evidence for various methods of umbilical cord management than could have been achieved with study-level meta-analysis alone.[5,9] The Neonatal Life Support Task Force used the process of adolopment to appraise this evidence and develop updated treatment recommendations.[10] Task force members and content experts overlapped with the iCOMP study team, but assessment of suitability of the iCOMP analyses for adolopment was assessed by task force members and content experts who had no conflict of interest. The IPD meta-analysis is presented first and then the NMA, because the PICOST structure differs. The pairwise IPD meta-analysis was used for subgroup analyses, and the NMA was used for multiple between-intervention comparisons.

The iCOMP SysRev was registered before initiation (PROSPERO Registration CRD42019136640). The full online CoSTR can be found on the ILCOR website.[10]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

Individual Patient Data Pairwise Meta-Analysis[5,8]

- Population: Preterm infants born at <37+0 weeks' gestation and their mothers
- Interventions:
  - Deferred (delayed/later) cord clamping (>15 seconds)
  - Umbilical cord milking (cord milking or stripping immediately after birth or after deferred cord clamping)
- Comparators:
  - Immediate (early) cord clamping (≤15 seconds or as defined by the trialist) without cord milking and without initiation of respiratory support for any reason
  - Between-intervention comparisons
- Outcomes:
  - Infant outcomes (importance assigned by task force consensus, in accordance with available guidelines11,12):
    - Mortality before hospital discharge (critical)

        - Major inpatient morbidities (including intraventricular hemorrhage), necrotizing enterocolitis, retinopathy of prematurity, bronchopulmonary dysplasia) for preterm infants <32 weeks' gestation (critical)
        - Neurodevelopmental outcomes (critical)
        - Resuscitation and stabilization interventions (eg, receiving positive pressure ventilation, intubation, chest compressions, medications) (important)
        - Blood transfusion (important)
        - Hematologic and cardiovascular status (in-hospital) (important)
        - Hematologic status (in infancy) (important)
        - Hyperbilirubinemia treated with phototherapy (important)
    - Maternal outcomes
        - Mortality (critical)
        - Maternal complications (postpartum hemorrhage and infection) (critical)
- Study designs: iCOMP included RCTs comparing umbilical cord management strategies but excluded trials with missing data, integrity issues, those not fitting intervention categories, and cluster- and quasi-randomized trials.[8] ILCOR systematic reviews typically exclude unpublished studies (eg, conference abstracts, trial protocols), while the iCOMP analysis includes such studies. However, the iCOMP study "…conducted extensive data processing, quality, and integrity checks of all included data,"[5] ensuring a level of integrity not usually available for unpublished data. Given these measures, the reduced publication bias from including unpublished studies was considered advantageous.[13] All languages were included.

- Time frame: All years were included. Medical databases, including MEDLINE, Embase, and CENTRAL, and clinical trial registries, including ClinicalTrials.gov, were originally searched up to February 2022 and WHO International Clinical Trials Registry Platform up to March 2022. The search was updated on June 6, 2023, and no additional eligible studies were identified.[5]

Consensus on Science

Comparison 1: Deferred cord clamping compared with immediate cord clamping. The pairwise IPD meta-analysis[5] identified 21 eligible studies including 3292 infants.[14-32] The median study sample size was 65 (IQR, 40–101). The median (IQR) gestational age at birth was 29 (27–33) weeks. Deferred cord clamping ranged from 30 to ≥180 seconds (some trials encouraging deferrals up to 5 minutes where feasible). For immediate cord clamping, most trials (14/21) specified clamping within 10 seconds. Of all infants, 61% were born by cesarean delivery 25% were multiples, and 56% were male. Trials were conducted in high-income (9/21), upper-middle-income (5/21), and lower-middle-income (7/21) countries as defined by World Bank country classification.[33] For this review, we present odds ratios, aligning with the iCOMP statistical analysis plan.[5,8,9] Key results are summarized in Table 19.

Table 19. Comparison 1: Deferred Umbilical Cord Clamping Compared With Immediate Cord Clamping

Outcomes (importance)	Participants (studies)	Certainty of the evidence (GRADE)	OR (95% CI)	Anticipated absolute effect	
				Risk or mean concentration (± SD) with ICC	RD (CI) or MD (CI) with DCC; NNTB or NNTH if applicable
Mortality before hospital discharge (critical)	3263 (20 RCTs)[14-32,34]	High	0.68 (0.51–0.91)	81/1000	25 fewer infants died per 1000 (38–7 fewer); NNTB, 40 (26–

Outcomes (importance)	**Participants (studies)**	**Certainty of the**	**OR (95% CI)**	**Anticipated absolute effect**	
					143) infants
Hemoglobin concentration (g/dL) for infants <32 weeks' gestation (important)	523 (8 RCTs)[15,18-21,28,31,32]	Moderate	NA	16 (± 2) g/dL	0.88 (0.52–1.24) g/dL
Red cell transfusion for infants <32 weeks' gestation (important)	1929 (13 RCTs)[15,17-19,21,22,24,26,28,29,31,32,34]	Moderate	0.59 (0.47–0.73)	57/1000	131 fewer infants received red cell transfusion per 1000 (186 fewer–78 fewer); NNTB, 7 (6–13) infants
Hypothermia on admission to NICU for infants <32 weeks' gestation (adverse effect—important)	1995 (8 RCTs)[17-19,26,28,31,32,34]	Moderate	1.28 (1.06–1.56)	449/1000	62 more infants were hypothermic per 1000 (14 more–111 more); NNTH, 16 (9–71) infants

DCC indicates deferred cord clamping; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; ICC, immediate cord clamping; MD, mean difference; NA, not applicable; NICU, neonatal intensive care unit; NNTB, number needed to treat to benefit; NNTH, number needed to treat to harm; OR, odds ratio; RCT, randomized controlled trial; RD, risk difference; SD, standard deviation.

For the subgroup of infants <32 weeks' gestation allocated to deferred cord clamping, higher hematocrit values were also demonstrated (moderate-certainty evidence). For the subgroup of infants ≥32 weeks' gestation allocated to deferred cord clamping, Hb and hematocrit values were also probably higher (low-certainty to moderate-certainty evidence). For other critical and important infant and maternal outcomes, clinical benefit or harm could not be determined.

Comparison 2: Umbilical cord milking compared with immediate cord clamping. The pairwise IPD meta-analysis[5] identified 18 trials including 1565 infants.[18,20,25,35-49] The median study sample size was 60 (IQR, 45–122). The median gestational age at birth was 29 (IQR, 27–31) weeks. The cord was milked intact 2 to 4 times in 12 trials (866 infants), whereas in 4 trials (340 infants) the cut cord was milked once, and in 2 trials (359 infants) there was a delay before intact-cord milking. Of all infants, 64% were born by cesarean delivery, 13% were multiples, and 56% were male. Trials were conducted in high-income (10/18), upper-middle-income (4/18), and lower-middle-income (4/18) countries. Key results are presented in Table 20.

Table 20. Comparison 2: Umbilical Cord Milking Compared With Immediate Cord Clamping

Outcomes (importance)	**Participants (studies)**	**Certainty of the evidence (GRADE)**	**OR (95% CI)**	**Anticipated absolute effect**	
				Risk or weighted mean concentration (± SD) with ICC	**RD (CI) or MD (CI) with UCM; NNTB or NNTH if applicable**
Mortality before hospital discharge (critical)	1565 (18 RCTs)[18,20,25,35-47,49,50]	Low	0.73 (0.44–1.20)	56/1000	14 fewer infants died per 1000 (30 fewer–10 more) infants
Hemoglobin concentration (g/dL) for infants <32 weeks' gestation (important)	944 (12 RCTs)[35,37,39-41,43,45-47,50]	Low	NA	15 (± 2) g/dL	0.45 (0.17–0.73) g/dL
Red cell transfusion for infants <32	1163 (15 RCTs)[18 35-37, 39-	Moderate	0.69 (0.51–	443/1000	92 fewer infants

Outcomes (importance)	**Participants (studies)**	**Certainty of the evidence**	**OR (95%**	**Anticipated absolute effect**	
weeks' gestation (important)	47,49,50		0.93)		received red cell transfusion per 1000 (167 fewer–18 fewer); NNTB, 11 (6–56) infants

DCC indicates deferred cord clamping; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; ICC, immediate cord clamping; NA, not applicable; NNTB, number needed to treat to benefit; OR, odds ratio; RCT, randomized controlled trial; RD, risk difference; UCM, umbilical cord milking.

For the subgroup of infants <32 weeks' gestation receiving umbilical cord milking, hematocrit values were also possibly higher (low-certainty evidence). For the subgroup of infants ≥32 weeks' gestation receiving umbilical cord milking, hemoglobin and hematocrit values were possibly higher, and body temperatures on admission were possibly lower (very low–certainty evidence) while red cell transfusions were possibly reduced (low-certainty evidence). For all other critical and important infant and maternal outcomes (for all included infants or either subgroup), clinical benefit or harm could not be determined.

Comparison 3: Umbilical cord milking compared with deferred cord clamping. The pairwise IPD meta-analysis[5] identified 15 trials including 1655 infants.[18,20,25,51-62] The median study sample size was 44 (IQR, 36–171). The median gestational age at birth was 30 (IQR, 28–33) weeks. The intact cord was milked 2 to 4 times in 14 studies including 1649 infants and once in 1 study including 6 infants. Deferral times in the deferred cord clamping group ranged from 30 to 120 seconds. Of all infants, 64% were born by cesarean delivery, 15% were multiples, and 54% were male. Trials were conducted in high-income (8/15), upper-middle-income (3/15), and lower-middle-income (4/15) countries. Results are summarized in Table 21.

Table 21. Comparison 3: Umbilical Cord Milking Compared With Deferred Cord Clamping

Outcomes (importance)	Participants (studies)	Certainty of the evidence (GRADE)	OR (95% CI)	Anticipated absolute effect	
				Risk or mean concentration (± SD) with DCC	RD or change with UCM; NNTB or NNTH if applicable
Mortality before hospital discharge (critical)	1303 (12 RCTs)[18,20,25,51,52,54,55,58-60,63,64]	Low	0.95 (0.59–1.53)	72/1000	3 fewer infants died per 1000 (28 fewer–34 more)
Severe IVH in preterm infants <32 weeks' gestation (critical)	860 (7 RCTs)[18,20,51,52,54,55,64]	Low	2.20 (1.13–4.31)	38/1000	42 more infants had severe IVH per 1000 (5 more–112 more); NNTH, 24 (9–200) infants
Maternal postpartum blood transfusion (critical)	653 (4 RCTs)[18,51,52,55]	Low	2.72 (1.11–6.65)	25/1000	39 more mothers received blood transfusion per 1000 (3 more–118 more); NNTH, 25 (8–333)

Outcomes (importance)	**Participants (studies)**	**Certainty of the**	**OR (95%**	**Anticipated absolute effect**	
					mothers

DCC indicates deferred cord clamping; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; ICC, immediate cord clamping; IVH, intraventricular hemorrhage; NNTB, number needed to treat to benefit; NNTH, number needed to treat to harm; OR, odds ratio; RCT, randomized controlled trial; RD, risk difference; UCM, umbilical cord milking.

For all other critical and important infant and maternal outcomes, clinical benefit or harm could not be determined.

Subgroup analyses: For all 3 comparisons, subgroup analyses by gestational age at birth, multiple versus singleton birth, caesarean section versus vaginal birth, study start year, perinatal mortality rate of country where study was conducted, and sex of infant did not influence the effect on mortality (very low–certainty to low-certainty evidence).

Individual Patient Data Network Meta-Analysis

- Population: Preterm infants born at <37+0 weeks' gestation and their mothers.
- Interventions:
  - Immediate (early) cord clamping at ≤15 seconds, without cord milking or initiation of respiratory support or as defined by the trialist
  - Short deferral of cord clamping for >15 seconds to <45 seconds without milking, with or without respiratory support
  - Medium deferral of cord clamping for ≥45 to <120 seconds without milking, with or without respiratory support
  - Long deferral of cord clamping for ≥120 seconds without milking, with or without respiratory support
  - Intact cord milking immediately after birth (with the umbilical cord attached to the placenta)
- Comparisons: Between-intervention comparisons

- Outcomes:
  - Mortality before hospital discharge (critical)
  - Intraventricular hemorrhage (critical)
  - Blood transfusion (important)
- Study design: As for the pairwise IPD meta-analysis,[5] RCTs comparing umbilical cord management strategies at preterm birth were included. Interventions were grouped into the following nodes: immediate clamping, short deferral, medium deferral, long deferral, and intact cord milking.[9]
- Time frame: As for the pairwise IPD meta-analysis[5,9]

Certainty of evidence was assessed using the Confidence in Network Meta-Analysis (CINeMA) framework, which is based on the GRADE framework but is adapted for network meta-analysis.[65]

Consensus on Science

The IPD NMA[9] identified 47 eligible studies including 6094 infants.[14-18,20-32,34,35,37-39,41,43,44,49,52-59,62,66-75] The median study sample size was 60 infants (IQR, 40–127). The median gestational age at birth was 29.6 weeks (IQR, 27.6–33.3). Of all infants, 61% were born by cesarean delivery, 17% were multiples, and 54% were male. The primary outcome was missing for 4 (<0.1%) infants.

Sufficient data were found to include comparisons of the following 5 interventions in the NMA:

1. Immediate (early) cord clamping (as soon as possible or within 15 seconds)
2. Short deferral of cord clamping (≥15 seconds–<45 seconds)
3. Medium deferral of cord clamping (≥45 seconds–<120 seconds)
4. Long deferral of cord clamping (≥120 seconds)

5. Intact cord milking immediately after birth (milking the umbilical cord before the cord was clamped)

For the outcomes of death before discharge, any intraventricular hemorrhage, and blood transfusion, the number of trials for each comparison ranged from 0 to 8 and the number of infants varied from 29 to 1993.[9] The largest number of trials providing data for each outcome were for the cord milking compared with immediate cord clamping, for cord milking compared with medium deferral of cord clamping, and for immediate cord clamping compared with medium deferral of cord clamping. Note that in each case, the analysis was by intention to treat. Only 70% of the 47 trials reported treatment adherence.[9] Key results are presented in Table 22.

Table 22. Network Meta-Analysis of Methods of Umbilical Cord Management

Comparison	Participants (studies)	Certainty of the evidence (GRADE)	OR (95% CI)	NNTB
Mortality before hospital discharge (critical)				
Long deferral (≥120 s) versus immediate cord clamping	469 (3 RCTs)[17,27,76]	Moderate	0.31 (0.11–0.80)	18 (4–143)
Red cell transfusion (important)				
Medium deferral versus immediate cord clamping	1933 (6 RCTs)[16,18,21,31,32,77]	Very low	0.45 (0.48–1.39)	NA
Short deferral versus immediate cord clamping	383 (5 RCTs)[14,15,22,24,34]	Moderate	0.44 (0.17–0.90)	NA
Intact cord milking versus immediate cord clamping	786 (9 RCTs)[35,37,39,41,44,49,70,78,79]	Very low	0.56 (0.31–0.97)	NA

GRADE indicates Grading of Recommendations, Assessment, Development, and Evaluation; NA, not applicable; NNTB, number needed to treat to benefit; RCT, randomized controlled trial.

