ILCOR Summary Statement

2022 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

The International Liaison Committee on Resuscitation conducts a continuous review of new, peer-reviewed published cardiopulmonary resuscitation science. This is the sixth annual summary of the International Liaison Committee on Resuscitation International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. This latest summary addresses the most recent published resuscitation evidence reviewed by International Liaison Committee on Resuscitation task force science experts. Topics covered by systematic reviews in this summary include cardiopulmonary resuscitation during transport, approach to resuscitation for a drowning victim (compressions-airway-breathing versus airway-breathing-compressions), passive ventilation techniques and minimizing pauses during cardiopulmonary resuscitation, temperature management after cardiac arrest, use of point-of-care ultrasound for diagnosing reversible causes during cardiac arrest, use of vasopressin and corticosteroids during cardiac arrest, coronary angiography after cardiac arrest, public access defibrillation devices for children, pediatric early-warning systems, maintaining normal temperature immediately after birth, suctioning of amniotic fluid at birth, tactile stimulation for resuscitation immediately after birth, use of continuous positive airway pressure for respiratory distress at term birth, respiratory and heart rate monitoring in the delivery room, supraglottic airway use in neonates, prearrest prediction of in-hospital cardiac arrest mortality, basic life support training for high-risk populations, effect of resuscitation team advanced life support training, blended learning for life support training, training and recertification for resuscitation instructors, and the recovery position for maintenance of breathing and prevention of cardiac arrest. Members from 6 International Liaison Committee on Resuscitation task forces have assessed, discussed, and debated the quality of the evidence—on

the basis of 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 listed priority knowledge gaps for

further research.

Key words: ILCOR, cardiac arrest, resuscitation, first aid, infant, newborn, pediatrics,

basic life support, advanced life support

ABBREVIATIONS

ACLS	Advanced Cardiovascular Life Support
AED	automated external defibrillator
ALS	Advanced Life Support
ARNI	Advanced Resuscitation of the Newborn Infant
ATLS	Advanced Trauma Life Support
BLS	Basic Life Support
CAG	coronary angiography
CARES	Cardiac Arrest Registry to Enhance Survival
CART	classification and regression tree
CPAP	continuous positive airway pressure
CPC	Cerebral Performance Category
CPR	cardiopulmonary resuscitation
DNACPR	do not attempt CPR
ECG	electrocardiogram
ECPR	extracorporeal CPR
EMS	Emergency medical services
EPALS	European Paediatric Advanced Life Support
EPILS	European Paediatric Intermediate Life Support
ETC	European Trauma Course
GO-FAR	Good Outcome Following Attempted Resuscitation
GRADE	Grading of Recommendations Assessment, Development, and Evaluation
HBB	Helping Babies Breathe
ICU	intensive care unit
IHCA	in-hospital cardiac arrest
ILCOR	International Liaison Committee on Resuscitation
IV	intravenous
NICU	neonatal intensive care unit
NLS	neonatal life support
NRP	Newborn Resuscitation Programs
NRT	neonatal resuscitation training
OHCA	out-of-hospital cardiac arrest
OR	odds ratio
PALS	Pediatric Advanced Life Support
PAM	prearrest morbidity
PAR	prognosis after resuscitation
PCI	percutaneous coronary intervention
PEWS	Pediatric Early Warning Systems
PICO	population, intervention, comparator, and outcome
PICOST	population, intervention, comparator, outcome, study design, and time frame
PIHCA	Prediction of Outcome for In-Hospital Cardiac Arrest
PLS	Pediatric Life Support
POCUS	point-of-care ultrasound
PPV	positive pressure ventilation
PROSPERO	Prospective Register of Systematic Reviews
RCT	randomized controlled trial
RD	risk difference
RFM	respiratory function monitor

ROSC	return of spontaneous circulation
RR	relative risk
SGA	supraglottic airway
TTM	targeted temperature management

INTRODUCTION

This is the sixth 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) publications summarizing the ILCOR task force analyses of published resuscitation evidence. The 2022 review includes 21 topics addressed with systematic reviews (SysRevs) by the 6 task forces. Although only a SysRev can generate a full CoSTR and updated treatment recommendations, many other topics were reviewed via more streamlined approaches, detailed below.

Draft CoSTRs for all topics evaluated with SysRevs were posted on a rolling basis from June 2021 through March 2022 on the ILCOR website. These draft CoSTRs include a summary of all data included in the review, as well as draft treatment recommendations. Each CoSTR posting is followed by a 2-week period, during which public comments are accepted. Task forces consider these comments and provide responses. The 21 draft CoSTR statements were viewed approximately XX times, and XX comments were provided as feedback. These CoSTRs are now available online, adding to the existing CoSTR statements.

This summary contains the final wording of the treatment recommendations and good practice statements as approved by the task forces and by the ILCOR member councils, but differs in several respects from the online CoSTRs: the language used to describe the evidence in this summary is not restricted to standard Grading of Recommendations Assessment, Development, and Evaluation (GRADE) terminology, thereby making it more transparent to a wider audience; in some cases, only the high-priority outcomes are reported, and results are presented in tables where possible, for improved clarity. The Justification and Evidence-to-Decision Framework Highlights sections are in some cases shortened but aim to provide insight

into the rationale behind the treatment recommendations. Finally, the task forces have prioritized knowledge gaps requiring future research. Links to the published reviews and full online CoSTRs are provided in the individual sections.

The CoSTRs are based on task force analysis of the data, using the GRADE approach. Each analysis has been detailed in either a systematic review conducted by an expert systematic reviewer, or as a task force–led SysRev, and always with input from ILCOR content experts. This GRADE approach rates the certainty of evidence supporting the intervention (predefined by the population, intervention, comparator, outcome [PICO] question) as high, moderate, low, or very low. Randomized controlled trials (RCT) begin the analysis as high-certainty evidence, and observational studies begin 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, a dose-response effect, or if any residual confounding would be thought to decrease the detected effect.

In addition to the certainty of evidence, each statement includes the pertinent outcome data. The format for the data varies by what is available but ideally includes both relative risk with 95% CI and risk difference with 95% CI. The risk difference is the absolute difference between the risks and is calculated by subtracting the risk in the control group from the risk in the intervention group. This absolute effect enables a more clinically useful assessment of the magnitude of the effect of an intervention and enables calculation of the number needed to treat (number needed to treat=1/risk difference). In cases where the data do not enable absolute effect estimates to be determined, alternative measures of effect, such as odds ratios, are reported.

Treatment recommendations are generated by the task forces after weighing the evidence and after task force discussion. The strength of a recommendation is determined by the task force

and is not necessarily tied to the certainty of evidence. Although ILCOR generally has not produced any guidance when the evidence is insufficient to support a recommendation, in some cases, good practice statements have been provided for topics thought to be of particular interest to the resuscitation community. Good practice statements are not recommendations but represent expert opinion in light of very limited data.

ILCOR's goal is to review at least 20% of all PICO questions each year so that the CoSTRs reflect current and emerging science. To facilitate this goal, and 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, which were also used for 2022. Scoping reviews (ScopRevs) are undertaken when there is a lack of clarity on the amount and type of evidence on a broader topic. ScopRevs are broad searches done in multiple databases with a rigor similar to that of a SysRev, but they do not include bias assessments or meta-analyses. The third and least rigorous form of evidence evaluation is the evidence update (EvUp), in which a less comprehensive search is carried out to screen for significant new data and assess whether there has been sufficient new science to warrant a new ScopRev or SysRev. Both ScopRevs and EvUps can inform a decision about whether a SysRev should be undertaken but are not used to generate a new or updated CoSTR because they do not include bias assessment, GRADE evaluation, or meta-analyses. In this document, the results of ScopRevs are included in a more concise form than in the online version, similar to the SysRevs. EvUps are tabulated by topic at the end of each task force section, with the associated documents provided in Appendix B.