For comparisons and outcomes not included in Table 22, clinical benefit or harm could not be determined, and details are provided in the online CoSTR.[10]

When ranking probabilities were calculated, to prevent *death before discharge,* long deferred cord clamping had a 91% probability of being the highest ranked treatment; immediate cord clamping had <1% probability of being the best treatment and a 53% probability of being the worst treatment; and medium-length deferred cord clamping and intact umbilical cord milking had a high probability of being second or third best.[9]

Prior Treatment Recommendations (2021)

In infants born at <34 weeks' gestational age who do not require immediate resuscitation after birth, we suggest deferring clamping the cord for at least 30 seconds (weak recommendation, moderate-certainty evidence).[6,7]

In infants born at 28+0 to 33+6 weeks' gestational age who do not require immediate resuscitation after birth, we suggest intact-cord milking as a reasonable alternative to deferring cord clamping (weak recommendation, moderate-certainty evidence).[6,7]

We suggest against intact-cord milking for infants born at <28 weeks' gestational age (weak recommendation, very low–certainty evidence).[6,7]

In infants born at <34 weeks' gestational age who require immediate resuscitation, there is insufficient evidence to make a recommendation with respect to cord management.[6,7]

There is also insufficient evidence to make recommendations on cord management for maternal, fetal, or placental conditions that were considered exclusion criteria in many studies (in particular, multiple fetuses, congenital anomalies, placental abnormalities, alloimmunization, fetal anemia, fetal compromise, and maternal illness). In these situations, we suggest individualized decisions based on severity of the condition and assessment of maternal and neonatal risk (weak recommendation, very low–certainty evidence).[6,7]

2024 Treatment Recommendations

In preterm infants born at less than 37 weeks' gestational age who are deemed not to require immediate resuscitation at birth, we recommend deferring clamping of the umbilical cord for at least 60 seconds (strong recommendation, moderate-certainty evidence).

In preterm infants born at 28+0 to 36+6 weeks' gestational age who do not receive deferred cord clamping, we suggest umbilical cord milking as a reasonable alternative to immediate cord clamping to improve infant hematologic outcomes. Individual maternal and infant circumstances should be taken into account (conditional recommendation, low-certainty evidence).

We suggest against intact cord milking for infants born at less than 28 weeks' gestation (weak recommendation, low-certainty evidence). There is insufficient evidence to make a recommendation regarding cut-cord milking in this gestational age group.

In preterm infants born at less than 37 weeks' gestational age who are deemed to require immediate resuscitation at birth, there is insufficient evidence to make a recommendation with respect to cord management (weak recommendation, low-certainty evidence).

There is insufficient evidence to make recommendations on cord management for maternal, fetal, or placental conditions that were considered exclusion criteria in many studies (monochorionic multiple fetuses, congenital anomalies, placental abnormalities, alloimmunization and/or fetal anemia, fetal compromise, and maternal illness). In these situations, we suggest individualized decisions based on severity of the condition and assessment of maternal and neonatal risk (weak recommendation, very low–certainty evidence).

Whenever circumstances allow, the plan for umbilical cord management should be discussed between maternity and neonatal providers and parents before delivery and should take into account individual maternal and infant circumstances (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table can be found in Appendix A4.

The strong recommendation for *deferring cord clamping for at least 60 seconds in preterm infants <37 weeks' gestation* reflects the following considerations:

- Evidence for reduced mortality after deferred cord clamping compared with immediate cord clamping was rated high-certainty.[5,10] The reduction in mortality was robust across several participant-level and trial-level subgroups (including gestational age at birth, mode of birth, multiple birth, sex, trial year, and perinatal mortality rate) and consistent in all prespecified sensitivity analyses.
- We place high value on the outcome of mortality, and this has guided the strong treatment recommendation. The certainty of evidence for other outcomes varied from low to moderate, and, therefore, we concluded that the overall certainty of evidence is moderate.
- There was moderate-certainty evidence in infants <32 weeks' gestation for fewer red cell transfusions and in infants both < and ≥32 weeks' gestation for higher hemoglobin concentrations within the first 24 hours after birth after deferred cord clamping compared with immediate cord clamping.
- Sixty seconds or more was chosen as the recommended interval for deferred cord clamping because that threshold defined 80% of infants who received deferred clamping in the combined studies. The evidence for medium (60–119 seconds) or long (>120 seconds) deferral of cord clamping is based on fewer infants and trials. Moreover, the

analysis was by intention to treat, many trials did not report actual interval from birth to cord clamping, and most trials allowed clinicians to clamp the cord when considered necessary to perform resuscitation. The reported adherence to long delay was lowest at 67% (compared with about 80% for medium deferral and 95% for immediate cord clamping, umbilical cord milking, and short deferred cord clamping), so the proportion and clinical characteristics of infants who benefited from medium or long delay are unclear. Furthermore, there were fewer than 121 extremely preterm infants in the trials of long delay.[26,27]

- Medium or long delay may be justified for infants who are coping well without resuscitation or where appropriate newborn stabilization can be provided before umbilical cord clamping (skilled team, proper training, appropriate equipment, enough space, and ability to provide measures to maintain normal temperature).
- The task force noted that there was moderate-certainty evidence for the adverse effect of an increase in the risk of hypothermia (body temperature <36·5°C) on admission after deferred cord clamping compared with immediate cord clamping for infants <32 weeks' gestation. Refer to ILCOR recommendations regarding maintaining normal temperature immediately after birth in preterm infants.[80]
- Parents report that deferred cord clamping provides a positive experience, with the mothers feeling closer and more attached to their infants.[81]

In making the suggestion to consider *umbilical cord milking as an alternative to immediate cord clamping* in infants born at 28+0 to 36+6 weeks' gestation, the task force considered the following:

- Low-certainty evidence that umbilical cord milking may not reduce the critical outcome of death before discharge compared with immediate cord clamping

- Moderate-certainty evidence for reduced red cell transfusion after umbilical cord milking compared with immediate cord clamping in infants both <32 weeks' gestation and ≥32 weeks' gestation
- Low-certainty evidence for higher hemoglobin after umbilical cord milking compared with immediate cord clamping in infants, both <32 weeks' gestation and ≥32 weeks' gestation.
- No evidence for adverse effects in preterm infants <37 weeks' gestation or their mothers after umbilical cord milking compared with immediate cord clamping
- No evidence for adverse effects after umbilical cord milking compared with deferred cord clamping in preterm infants born at 28+0 to 36+6 weeks' gestation
- The IPD meta-analyses did not distinguish between the 2 methods of cord milking (intact-cord and cut-cord). The intact cord was milked 2 to 4 times in most trials, while a few trials milked the cut cord once; therefore, no specific recommendations are made for either method.

In making the suggestion against *intact umbilical cord milking in infants <28 weeks' gestation*, but not in infants of higher gestational age, the task force considered the following:

- Low-certainty evidence for increased severe intraventricular hemorrhage after intact-cord milking compared with deferred cord clamping
- One trial was stopped early because of increased rates of severe intraventricular hemorrhage in the prespecified subgroup of preterm infants born at <28 weeks' gestation.[54]
- The same RCT has subsequently reported that for infants born at 28 to 32 weeks' gestation there was no increase in severe intraventricular hemorrhage, mortality, or other

adverse clinical outcomes after umbilical cord milking compared with deferred cord clamping.[82] This study was not included in the analysis because it was published after the iCOMP meta-analysis was completed and the CoSTR development process was started.

There was insufficient evidence to make a recommendation regarding *cord management of preterm infants who are deemed to require resuscitation at birth*. This conclusion reflected the following:

- Adherence to deferred cord clamping was low (<75% in those trials reporting adherence), in most cases because health care providers chose immediate cord clamping or cord milking in preference to deferred cord clamping when they judged that the infant required assisted ventilation.[5] Some studies did not report adherence. Taken together, these factors led to a conclusion that the benefits and risks of deferred cord clamping remain unclear for nonvigorous preterm infants and those who require resuscitation at birth.[5]
- The evidence from animal studies and feasibility studies in human infants increasingly supports provision of some resuscitation measures while deferring cord clamping (variously described in studies as resuscitation with intact cord, physiologic cord clamping, or baby-directed cord clamping). Results of studies currently underway that evaluate these strategies may lead to changes in recommendations in the future, but there was insufficient evidence to make a recommendation now.

The suggestion for *individualized decision-making in the context of maternal, fetal, or placental conditions that were exclusion criteria* is unchanged from 2021 and took into account that similar constraints applied to the results of the iCOMP systematic reviews.

In suggesting discussion before birth (whenever possible) about the plan for umbilical cord management, the task force considered that this approach is most likely to lead to the best decisions about what plan of cord management to use and how to coordinate the steps in care of the infant among different care providers and the parents.

Knowledge Gaps

- Long-term neurodevelopment and health outcomes following different cord management strategies
- Effectiveness of optimized cord management as a public health strategy to improve child health and development
- Optimal cord management of preterm infants who are not breathing after initial steps of resuscitation
- Optimal cord management for preterm infants born with specific maternal, fetal, and placental conditions that led to exclusion from RCTs
- Optimal measures to prevent hypothermia during deferred cord clamping
- Optimal duration of deferred cord clamping, and the criteria to determine that duration
- Circumstances where cut-cord milking represents best-available management
- Impact of cord management on vertical transmission of infectious diseases
- Widely agreed-upon nomenclature and definition of different interventions, including delayed, deferred, later, optimal, and physiologic cord clamping as well as milking, stripping, intact-cord milking, and cut-cord milking

Effect of Rewarming Rate on Outcomes for Newborns Who are Unintentionally Hypothermic After Delivery (NLS 5700: SysRev)

Rationale for Review

Both term and preterm newborn infants are at high risk of hypothermia during and immediately after resuscitation in high-, middle-, and low-income countries.[83-85] Previous large observational studies have found an association between hypothermia and neonatal mortality and morbidity.[86-93] The optimal rate of rewarming for unintentionally hypothermic infants has not been defined. Slow rewarming could prolong metabolic demands and increase adverse outcomes of hypothermia such as apnea, respiratory distress, and hypoglycemia,[86,94,95] but there is a suggestion from a few preclinical and clinical studies in other age groups and contexts (such as after therapeutic hypothermia) that rapid rewarming could be harmful.[96] In 2020, the Neonatal Life Support Task Force undertook an evidence update which concluded that there were sufficient new studies to consider updating the systematic review.[97] The SysRev was registered before initiation (PROSPERO Registration CRD42022359005). The full online CoSTR can be found on the ILCOR website.[98]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Newborn infants who are hypothermic (<36.0˚C) on admission
- Intervention: Rapid rewarming (≥0.5°C/hour)
- Comparators: Slow rewarming (<0.5°C/hour)
- Outcomes (importance assigned by task force consensus, in accord with available guidelines[11,12]):
  - Mortality rate (critical)
  - Neurodevelopmental impairment (critical)
  - Need for respiratory support during the first 48 hours of life (important)
  - Hypoglycemia during the first week of life (important)
  - Convulsions/seizures during hospital stay (important)
  - Length of hospital stay (important)
  - In addition, for preterm infants born at <34 weeks:

        - Intraventricular hemorrhage (all grades—important; severe [III or IV]—critical)
        - Periventricular leukomalacia (critical)
        - Necrotizing enterocolitis (important)
- Study designs: RCTs and nonrandomized studies (nonrandomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols), case series, case reports, and animal studies were excluded.
- Time frame: All years and all languages were included if there was an English abstract. The search strategy designed for the 2020 evidence update was rerun in July 2022 and updated in July 2023.

Consensus on Science

The review identified 1 RCT of 42 infants comparing maximum temperature set points for the servo-controlled radiant warmers used for rewarming; rates of rewarming depended on these set points.[99] The study enrolled only otherwise well, term newborn infants of normal birth weight. The review also identified 2 observational studies including a total of 280 infants, one of which included only infants born at ≤28 weeks' gestation and/or birth weight ≤1000 g[100] while the other enrolled only infants with birthweight <1500 grams.[101] For the critical outcome of mortality, these 2 studies could not exclude benefit or harm from rapid rewarming compared with slow rewarming (RR, 1.09 [95% CI, 0.7–1.71]; absolute risk difference, 17 fewer deaths per 1000 infants [95% CI, from 58 fewer–138 more]) (low-certainty evidence).[100,101]

For other critical and important outcomes, either data were inconclusive or there were no data.

Prior Treatment Recommendations (2015)

The confidence in effect estimates is so low that a recommendation for either rapid rewarming (0.5°C/h or greater) or slow rewarming (0.5°C/h or less) of unintentionally hypothermic newborn infants (temperature less than 36°C) at hospital admission would be speculative.[102]

2024 Treatment Recommendations

In newborn infants who are unintentionally hypothermic after birth, rewarming should be commenced, but there is insufficient evidence to recommend either rapid (≥0.5˚C/hour) or slow (<0.5˚C/hour) rates of rewarming.

Regardless of the rewarming rate chosen, a protocol for rewarming should be used. Frequent or continuous monitoring of temperature should be undertaken, particularly if using a supraphysiological set temperature point to accelerate the rewarming rate, because of the risk of causing hyperthermia. In any hypothermic infant, monitor blood glucose because there is a risk of hypoglycemia (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table can be found in Appendix A4.

- Although hypothermia after birth is associated with increased mortality and morbidity, the included studies were too small to determine the effect of rate of rewarming on mortality and other outcomes. One observational study showed an association of rapid rewarming with a reduced rate of respiratory distress syndrome in preterm infants.[100] However, numbers were small, the absolute risk difference was not shown, and the authors did not report whether this resulted in a clinical difference in need for respiratory support for respiratory distress syndrome.

- The task force considered that both the intervention and control treatment were acceptable and feasible. Two of the 3 included studies used servo-controlled devices to monitor and control the rate of rewarming. Regarding equity, servo-controlled devices (eg, servo-controlled radiant warmers, incubators, or thermal mattresses) have not yet been demonstrated to improve outcomes of rewarming. The cost of devices capable of operating in servo mode and disposable temperature probes may be unaffordable in resource-limited settings.
- The rate of rewarming varied widely in the rapid rewarming groups in the included studies. The task force noted that a safe maximum rate of rewarming has not been identified. Furthermore, none of the included studies reported hyperthermia as an outcome. One observational study that did not meet inclusion criteria found that 43 (12.5%) of 344 included infants developed hyperthermia (>37.5˚C).[103] In this study, a rapid rewarming rate, compared with a slow rewarming rate, was associated with hyperthermia. It is unclear whether this related to specific settings of the devices used for rewarming (which were radiant warmers and incubators in manual mode) in this study or to other characteristics of the included infants. These findings may be clinically important because recent observational studies have confirmed an association between hyperthermia on neonatal ICU admission and adverse outcomes.[104,105] Future studies should consider this important outcome.

Knowledge Gaps

- The optimal method and rate of rewarming, including equipment and settings
- Effect of rewarming rate on short-term and long-term outcomes, for both preterm and term infants

- Effect of rewarming rate on metabolic markers such as acidosis and glycemic status
- Cost-effectiveness of rewarming strategies, including equipment and the need for and duration of neonatal ICU admission
- The effects of protocols for rewarming on parental separation and the establishment of breastfeeding and on the safety and effectiveness of skin-to-skin care for rewarming

Therapeutic Hypothermia in Limited-Resource Settings (NLS 5701: SysRev)

Rationale for Review

Therapeutic hypothermia is now standard care in high-income countries for the treatment of moderate or severe hypoxic ischemic encephalopathy in term and near-term infants.[106] However, uncertainty persists about the efficacy of therapeutic hypothermia in low-resource settings or in low- and middle-income countries. Because asphyxia is a leading cause of neonatal mortality and morbidity in low- and middle-income countries, it is critical to determine whether therapeutic hypothermia improves mortality and neurodevelopmental outcomes in this setting. The treatment shown to be effective in high-income countries generally consists of cooling to 33.5°C commencing within 6 hours of birth and for a duration of 72 hours. Servo-controlled cooling devices are increasingly used in high-income countries because they achieve more consistent adherence to target temperatures,[107] although effective cooling can be accomplished by removal of heat sources and clothing and by applying refrigerated gel packs, making the treatment feasible in low-resource settings.[108] The topic was last reviewed by the task force in 2015, with an emphasis on the use of passive hypothermia and/or cold packs.[1] An evidence update in 2020[97] identified new studies and an ongoing large multicenter RCT that has since been published.[109]

The SysRev was registered before initiation (PROSPERO Registration CRD42022360554). The full online CoSTR can be found on the ILCOR website.[110]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Late preterm and term infants (34+0 or more weeks' gestation) with moderate or severe hypoxic ischemic encephalopathy managed in low-resource settings
- Intervention: Therapeutic hypothermia to a specified target temperature for a defined duration
- Comparators: Standard care
- Outcomes (importance assigned by task force consensus, in accord with available guidelines[11,12]):
  - Death or neurodevelopmental impairment at 18 months to 2 years—composite outcome (critical)
  - Death at hospital discharge (critical)
  - Neurodevelopmental impairments at 18 months to 2 years (critical)
  - Cerebral palsy (critical)
  - Blindness (critical)
  - Deafness (critical)
  - Persistent pulmonary hypertension of the newborn or other adverse outcome (as defined by the study authors)

Neurodevelopmental impairment was defined as abnormal motor, sensory, or cognitive function using an appropriate standardized test.