The following topics are addressed in this CoSTR summary:

Basic Life Support

- Passive ventilation techniques (SysRev)

- Minimizing pauses in chest compressions (SysRev)

- Cardiopulmonary resuscitation (CPR) during transport (SysRev)

- Compressions-airway-breaths (C-A-B) or airway-breaths-compressions (A-B-C) in drowning (new topic: SysRev)

- Paddle size and placement for defibrillation (EvUp)

- Barrier devices (EvUp)

- Chest compression rate (EvUp)

- Rhythm check timing (EvUp)

- Timing of CPR cycles (2 minutes versus other) (EvUp)

- Public-access automated external defibrillator (AED) programs (EvUp)

- Checking for circulation during basic life support (BLS) (EvUp)

- Rescuer fatigue in compression-only CPR (EvUp)

- Harm from CPR to victims not in cardiac arrest (EvUp)

- Harm to rescuers from CPR (EvUp)

- Hand positioning during compressions (EvUp)

- Dispatch-assisted compression-only versus conventional CPR (EvUp)

- Emergency medical services chest compression–only versus conventional CPR (EvUp)

- Compression-to-ventilation ratio (EvUp)

- CPR before defibrillation (EvUp)

- Chest compression depth (EvUp)

- Chest wall recoil (EvUp)

- Foreign body airway obstruction (EvUp)

- Firm surface for CPR (EvUp)

- In-hospital chest compression–only CPR versus conventional CPR (EvUp)

- Analysis of rhythm during chest compressions (EvUp)

- Alternative compression techniques (cough, precordial thump, fist pacing) (EvUp)

- Tidal volumes and ventilation rates (EvUp)

- Lay rescuer chest compression–only versus conventional CPR (EvUp)

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

- Dispatcher recognition of cardiac arrest (EvUp)

- Resuscitation care for suspected opioid-associated emergencies (EvUp)

- CPR before call for help (EvUp)

- Video-based dispatch (EvUp)

- Head-up CPR (EvUp)

Advanced Life Support

- Targeted temperature management (TTM) after cardiac arrest (SysRev)

- Point-of-care ultrasound as a diagnostic tool during cardiac arrest (SysRev)

- Vasopressin and corticosteroids for cardiac arrest (SysRev)

- Post–cardiac arrest coronary angiography (SysRev Update)

- Vasopressors during cardiac arrest (EvUp)

- Cardiac arrest from pulmonary embolism (EvUp)

Pediatric Life Support

- Public-access devices (SysRev)

- Pediatric early warning systems (SysRev)

- Sequence of compression and ventilation (EvUp)

- Chest compression–only versus conventional CPR (EvUp)

- Drugs for the treatment of bradycardia (EvUp)

- Emergency transcutaneous pacing for bradycardia (EvUp)

- Extracorporeal CPR for pediatric cardiac arrest (EvUp)

- Intraosseous versus intravenous route of drug administration (EvUp)

- Sodium bicarbonate administration for children in cardiac arrest (EvUp)

- TTM (EvUp)

Neonatal Life Support

- Maintaining normal temperature immediately after birth in late preterm and term infants (SysRev)

- Suctioning clear amniotic fluid at birth (SysRev)

- Tactile stimulation for resuscitation immediately after birth (SysRev)

- Delivery room heart rate monitoring to improve outcomes for newborn infants (SysRev)

- Continuous positive airway pressure (CPAP) versus no CPAP for term respiratory distress in the delivery room (SysRev)

- Supraglottic airways (SGAs) for neonatal resuscitation (SysRev)

- Respiratory function monitoring during neonatal resuscitation at birth (SysRev)

Education, Implementation, and Teams

- Prearrest prediction of survival following in-hospital cardiac arrest (SysRev)

- BLS training for high-risk populations (SysRev)

- Patient outcome and resuscitation team members attending advanced life support courses (SysRev with EvUp)

- Blended learning for life support education (SysRev)

- Faculty Development Approaches for Life Support Courses (ScopRev)

- Willingness to provide CPR (EvUp)

- Team and leadership training (EvUp)

- Medical emergency teams (METs) for adults (EvUp)

- Community initiatives to promote BLS (EvUp)

- Debriefing of CPR performance (EvUp)

- Spaced learning (EvUp)

First Aid

- The recovery position for maintenance of adequate ventilation and the prevention of cardiac arrest (SysRev)

- Oral dilution for caustic substance ingestion (EvUp)

- Recognition of anaphylaxis (EvUp)

- Compression wraps for acute closed ankle joint injury (EvUp)

- Open chest wound dressings (EvUp)

- Bronchodilators for acute asthma exacerbation (EvUp)

- Optimal duration of cooling of burns with water (EvUp)

- Preventive interventions for presyncope (EvUp)

- Single-stage scoring systems for concussion (EvUp)

- Cooling techniques for exertional hyperthermia and heatstroke (EvUp)

- First aid use of supplemental oxygen for acute stroke (EvUp)

- Methods of glucose administration for hypoglycemia in first aid setting (EvUp)

- Pediatric tourniquet types for life-threatening extremity bleeding (EvUp)

Readers are encouraged to monitor the ILCOR website[1] to provide feedback on planned

SysRevs and to provide comments when additional draft reviews are posted.

BASIC LIFE SUPPORT

Passive Ventilation Techniques (SysRev)

Rationale for Review

This topic was prioritized by the BLS Task Force because the topic had not been

reviewed since the 2015 CoSTR recommendations. This systematic review was registered in the

International Prospective Register of Systematic Reviews (PROSPERO; CRD42021293309).

The full text of this CoSTR can be found on the ILCOR website.[2]

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

- **Population:** Adults and children with presumed cardiac arrest in any setting

- **Intervention:** Any passive ventilation technique (eg, positioning the body, opening the

  airway, passive oxygen administration, Boussignac tube, constant flow insufflation of

  oxygen) in addition to chest compressions

- **Comparator:** Standard CPR

- **Outcomes:**

  – Critical: Survival to hospital discharge with good neurological outcome, survival to

    hospital discharge

  – Important: Return of spontaneous circulation (ROSC)

- **Study design:** RCTs and nonrandomized studies (nonrandomized controlled trials [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.

- **Time frame:** All years and all languages were included if there was an English abstract. Literature search updated to October 16, 2021.

Consensus on Science

Two RCTs, 1 observational study, and a very small pilot RCT were identified.[3-6] The overall certainty of evidence was rated as very low. The individual studies were all at a critical risk of bias and indirectness. Because of a high degree of heterogeneity, the meta-analyses included only 2 RCTs, in which passive ventilation through constant-flow insufflation of oxygen with the aid of a modified tracheal tube was compared with mechanical ventilation.[3,4] The observational study evaluated passive oxygen insufflation as a part of a minimally interrupted CPR bundle (also including uninterrupted preshock and postshock chest compressions and early epinephrine administration).[5] The pilot RCT compared 9 patients who received chest compression–induced ventilation that included continuous positive airway pressure with 11 patients who received volume-controlled ventilation during CPR.[6] Key results are presented in Table 1.