- Study designs: RCTs and nonrandomized studies (nonrandomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All languages were included if there was an English abstract.

- Time frame: Databases were searched from inception until September 2022, and the search was updated to July 2023.

Consensus on Science

The systematic review identified 21 RCTs involving 2145 infants with hypoxic ischemic encephalopathy.[111-131] Most studies were single site, but 3 were multicenter.[121,128,130] Key results are summarized in Table 23.

Table 23. Use of Therapeutic Hypothermia for Infants With Moderate or Severe Hypoxic Ischemic Encephalopathy in Low- or Middle-Income Countries

Outcomes (importance)	Participants (studies)	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effect	
				Risk with standard care	RD with therapeutic hypothermia; NNTB if applicable
Death or NDI at 18–24 months (critical)	813 (5 RCTs)[112,121,128,130,131]	Moderate	0.67 (0.45–0.99)	458/1000	151 fewer infants died or had NDI per 1000 (5 fewer–252 fewer); NNTB, 7 (4–200) infants
Death or NDI at any time of follow-up (critical) (post-hoc outcome)	1168 (9 RCTs)[112,114,117,118,121,126,128,130,131]	Low	0.50 (0.35–0.71)	474/1000	237 fewer infants died or had NDI per 1000 (138 fewer–308 fewer);

Outcomes (importance)	**Participants (studies)**	**Certainty of the**	**RR (95%**	**Anticipated absolute effect**	
					NNTB, 5 (4–8) infants
Death at hospital discharge (critical)	1488 (15 RCTs)[112-116,120,122-129,131]	Moderate	0.70 (0.47–1.02)	215/1000	64 fewer infants died per 1000 (114 fewer–4 more)
Cerebral palsy (critical)	919 (6 RCTs)[112,119,121,126,128,130]	High	0.52 (0.37–0.72)	186/1000	89 fewer infants had cerebral palsy per 1000 (52 fewer–117 fewer); NNTB, 12 (9–20) infants
Blindness (critical)	718 (4 RCTs)[117-119,128]	Moderate	0.48 (0.22–1.03)	53/1000	28 fewer infants were blind per 1000 (41 fewer–2 more)
Deafness (critical)	718 (4 RCTs)[117-119,128]	Moderate	0.42 (0.21–0.82)	72/1000	42 fewer infants were deaf per 1000 (57 fewer–13 fewer); NNTB, 24 (18–77) infants
PPHN	564	High	1.31	74/1000	23 more

Outcomes (importance)	Participants (studies)	Certainty of the	RR (95%	Anticipated absolute effect	
(adverse effect—critical)	(3 RCTs)[111,127,128]		(0.76–2.25)		infants had PPHN per 1000 (18 fewer–92 more)

GRADE indicates Grading of Recommendations, Assessment, Development, and Evaluation; NDI, neurodevelopmental impairment; NNTB, number needed to treat to benefit; PPHN, persistent pulmonary hypertension; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

Apart from persistent pulmonary hypertension, reporting of adverse events during therapeutic hypothermia was inconsistent between studies. Subgroup analysis suggested that non–servo-controlled methods were more efficacious, although the task force considered that these results were more likely due to other aspects of study design than to a benefit of non–servo-controlled methods.

Prior Treatment Recommendations (2015)

We suggest that newly born infants at term or near term with evolving moderate-to-severe hypoxic-ischemic encephalopathy in low-income countries and/or other settings with limited resources may be treated with therapeutic hypothermia (weak recommendation, low-quality evidence).[102]

Cooling should only be considered, initiated, and conducted under clearly defined protocols with treatment in neonatal care facilities with the capabilities for multidisciplinary care and availability of adequate resources to offer intravenous therapy, respiratory support, pulse oximetry, antibiotics, antiseizure medications, and pathology testing. Treatment should be consistent with the protocols used in the randomized clinical trials in developed countries, ie, cooling to commence within 6 hours, strict temperature control at 33°C to 34°C for 72 hours, and rewarming over at least 4 hours.[102]

2024 Treatment Recommendations

We suggest the use of therapeutic hypothermia in comparison with standard care alone for term (≥37+0 weeks' gestational age) newborn infants with evolving moderate-to-severe hypoxic-ischemic encephalopathy in low- and middle-income countries in settings where a suitable level of supportive neonatal care is available (weak recommendation, low-certainty evidence).

For late preterm infants, 34+0 to 36+6 weeks' gestational age infants, a recommendation cannot be made due to insufficient evidence.

Therapeutic hypothermia should only be considered, initiated, and conducted under clearly defined protocols with treatment in neonatal care facilities with the capabilities for multidisciplinary care and availability of adequate resources to offer intravenous therapy, respiratory support, pulse oximetry, antibiotics, antiseizure medication, transfusion services, radiology (including ultrasound), and pathology testing, as required. Treatment should be consistent with the protocols used in RCTs. Most protocols included commencement of cooling within 6 hours after birth, strict temperature control to a specified range (typically 33°C–34°C) and most commonly for a duration of 72 hours with rewarming over at least 4 hours. Adoption of hypothermia techniques without close monitoring, without protocols, or without availability of comprehensive neonatal intensive care may lead to harm (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table can be found in Appendix A4.

- The largest included (multicenter) RCT found that therapeutic hypothermia significantly increased mortality and did not reduce the combined outcome of death or disability at 18 months.[128]

- Nevertheless, the combined (moderate certainty) evidence from all RCTs that assessed death plus disability at 18 to 24 months or cerebral palsy found that therapeutic hypothermia reduced neurodevelopmental impairment without increasing mortality. For several of the critical outcomes, there was high heterogeneity, which together with the preponderance of smaller, single-center trials mostly reporting benefit, raised the possibility of publication bias. For some studies, concerns have been raised about study methodology underlying participant heterogeneity, including methods of patient selection, as well as consistency of diagnosis and etiology.[132] Therefore, the task force concluded that the overall certainty of evidence was low. Furthermore, for adverse effects of therapeutic hypothermia, there was heterogeneity and inconsistency of reporting among the included studies, precluding meta-analysis.
- Although the PICOST intended to evaluate infants ≥34+0 weeks of gestational age, 15 of the 21 included studies specified ≥37 weeks of gestational age as an inclusion criterion, making the data for late preterm infants insufficient to support a treatment recommendation.
- Distinction between low- and middle-income countries versus high-income countries, based on World Bank determinations, is straightforward.[133] However, the hospitals in the included studies (all in low- and middle-income countries) could provide neonatal ICU care, including advanced respiratory support, indicating a high level of resources despite their location in low- and middle-income countries. Therefore, the recommendation is made in relation to low- and middle-income countries rather than to the low-resource settings intended by the PICOST.

- In high-income countries, adequate follow-up assessment and care are also considered necessary to optimize neurodevelopmental outcomes and to monitor the effectiveness of treatment.

Knowledge Gaps

- The minimum intensive care resources required for safe and effective provision of therapeutic hypothermia in low- and middle-income countries
- Cost effectiveness of therapeutic hypothermia in low- and middle-income countries
- Resource implications for safe and effective care of infants during provision of therapeutic hypothermia in low- and middle-income countries
- Strategies for optimal case selection of infants who may benefit from or may be harmed by therapeutic hypothermia in countries at all income levels

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EDUCATION, IMPLEMENTATION, AND TEAMS

Cardiac Arrest Centers (EIT 6301: SysRev)

Rationale for Review

Specialized post–cardiac arrest care at a cardiac arrest center (CAC) may improve long-term survival from OHCA. Previous studies have reported an association between survival to hospital discharge and transport to a CAC, but there is inconsistency in the hospital factors that are most related to patient outcome.[1]

In 2020, ILCOR reviewed the evidence on CACs despite a lack of high-quality data to support their implementation.[2] Since then, new evidence on CACs has been published, triggering this update of the SysRev (PROSPERO number CRD420180933690). CACs are defined as specialized institutions offering treatment or services for patients with OHCA, including a coronary angiography laboratory with 24/7 percutaneous coronary intervention, post–cardiac arrest temperature control, extracorporeal membrane oxygenation, mechanical ventilation, and neurologic prognostication.[3] For this review, we defined CAC as having the capability for 2 or more of the above interventions and explicitly referred to by study authors as CACs (or synonymous terms such as *critical care medical center*, *tertiary heart center*, or *regional center*).[4] We excluded studies that used high volume (number of cases/patients) or percutaneous coronary intervention capability as the only distinguishing characteristics. The full CoSTR can be found online.[5]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adults and children with attempted resuscitation after nontraumatic IHCA or OHCA
- Intervention: Care at a specialized CAC

- Comparator: Care in an institute not designated as a specialized CAC
- Outcome:
  - Critical: Survival at 30 days with favorable neurological outcome, survival at hospital discharge with favorable neurological outcome, survival at 30 days, and survival at hospital discharge
  - Important: ROSC after hospital admission for patients with ongoing CPR
- Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All relevant publications in any language were included as long as there was an English abstract available.
- Time frame: Literature search included all years to June 23, 2023.

Consensus on Science

Sixteen studies were included in our review.[6-21] All studies had moderate to serious risk of bias from confounding, and the certainty of evidence was rated as low. Because of substantial heterogeneity, no meta-analyses could be performed.

Individual study details are provided in the published SysRev and online.[5] Three observational studies showed improved outcomes associated with treatment at a CAC for survival to 30 days with favorable neurological outcomes (Figure 1),[6-8] 10 for hospital discharge with favorable neurological outcomes (Figure 2),[6,7,9-16] and 3 for survival to 30 days (Figure 3).[6,8,12]

The only RCT identified did not show any difference in outcomes, but its results were limited to non–ST-segment elevation myocardial infarction (non-STEMI) patients with prehospital ROSC in an urban setting. Findings were not generalizable to other patient cohorts.[6]

Study or Subgroup	CAC Events	CAC Total	non CAC Events	non CAC Total	Risk ratio M-H, Random, 95% CI
1.1.1 Non-randomised trials					
Matsuyama 2017	750	15118	355	24827	3.47 [3.06 , 3.93]
Tagami 2012	21	712	4	770	5.68 [1.96 , 16.46]
1.1.2 Randomised trial					
Patterson 2023	115	414	121	413	0.95 [0.76 , 1.18]

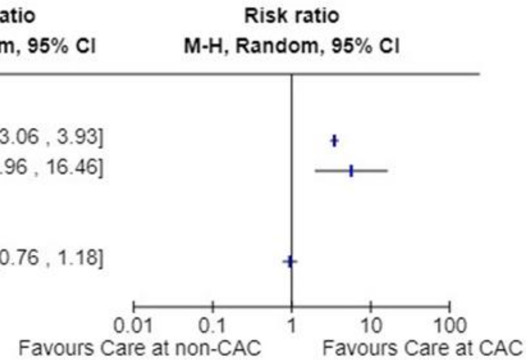

Figure 1. Survival to 30 days with favorable neurological outcomes.[6-8]
CAC indicates cardiac arrest center.

Study or Subgroup	CAC Events	CAC Total	non-CAC Events	non-CAC Total	Risk ratio M-H, Random, 95% CI
1.2.1 Non-randomised trials					
Jung 2022	2113	23292	3450	72639	1.91 [1.81 , 2.01]
Kim 2019	251	4036	87	5876	4.20 [3.30 , 5.34]
Kragholm 2017	400	1359	20	148	2.18 [1.44 , 3.30]
McKenzie 2018	206	404	46	105	1.16 [0.92 , 1.47]
Soholm 2015	218	586	96	492	1.91 [1.55 , 2.35]
Spaite 2014	153	1727	26	439	1.50 [1.00 , 2.24]
Sunde 2007	34	61	15	58	2.16 [1.32 , 3.52]
Tagami 2012	21	712	4	770	5.68 [1.96 , 16.46]
Yeh 2021	160	1222	18	366	2.66 [1.66 , 4.27]
1.2.2 Randomised trial					
Patterson 2023	130	413	130	402	0.97 [0.80 , 1.19]

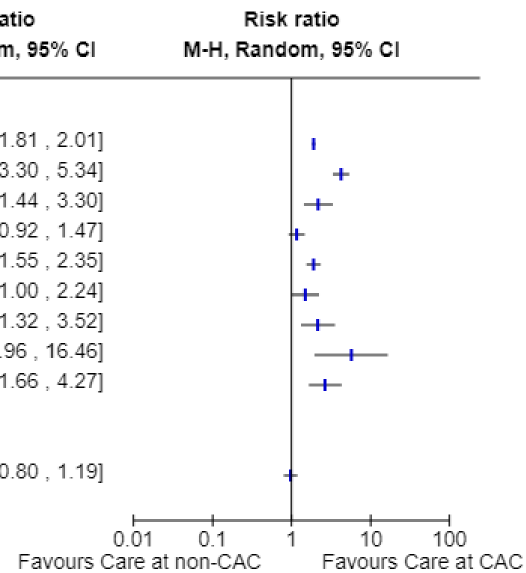

Figure 2. Hospital discharge with favorable neurological outcomes.[6,7,9-16]
CAC indicates cardiac arrest center.

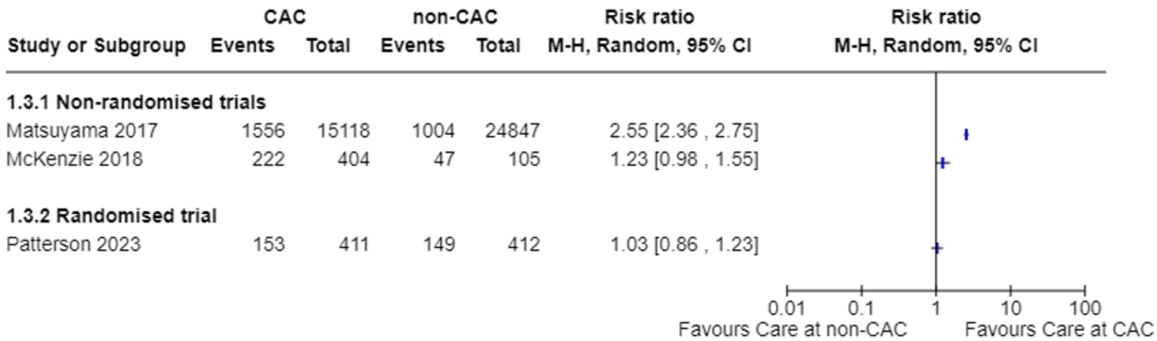

Figure 3. Survival to 30 days.[6,8,12]
CAC indicates cardiac arrest center.

Eleven observational studies showed improved outcome of survival to hospital discharge associated with care at a CAC (Figure 4).[7,9-18]

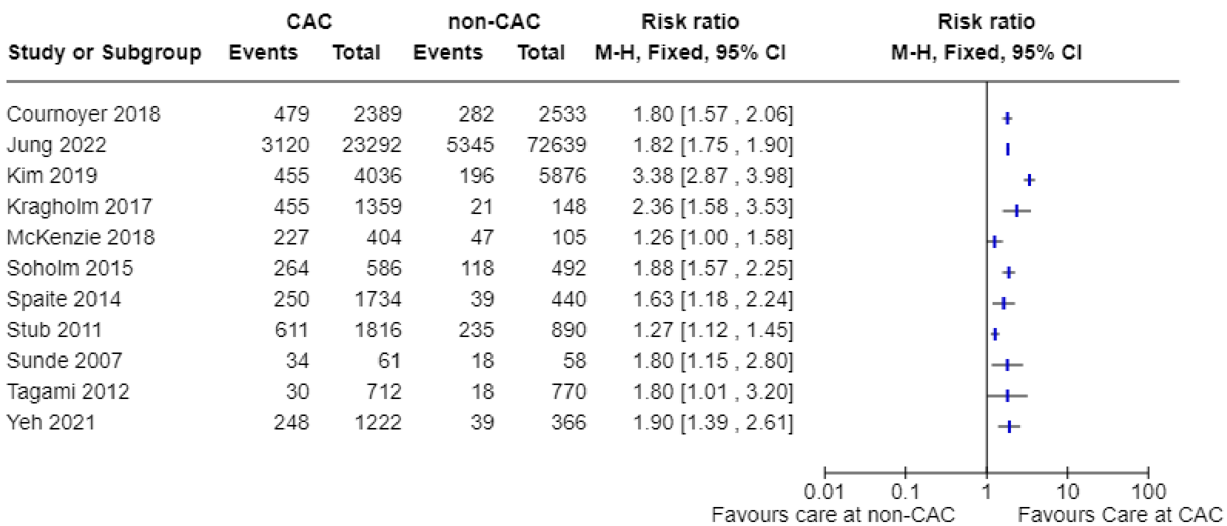

Figure 4. Survival to hospital discharge.
CAC indicates cardiac arrest center.

Three observational studies showed improved outcome for ROSC associated with care at a CAC (Figure 5).[8,10,17]

Study or Subgroup	CAC Events	CAC Total	non-CAC Events	non-CAC Total	Risk ratio M-H, Random, 95% CI
Cournoyer 2018	1021	2389	666	2533	1.63 [1.50 , 1.76]
Kim 2019	1025	4036	656	5876	2.27 [2.08 , 2.49]
Matsuyama 2017	1713	15118	1146	24847	2.46 [2.29 , 2.64]

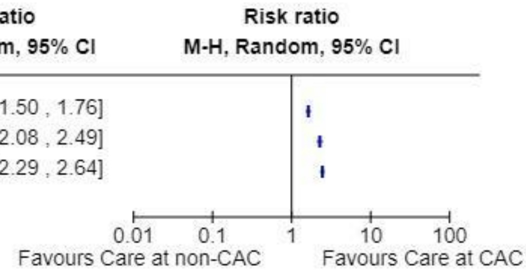

Figure 5. Return of spontaneous circulation.
CAC indicates cardiac arrest center.

Prior Treatment Recommendation (2019)

We suggest adult patients with nontraumatic OHCA be cared for in CACs rather than in non-CACs (weak recommendation, very low–certainty evidence).[22]

2024 Treatment Recommendation

We suggest adults with OHCA should be cared for in cardiac arrest centers (weak recommendation, low-certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Appendix A5.

- This topic was prioritized by the EIT Task Force on the basis of ongoing interest in improving patient outcomes after OHCA.
- A trial of expedited transfer to a CAC for non–ST-segment elevation OHCA (ARREST trial) was published in 2023.[6] The results did not show any benefits among patients transferred to a CAC. Based on these results, we are unable to recommend for or against transferring OHCA adults with presumed cardiac cause presenting with non–ST-segment elevation with prehospital ROSC to a CAC, because this RCT was in a very large urban city setting.
- Given the lack of generalizability of the above trial, we included published data from nonrandomized studies in our review.

- We considered the successful implementation of regionalized care for trauma, stroke, and STEMI with improved outcomes.
- We reflected on the high level of resources required, particularly in regions with no regionalized emergency transport in place for other conditions (eg, trauma, stroke, STEMI) and concluded that the benefits potentially outweigh issues associated with implementation of CACs.
- We recognized that implementing this recommendation may be resource and cost intensive, and although it has been successfully implemented in some countries, it may not be feasible in all regions.
- There were insufficient data for subgroup analyses to make any recommendations about specific subgroups, including age group, presenting rhythm, and primary versus secondary transfer, except from 1 RCT in a very specific setting.
- We did not identify any studies on children or in-hospital cardiac arrest in this review.

Knowledge Gaps

- The effect of CACs for cardiac arrest in children or in the in-hospital setting
- The effect of CACs on long-term neurological intact survival
- The long-term benefits of CACs and the impact on patient-reported outcomes[23]
- The effect of care at CACs in specific subgroups (eg, age, cardiac etiology, shockable or nonshockable rhythm)
- The cost-effectiveness of transferring and/or caring for patients at CACs
- Whether there are any negative outcomes associated with bypassing the closest hospitals (eg, deskilling in postarrest management) and transferring patients to CACs
- What defines a safe distance or time for transport to a CAC

- The impact on families, particularly those from remote regions
- The potential impact on organ donation
- There are insufficient data from large RCTs, including a broad variety of populations and etiology of cardiac arrest, because all but 1 study are observational trials.

Cognitive Aids During Resuscitation (EIT 6400: SysRev)

Rationale for Review

The management of cardiac arrest and other medical emergencies can be complex. Cognitive aids have been widely adopted to enhance adherence to guidelines, improve performance, and reduce errors. These aids may provide a structured framework and clinical guidance through complex and dynamic processes. Resuscitation councils worldwide use cognitive aids during training and clinical practice in the form of algorithms, flow charts, checklists, posters, digital applications, and other formats. Whether use of such cognitive aids during resuscitation improves performance and patient outcomes is uncertain.

ILCOR reviewed the evidence in 2020 and did not recommend cognitive aids for laypersons during training and real CPR; however, they were suggested for training of health care professionals.[24,25] Since then, new evidence has been published, triggering this update of the SysRev (PROSPERO registration CRD42020159162). The complete CoSTR can be found online.[26]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adults, children, and neonates in any setting (in-hospital or out-of-hospital) requiring resuscitation, or laypersons and health care professionals providing resuscitation or learning to provide resuscitation
- Intervention: The use of cognitive aids or checklists during resuscitation

- Comparator: No use of cognitive aids or checklists
- Outcome:
  - Critical: Survival to hospital discharge with good neurological outcome, survival to hospital discharge
  - Important: Quality of performance in actual resuscitations, skill performance 1 year after course conclusion, skill performance between course conclusion and 1 year, skill performance at course conclusion, knowledge at course conclusion, adherence to resuscitation guidelines, CPR quality and test scores
- Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All years and all languages were included as long as there was an English abstract available.
- Time frame: Literature search was updated from January 1990 to October 28, 2023.

Consensus on Science

All 29 studies included in this review were simulation studies that investigated the use of cognitive aids to facilitate clinical performance. No study investigated cognitive aids as an educational tool. No meta-analyses could be performed because of a high degree of heterogeneity in the studies, and the overall certainty of evidence was very low for all outcomes. Details of individual studies are included in the published review and online.[26]

Four simulation studies[27-30] investigated the effects of cognitive aids in neonatal resuscitation by health care professionals. Findings included improvement in performance score with a decision support toll using augmented reality (AR),[30] fewer deviations from a resuscitation algorithm with a decision support tool with auditory and visual prompts,[28] and improved adherence to a resuscitation algorithm and performance to a guideline with audio voice guidance.[29] A poster of an algorithm demonstrated no difference in performance.[27]

The use of cognitive aids during simulated pediatric resuscitation was assessed in 3 studies[31-33] and showed no difference in CPR performance by using a noninteractive CPR checklist,[33] and no difference in CPR quality metrics with a decision support app.[32] However, improved adherence to protocols or processes was found in 2 RCTs.[31,32] A computer-based resuscitation tool improved task completion,[31] and a decision support app found significantly fewer deviations from guideline recommendations.[32]

Eight studies[34-41] used interactive cognitive aids during adult ALS simulated resuscitation (smartphone apps,[34,38,40] tablet apps,[36,37,39] computer-based clinical decision display system[35,41]) with improved adherence to a protocol or process in all studies.

Five studies[42-46] investigated the effects of cognitive aids (noninteractive checklists) used by health care professionals managing other emergencies in simulated events. In 4 RCTs: average performance scores increased,[44] failure to adhere to critical steps was reduced,[42] use of a medical emergency checklist improved adherence to guideline-adherent critical process steps,[45] and longer checklists seemed to be superior to shorter checklists or no checklist for overall CPR performance on procedural variables but not for CPR quality.[46] Access to crisis checklists shortened time to adequate administration of glucose in a hypoglycemic coma scenario.[43]

Seven RCTs[47-53] and 2 observational studies[54,55] investigated the effects of cognitive aids used by lay rescuers during simulated resuscitation. Three RCTs[48,49,51] of mobile phone applications found improved adherence to clinical processes, while another mobile phone application RCT[53] found no improvement. Other RCTs found that using instruction cards improved adherence to AED sequences and time to shock,[47] a voice-activated visual and auditory-assisted decision device improved adherence to a 30:2 CPR ratio,[50] and use of a flowchart demonstrated reduced hands-off time during CPR.[52]

An observational study[54] investigated the use of speech recognition software and found improved adherence to a clinical protocol assessed in an objective structured clinical examination. Another observational study[55] investigated the feasibility of Chatbot guidance, which produced mixed results.

Three studies reported undesirable effects: increase in time to commencing chest compressions [50,52] and delays in calling emergency services.[51]

Prior Treatment Recommendations (2020)

- We recommend against the use of cognitive aids for the purposes of lay providers initiating CPR (weak recommendation, low-certainty evidence).
- We suggest the use of cognitive aids for health care providers during trauma resuscitation (weak recommendation, very low–certainty evidence). In the absence of studies on CPR, no evidence-based recommendation can be made.
- There are insufficient data to suggest for or against the use of cognitive aids in lay provider training.
- We suggest the use of cognitive aids for training of health care providers in resuscitation (weak recommendation, very low–certainty evidence).[24,25]

2024 Treatment Recommendations

- We suggest the use of cognitive aids by health care professionals in resuscitation (weak recommendation, very low–certainty evidence).
- We do not recommend the use of cognitive aids for lay providers initiating CPR (weak recommendation, low-certainty evidence).

- We did not examine the use of cognitive aids in health professional or lay rescuer training in resuscitation so no recommendation for or against can be issued.

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision tables are provided in Appendix A5.

- The EIT Task Force continues to prioritize this topic because international resuscitation councils commonly provide cognitive aids to resuscitation course participants and health care organizations (algorithms, pocket cards, etc). However, it has not been determined if they are effective in improving patient outcomes or provider performance during actual resuscitation, because no evidence was found for the use of cognitive aids by trained health care professionals during actual resuscitation events.
- The 2021 EvUp focused on outcomes associated with CPR quality. In this review, the outcomes focused on improved team performance through adherence to clinical protocols and processes of care.
- The task force's recommendations differentiate between health care professionals and laypersons, as well as between use during resuscitation and during training, because the evidence for use of cognitive aids in these different groups and conditions differs substantially.
- For lay providers, there is consistent evidence that there are potentially clinically important delays in initiating CPR when using a cognitive aid; however, the evidence for impact on CPR-quality metrics (eg, rate, depth, chest compression fraction) is less consistent. We found insufficient evidence to issue a recommendation for the use of cognitive aids in layperson training.

- For health care professionals, sufficient new studies provided the evidence to issue a recommendation for the use of cognitive aids during resuscitation. Because no study reported the use of cognitive aids during patient resuscitation, results from simulation studies might be used as a surrogate to justify the use of cognitive aids, as these have been used over decades by all resuscitation councils.
- Because no studies on resuscitation were found in the review in 2019, the task force previously considered the trauma resuscitation environment sufficiently similar to the CPR environment to extrapolate evidence that shows that trauma resuscitation teams generally adhere to resuscitation guidelines better, make fewer errors, and perform key clinical tasks more frequently if they use cognitive aids. In this review, sufficient new studies addressed the use of cognitive aids in resuscitation (however, only in a simulated environment) that the task force decided to exclude trauma studies from this review.
- There were several studies that used composite scores as their primary outcome (eg, score calculated on the basis of completing several clinical tasks). We included these studies for this SysRev; however, given their heterogeneity, comparing and pooling the results were not possible.
- Even though all studies were simulation studies, none specifically investigated the use of cognitive aids as an educational tool. Therefore, we could not examine the use of cognitive aids for health care professionals or lay rescuer training in resuscitation. This needs to be examined in our next review.

Knowledge Gaps

- The impact of cognitive aids in real-life cardiac arrests and on patient survival

- Effective strategies for implementation of cognitive aids during training and real-life resuscitation for health care professionals
- The most effective type of cognitive aid
- Cost-effectiveness of the use of cognitive aids during resuscitation and training
- The effect of cognitive aids for health care professional and layperson training

Immersive Technologies for Resuscitation Teaching (EIT 6405: SysRev)

Rationale for Review

Current methods for training laypeople and health care professionals often fall short, resulting in poor skill acquisition and long-term skill decay. Identification of alternative educational strategies with improved learning outcomes will help to enhance process of care and patient outcomes from cardiac arrest. Immersive technologies, such as virtual reality (VR) (defined as real-time simulation and interactions through sensorial channels created by a computer and displayed on a head-mounted or smartphone device)[56] and AR (defined as computer-generated holographic images overlaid into the real environment enabling users to interact with both the hologram and real objects),[57] provide an alternative learning modality to traditional instructor-led training. These technologies can support training when combined with other instructional methodologies such as video, manikin-based training, and/or online learning. Implementation of immersive technology comes with a cost for both hardware and software components. VR and AR technology have been used in educational settings for both laypersons and health care professionals, but ILCOR has not previously reviewed the available evidence. A SysRev was initiated because the overall impact of VR and AR on learning and performance outcomes is unclear (PROSPERO registration CRD42023376751). The full CoSTR can be found online.[58]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Laypersons and health care professionals in any educational setting
- Intervention: Immersive technologies (VR, AR, mixed reality, extended reality) as part of instructional design to train neonatal, pediatric, and adult BLS and ALS
- Comparator: Other methods of resuscitation training in BLS and ALS (eg, traditional manikin-based simulation training)
- Outcome: Knowledge acquisition and retention, skills acquisition and retention, skill performance in real CPR, willingness to help, bystander CPR rate, patients' survival
- Study design: RCTs, nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies and case series where n >5, conference abstracts), and research letters were eligible for inclusion. All years and all languages were included as long as there was an English abstract available.
- Time frame: Literature search from January 1, 1990, to April 3, 2023

Consensus on Science

No meta-analyses could be performed because of a high degree of heterogeneity in the studies, and the overall certainty of evidence was very low for all outcomes. Details of individual studies are included in tables in the published review and online.[58]

Out of 18 studies[56,57,59-74] included in this review, 3 studies used AR in BLS training.[56,57,60] Two of these used AR to provide real-time CPR feedback, with one study favoring AR and the other favoring the non-AR feedback.[56,60] The third study used AR to provide clinical guidance during training, and results favored the AR intervention but were not significant.[57]

VR for BLS was explored in 9 studies assessing laypersons[59,61-67,74] and 3 studies of health care professionals.[68-70] All featured VR as the primary instructional methodology. An additional 3 studies described VR use for ALS training in health care professionals.[71-73] Because of significant heterogeneity in the design of the interventions, control groups, participant types, and outcome measures, meta-analysis was not possible.