Table 1. Overview of Key Outcomes for Passive Ventilation During CPR Compared With Standard CPR

Outcomes (importance)	Participants (n), studies	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Discharge with favorable outcome (critical)	1019 patients, 1 observational study[5]	Very low	1.03 (0.84–1.26)	3 patients more/1000 (15 fewer to 25 more)

Outcomes (importance)	Participants (n), studies	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Survival to ICU discharge (critical)	791 patients, 2 RCTs[3,4]	Low	0.96 (0.31–2.85)	1 patient fewer/1000 (14 fewer to 38 more)
Survival to admission (important)	791 patients, 2 RCTs[3,4]	Low	0.92 (0.64–1.24)	14 patients fewer/1000 (61 fewer to 41 more)
ROSC (important)	791 patients, 2 RCTs[3,4]	Low	0.98 (0.85–1.12)	4 patients fewer/1000 (31 fewer to 25 more)
ROSC (important)	1019 patients, 1 observational study[5]	Very low	0.85 (0.77–1.00)	45 patients fewer/1000 (69 fewer to 0 more)
ROSC (important)	20 patients, 1 pilot RCT study[6]	Very low	0.85 (0.77–1.00)	45 patients fewer/1000 (69 fewer to 0 more)

CPR indicates cardiopulmonary resuscitation; ICU, intensive care unit; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; RCT, randomized controlled trial; ROSC, return of spontaneous circulation; and RR, risk ratio.

Treatment Recommendations

We suggest against the routine use of passive ventilation techniques during conventional CPR (weak recommendation, very low–certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is included in Appendix A.

Passive ventilation may represent an alternative to intermittent positive-pressure ventilation. It may shorten interruptions in chest compressions for advanced airway management and may overcome the potential harm from positive-pressure ventilation (increased intrathoracic pressure leading to reduced venous return to the heart and reduced coronary perfusion pressure, then increased pulmonary vascular resistance).

The 2 larger RCTs[3,4] that were included compared intermittent positive-pressure ventilation via a tracheal tube with continuous insufflation of oxygen through a modified tracheal tube, ie, a *Boussignac tube*. The Boussignac tube used in these studies generates a constant

tracheal pressure of approximately 10 cm H_2O. When available, the active compression-decompression device was used to perform CPR. These adjuncts may have played a role in the generation and magnitude of passive ventilation. The included observational study[5] was highly confounded because multiple aspects of the CPR protocols compared were different, including the ventilation strategies, rhythm check timing, compression-to-ventilation ratios, and compression intervals between shocks. Overall, certainty of evidence was rated as very low primarily because of the risk of bias due to indirectness.

We acknowledge that where emergency medical services systems have adopted a bundle of care that includes minimally interrupted cardiac resuscitation with passive ventilation, it is reasonable to continue with that strategy in the absence of compelling evidence to the contrary.

Task Force Knowledge Gaps

- The efficacy of passive ventilation in the lay rescuer setting

- The optimal method for ensuring a patent airway

- Whether there is a critical volume of air movement required to maintain ventilation/oxygenation

- The effectiveness of passive insufflation in children

Minimizing Pauses in Chest Compressions (SysRev)

Rationale for Review

This topic was prioritized by the BLS Task Force because the topic had not been reviewed since the 2015 CoSTR. This systematic review was registered in PROSPERO (CRD42019154784). The full text of this CoSTR can be found on the ILCOR website.[7]

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

- **Population:** Adults in cardiac arrest in any setting

- **Intervention:** Minimizing of pauses in chest compressions (higher CPR or chest compression fraction or shorter perishock pauses compared with control)

- **Comparator:** Standard CPR (lower CPR fraction or longer perishock pauses compared with intervention)

- **Outcomes:**

    – Critical: Survival to hospital discharge with good neurological outcome and survival to hospital discharge

    – Important: ROSC

- **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.

- **Time frame:** All years and all languages were included if there was an English abstract. Literature search updated to December 17, 2021.

Consensus on Science

Three RCTs[8-10] and 21 observational studies were identified.[11-31] The evidence identified was divided into 5 categories, and results are summarized in Table 2:

1. RCTs designed to evaluate interventions affecting quality of CPR

2. Observational studies comparing outcomes before and after interventions designed to improve quality of care (including pauses in chest compressions) or between different systems that had differences in CPR fraction

3. Observational studies exploring associations between pauses in chest compressions and outcomes

4. Observational studies where outcomes were compared between groups in different chest compression pause categories

5. Observational studies where pauses in compressions were compared between survivors and nonsurvivors

The overall certainty of evidence was rated as very low for all outcomes, primarily because of a very serious risk of bias. The individual studies were all at a critical risk of bias due to confounding. Because of this and a high degree of heterogeneity, no meta-analyses could be performed and the individual studies are difficult to interpret.

Table 2. Minimizing Pauses in Chest Compressions

Category	Studies	Certainty of evidence (GRADE)	Main findings
1. RCTs on interventions that affect pauses	3 RCTs[8-10]	Very low	New AED strategies resulted in higher CPR fractions and shorter preshock and postshock pauses but no differences in survival.[8,9] Continuous chest compression strategy resulted in higher CPR fractions and lower survival to hospital admission; no difference in survival to discharge.[10]
2. Studies comparing before and after or different systems' CPR fraction	6 observational studies[11-16]	Very low	One study evaluated incremental changes in various CPR quality metrics and outcomes over time and found that from 2006 to 2016, both CPR fraction and the proportion of survivors with favorable survival increased.[12] The other studies observing improved CPR fractions and perishock pauses did not observe significant improvements in survival.[11,13-16]
3. Associations between chest compression pauses and outcomes	5 observational studies[17-21]	Very low	Two studies found increased CPR fraction to be associated with improved survival[17,18] whereas 2 did not.[19,20] The fifth study found increasing CPR fraction to be associated with improved ROSC.[21] One study found increasing perishock pause to be associated with lower survival[19] while another did not.[20]
4a. Outcomes compared for chest	7 observational studies[17,20-25]	Very low	One study showed higher favorable neurologic outcome and survival to discharge in arrests with CPR fraction >80% compared with <80% in the

Category	Studies	Certainty of evidence (GRADE)	Main findings
compression pause categories: CPR fraction			subgroup with >20 minute CPR duration but no differences in survival in the corresponding patient subgroups with 5 or 10 min CPR durations.[22] Two studies observed higher survival to discharge in arrests with lower CPR fractions (<40% vs >80%) and lower survival with higher CPR fractions (<60% vs <80% and 60%–79%).[23,24] One study observed lower ROSC with CPR fraction >80% compared with <80%.[25] There were no significant differences in outcomes in the remaining 3 studies.[17,20,21]
4b. Outcomes compared for pause categories: perishock pauses	4 observational studies[20,24,27,28]		Three studies observed higher survival in patients with shorter preshock pauses (<10 seconds) compared with longer preshock pauses (>10–20 seconds),[20,24,27,28] and 2 observed higher survival in patients with shorter perishock pauses (<20 seconds) compared with longer perishock pauses (>20–40 sec).[24,27] One study did not find improved survival with preshock pause <10 seconds compared with >10 seconds.[20]
5. Pauses compared between survivors and nonsurvivors	8 observational studies[19,25-31]	Very low	One study observed higher CPR fractions during the first 5 minutes in nonsurvivors compared with survivors[19]; 1 observed higher CPR fractions in patients with downtimes >15 minutes without ROSC[25]; 1 observed higher CPR fractions in patients with ROSC.[26] Remaining 5 studies: no difference observed[27-31]

CPR indicates cardiopulmonary resuscitation; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; and ROSC, return of spontaneous circulation.

Treatment Recommendations

We suggest that CPR fraction and perishock pauses in clinical practice be monitored as

part of a comprehensive quality improvement program for cardiac arrest designed to ensure high-

quality CPR delivery and resuscitation care across resuscitation systems (weak recommendation,

very low–certainty evidence).

We suggest that preshock and postshock pauses in chest compressions be as short as

possible (weak recommendation, very low–certainty evidence).

We suggest that the CPR fraction during cardiac arrest (CPR time devoted to compressions) should be as high as possible and be at least 60% (weak recommendation, very low–certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is included in Appendix A.