Of the 3 studies investigating AR, 2 demonstrated no difference in CPR depth performance with and without use of AR during training.[56,57] One study reported better CPR depth compliance with the use of AR during training.[60] Two studies showed no difference in CPR-quality parameters (compression depth and rate),[56,57] while an additional study found no difference in compression rate but a difference in depth with the use of AR during training.[60] Overall CPR performance was assessed in 2 studies[56,60] and demonstrated mixed results.

Six studies looked at VR for acquisition of BLS knowledge. Knowledge acquisition was significantly greater with VR in 3 studies compared with a serious game,[68] e-learning with video,[63] and video-based training.[64] Two studies showed no difference compared with traditional training[66] or video-based training.[65] Knowledge retention with kindergarten teachers improved at 5 weeks after training with VR.[64] Two other studies showed no difference at 6 months.[62,66]

Nine studies investigated the effects of VR on BLS skills outcomes. Adult laypeople achieved significantly greater chest compression fraction with instructor-led training compared with VR.[59] Results for no-flow time were mixed. One study favored VR over web-based BLS training,[70] and the other favored conventional BLS training over VR.[69]

Three studies in adult laypersons showed significantly better CPR depth in the control group compared with VR.[59,61,74] Two other studies showed no difference in CPR depth between groups.[66,67] Participants in instructor-led CPR training had significantly better CPR depth compliance compared with VR.[59,74] One study demonstrated higher CPR rates with VR (however, both groups were within the suggested guideline range for CPR rate).[59] Two other studies found no difference in CPR rate.[61,67] CPR rate compliance was not better with VR; CPR rate compliance was either better for instructor-led training,[59,74] or no difference was found.[66] One study reported better chest recoil compliance with VR,[59] but 3 studies demonstrated no difference.[66,67,74] For overall CPR performance after training, 3 studies found no difference when comparing VR with instructor-led training[67,74] or video-based training.[65] Two studies measured retention of CPR skills at 6 months[66] and 3 months[74] after training and found no difference in CPR depth, rate, or chest recoil when comparing traditional training and VR.[66,74]

A study in adult laypersons found more willingness to perform CPR with instructor-led CPR training at 6 months after training than with VR-based CPR training [81% willing in the instructor-led control group compared with 71% in the VR intervention group, P=0.02].[62]

Three studies investigated VR for ALS training. A study in neonatal resuscitation compared high-fidelity simulation with VR and showed no difference in knowledge immediately after training.[73] An advanced cardiovascular life support study found significantly improved adherence to guidelines with traditional training compared with VR training with limited feedback. No difference was found when comparing traditional training with VR training with comprehensive feedback.[71] An additional study found no difference in objective structured clinical examination scores for clinical performance between standard Helping Babies Breathe training and VR-based Helping Babies Breathe immediately after training and 6 months later.[72]

2024 Treatment Recommendations (New)

We suggest the use of either augmented reality or traditional methods for BLS training of laypeople and health care professionals (weak recommendation, very low–certainty evidence).

We suggest against the use of virtual reality only for BLS and ALS training of laypeople and health care professionals (weak recommendation, very low–certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table can be found in Appendix A5.

Augmented Reality

- The evidence was either equivocal or in support of AR.
- Only a few studies were identified, with few participants.
- Two studies used AR for feedback[56,60] and 1 for clinical guidance[57] (ie, different applications of the technology), and the control groups were different across these 3 studies (some included CPR feedback, others did not).

Virtual Reality

- The evidence was mixed but predominantly in favor of non–VR-based training or equivocal in nature.
- Studies were very heterogeneous with respect to type of intervention, type of control, and outcome measures.
- Although some studies reported improved knowledge acquisition with VR training, the results for more important outcomes (ie, skills outcomes, adherence to guidelines, clinical performance) were either in favor of non–VR-based training or equivocal in nature.

Knowledge Gaps

- The relative and synergistic effect of immersive technologies when combined with other educational strategies (eg, video, gamification, feedback)
- The effects of different applications of AR and VR, which can be used in many ways (eg, real-time feedback, gamification, knowledge delivery)

- The impact of immersive technology on the acquisition and retention of knowledge and skills
- The effect of immersive technology–based training on team-based skill performance and process measures (eg, time to epinephrine, time to defibrillation)
- The role of the instructor when immersive technology is being used (eg, when it is beneficial for the instructor to provide feedback and the type of training the instructor requires when using immersive technology in resuscitation courses)
- The costs associated with implementing and maintaining AR and VR devices as well as cost-effectiveness of these training modalities

Gamified Learning Compared With Other Forms of Resuscitation Learning (EIT 6412: SysRev)

Rationale for Review

Increased familiarity and ease with technology and digital media are features of younger generations. More effective teaching strategies for these learners may include a greater degree of stimulation and engagement with the use of active participation with and alongside peers. *Gamification* refers to the use of game-like elements (competition, point systems, scaffolded levels of difficulty, leaderboards), usually in a digital format, to encourage interactive and intuitive participation by learners. Some preliminary studies have found that gamified learning improves knowledge and skill during CPR training, either alone or used as pretraining to a standard life support course; other studies have found no significant difference. The task force undertook a SysRev because the impact of gamified learning on learning and performance outcomes is unclear (PROSPERO registration CRD42023483540). The full CoSTR can be found online.[75]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Learners training in BLS or ALS
- Intervention: Instruction using gamified learning (use of game-like elements in the context of training, eg, point systems, intergroup competition, leaderboards, scaffolded learning with increasing challenge, “medals” or “badges”)
- Comparator: Traditional instruction or other forms of nongamified learning
- Outcome:
  - Educational outcomes:
    - Skill (eg, CPR performance, other procedural performance, scores in scenarios, time to task performance): Immediately after training (ie, end of course), at 3 months, 6 months, 1 year
    - Knowledge (eg, test scores): Immediately after training (ie, end of course), at 3 months, 6 months, 1 year
    - Attitudes: Participant satisfaction, learner preference, learner confidence
  - Clinical outcomes: Change in health care practitioner behavior at resuscitation in case of real cardiac arrest (CPR quality, time to task completion, teamwork/crisis resource management)
  - Patient outcomes: ROSC, survival to hospital discharge, neurologic intact survival
  - Process: Costs and resources utilization
- Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All languages were included as long as there was an English abstract available.

- Time frame: All years up to May 30, 2023

Consensus on Science

Six randomized trials and 7 observational studies were identified.[76-88] Details of study design and key findings are presented in table form in the published review and online.[75] No meta-analyses could be performed because of a high degree of heterogeneity in the studies, and the overall certainty of evidence was low to very low for all outcomes.

Eleven studies used digital platforms, including online or screen-based platforms,[76,77,82,85,86,88] a digital leaderboard,[78,81,82] and smartphone applications.[84,87] One study used a board game, and another a card game.[79,80] Eleven studies involved health care professionals,[76-84,87,88] and 2 involved laypersons (high school students).[85,86] Three studies examined performance of teams[80,86,87]; the remaining 10 examined individual performance. No study reported on outcomes of process, costs, and resources utilization, or on critical clinical and patient outcomes.

Overall CPR performance was addressed in 4 RCTs[77,78,82,83] and 1 observational study.[86] Three RCTs[77,82,83] found better performance with gaming for health care professionals and laypersons. A multicenter RCT found no effect.[78] The observational study in laypersons found improved performance 6 months after training with gaming.[86] In an observational study of BLS training amongst high school students using a screen-based gamified learning interface, chest compression depth and rate was improved immediately after training and remained improved 3 months later.[85]

Two observational studies of health care professionals demonstrated improved knowledge scores after gamified learning during the Neonatal Resuscitation Program, a finding that persisted at 6 months in 1 of the studies.[79,88] A card game to enhance Neonatal Resuscitation

Program knowledge reported high levels of perceived usefulness.[80] Another observational study found improved skills scores and faster time to positive pressure ventilation in a neonatal scenario that followed gamified learning.[76]

For ALS knowledge, 2 RCTs in health care professionals showed improvements with smartphone-based games.[84,87] The latter study showed no difference for skills during ALS scenarios used in a smartphone-based game involving ALS scenarios but led to better self-reported confidence among users.

An observational study[81] of nurses using a leaderboard showed decreased time to epinephrine dosing in children as well as increased proportion of learners knowing the correct concentration of epinephrine.

2024 Treatment Recommendation (New)

We suggest the use of gamified learning be considered as a component of resuscitation training for all types of BLS and ALS courses (weak recommendation, very low–certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Appendix A5.

- All studies were very heterogeneous with respect to subjects, type of intervention, type of control, and outcome measure, and GRADE assessment showed that evidence was of very low certainty.
- All studies reported at least 1 domain of learner outcome (skill, knowledge, attitude) with a positive result when gamified learning elements were included; no studies found a negative impact of gamified learning elements on any domain of learner outcomes.

- Most studies involved an intervention requiring a digital platform (eg, video-based, smartphone-based); no studies reported any information about cost, implementation outside their study group, or wider dissemination to other settings or learners.

Knowledge Gaps

- A more consistent definition of *gamification* across research studies (eg, use of video-based content delivery alone does not necessarily constitute a "game," although this term is frequently used to describe such training elements)
- No studies found on dissemination of gamified learning elements as well as platforms to varied learner groups and settings
- Costs, resources, and time requirements for implementation of gamified learning
- The association between gamified learning elements and differences in stress and/or cognitive load
- The impact of gamified learning on care delivery and/or patient outcomes

Rapid Cycle Deliberate Practice in Resuscitation Training (EIT 6414: SysRev)

Rationale for Review

Rapid cycle deliberate practice (RCDP) is a type of training in which feedback occurs within the training. It should not be confused with repetitive practice. RCDP is characterized by a goal to be achieved, a stop-and-go practice with immediate feedback on the performance, ample time for repetition to improve performance aiming to improve clinical outcomes, and a safe environment that fosters an atmosphere where students have no fear of making mistakes and receive feedback from a constructive perspective.[89] ILCOR has not previously reviewed available evidence about RCDP in resuscitation training. Therefore, a SysRev was initiated (PROSPERO registration CRD42023468862). The full CoSTR can be found online.[90]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Learners training in BLS or ALS
- Intervention: Instruction that uses RCDP
- Comparator: Traditional instruction or other forms of learning without RCDP
- Outcome: Knowledge acquisition and retention, skills acquisition and retention, skill performance in real CPR, attitudes, willingness to help, and patients' survival
- Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All years and all languages were included as long as there was an English abstract available.
- Time frame: All years up to November 1, 2023

Consensus on Science

Seven RCTs[91-97] and 1 observational before-after study[89] were identified.[89,91-97] The studies included medical students,[96] interns,[93,94] residents,[89,92,97] physicians,[95] and a mix of fellows, nurses, and respiratory therapists[91]—all involved in adult,[95,96] pediatric,[89,91,92,94,97] and neonatal[93] simulated scenarios. Seven of them referred directly to RCDP[89,91-95,97]; 1 used "in-simulation debriefing" during the clinical scenario, which contained the key components of RCDP.[96]

Details of individual studies are presented in the published review and online.[90] No studies reported clinical or patient outcomes, and meta-analysis was only possible for time to chest compressions.

For time to chest compressions, 2 pediatric[92,97] studies and 1 neonatal[93] study provided very low–certainty evidence of no benefit from RCDP when compared with after-event debriefing (Figure 6). In an observational study, RCDP resulted in a significantly shorter time from cardiac arrest to initiation of chest compressions.[89]

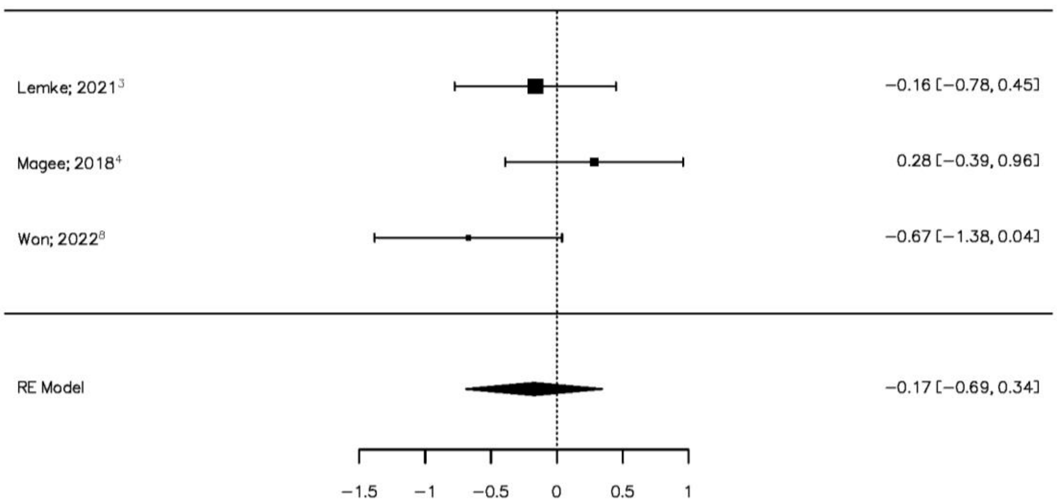

Figure 6. Meta-analysis forest plot for time to chest compressions comparing RCDP with after-event debriefing. Data are given for the estimated standardized mean difference in seconds using a random effects model (*P*=0.5105).

RCDP indicates rapid cycle deliberative practice; RE, random effects.

A single RCT found no benefit in time to recognition of cardiac arrest with RCDP.[95] An observational study found no benefit in time to bag-mask ventilation.[89] In an RCT, time to positive-pressure ventilation within 1 minute was more frequent with RCDP than in the control.[93] Three RCTs[92,95,97] and 1 observational study[89] assessed time to defibrillation, with shorter time from rhythm recognition to defibrillation in 2 RCTs[92,95] and in the observational study.[89] Two RCTs assessed time to administration of epinephrine,[92,93] with 1 study describing a benefit with RCDP.[93] RCDP also resulted in shorter pre-defibrillation pause durations in 2 studies.[89,95] RCDP improved compression fraction/no-flow fraction in an RCT[95] and in an observational study.[89] Retention of skills at 4 months was analyzed in an RCT, and there was no difference with RCDP.[93]

For adherence to protocol, 1 RCT reported higher scores,[93] but 2 others found no difference.[91,94] Team leader performance was better with RCDP in 1 study.[97] In contrast, participants' subjective perception of the teaching effectiveness scored lower for RCDP.[96]

2024 Treatment Recommendation (New)

We suggest that it may be reasonable to include Rapid Cycle Deliberate Practice as an instructional design feature of BLS and ALS training (weak recommendation, very low–certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Appendix A5.

- We favored RCDP as a teaching modality because no side effects or harmful outcomes were reported and most outcomes showed a benefit from RCDP. Notably, shorter time to critical task performance (ventilation, defibrillation, administration of epinephrine) and shorter preshock pause durations were described in several studies.
- The only meta-analysis performed (for time to chest compressions) did not show a difference. This contributed to the weakness of the recommendation, despite other evidence being found in favor of RCDP.
- Only 1 study (addressing teaching effectiveness) out of the 8 included in the review favored the control group.
- As most of the RCDP studies included trainees, generalizability of the findings to other groups needs to be further explored.

Knowledge Gaps

- The effect of RCDP in other populations (laypeople, first responders, and experienced health care professionals)

- The medium or long-term follow-up effect of RCDP
- Resources required and costs of implementation of RCDP in resuscitation training curriculum of health care professionals and other populations
- The effect of RCDP on resuscitation training and clinical outcomes and patient survival
- There is heterogeneity in the use of terms, and standardized definitions of *deliberate practice* and RCDP were not used across studies, making identification of relevant comparative studies difficult.