In making these recommendations, the BLS Task Force considered that low CPR fractions may not necessarily reflect lower quality of CPR, but we felt that it was important to provide a minimum value to aid guideline providers. The consensus within the resuscitation community is that high-quality CPR is important for patient outcomes and that high-quality CPR includes high CPR or chest compression fraction and short perishock pauses. Although the exact targets of these CPR metrics are uncertain, the strong belief in the benefit of minimizing pauses in compressions (along with the physiological rationale for the detrimental effect of no compressions) make prospective clinical trials of long versus short compression pauses unlikely. The evidence identified in this review was either indirect (in that the interventional studies were developed for related purposes) or observational. Observational studies are challenged by the association between pauses in compressions and good outcome because resuscitation attempts of short duration in patients with shockable rhythms tend to have better outcomes than resuscitation attempts of long duration in patients with nonshockable rhythms. The number and proportion of pauses will be dependent on both cardiac rhythm and the duration of the resuscitation attempt, and an optimal target will therefore depend on the cardiac arrest characteristics. These factors make interpreting observational data and providing guidance for CPR metrics particularly challenging.

Experimental animal data indicate possible positive effects of postconditioning (improved cardiac and neurologic function in animals treated with short, controlled pauses during initial CPR).[32,33] There are no human data to inform postconditioning during cardiac arrest. Weighing a theoretical possibility of positive effects from limited pauses in chest compressions against a certain detrimental effect of lack of chest compressions, it is reasonable to assume that there is a low risk of harm from lack of chest compression pauses and that the possibility for desirable effects from fewer pauses outweighs the possible undesirable effects.

Task Force Knowledge Gaps

- Effect of a strategy of minimizing pauses in compressions compared with longer pauses in compressions

- Evaluation of limited pauses in compressions as part of a postconditioning strategy in humans

- Optimal pauses and CPR metrics for various subgroups (shockable versus nonshockable, short versus longer resuscitations, etc)

CPR During Transport (SysRev)

Rationale for Review

A scoping review (ScopRev) was completed for the 2020 CoSTR, and this topic was subsequently prioritized by the BLS Task Force. This systematic review was registered in PROSPERO (CRD42021240615). The full text of these CoSTRs can be found on the ILCOR website.[34]

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

- **Population:** Adults and children receiving CPR following out-of-hospital cardiac arrest

- **Intervention:** Transport with ongoing CPR

- **Comparator:** Completing CPR on scene

- **Outcomes:**

  - Critical: Survival to hospital discharge with good neurological outcome and survival to hospital discharge

  - Important: Quality of CPR metrics on scene versus during transport (reported outcomes may include rate of chest compressions, depth of chest compressions, chest compression fraction, interruptions to chest compressions, leaning on chest/incomplete release, rate of ventilation, volume of ventilation, duration of ventilation, pressure of ventilation), ROSC

- **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.

- **Time frame:** All years and all languages were included if there was an English abstract. Literature search updated to 15 June 2021.

Consensus on Science

The identified studies were divided into those evaluating the effect of transport with ongoing CPR on CPR quality and those evaluating the effect of transport with ongoing CPR on patient outcomes (survival). These results are reported in separate tables (Tables 3 and 4). The studies evaluating the effect of transport with ongoing CPR on CPR quality included a wide range of quality outcomes including the impact of transport on:

1. Correct hand positioning

2. Chest compression rate

3.   Chest compression depth

4.   Pauses in compressions

5.   Leaning on the chest/incomplete release

6.   Chest compression fraction/hands-off time

7.   Ventilation

8.   Overall correct CPR

Table 3. Effect of Transport on CPR Quality

Category	Studies	Certainty of evidence (GRADE)	Main findings
Correct hand positioning	2 manikin studies [35,36]	Very low	Simulated helicopter rescue; 1 study with fewer correct compressions in flight,[36] 1 study with no difference[35]
Chest compression rate	5 observational studies[37-41] 4 manikin studies[35,42-44]	Very low	One study with slightly faster compressions during transport,[41] 2 showed increased variation,[39,41] 3 showed no difference.[37,38,40] Manikin studies had divergent results.[35,42-44]
Chest compression depth	4 observational studies[38-41] 4 manikin studies[35,42-44]	Very low	One study with deeper compressions[41] and 1 with more correct depth[40] during transport, 2 with no difference.[38,39] Manikin studies had divergent results.[35,42-44]
Pauses	1 manikin study[44]	Very low	Pauses during transport within guidelines[44]
Leaning on the chest/ incomplete release	2 manikin studies[36,44]	Very low	Manikin studies with divergent results[36,44]
CPR fraction	4 observational studies[37-39,41] 2 manikin studies[42,44]	Very low	3 studies showed lower CPR fractions during transport,[37-39] 1 showed no difference.[39] Manikin studies had divergent results.[42,44]
Ventilation	2 observational studies[37,38]	Very low	One study with faster ventilations during transport,[38] 1 study with no difference[37]
Overall correct CPR	1 observational study[41] 1 manikin study[45]	Very low	High-quality CPR observed both before and during transport.[41] Fewer correct compressions on manikin during transport [45]

CPR indicates cardiopulmonary resuscitation; and GRADE, Grading of Recommendations, Assessment, Development, and Evaluation.

Table 4. Effect of Transport on Survival

Outcomes (importance)	Participants (n), number of studies	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Discharge with favorable outcome (critical)	27 705 patients, 1 observational study[46]	Very low	0.39 (0.33, 0.47)	2 patients fewer/1000 (2 fewer to 3 fewer)
Survival to discharge (critical)	27 705 patients, 1 observational study[46]	Very low	0.46 (0.42, 0.52)	5 patients fewer/1000 (4 fewer to 5 fewer)
ROSC (important)	27 705 patients, 1 observational study[46]	Very low	0.41 (0.39, 0.43)	23 patients fewer/1000 (22 fewer to 24 fewer)

GRADE indicates Grading of Recommendations, Assessment, Development, and Evaluation; ROSC, return of spontaneous circulation; and RR, risk ratio.

Treatment Recommendations

We suggest that providers deliver resuscitation at the scene rather than undertake ambulance transport with ongoing resuscitation unless there is an appropriate indication to justify transport (eg, extracorporeal membrane oxygenation) (weak recommendation, very low-certainty evidence).

The quality of manual CPR may be reduced during transport. We recommend that whenever transport is indicated, emergency medical services providers should focus on the delivery of high-quality CPR throughout transport (strong recommendation, very low–certainty evidence).

Delivery of manual CPR during transport increases the risk of injury to providers. We recommend that emergency medical services systems have a responsibility to assess this risk and, where practicable, to implement measures to mitigate the risk (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is included in Appendix A.

In making these recommendations, the BLS Task Force considered the complexity of the decision to transport or remain on scene, including patient factors (age, comorbidities), clinical considerations (scope of practice of providers, aetiology, rhythm, response to treatment), logistic considerations (location of arrest, challenges of extrication, resources required, journey to hospital), patient and provider safety considerations, and hospital capability (extracorporeal membrane oxygenation or other advanced interventions). The BLS Task Force's interpretation of available evidence for CPR quality outcomes is summarized in Table 5.

Table 5. The BLS Task Force Interpretation of Available Evidence for CPR Quality Outcomes

Category	Interpretation
Correct hand positioning	Transport appears to have little impact on correct hand positioning.
Chest compression rate	Appropriate chest compression rates can be achieved during transport; however, there is greater variation in chest compression rate during transport compared with at the scene.
Chest compression depth	Appropriate chest compression depth can be achieved during transport; however, there is greater variation in chest compression depth during transport compared with at the scene.
Pauses	Transport appears to have little impact on extending pauses.
Leaning on the chest/incomplete release	Transport appears to have little impact on complete release.
CPR fraction	There is significant variation in chest compression fraction. Transport appears to have a negative impact on chest compression fraction.
Ventilation	Transport appears to have little impact on ventilation rates.
Overall correct CPR	There is significant variation in overall correct CPR. Transport appears to have a negative impact on overall correct CPR.

Abbreviations: CPR indicates cardiopulmonary resuscitation.

The BLS Task Force's interpretation of available evidence for survival outcomes was that the single study that was identified reported lower survival among transported patients.[46] The certainty of evidence was very low, with considerable risk of remaining confounding despite the use of propensity score matching. Overall, the task force's concerns about decreased CPR quality and provider safety when delivering CPR during transport outweighed the benefits of bringing patients to the hospital unless the hospital could offer specific treatments not available in the

prehospital setting (eg, extracorporeal membrane oxygenation, coronary angiography, echocardiography, or other potential investigations or treatments).

Task Force Knowledge Gaps

- There are only a few studies in humans.

- There are no studies in children.

- There are no studies addressing the impact on patient outcomes of CPR quality during transport.

C-A-B or A-B-C in Drowning (SysRev)

Rationale for Review

This topic was prioritized by the BLS Task Force after the ScopRev that was completed for the 2020 CoSTR. This systematic review was registered in PROSPERO (CRD42021259983). The full text of this CoSTR can be found on the ILCOR website.[47]

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

- **Population:** Adults and children in cardiac arrest following drowning

- **Intervention:** Resuscitation that employs a compression-first strategy (compressions, airway, breaths, or C-A-B)

- **Comparator:** Resuscitation that starts with ventilation (airway, breaths, compressions, or A-B-C)

- **Outcomes:**

  - Critical: Survival to hospital discharge with good neurological outcome and survival to hospital discharge

  - Important: ROSC

- **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.

- **Time frame:** All years and all languages were included if there was an English abstract. Literature search updated to 16th October 2021.

Consensus on Science

Seven hundred and thirty abstracts were reviewed, of which 9 were reviewed in full text. No studies were identified as relevant to the PICO question comparing initial resuscitation strategies (ventilation first or compression first) for cardiac arrests caused by drowning. To determine good practice statements, the reviewers identified literature and other consensus statements that related indirectly to the research question.

Treatment Recommendations

We recommend a compression-first strategy (C-A-B) for lay persons providing resuscitation for adults and children in cardiac arrest caused by drowning (good practice statement).

We recommend that healthcare professionals and those with a duty to respond to drowning (eg, lifeguards) consider providing rescue breaths/ventilation first (A-B-C) before chest compressions if they have been trained to do so (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The rationale for the ventilation-first strategy (differing from adult BLS treatment recommendations) is based on the hypoxic mechanism of cardiac arrest in drowning and the belief that earlier ventilation will reverse the hypoxia sooner, either preventing the patient from

progressing from respiratory arrest to cardiac arrest or increasing the likelihood of ROSC after correcting the underlying etiology.

A similar rationale is commonly invoked in pediatric cardiac arrest, where hypoxia is a more common etiology than primary cardiac events.[48] ILCOR reviewed the evidence for initial resuscitation strategy in pediatric cardiac arrest in both 2015 and 2020.[49,50] No human studies were identified, and the Pediatric Life Support (PLS) Task Force did not recommend either strategy as superior. Instead, they noted that a compression-first strategy prioritized uniformity with adult guidelines and simplicity, and a ventilation-first strategy prioritized more rapid reversal of hypoxia. Two manikin RCT studies that were identified in the review demonstrated that ventilation was delayed by only 5.7 to 6 seconds with a compression-first strategy compared with a ventilation-first strategy.[51,52]

There is only indirect evidence to support a ventilation-first strategy in drowning. Another systematic review of resuscitation after drowning is currently being done to determine the impact of any ventilation at all as part of the resuscitation strategy. However, a recent scoping review found that bystander CPR including ventilation was associated with better survival.[53] One retrospective observational study compared in-water resuscitation (ie, ventilation) with no ventilation for drowning victims in respiratory (and possibly cardiac) arrest. Survival (87.5% versus 25%) and survival with favorable functional outcome (52.6% versus 7.4%) were higher in the in-water resuscitation cohort.[54] Another study describes significantly worse functional outcomes in drowned children who experience cardiac arrest compared with respiratory arrest only (81% versus 0%, p<0.001). By intervening with ventilation early in the arrest process before the heart has stopped (ie, addressing the hypoxic mechanism), outcomes may be improved.[55]

The recommendation for a compression-first strategy (C-A-B) for lay rescuers prioritizes simplicity and cohesiveness in training recommendations for lay persons, with the goal of faster resuscitation initiation. The recommendation is supported by manikin studies finding that there was limited delay in ventilation even with a compression-first strategy.

The recommendation for healthcare professionals and those with a duty to respond to consider providing rescue breaths/ventilation first (A-B-C) considers the indirect evidence suggesting that earlier ventilations may improve outcomes. It is unclear whether earlier ventilation may improve outcomes after cardiac arrest has occurred or if the benefit is exclusively in preventing respiratory arrest from deteriorating into cardiac arrest.

Task Force Knowledge Gaps

- No studies directly evaluated this question.

- Further research informed by the Utstein template for drowning may address this ongoing uncertainty.

Topics Reviewed by EvUps

The topics reviewed by evidence updates (EvUps) are summarized in Table 6, with the PICO number, existing treatment recommendation, number of relevant studies identified, key findings, and whether a SysRev was deemed worthwhile. Complete EvUps can be found in Appendix C.

Table 6. BLS Topics Reviewed by EvUps*

Topic/PICO	Year(s) last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
ALS-E-030A Paddle size and placement for defibrillation	2010 CoSTR; 2020 ScopRev	It is reasonable to place pads on the exposed chest in an anterior-lateral position. An acceptable alternative position is anterior posterior. In large-breasted	0	0	No new studies identified	No

Topic/PICO	Year(s) last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		individuals, it is reasonable to place the left electrode pad lateral to or below the left breast, avoiding breast tissue. Consideration should be given to the rapid removal of excessive chest hair before the application of pads, but emphasis must be on minimizing delay in shock delivery. There is insufficient evidence to recommend a specific electrode size for optimal external defibrillation in adults. However, it is reasonable to use a pad size greater than 8 cm.				
BLS 342 Barrier devices	2005 CoSTR	Providers should take appropriate safety precautions when feasible and when resources are available to do so, especially if a victim is known to have a serious infection (eg, HIV, tuberculosis, HBV, or SARS).	0	0	No new studies identified	No
BLS 343 Chest compression rate	2015 CoSTR; 2020 ScopRev	We recommend a manual chest compression rate of 100–120/min (strong recommendation, very low–certainty evidence).	0	2	PICOSTs BLS 343, 366, and 367 have been evaluated together to identify any evidence looking at the interplay between the 3 CPR metrics. Two new observational studies on rate and depth—but not on recoil—since last ScopRev. Findings were consistent with current guidelines.	No
BLS 345 Rhythm check timing	2020 CoSTR	We suggest immediate resumption of chest compressions after shock delivery for adults in cardiac arrest in any setting (weak recommendation, very low–certainty evidence).	0	0	No new studies identified	No
BLS 346 Timing of CPR cycles (2 min vs other)	2020 CoSTR	We suggest pausing chest compressions every 2 minutes to assess the cardiac rhythm (weak recommendation, low-certainty evidence).	0	0	No new studies identified	No