Team Competencies Training for Resuscitation (EIT 6415: SysRev)

Rationale for Review

Team competencies are defined as nontechnical skills, including team-related communication, task allocation, and leadership, that are known to be associated with patient outcomes in resuscitation. Investigating whether specific training of team competencies improves resuscitation performance could impact the organization of resuscitation services worldwide and potentially improve patient care. In 2020 we recommended the use of specific leadership training for resuscitation courses on the basis of very low–certainty evidence.[24] This SysRev aimed to assess the effect of specific training on a broader range of team competencies as part of resuscitation training (PROSPERO registration CRD42023473154). The full CoSTR can be found online.[98]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Learners undertaking life support training in any setting
- Intervention: Life support training with a specific emphasis on team competencies
- Comparator: Life support training without specific emphasis on team competencies

- Outcome: Patient survival, CPR skill performance at course completion, CPR skill performance in actual resuscitation and simulation, CPR quality, confidence, and team competencies—all at course completion, <1 year and ≥1 year after course completion; resources (time, equipment, cost)
- Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Studies evaluating scoring systems (no relevant outcome), studies with self-assessment as the only outcome, reviews, and abstracts were excluded. All languages were included as long as there was an English abstract available.
- Time frame: Literature search January 1, 1999, to August 30, 2023

Consensus on Science

Seventeen studies were included in this review, and individual study details are provided in the published review and online.[98-115] No evidence was identified for CPR-skill quality and performance, confidence, and team competencies beyond 1 year. One RCT[104] reported descriptive data on patient survival outcomes favoring team competencies, but this was not powered to make inferences.

For *CPR skills and quality* at course completion, 2 RCTs[99,109] reported shorter time to at least 1 CPR-skills performance. One nonrandomized study for pediatric ALS[105] reported higher checklist scores for CPR skills with team training, and 1 RCT[103] found greater adherence to ALS guidelines. Nine studies (1 observational,[105] 8 RCTs[101,104,108-110,112,114,115]) reporting CPR performance found no effect from team competence training. One RCT[100] reported shorter no-flow time, whereas another found no difference.[103] Two studies found no difference in hands-on time or compression rate [108] or chest compression quality.[107]

Two RCTs found no difference in CPR performance at 4 months[115] and 6 months.[110] Another RCT[108] reported increased hands-on time and higher compression rates 4 months after course completion. Confidence at course completion and at a nonspecified follow-up interval showed was not different in 1 RCT.[101]

Team competencies were evaluated at course completion by 14 studies (12 RCTs,[99-102,106-109,112-115] 2 nonrandomized studies[105,111]). Three RCTs[107,108,113] reported more leadership statements, 3 RCTs[102,112,113] identified increased directed team communication, 1 RCT[112] found increased closed-loop communication, and another RCT[100] reported higher “teamwork verbalizations” (eg, directed orders, task assignments, planning).

Decision-making improved in 1 RCT.[107] Leadership behavior was better in 2 RCTs,[104,106] with 1 also reporting increased correction of improper chest compressions. A nonrandomized study[111] reported no difference in leadership behavior.

Teamwork improved in 1 RCT[101] with higher team-level efficacy, and 1 nonrandomized study[105] reported more teamwork intervention events. Two RCTs[114,115] and a nonrandomized study[111] found no differences in teamwork measures. Nontechnical skills performance was found to be higher in 2 RCTs,[99,109] and 2 RCTs[113,114] reported improved workload management.

Beyond course completion, 1 RCT reported more leadership statements, task assignments, commands, and decisions at 4 months.[108] Another RCT found higher ratings on a self-reported teamwork scale,[101] but no difference was found in teamwork scores (TEAM) at 3 months in another RCT.[115]

Prior Treatment Recommendation (2020)

We suggest that specific team and leadership training be included as part of ALS training for health care providers (weak recommendation, very low–certainty evidence).[24]

2024 Treatment Recommendation

We suggest that teaching team competencies be included in BLS and ALS training (weak recommendation, very low–certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Appendix A5.

- We identified no harmful effects of team competencies training in any course format.
- Several studies reported that team competencies training improved CPR skill performance, which persisted beyond course completion.
- The evidence relating to team competency outcomes varies but was mostly positive.
- Previous clinical studies suggest that a lack of team competencies is a barrier to successful resuscitation, and team competencies have been associated with improved technical skill performance during clinical resuscitation attempts.
- We valued the fact that team competencies training appears widely accepted.

Knowledge Gaps

- Benefits of training team competencies on clinical resuscitation performance outcomes and patient outcomes
- The optimal instructional design, duration, and mode of delivery for training of team competencies
- Whether training in particular competencies is more important than others and whether this depends on the group of learners
- Cost-effectiveness of team competencies training and effectiveness in low-resource settings

BLS Education Tailored to Specific Populations (EIT 6108: ScopRev)

Rationale for Review

The task force undertook this ScopRev because the individual backgrounds of specific populations (eg, working in a special environment, someone with special needs, impairments, or disabilities) who are not health care professionals may warrant specific BLS training that differs from standard courses.[116-118] However, it is unclear which specific populations exactly could benefit from adapted tailored teaching. The complete report of this ScopRev can be found online.[119]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Specific adult layperson populations and/or groups participating in BLS training
- Intervention: Tailored BLS training
- Comparator: Nontailored BLS training
- Outcomes:
- Patient outcomes:
    - Critical: Survival to hospital discharge, 30-day survival, 12-month survival, neurological outcome
    - Important: ROSC
- BLS quality outcomes: Starting CPR in case of real cardiac arrest, performance during real CPR
- Educational outcomes: Knowledge and skills acquisition, willingness to perform CPR, barriers toward performing CPR, participant satisfaction and/or knowledge and skills

retention at the end of the respective course and later (eg, 3 months, 1 year), implementation success, resource implications, and cost-effectiveness

- Study design: RCTs and nonrandomized studies (non-RCTs, controlled before-and-after studies, cohort studies, and case series n ≥5), reviews, and surveys in respective population groups with at least an abstract in English were eligible for inclusion. Research aimed at teaching BLS to children and research on CPR training for health care professionals (both sufficiently covered elsewhere) were excluded.
- Time frame: All years to July 10, 2023

Definitions

A) Specific population/subgroup: A group with a specific feature (eg, job, age group)

B) Layperson: An adult who is not a qualified, retired, or in-training health care professional. We defined 2 groups of laypersons:

1) Duty to respond: Laypersons who have a duty to attend victims of an emergency because of their profession (eg, law enforcement, firefighters, lifeguards, flight crews)
2) No duty to respond: Community laypersons who have no duty (occupational expectation) to respond to a cardiac arrest

C) Standard BLS training (nontailored BLS courses): BLS courses that follow current recommendations from the large course developers and organizers like the American Heart Association or the European Resuscitation Council.

D) Tailored training (tailored courses): Courses altered to serve the special needs of a population (eg, duration, frequency, content, assessment, feedback, materials and devices used, specific aids, contextualization of the environment, specially trained instructors)

Summary of Evidence

Details of the included studies and findings are presented in the published review and online.[119] Most studies addressed training in those with disabilities, including Down syndrome,[120,121] blindness,[122,123] and deafness or hearing impairment.[124-126] No studies comparing an approach tailored to specific populations with a standard course were identified. Only a small percentage of persons with Down syndrome were able to perform high-quality chest compression–only CPR after a tailored course (shorter sessions and videos with comic elements).[120,121] Two studies assessed CPR education for blind learners, which resulted in chest compression–only CPR similar to other BLS providers[122]; supervisors with special pedagogic training were able to teach rescue breaths.[123] Tailored courses for trainees with hearing impairment[124-126] incorporated sign language interpreters without altering the 30:2 approach. Activating emergency medical services and following automated external defibrillator voice prompts were the most challenging points. One tailored chest compression–only CPR course for refugees was deemed feasible but needed translators and a special focus on general health literacy.[127]

Task Force Insights

No studies were found comparing tailored courses with standard BLS courses, which was the intended aim of this review. Thus, whether tailoring BLS courses to specific populations yields better results than standard courses remains unknown. An overview of studies reporting tailored courses for specific populations was provided instead. Unfortunately, studies reported few details on the tailoring done or the development process. We acknowledge that educators will often make minor adaptations in courses to meet individual needs of students, but real tailoring has to address the needs of the special learners, include the specific populations in such developments, and undergo proper validation to ensure benefits to the learners.

The task force thought that tailored BLS education for specific populations is probably feasible and could expand the pool of potential bystander CPR providers to include groups that may otherwise have been left out (eg, individuals with disabilities). The importance of defining a structured way to tailor courses to those with specific needs and ways that members of specific groups might be involved in developing such courses were also discussed.

Knowledge Gaps

- Which specific population groups may benefit from tailored BLS education
- Whether tailored BLS education is cost-effective across different populations
- What kind and amount of tailoring are optimal
- Whether tailored courses would be effective for first responders with and without a duty to respond, including but not limited to police, firefighters, or lifeguards
- How standard courses compare with tailored courses in specific populations

International Facets of the Chain of Survival (EIT 6311: ScopRev)

Rationale for Review

The term *Chain of Survival* is widely used in literature, scientific presentations, education, and awareness campaigns, with significant heterogeneity. This leads to confusion on which version should be used for which purpose, and the educational and clinical impacts of this heterogeneity are unclear. The American Heart Association issued various iterations of the Chain of Survival in their latest guidelines.[117] The European Resuscitation Council switched to the concept of Systems Saving Lives, and, while still mentioning the Chain of Survival, no longer uses a depiction of the Chain of Survival.[118] No review of this topic has been done by ILCOR previously. The full report of the ScopRev can be found online.[128]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Literature using the term *Chain of Survival* or similar terms (eg, *survival chain, chain of [other pathology]*)
- Intervention and exposure: Adaptations of the original Chain of Survival
- Comparator: The original Chain of Survival
- Outcome:
  - Composition of the specific variations in adapted versions
  - Attitudes, rationale, and views concerning the adaptation
  - Incentives to develop novel versions
  - Way of implementation of adapted versions
  - Way of utilization of adapted versions in education
  - Variations in visualization
  - Effect of the use of the Chain of Survival or variants on teaching, implementation, and patient outcomes
- Study design: All types of studies, including randomized trials or non-RCTs, narrative literature, letters, commentaries, or editorials in all languages
- Time frame: All years to August 14, 2023

Summary of Evidence

The heterogeneity of works identified made a SysRev or meta-analysis impossible. Details of individual studies are summarized in the published review and online.[128] We grouped the publications into novel concepts related to resuscitation (n=8),[117,129-135] novel concepts not directly related to resuscitation (n=23),[136-158] simple adaptations of the original Chain of Survival (n=9),[159-167] and impact on outcomes (n=3).[168-170]

Novel Chains of Survival have been suggested for resuscitation for IHCA,[117,130,133] pediatric resuscitation,[117,134] and mass gatherings (including early planning).[131] A chain mail of survival[132] and a specific Chinese version have also been proposed.[135] Adaptations of the existing chains (mostly expansions) included survival after ventricular fibrillation,[167] rehabilitation,[163] general prevention,[164] family support,[165] making the chain into a circle,[159] STEMI,[162] the chain mail of survival for low-resource settings,[166] survival odds along the chain in contrast to research funding,[160] and a visual adaptation of the rings according to their impact on outcome in ratios.[161] Increased survival rates and better neurologic outcome after the introduction of the fifth link of the chain by the American Heart Association in 2010 was observed.[168,169] After a public campaign about the Chain of Survival in France, bystander CPR rates increased.[170] No educational or other outcomes were reported.

Several versions or adaptations not directly related to CPR were found [136-158], covering specific pathologies (trauma,[136,150,157] severe hemorrhage,[146] land mine incidents,[141] stroke,[142,149] STEMI,[138,148] drowning,[151,152] septic shock,[143] complicated deliveries[140]) or occasions and situations (pandemics,[153,158] events,[147] terror attacks,[156] chemical/biological/radiological/nuclear incidents,[139] industrial incidents[144]). Others rethought the concept and proposed the survival ladder,[155] or a Chain of Survival behaviors in first aid.[154] Peculiarities were the animal Chain of Survival for veterinary patients,[137] and 1 for anesthesia equipment.[145]

Task Force Insights

Chains of Survival range from classic versions used by resuscitation councils with minor adaptations to completely novel versions covering a variety of pathologies or situations. Most health care workers know one or another version of the Chain of Survival because the concept has penetrated scientific literature and guiding documents, including gray literature. Also, the term is clinically and scientifically used as a synonym for whole systems of cardiac arrest care.

An educational aspect of the Chain of Survival does not really play a role in publications included in this review. Several adaptations of the classic chain lack essential links of the chain. Rehabilitation and prevention seem to be accepted as cornerstones of patient care. Special circumstances of cardiac arrest (eg, pediatric, out-of-hospital, in-hospital, drowning) may require consensus on more substantial modifications. Interestingly, only 3 publications assessed the impact of the Chain of Survival on outcomes,[168-170] but the exact role the chain played in altering outcomes, if any, is unclear.

The EIT Task Force concluded that a version of the classic Chain of Survival with 6 links (as currently proposed by the American Heart Association)[117] (Figure 7) is a sensible choice as a cognitive aid for laypersons in education, awareness campaigns, etc to convey the message of needed actions to save lives. If needed, modified versions of the chain for specific situations like drowning or trauma might also be acceptable. The task force also thought that ILCOR, as the international body on resuscitation, should provide the basic structure of this framework. Regional resuscitation councils can provide regional applications for their implementation strategies.

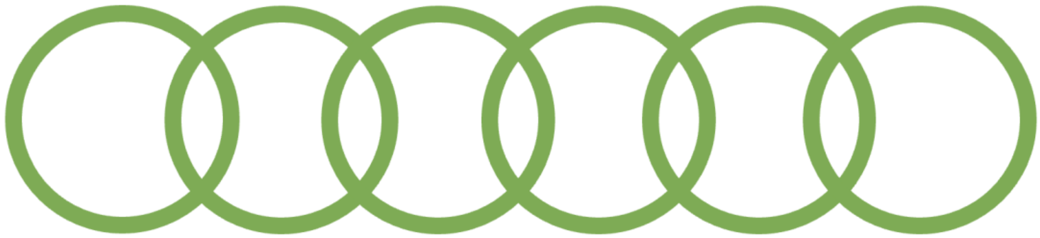

Figure 7. The basic Chain of Survival with 6 links.
CA indicates cardiac arrest; CPR, cardiopulmonary resuscitation.

Knowledge Gaps

- Whether there is a need for revising the classic Chain of Survival
- Who the Chain of Survival is targeted toward (clinicians, scientists, laypeople, stakeholders, or all of them), if laypersons need a simpler Chain of Survival than health care professionals do, and how it should be used optimally (a depiction of local systems to save lives, an educational framework, a cognitive aid, etc)
- Which of the various published Chains of Survival should be used by default; a comprehensive system could be evaluated for applicability in the future
- The impact of various kinds of Chains of Survival on educational outcomes, clinical outcomes, and patient survival

Provider Workload and Stress During Resuscitation (EIT 6401: ScopRev)

Rationale for Review

The workload and stress health care professionals might experience during resuscitation have the potential to affect the performance of individual rescuers or the resuscitation team.[171,172] This ScopRev investigated what variables influence (ie, increase or decrease) health care professional workload and stress during cardiac arrest, in both real-world and simulated scenarios. The full report of the ScopRev can be found online.[173]

Population, Exposure, Comparator, Outcome, Study Design, and Time Frame

- Population: Health care professionals performing resuscitation on patients in cardiac arrest in clinical settings or on manikins in a simulated setting
- Exposure: Presence of any factors that would possibly impact the health care professional's perceived workload or stress
- Comparator: Absence of the specific factor
- Outcome: Objective or subjective measures of workload and/or stress experienced by health care professionals during resuscitations
- Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies), unpublished studies (eg, conference abstracts, trial protocols), letters, editorials, comments, case reports, gray literature, and social media were eligible for inclusion. All relevant publications in any language were included as long as there was an English abstract available.
- Timeframe: From inception to April 21, 2023

Summary of Evidence

We included 21 studies,[37,45,174-193] including 17 RCTs,[37,45,175,177-183,185-188,191-193] 2 nonrandomized trials,[190] and 2 observational studies.[174,189] Because of heterogeneity in study design, SysRev with meta-analysis could not be performed. Study characteristics and key findings are provided in table form in the published review and online.[173] All but 2 studies[174,189] were simulation studies.

The NASA Task Load Index[37,175,177-180,183,185-194] was used to measure subjective workload, and the State-Trait Anxiety Inventory,[182] visual analog scale,[195] and structured survey questions[45] were used to measure stress. Physiologic stress markers included salivary cortisol, αamylase levels, heart rate, and BP.[176,188] Variables influencing perceived stress or workload were categorized into (1) team composition and roles, (2) telemedicine, (3) workflows, (4) tools like CPR-feedback devices, (5) cognitive aids, (6) presence of friends and families, and (7) provider experience and exposure. Findings by category include the following:

- Team composition and roles: A dedicated nursing team leader alleviated the medical team leader's workload during resuscitation.[193] CPR coaches decreased mental workload and increased physical workload among CPR providers[187] but did not impact the team leader’s workload.[180,187] In real pediatric resuscitations, the team leader reported higher mental load, whereas chest compressors had higher physical workload.[174]
- Telemedicine: Remotely led resuscitation teams experienced higher-overall workload and mental demand compared with on-site leading.[178] Active remote team leaders versus a remote consultant on request increased workload for team members with teleconsulting only.[191]
- Workflows: Adjustment of workflows (prioritizing chest compression automation with mechanical CPR device[192]), or deliberate reorientation with task-focusing questions,[181] reduced perceived workload and stress in simulation.
- Tools: The use of ventilation feedback devices or chest compression feedback devices increased workload for CPR providers.[175] Real-time feedback devices had no effect on team leaders, while chest-compressing CPR providers reported higher workloads.[183] Interestingly, equipment failure (defective defibrillator) in simulation did not increase stress for the team.[188]
- Cognitive aids and smart apps: A smart app designed to help drug preparation reduced acute stress in paramedics in simulated pediatric cardiac arrest.[182] A smart app with a

resuscitation algorithm did not increase workload for team leaders.[190] A tablet-based decision support tool's effect on workload was inconclusive because the increase in workload disappeared later during simulation.[185]

- Family presence and socioemotional stress: Presence of next of kin increased mental demands but did not change physical demands in simulation.[179] An observational study of real pediatric resuscitations showed lower workload when at least 1 parent was present.[189] This is in accordance with an ILCOR CoSTR on family presence during resuscitation in pediatric and neonatal cardiac arrest.[196,197]
- Provider experience: A quasi-experimental study found no association between level of clinical experience and subjective stress and physiologic parameters among nursing students during resuscitation simulation.[176]

Task Force Insights

In these studies, designated medical team leaders tended to experience increased workload, which was attenuated by assistance from senior nurse leaders. However, additional CPR coaches did not affect the team leader's overall workload, and remote team leaders increased team workload. A goal-directed approach or use of task-focusing questions during resuscitations can reduce perceived workload or stress for the team. External support from cognitive aids reduced stress and workload, but workload was sometimes higher with first use. Therefore, introducing new equipment could potentially impose an additional cognitive burden if the users are not adequately familiarized with it.

The factors identified in this review (team composition and roles, workflows, tools, telemedicine, cognitive aids, smart apps, and socioemotional stress) represent potential modifiable elements. Adjusting these factors could alleviate or increase their impact on workloads or stress and, consequently, on resuscitation performance as well. However, there may be additional factors influencing the workload of resuscitation team members that were not covered in our review.[198]

Given the few studies specifically designed to manipulate workload and its impact on resuscitation performance, and that stress and workload may affect individuals' performance differently, the task force did not include resuscitation performance in this review to avoid incorrect conjecture and to maintain the integrity of the results.

Knowledge Gaps

- The association between workload/stress and resuscitation performance; more well-crafted experimental studies exploring the relationship between workload and performance of resuscitation teams are needed to gain more insight into this complex interaction
- Health care professionals' workload or stress during resuscitation on actual patients and how such workload and stress are associated with patient outcome
- The influence of personal factors, contextual factors, and clinical experience in mitigating the impact of external stressors and perceived workload

Scripted Debriefing Compared With Nonscripted Debriefing in Resuscitation Training (EIT 6413: ScopRev)

Rationale for Review

Debriefing conducted during simulation-based training improves provider knowledge, clinical performance, and nontechnical skills performance.[199-204] Studies assessing the impact of debriefing after cardiac arrest events demonstrate improved provider performance,[205,206] while debriefings informed by clinical data have been associated with enhanced survival outcomes from cardiac arrest.[207,208] Many different debriefing frameworks have been developed and implemented, leading to variability in how debriefing is conducted across programs and institutions.[209]

Debriefing scripts and tools have been developed to help standardize the approach to debriefing during resuscitation training. While their use has gained traction in both educational[210,211] and clinical settings,[212-214] the benefits of debriefing scripts in resuscitation education have not been clearly delineated, prompting this ScopRev.[215] The full report of the ScopRev can be found online.[216]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Health care professionals or laypeople receiving resuscitation training (primary) and instructors teaching resuscitation courses (secondary)
- Intervention: Debriefing with a cognitive aid, checklist, script, or tool
- Comparator: Debriefing without the use of a cognitive aid, checklist, script, or tool
- Outcome: Patient outcome, improved resuscitation performance in clinical environments, improved learning outcomes (knowledge and skill acquisition and retention), satisfaction of learning, quality of teaching/debriefing, workload/cognitive load of debriefer
- Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) and gray literature were excluded. All relevant publications in any language were included as long as there was an English abstract available.
- Time frame: All years to April 18, 2023

Summary of Evidence

Six studies (5 RCTs [210,217-220] and 1 quasi-experimental study[221]) were included in this review. Details of the included studies are summarized in the published review and online.[215,216] No studies evaluated patient outcomes or provider performance on real patients.

Three studies used pediatric resuscitation scenarios[210,218,219] and 3 others adult scenarios[217,220,221] as the trigger for the debriefing. Five studies[210,217-219,221] used a debriefing script, including debriefing framework, topics for discussion, and suggested phrasing; the other RCT[220] did not use suggested phrases. Only 1 study incorporated CPR-quality parameters as objective data.[219] Only 4 studies trained the debriefer in the use of the script.[217-219,221] The PEARLS tool (Promoting Excellence and Reflective Learning in Simulation)[217,219,221] was used most often, followed by advocacy-inquiry,[210,218] and then the gather-analyze-summarize model.[220] A multicenter trial reported that scripting led to debriefings of higher quality, with significant effects in novices,[218] whereas another RCT found no difference when using a PEARLS script.[217] The latter study found reduced cognitive load with script debriefing for novice debriefers (ie, simulation fellows).

Data-informed, PEARLS-scripted debriefing after a simulated pediatric cardiac arrest scenario improved leaning outcomes (excellent CPR, guideline-compliant depth, chest compression fraction, perishock pause) in 1 RCT.[219] A study including medical and nursing students showed no difference in teamwork performance comparing scripted with nonscripted debriefings.[220] A multicenter RCT of health care professionals reported improved team leadership skills and improved knowledge acquisition but no difference in clinical performance scores with scripted debriefing by novice instructors.[210]

Task Force Insights

All studies had significant heterogeneity in design and implementation of scripted debriefing interventions (eg, blended method and framework of debriefing,[217,219,221] single debriefing method like advocacy inquiry[210,218]). There were differences in the methods of familiarization of facilitators with scripts (from handing the debriefing script to facilitators before debriefing to comprehensive debriefing training). These variables may have contributed to the variability in results.

Our ScopRev did not identify any studies reporting patient or process outcomes in real resuscitations. Only 1 study integrated CPR performance metrics directly into the debriefing script,[219] enabling a direct link between debriefing to clinically relevant performance metrics, which might enhance the overall impact of debriefing during resuscitation education.[219]

2024 Good Practice Statement

Consider using debriefing scripts to support instructors during debriefing in resuscitation programs because they may improve learning and performance. Instructors need to ensure they have a complete understanding of how the debriefing script should be used (good practice statement).

Knowledge Gaps

- The relative and synergistic effect of scripted wording versus data-informed debriefing during resuscitation training
- The impact of scripted debriefing on knowledge and skill retention
- The impact of scripted debriefing during training on patient or process outcomes in real resuscitations

- The importance of debriefer adherence to debriefing scripts and its influence on learning and performance outcomes
- The influence of debriefer experience and learner characteristics on the impact of debriefing scripts
- The impact of linking the content of debriefing scripts to clinically important metrics and clinically relevant outcomes on learning outcome

EIT Topics Reviewed by EvUps

Topics reviewed by EvUps are summarized in Table 24. Complete EvUps are provided in Appendix B4.

1 **Table 24. Topics Reviewed by EvUps**

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
EMS experience and exposure (EIT 6104: EvUp)	2021	We suggest that EMS systems (1) monitor their clinical personnel's exposure to resuscitation and (2) implement strategies, where possible, to address low exposure or ensure that treating teams have members with recent exposure (weak recommendation, very low–certainty evidence).	None	None	None	No
Patient outcomes of team member attending a CPR course (EIT 6106: EvUp)	2022	We recommend the provision of accredited ALS training (ACLS, ALS) for health care providers who provide ALS care for adults (strong recommendation, very low–certainty	None	2 pre-post studies; one on implementation of newborn resuscitation trainings in Nepal (HBB)	Decreases in intrapartum stillbirths, neonatal deaths (within first 24 hours), sick newborns transferred from maternity unit; for all *P*<0.001. No differences	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		evidence). We recommend the provision of accredited courses in NRT (NRT, NRP) and HBB for health care providers who provide ALS care for newborns and babies (strong recommendation, very low–certainty evidence). We have made a discordant recommendation (strong recommendation despite very low–certainty evidence) because we have placed a very high value on an uncertain but potentially life-preserving benefit, and the intervention is not associated with prohibitive		and one on training of health care professionals on neonatal outcomes in the delivery room in Brazil.	were observed in neonatal deaths after 24 hours. Items required for neonatal resuscitation increased postintervention substantially. Delivery room mortality decreased by 73%.	

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		adverse effects.				
Willingness to provide CPR (EIT 6304: EvUp)	2021	To increase willingness to perform CPR, laypeople should receive training in CPR. This training should include the recognition of gasping or abnormal breathing as a sign of cardiac arrest when other signs of life are absent. Laypeople should be trained to start resuscitation with chest compressions in adult and pediatric victims. If unwilling or unable to perform ventilation, rescuers should be instructed to	None	37 observational studies: 23 studies explored factors linked to bystander CPR or AED use, and 14 studies focused on the COVID-19 pandemic. These studies included patients with OHCA who receive bystander CPR, with the thought	These factors had already been identified in the 2020 scoping review and the 2021 EvUp.	Yes. However, the PICOST needs to be refined: The past PICOST was on bystanders' real-life OHCA factors linked to bystander engagement in CPR. A separation is needed in a SysRev between factors

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		continue compression-only CPR. EMS dispatchers should provide CPR instructions to callers who report cardiac arrest. When providing CPR instructions, EMS dispatchers should include recognition of gasping and abnormal breathing. (ILCOR 2020, 2022 CoSTR, unchanged from 2010)		that bystanders were less likely to perform CPR during the COVID-19 pandemic.		associated with OHCA patients receiving CPR (eg, community level) and factors associated with bystanders performing CPR and AED use (eg, personal level).
Implementation of guidelines in communities (EIT 6306: EvUp)	2021	This treatment recommendation remains unchanged since 2015: We recommend implementation of resuscitation guidelines within organizations that provide care for patients in cardiac arrest in any setting	None	2: One study in neonatal resuscitation in low-resource settings, and another reported on the World Restart a Heart	No significant effect on survival rates; at least 302 million people received CPR training	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		(strong recommendation, very low–quality evidence).		campaign		
Debriefing of resuscitation performance (EIT 6307: EvUp)	2021	We suggest data-driven, performance-focused debriefing of rescuers after IHCA for both adults and children (weak recommendation, very low–certainty evidence). We suggest data-driven, performance-focused debriefing of rescuers after OHCA in both adults and children (weak recommendation, very low–certainty evidence).	None	None	NA	No
CPR feedback devices during training (EIT 6404: EvUp)	2022	We suggest the use of feedback devices that provide directive feedback on compression rate, depth,	4: 2 RCTs in BLS in health care professionals.	1 pre-post cohort study	For RCTs: Feedback devices improve CPR-quality metrics, including long-term	Yes

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		release, and hand position during CPR training (weak recommendation, low-certainty evidence). If feedback devices are not available, we suggest the use of tonal guidance (eg, music or metronome) during training to improve compression rate only (weak recommendation, low-certainty evidence).	2 RCTs in simulation-based cardiac arrest training: 1 included augmented-reality CPR feedback devices, and the other assessed infant CPR-performance.		retention. Augmented reality–assisted feedback results in better performance in all CPR-quality metrics. Simulated infant CPR performance with a real-time feedback device was similar to CPR without such devices. For the observational study, defibrillator with CPR feedback features: Code teams achieve higher adherence to AHA guidelines for chest compression rate and chest compression fraction.	

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
Blended-learning approach for life support education (EIT 6409: EvUp)	2021	We recommend a blended-learning as opposed to nonblended approach for life support training when resources and accessibility permit its implementation (strong recommendation, very low–certainty evidence).	None	1: cross-sectional cohort study on BLS blended learning in a classroom versus remote virtual attendance	Remote and classroom blended learning was not different in chest compression release, depth, or rate scores. Retakes of the final assessment were higher in remote blended learning.	No
High-fidelity training for resuscitation (EIT 6410: EvUp)	2021	We suggest the use of high-fidelity manikins when training centers/organizations have the infrastructure, trained personnel, and resources to maintain the program (weak recommendations, very low–quality evidence). If high-fidelity manikins are not available, we suggest	2: 1 pilot study of manikins with slightly increased fidelity versus none in 15 nursing students. 50 ACLS-certified third-	None	No difference in CPR quality parameters (no statistics reported and no difference in self-report confidence questionnaire; higher scores for procedures with high-fidelity manikins, and in a pre- and postintervention confidence	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		that the use of low-fidelity manikins is acceptable for standard ALS training in an educational setting (weak recommendations, low-quality evidence).	year medical students; high-fidelity simulator versus traditional manikin		questionnaire	

ACLS indicates advanced cardiovascular life support; AED, automated external defibrillator; AHA, American Heart Association; ALS, advanced life support; BLS, basic life support; CoSTR, Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations; CPR, cardiopulmonary resuscitation; EIT, Education, Implementation, and Teams; EMS, emergency medical services; EvUp, evidence update; HBB, Helping Babies Breathe; IHCA, in-hospital cardiac arrest; ILCOR, International Liaison Committee on Resuscitation; NRP, Neonatal Resuscitation Program; NRT, neonatal resuscitation training; OHCA, out-of-hospital cardiac arrest; PICO, population, intervention, comparator, outcome; PICOST, population, intervention, comparator, outcome, study design, time frame; RCT, randomized controlled trial; SysRev, systematic review.