Topic/PICO	Year(s) last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
BLS 347 Public access AED programs	2020 CoSTR	We recommend the implementation of PAD programs for patients with OHCA (strong recommendation, low-certainty evidence).	0	1	One observational study on a PAD program at Tokyo railroad stations presented significant benefits and cost-effectiveness in line with previous recommendations.	No
BLS 348 Check for circulation during BLS	2015 CoSTR	Outside of the ALS environment, where invasive monitoring is available, there are insufficient data about the value of a pulse check while performing CPR. We therefore do not make a treatment recommendation regarding the value of a pulse check.	0	0	No new studies since 2021. Some relevant papers showing the effectives of ultrasound to check for circulation were identified.	No
BLS 349 Rescuer fatigue in chest compression–only CPR	2015 CoSTR	We recommend no modification to current CCO-CPR guidelines for cardiac arrest to mitigate rescuer fatigue (strong recommendation, very low–certainty evidence).	0	0	No new clinical or simulation studies were identified that addressed the criteria. Simulation studies on manikins were identified. Consider reviewing CCO-CPR rest intervals in the future.	No
BLS 353 Harm from CPR to victims not in arrest	2020 CoSTR	We recommend that lay people initiate CPR for presumed cardiac arrest without concerns of harm to patients not in cardiac arrest (strong recommendation, very low–certainty evidence).	0	0	No new studies identified	No
BLS 354 Harm to rescuers from CPR	2015 CoSTR; 2020 ScopRev	Evidence supporting rescuer safety during CPR is limited. The few isolated reports of adverse effects resulting from the widespread and frequent use of CPR suggest that performing CPR is relatively safe. Delivery of a defibrillator shock with an AED during BLS is also safe. The incidence and morbidity of defibrillator-related injuries in the rescuers are low.	0	2	One study found low risk of physical injury reported by volunteer citizen responders dispatched to out-of-hospital cardiac arrest. One study found low risk of harm from defibrillation in rescuers wearing polyethylene gloves. Future reviews might focus specifically on safety of lay responder programs.	No
BLS 357 Hand position during compressions	2020 CoSTR	We suggest performing chest compressions on the lower half of the sternum on adults in cardiac arrest (weak recommendation,	0	0	No new studies addressing this question, but two simulation/ training studies highlighting	No

Topic/PICO	Year(s) last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		very low–certainty evidence).			difficulties for lay rescuers in identifying correct hand position were identified.	
BLS 359 Dispatch-assisted compression-only versus conventional CPR	2019 CoSTR	We recommend that dispatchers provide compression-only CPR instructions to callers for adults with suspected OHCA (strong recommendation, low-certainty evidence).	0	0	No new studies identified	No
BLS 360 EMS chest compression–only vs conventional CPR	2020 CoSTR	We recommend that EMS providers perform CPR with 30 compressions to 2 breaths (30:2 ratio) or continuous chest compressions with positive pressure ventilation delivered without pausing chest compressions until a tracheal tube or supraglottic device has been placed (strong recommendation, high-certainty evidence).\n\nWe suggest that, when EMS systems have adopted minimally interrupted cardiac resuscitation, this strategy is a reasonable alternative to conventional CPR for witnessed shockable OHCA (weak recommendation, very low–certainty evidence).	0	1	One new study since 2021. Median inspiratory tidal volume generated by manual chest compressions without ventilation was 20 mL (IQR 13, 28 mL) which were judged inadequate to provide adequate alveolar ventilation.	No
BLS 362 Compression-to-ventilation ratio	2017 CoSTR	We suggest a CV ratio of 30:2 compared with any other CV ratio in patients with cardiac arrest (weak recommendation, very low–quality evidence).	0	0	No new studies identified	No
BLS 363 CPR prior to defibrillation	2020 CoSTR	We suggest a short period of CPR until the defibrillator is ready for analysis and/or defibrillation in unmonitored cardiac arrest. (weak recommendation, low-certainty evidence).	0	0	No new studies identified. Observational data exploring AMSA and $ETCO_2$ to guide defibrillation might be relevant for ALS.	No
BLS 366 Chest compression depth	2015 CoSTR; 2020 ScopRev	We recommend a chest compression depth of approximately 5 cm (2 in) (strong recommendation, low-certainty evidence) while avoiding excessive chest compression depths (greater than 6 cm [greater than 2.4 in] in an average	0	2	PICOSTs BLS 343, 366, and 367 have been evaluated together to identify any evidence looking at the interplay between the three CPR metrics. Two new observational	No

Topic/PICO	Year(s) last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		adult) during manual CPR (weak recommendation, low-certainty evidence).			studies on rate and depth–but not recoil–since last ScopRev. Findings were consistent with current guidelines.	
BLS 367 Chest wall recoil	2015 CoSTR; 2020 ScopRev	We suggest that rescuers performing manual CPR avoid leaning on the chest between compressions to allow full chest wall recoil (weak recommendation, very low–quality evidence).	0	2	PICOSTs BLS 343, 366, and 367 have been evaluated together to identify any evidence looking at the interplay between the 3 CPR metrics. Two new observational studies on rate and depth–but not recoil–since last ScopRev. Findings were consistent with current guidelines.	No
BLS 368 Foreign body airway obstruction	2020 CoSTR	We suggest that back slaps be used initially in adults and children with a foreign-body airway obstruction and an ineffective cough (weak recommendation, very low–certainty evidence). We suggest that abdominal thrusts be used in adults and children (older than 1 year) with a foreign-body airway obstruction and an ineffective cough when backslaps are ineffective (weak recommendation, very low–certainty evidence). We suggest that rescuers consider the manual extraction of visible items in the mouth (weak recommendation, very low–certainty evidence). We suggest against the use of blind finger sweeps in patients with a foreign-body airway obstruction (weak recommendation, very low–certainty evidence). We suggest that appropriately skilled healthcare providers use Magill forceps to remove a foreign-body airway obstruction in patients with OHCA resulting from foreign body airway obstruction (weak	0	1	A single new case series identified that describes 8 cases of the use of a vacuum cleaner to clear foreign body airway obstruction.	No

Topic/PICO	Year(s) last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		recommendation, very low–certainty evidence). We suggest that chest thrusts be used in unconscious adults and children with a foreign-body airway obstruction (weak recommendation, very low–certainty evidence). We suggest that bystanders undertake interventions to support foreign-body airway obstruction removal as soon as possible after recognition (weak recommendation, very low–certainty evidence). We suggest against the routine use of suction-based airway clearance devices (weak recommendation, very low–certainty evidence).				
BLS 370 Firm surface for CPR	2020 CoSTR	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 favour of either a backboard or no-backboard strategy, to improve chest compression depth, (Conditional recommendation, very low certainty of evidence).	0	3	Three additional manikin RCTs were identified, evaluating CPR quality with a backboard, on a dentist chair, and on a dynamic mattress.	No

Topic/PICO	Year(s) last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
BLS 372 In-hospital chest compression-only CPR vs conventional CPR	2017 CoSTR	Whenever tracheal intubation or a supraglottic airway is achieved during in-hospital CPR, we suggest that providers perform continuous compressions with positive pressure ventilation delivered without pausing chest compressions (weak recommendation, very low–certainty evidence).	0	0	No new studies identified	No
BLS 373 Analysis of rhythm during chest compression	2020 CoSTR	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	2	Two new observational studies since last SysRev. Analysis during CPR led to fewer pauses in chest compressions.	Yes
BLS 374 Alternative compression techniques (cough, precordial thump, fist pacing)	2020 CoSTR	We recommend against the routine use of cough CPR for cardiac arrest (strong recommendation, very low–certainty evidence). We suggest that cough CPR may be considered only as a temporizing measure in exceptional circumstance of a witnessed, monitored IHCA (eg, in a cardiac catheterization laboratory) if a nonperfusing rhythm is recognized promptly before loss of consciousness (weak recommendation, very low–certainty evidence). We recommend against fist pacing for cardiac arrest (strong recommendation, very low–certainty evidence). We suggest that fist pacing may be considered only as a	0	0	No new studies identified	No