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First Aid

Use of Supplemental Oxygen in First Aid (ScopRev FA1649)

Rationale for Review

Training in oxygen administration is typically not included in standard first aid courses but is sometimes offered in a separate first aid oxygen course. In the first aid setting, oxygen use has been described for loss of consciousness, diving emergencies, carbon monoxide poisoning, and during cardiac arrest. A 2015 CoSTR[1,2] followed by a 2022 ScopRev[3] identified evidence of potential harm with oxygen use in acute exacerbations of chronic obstructive pulmonary disease (COPD) but used limited search dates and broad exclusion criteria. The current ScopRev expands the search dates and inclusion criteria. Topics recently reviewed were once again excluded, such as the use of supplemental oxygen in acute coronary syndrome,[4] suspected stroke,[5] drowning,[6] and after the return of spontaneous circulation following cardiac arrest.[7] The full online ScopRev can be found online.[8]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adults and children who exhibit symptoms or signs of shortness of breath, difficulty breathing, or hypoxia outside of a hospital
- Intervention: Administration of oxygen by a first aid provider
- Comparator: No administration of oxygen
- Outcomes: Functional outcome at discharge, 30 days, 60 days, 180 days, or 1 year; survival only at discharge, 30 days, 60 days, 180 days, or 1 year; length of hospital stay; resolution of symptoms or signs; patient comfort; therapeutic endpoints (eg, oxygenation, ventilation)

- Study designs: RCTs and non-randomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies), case series, and reports in English were eligible for inclusion. Non–peer-reviewed studies, unpublished studies, conference abstracts, evidence-based guidelines, trial registries, and protocols were eligible for inclusion.
- Time frame: All dates to July 2023. The literature search was updated on December 1, 2023.

Summary of Evidence

The search identified 3305 records, of which 31 underwent full-text review. No articles that directly addressed the PICOST were identified. The articles identified related to 3 main areas: supplemental oxygen for the treatment of carbon monoxide poisoning in the out-of-hospital setting (n=6), supplemental oxygen in the treatment of decompression injuries/illness in divers using compressed gas (n=11), and titrated oxygen in the treatment of persons with an acute exacerbation of COPD (n=13). One paper was identified that reviewed the supplemental use of oxygen in the out-of-hospital management of spinal cord injury.[9]

For the use of supplemental oxygen in acute exacerbations of COPD, we identified 2 SysRevs,[10,11] 1 cluster RCT,[12] 1 commentary on the same RCT,[13] 5 observational studies,[14-18] 1 literature review,[19] 3 evidence-based guidelines,[20-22] and 1 registered with associated published study protocol for an ongoing trial.[23,24] In the cluster RCT,[12] 405 patients with acute exacerbations of COPD in the out-of-hospital setting were treated either with high-flow oxygen (defined as 8–10 L/min by nonrebreathing face mask and nebulized bronchodilators administered with oxygen at 6–8 L/min) or with titrated oxygen delivered by nasal cannula to achieve oxygen saturations between 88% and 92% and nebulized bronchodilators administered with compressed air and delivered with a face mask placed over the nasal cannula. In the intention-to-treat analysis for the subgroup of patients with confirmed COPD, mortality was 9% (11 deaths) in the high-flow arm compared with 2% (2 deaths) in the titrated oxygen group (RR, 0.22; 95% CI, 0.05–0.91; *P*=0.04).

The remaining observational studies of oxygen administration for acute exacerbations of COPD in the out-of-hospital setting reported mixed results and were noted to have significant within-study confounders and heterogeneity between the studies.[14-18]

For the use of supplemental oxygen for carbon monoxide poisoning in the out-of-hospital setting, no clinical studies were identified. One older case series[25] reported the prehospital and in-hospital management and clinical course of 206 patients with carbon monoxide poisoning, whereas 4 literature reviews[26-29] and 1 guideline[30] focused on in-hospital management. All articles commented on the need for immediate treatment with supplemental high-concentration oxygen.

For the use of supplemental oxygen for diving emergencies, 3 case series[31-33] described use of oxygen in decompression sickness, with 1 case series[33] specifically describing the use of first aid oxygen in 1045 cases in a sequential series of 2231 diving injury reports. The median time for oxygen administration was 2.2 hours after symptom onset and 4 hours after surfacing. First aid oxygen was reported to be associated with persistent complete relief in 14% and improvement of symptoms in 51%. The odds of multiple recompression treatments were reduced when oxygen was given at any time after surfacing (OR, 0.83; 95% CI, 0.70–0.98). The remaining articles identified in the search were literature reviews,[34-39] a medical journal summarizing other articles[40], and 1 experimental study[41] in healthy divers to compare tissue oxygenation levels while breathing oxygen by using different noninvasive delivery devices and oxygen flow rates.

A summary of all articles identified can be found in Tables 1 through 3 in Appendix C.

Task Force Insights

This ScopRev did not identify evidence to suggest for or against the first aid administration of oxygen for adults or children with signs or symptoms of difficulty breathing. However, we specifically excluded the use of supplemental oxygen in several settings because these indications have been covered in recent reviews. The studies included are from the out-of-hospital setting, and the evidence is considered indirect to the population of first aid providers trained in oxygen use.

The 1 RCT[12] that identified evaluating the use of out-of-hospital titrated versus high-flow oxygen in acute exacerbations of COPD reported a 78% reduction in mortality with the use of titrated oxygen in the out-of-hospital setting. In task force discussions, there was concern about the potential for harm if high-flow oxygen was withheld from patients with acute exacerbations of COPD and life-threatening hypoxemia. Task force members emphasized the need for first aid providers trained in oxygen delivery to use pulse oximetry and to recognize that high-flow oxygen may be necessary if oxygen saturations are less than 88%. An update to the good practice statement on this topic reflects this concern.

There was insufficient evidence identified to pursue SysRevs related to oxygen use in the first aid setting for carbon monoxide poisoning, diving emergencies, general signs and symptoms of shortness of breath or difficulty breathing, or any other specific condition.

Prior Good Practice Statement (2023)

If first aid providers, trained to use oxygen, are administering supplemental oxygen to a person with known COPD, they should titrate the supplemental oxygen to maintain the oxygen saturation by pulse oximetry between 88% and 92% (good practice statement).[3]

2024 Good Practice Statement

When a first aid provider trained in oxygen use administers oxygen to a person with acute difficulty breathing who confirms that they have chronic obstructive pulmonary disease, it is suggested that pulse oximetry be used and that oxygen be titrated to maintain an oxygen saturation between 88% and 92% (good practice statement).

Although high-flow oxygen should in general be avoided in patients with chronic obstructive pulmonary disease with difficulty breathing in the out-of-hospital setting, high-flow oxygen should not be withheld in the presence of life-threatening hypoxemia (oxygen saturation <88%) (good practice statement).

Recognition of Sepsis (ScopRev FA 7180)

Rationale for Review

A significant proportion of preventable deaths worldwide are caused by sepsis, and early detection and treatment is beneficial. No prior review has been undertaken, and in 2022, the task force elected by consensus to undertake a ScopRev on the recognition and awareness of sepsis by first aid providers evaluating adults with an acute illness. The full text of this ScopRev can be found online.[42]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- Population: Adults who are being evaluated by a first aid provider for an acute illness

- Intervention: The presence of any specific signs or symptoms (ie, pale, blue, or mottled skin, lips, tongue, gums, or nails; nonblanching rash; difficulty breathing or rapid respiratory rates; rigors/shivering; lack of urination in a day; muscle pain; confusion; or slurred speech)
- Comparator: Fever (≥38° C, 100.4° F) with signs of infection
- Outcomes: Recognition of a seriously ill person requiring hospitalization or evaluation by a physician for sepsis and increased awareness of sepsis
- Study designs: RCTs and non-randomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Gray literature, social media posts, non–peer-reviewed studies, unpublished studies, conference abstracts, and trial protocols were eligible for inclusion. All relevant publications in any language are included as long as there was an English abstract.
- Time frame: Inception through December 2, 2023

Summary of Evidence

There were insufficient studies to support a SysRev. Studies that were selected for inclusion evaluated physiologic variables that a lay provider could obtain in a first aid setting, such as temperature, heart rate, and respiratory rate, either in isolation or when assessing by using clinical scoring tools. It was noted that online resources that focused on educating the public on sepsis recognition listed presenting signs and symptoms of sepsis under 9 general categories: temperature (fever or hypothermia), neurologic (change in mental state, dizziness, slurred speech), musculoskeletal (severe muscle pain, extreme shivering), urologic (poor urine output), respiratory (rapid breathing or breathlessness), skin (clammy/sweaty, new rash, mottled or discolored), cardiac (elevated heart rate), gastrointestinal (nausea, vomiting, diarrhea), and subjective (feeling very unwell or impending sense of doom). However, there was variability as to which signs or symptoms were highlighted by each campaign or organization.

Task Force Insights

Given the lack of any direct studies, the task force agreed to include studies that were performed in either the prehospital setting by emergency medical service providers or the in-hospital setting, using extrapolated data to suggest relevance to the first aid setting. Despite the use of early warning scoring tools to assist in the detection of sepsis, sepsis recognition by trained clinicians in the health care setting remains challenging. Additionally, the definition of sepsis and the criteria defining sepsis continues to change. Therefore, it was felt by the task force that it was beyond the scope of a first aid provider to recognize and subsequently diagnose an acute illness as sepsis. Because sepsis cannot occur without an infection, a more reasonable expectation of a lay provider is to suspect an infection in a person presenting with an acute illness. Therefore, those providing first aid should consider an infection in any person who presents with an acute illness, and if the illness is associated with any abnormal signs or symptoms, they should urgently seek further medical evaluation.

2024 Good Practice Statement

Those providing first aid should consider an infection in any person who presents with an acute illness, and if the illness is associated with any abnormal signs or symptoms, they should urgently seek further medical evaluation (good practice statement).

Topics Reviewed by Evidence Updates

Topics reviewed by EvUps are summarized in Table 25. Complete EvUps are provided in Appendix B5.

Table 25. First Aid Topics Reviewed

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
Stroke recognition (FA 7170)	2020	We recommend that first aid providers use stroke assessment scales/tools for adults with suspected acute stroke (strong recommendation, low-certainty evidence). For first aid, we suggest the use of FAST, MASS, CPSS or LAPSS scales/tools for stroke assessment (weak recommendation, low-certainty evidence). For first aid, we suggest the use of stroke assessment scales/tools that include blood glucose measurement when available, such as MASS or LAPSS, to increase specificity of stroke recognition (weak	0	4	None of the new studies of established stroke scoring systems, or of new stroke scoring systems, offer any improvement in the public recognition of stroke by lay public or first aid provider.	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		recommendation, low-certainty evidence). For first aid, we suggest the use of FAST or CPSS stroke assessment scales/tools when blood glucose measurement is unavailable (weak recommendation, low-certainty evidence).				
Oxygen in stroke (FA7031)	2021	For adults with suspected acute stroke, we suggest against the routine use of supplementary oxygen in the first aid setting compared with no use of supplementary oxygen (weak recommendation, low- to moderate-certainty evidence).	2	1	One RCT on high-flow oxygen compared with no oxygen found no significant difference in global disability scores. Another RCT found better outcomes with normobaric hyperoxia compared with room air.	Yes
Dental avulsion	2020	We suggest the use of HBSS, propolis (from 0.04 mg to 2.5 mg per	1	2	One RCT found that, in general, PDL viability	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
(FA 7361)		mL 0.4% ethanol), oral rehydration salt solutions including Ricetral (oral rehydration salt solutions containing sodium chloride, glucose, potassium chloride, citrate [or extruded rice]), or cling film compared with any form of cow's milk for temporary storage of an avulsed tooth that cannot be immediately replanted (weak recommendation, very low–certainty evidence). If none of the above choices are available, we suggest the use of cow's milk, any percent fat or form, compared with tap water, buttermilk, castor oil, turmeric extract, or saline (sodium chloride) for temporary storage of an avulsed tooth (weak recommendation, very low–certainty evidence).			was better at the cooler temperature for all storage media, except HBSS. Milk was the most effective, followed by propolis and HBSS at 5° C, but at 20° C, HBSS was the most effective, followed by milk. Results from each of the observational studies suggested that propolis, as well as cow and almond milk, can be alternative storage mediums.	

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		There is insufficient evidence to recommend for or against temporary storage of an avulsed tooth in saliva compared with alternative solutions. There is insufficient evidence to recommend for or against temporary storage of an avulsed tooth in probiotic media, epigallocatechin-3-gallate, Dentosafe box, or egg white compared with cow's milk.				
Second dose of epinephrine for anaphylaxis (FA 7111)	2021	We suggest a second dose of epinephrine be administered by autoinjector to adults and children with severe anaphylaxis whose symptoms are not relieved by an initial dose (weak recommendation, very low–quality evidence).	0	1	Observational study identifying that 29% (n=11) needed 2 doses and 5% (n=2) needed 3 doses of epinephrine	No
Naloxone for opioid	2020	We suggest that CPR be started without delay in any unconscious	0	0	N/A	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
emergencies (FA7442)		person not breathing normally and that naloxone be used by lay rescuers in suspected opioid-related respiratory or circulatory arrest (weak recommendation based on expert consensus).				
Exertion-related dehydration and rehydration (FA7241)	2022	We recommend the use of any readily available rehydration drink or water for treating exertion-related dehydration in the first aid setting (good practice statement). We suggest rehydration for exertion-related dehydration with a 4% to 9% CED. Alternative rehydration options include 0% to 3.9% CEDs, water, coconut water, or skim or low-fat cow's milk (weak recommendation, very low–certainty evidence). There is insufficient evidence to	2	0	One RCT found that the percentage of fluid retained at 3.5 hours after ingestion of a sports drink was statistically significantly higher than after ingestion of water. In a second RCT that compared green tea with water, no differences in body fluid balance and cumulative urine output	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		recommend for or against rehydration with beer (0%–5% alcohol).			were observed.	
Counter-pressure maneuvers for prevention of syncope FA7550	2021	We recommend the use of any type of physical counter-pressure maneuver by individuals with acute symptoms of presyncope due to vasovagal or orthostatic causes in the first aid setting (strong recommendation, low-certainty and very low–certainty evidence). We suggest that lower body physical counter-pressure maneuvers are preferable to upper body and abdominal physical counter-pressure maneuvers (weak recommendation, very low–certainty evidence).	1	0	1 unblinded RCT; 0/15 using physical maneuvers had syncope compared with 5/15 in control arm	No
Recovery position	2021	When providing first aid to a person with a decreased level of	0	0		No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
(FA7040)		responsiveness of nontraumatic etiology and who does not require immediate resuscitative interventions, we suggest the use of the recovery position (weak recommendation, very low–certainty evidence). When the recovery position is used, monitoring should continue for signs of airway occlusion, inadequate or agonal breathing, and unresponsiveness (good practice statement). If body position, including the recovery position, is a factor impairing the first aid provider's ability to determine the presence or absence of signs of life, the person should be immediately positioned				

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		supine and reassessed (good practice statement). Persons found in positions associated with aspiration and positional asphyxia, such as face down, prone, or in neck and torso flexion positions, should be repositioned supine for reassessment (good practice statement).				

Abbreviations: CED, carbohydrate-electrolyte drink; CPR, cardiopulmonary resuscitation; CPSS, Cincinnati Prehospital Stroke Scale; FAST, Face, Arm, Speech, Time to call; HBSS, Hank's Balanced Salt Solution; LAPSS, Los Angeles Prehospital Stroke Scale; MASS, Melbourne Ambulance Stroke Screen; PDL, periodontal ligament; RCT, randomized controlled trial.

Acknowledgments

The writing group acknowledges Jack Billi, Eddy Lang, and Veronica Zamora.

Collaborators

Zehra Al-Hilali; Mohammed Aljanoubi; Abdulkarim A. Almazrua; Luke Andrea; Huba Atiq; Arna Banerjee; Adam Boulton; Maaret Castreen; Nino Fijačko; Juul Grabmayr; Kevin Kai-Wei Lin; Elina Koota; Joel Kian-Boon Lim; Kai-Wei Lin;

Cheng-Heng Liu; Marco Neymayer; Justine Odakha; Leandra Rech; Josh Reynolds; Eitan Schachna; Amir Shamshiraz; Erwin Snijders; Lucas Snow; Devita Stallings; Lorrel Toft; James Whiting; Dyan Zhe-Wei Zhang

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