Topic/PICO	Year(s) last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		temporizing measure in the exceptional circumstance of a witnessed, monitored IHCA (eg, in a cardiac catheterization laboratory) due to bradyasystole if such a nonperfusing rhythm is recognized promptly before loss of consciousness (weak recommendation, very low–certainty evidence). We recommend against the use of a precordial thump for cardiac arrest (strong recommendation, very low–certainty evidence).				
BLS 546 Tidal volumes and ventilation rates	2010 CoSTR	For mouth-to-mouth ventilation for adult victims using exhaled air or bag-mask ventilation with room air or oxygen, it is reasonable to give each breath within a 1-second inspiratory time and with an approximate volume of 600 mL to achieve chest rise. It is reasonable to use the same initial tidal volume and rate in patients regardless of the cause of the cardiac arrest.	0	0	No new studies identified. Studies identified evaluating tidal volumes during mechanical ventilation, and after ROSC.	No
BLS 547 Lay rescuer chest compression–only CPR vs conventional CPR	2020 CoSTR	We continue to recommend that bystanders perform chest compressions for all patients in cardiac arrest (good practice statement). We suggest that bystanders who are trained, able, and willing to give rescue breaths and chest compressions do so for all adult patients in cardiac arrest (weak recommendation, very low–certainty evidence).	0	0	Only manikin/training studies since 2020	No
BLS 661 Starting CPR (C-A-B vs A-B-C)	2020 CoSTR	We suggest commencing CPR with compressions rather than ventilation in adults with cardiac arrest (weak recommendation, very low–certainty evidence).	0	0	No new studies identified	No
BLS 740 Dispatcher recognition of cardiac arrest	2020 CoSTR	We recommend that dispatch centers implement a standardized algorithm and/or standardized criteria	1	6	One RCT where calls processed using machine learning recognized arrest	Yes

Topic/PICO	Year(s) last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		to immediately determine if a patient is in cardiac arrest at the time of emergency call (strong recommendation, very low–certainty evidence). We suggest that dispatch centers monitor and track diagnostic capability. We suggest that dispatch centers look for ways to optimize sensitivity (minimize false negatives). We recommend high-quality research that examines gaps in this area.			93.1% vs 90.5% in control group. (p=0.15). Six observational studies evaluated various interventions or compared different systems with regard to recognition of cardiac arrest.	
BLS 811 Resuscitation care for suspected opioid-associated emergencies	2020 CoSTR	We suggest that CPR be started without delay in any unconscious 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).	0	0	No new studies identified	No
BLS 1527 CPR prior to call for help	2020 CoSTR	We recommend that a lone bystander with a mobile phone should dial EMS, activate the speaker or other hands-free option on the mobile phone, and immediately begin CPR with dispatcher assistance, if required (strong recommendation, very low–certainty evidence).	0	0	No new studies identified	No
BLS Video-Based Dispatch Systems	2021 CoSTR	We suggest that the usefulness of video-based dispatch systems be assessed in clinical trials or research initiatives (weak recommendation, very low–certainty evidence).	0	2	Two additional observational studies identified. One study reported an association between video dispatch and survival. The other reported better CPR quality with video dispatch.	No
BLS Head-up CPR	2021 CoSTR	We suggest against the routine use of head-up CPR during CPR (weak recommendation, very low–certainty evidence).	0	0	No new studies identified. Observational data exploring AMSA and $ETCO_2$ to guide defibrillation might be relevant for ALS.	No

Topic/PICO	Year(s) last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		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).				

AED indicates automated external defibrillator; ALS, advanced life support; AMSA, amplitude spectral area; BLS, basic life support; CCO-CPR, chest compression–only CPR; CPR, cardiopulmonary resuscitation; CV, compression-to-ventilation; EMS, emergency medical services; EvUp, evidence update; HIV, human immunodeficiency virus; IQR, interquartile range; HBV, hepatitis B virus; IHCA, in-hospital cardiac arrest; OHCA, out-of-hospital cardiac arrest; PAD, public access defibrillation; PICO, population, intervention, comparator, outcome; PICOST, population, intervention, comparator, outcomes, study design, timeframe; RCT, randomized controlled trial; SARS, severe acute respiratory syndrome; ScopRev, scoping review.
*Complete Evidence Updates are in Appendix C.

ADVANCED LIFE SUPPORT TASK FORCE

Temperature Management After Cardiac Arrest (SysRev)

Rationale for Review

Active temperature control has been a cornerstone of care for those who remain comatose after cardiac arrest. This SysRev was prompted by the publication of 2 large randomized trials comparing different strategies of temperature management since the previous ILCOR review in 2015.[56] A SysRev was therefore conducted on behalf of the Advanced Life Support (ALS) Task Force (PROSPERO; Registration CRD42020217954).[57] The complete CoSTR can be found online.[58]

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

For this PICOST, 6 comparisons were included. Population, outcome, study design, and time frame included were the same for all comparisons.

Population: Adults in Any Setting (In-Hospital or Out-of-Hospital) With Cardiac Arrest

Use of TTM

- **Intervention:** TTM at 32°C to 34°C

- **Comparator:** No TTM (normothermia/fever prevention)

Timing

- **Intervention:** TTM induction before a specific time point (eg, prehospital or intra-cardiac arrest, ie, before ROSC)

- **Comparator:** TTM induction after that specific time point

Temperature

- **Intervention:** TTM at a specific temperature (eg, 33°C)

- **Comparator:** TTM at a different specific temperature (eg, 36°C)

Duration

- **Intervention:** TTM for a specific duration (eg, 48 hours)

- **Comparator:** TTM at a different specific duration (eg, 24 hours)

Method

- **Intervention:** TTM with a specific method (eg, external)

- **Comparator:** TTM with a different specific method (eg, internal)

Rewarming

- **Intervention:** TTM with a specific rewarming rate

- **Comparator:** TTM with a different specific rewarming rate or no specific rewarming rate

- **Outcome:**

  - Critical: Survival and favorable neurologic/functional outcome at discharge/30 days or longer

- **Study design:** Controlled trials in humans, including RCTs and nonrandomized trials (eg, pseudo-randomized trials). Observational studies, ecological studies, case series, case reports, reviews, abstracts, editorials, comments, letters to the editor, or unpublished studies were not included. Studies assessing cost-effectiveness were included for a descriptive summary.

- **Time frame:** All years and all languages were included if there was an English abstract. The literature search was conducted on October 30, 2020, and updated for clinical trials on June 17, 2021.

Consensus on Science

The search identified 2328 unique records, of which 139 full-text articles were assessed for eligibility. Manuscripts reporting data from 32 trials published between 2001 and 2021 were included. The search identified 1 cost-effectiveness analysis. We did not identify any trials assessing rewarming rate.

A note on terminology: In the SysRev, studies were pooled such that the intervention labeled as *TTM* in the PICO question was targeting hypothermia (32°C–34°C), and the comparator labeled as *no TTM* was targeting normothermia or fever prevention. To avoid confusion and accurately reflect the content of the included trials, we have replaced the term *TTM* with *temperature control with hypothermia*, and we replaced *no TTM* with *temperature control with normothermia or fever prevention*. To provide additional clarity for interpreting future clinical trials, SysRevs, and CoSTRs, the Task Force proposes new ILCOR definitions for

the various forms of temperature control in post–cardiac arrest care under Justification and

Evidence-to-Decision Framework Highlights.

Use of temperature control with hypothermia: We identified 6 RCTs comparing the use

of temperature control with hypothermia to temperature control with normothermia or fever

prevention.[59-64] No differences were found across any outcome, and key results are presented in

Table 7.

Table 7. Summary of Key Findings From 6 RCTs Comparing Temperature Control With Hypothermia to Temperature Control With Normothermia or Fever Prevention

Outcomes (importance)	Participants, studies	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Survival to hospital discharge (critical)	2836 patients, 5 RCTs[59,60,62-64]	Low	1.12 (0.92–1.35)	55 patients more/1000 (37 fewer–161 more)
Favorable neurologic outcome at discharge or 30 days (critical)	2139 patients, 3 RCTs[59,60,62]	Low	1.30 (0.83–2.03)	115 patients more/1000 (65 fewer–395 more)
Survival to 90 or 180 days (critical)	2776 patients, 5 RCTs[60-64]	Low	1.08 (0.89–1.30)	35 patients more/1000 (48 fewer–130 more)
Favorable neurologic outcome at 90 or 180 days (critical)	2753 patients, 5 RCTs[60-64]	Low	1.21 (0.91–1.61)	76 patients more/1000 (33 fewer–222 more)

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; RCT, randomized controlled trial; and RR, risk ratio.

Use of prehospital cooling: We identified 10 RCTs[65-74] comparing use of prehospital

cooling to no prehospital cooling after out-of-hospital cardiac arrest (OHCA), and no differences

in critical outcomes were found (Table 8).

Table 8. Key Outcomes From RCTs of Prehospital Cooling

Outcomes (importance)	Participants, studies	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Survival to hospital discharge (critical)	4808 patients, 10 RCTs[65-74]	Moderate	1.01 (0.92–1.11)	2 patients more/1000 (19 fewer–27 more)
Favorable neurologic outcome at discharge (critical)	4666 patients, 9 RCTs[59,65-71,73,74]	Moderate	1.00 (0.90–1.11)	0 patients fewer/1000 (22 fewer–24 more)

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; RCT, randomized controlled trial; and RR, risk ratio.

Specific temperature comparisons: A single large RCT,[75] now known as the TTM trial, compared temperature control at 33°C with temperature control at 36°C and found no statistically significant difference in patient outcomes. Key results are presented in Table 9. Two much smaller RCTs compared management at 32°C versus 34°C, 32°C versus 33°C, and 33°C versus 34°C, finding no statistically significant difference for any of the comparisons.[76,77]

Table 9. Effect on Critical Outcomes of Temperature Control at 36°C Compared With 33°C

Outcomes (importance)	Participants, studies	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Favorable neurologic outcome at 180 days (critical)	933 patients, 1 RCT[75]	Low	0.98 (0.86–1.13)	10 patients fewer/1000 (68 fewer–63 more)
Survival at 180 days (critical)	939 patients, 1 RCT[75]	Low	0.99 (0.88–1.12)	5 patients fewer/1000 (63 fewer–63 more)
Favorable neurologic outcome at discharge (critical)	938 patients, 1 RCT[75]	Low	0.96 (0.83–1.11)	18 patients fewer/1000 (78 fewer–50 more)

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; RCT, randomized controlled trial; and RR, risk ratio.

Duration of cooling: A single RCT[78] including 451 patients found no statistically significant difference in survival or favorable neurologic outcome at 6 months between 48 hours and 24 hours of temperature control with hypothermia.

Method of temperature control: Three RCTs[79-81] including a total of 523 patients found no difference in survival or favorable neurologic outcome at hospital discharge/28 days with endovascular cooling compared with surface cooling devices.

Rewarming: No studies were identified evaluating rewarming strategies.

Treatment Recommendations

We suggest actively preventing fever by targeting a temperature $\leq$37.5℃ 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℃ to 34℃ 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 IV 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).

We suggest active prevention of fever for at least 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 A.

In making these recommendations, the ALS Task Force agreed that we should continue to recommend active temperature control to prevent fever in post–cardiac arrest patients, although the evidence for this is limited.

The ALS Task Force also discussed the terminology of temperature control and felt that current terminology is somewhat problematic. The term *TTM* on its own is not helpful, and it is preferable to use the terms *active temperature control*, *hypothermia*, *normothermia*, or *fever prevention*. The ALS Task Force has also avoided use of the term *TTM* because this term is now very closely linked with the TTM and TTM2 RCTs. To provide additional clarity for interpreting future clinical trials, SysRevs, and CoSTRs, the Task Force proposes the following terms be used:

- *Temperature control with hypothermia*: Active temperature control with the target temperature below the normal range

- *Temperature control with normothermia*: Active temperature control with the target temperature in the normal range

- *Temperature control with fever prevention*: Monitoring temperature and actively preventing and treating temperature above the normal range

- *No temperature control*: No protocolized active temperature control strategy

The majority of the ALS Task Force favored fever prevention as a strategy over hypothermia, on the basis of evidence and because this intervention requires fewer resources and had fewer side effects than hypothermia treatment. The specifics of how normothermia was achieved were thought important, and the Task Force noted that in the TTM2 trial[60] pharmacological measures (acetaminophen), uncovering the patient, and lowering ambient temperature were used to maintain a temperature of 37.5°C (99.5°F) or lower in the

normothermia/fever prevention group. If the temperature was higher than 37.7°C (99.9°F), a cooling device was used and set at a target temperature of 37.5°C (99.5°F). Ninety-five percent of patients in the hypothermia group and 46% in the fever prevention group received temperature control with a device.

Several members of the task force wanted to leave open the option to use hypothermia (33°C). The discussions included the following:

- No trials have shown that normothermia is better than hypothermia.

- Among nonshockable cardiac arrest patients, the Hyperion trial[63] showed better survival with favorable functional outcome in the hypothermia group (although 90-day survival was not significantly different, and the Fragility Index was only 1).

- The largest temperature control studies have mainly included cardiac arrests with a primary cardiac cause, and this may not reflect the total population of post–cardiac arrest patients treated.

- Concerns were raised that the TTM2 trial cooling rates, which were similar to other studies, were too slow and that the time to target temperature was outside the therapeutic window.

- There was a unanimous desire to leave open the opportunity for further research on post–cardiac arrest hypothermia.

- Finally, there were concerns that poor implementation of temperature control may lead to patient harm—for example, the publication of the TTM trial in 2013 may have led to some clinicians abandoning temperature control after cardiac arrest, which in turn was associated with worse outcomes.[82-84]

- The comparison between 33°C versus 36°C was included in a sensitivity analysis of 33°C versus normothermia/fever prevention—this did not change the point estimates.

- The task force made a good practice statement supporting the avoidance of active warming of patients who have passively become mildly hypothermic (eg, 32°C–36°C) immediately after ROSC because there was concern that rewarming may be a harmful intervention. In the TTM2 trial, patients in the normothermia/fever prevention arm who had an initial temperature above 33°C were not actively warmed.[60] In the Hyperion trial, patients allocated to normothermia whose temperature was below 36.5°C at randomization were warmed at 0.25°C to 0.5°C/hour and then maintained at 36.5°C to 37.5°C.[63]

The recommendation about prehospital cooling is unchanged from 2015 because we found no evidence that any method of prehospital cooling improved outcomes. The ALS Task Force recommends against the rapid infusion of large volumes of cold fluid immediately after ROSC in the prehospital setting because of higher rates of rearrest and pulmonary edema with that intervention in the largest of the included studies.[71]

There was no consensus on whether a feedback (versus no feedback) cooling device should be used routinely, so this was added as a good practice statement because there is no evidence that this approach improves outcomes. There was consensus that temperature should be continually monitored by the cooling device to enable active control of temperature and to maintain a stable temperature. There was a comment that endovascular cooling may be superior for temperature control—there are 2 recent SysRevs with conflicting conclusions.[85,86]

Our treatment recommendation on duration of temperature control is a good practice statement based on trials controlling temperature for at least 72 hours in those patients who remained sedated or comatose.

Task Force Knowledge Gaps

- Whether fever prevention changes outcome compared with no temperature control

- The effect of temperature control after extracorporeal CPR

- The effect of temperature control after in-hospital cardiac arrest (IHCA)

- 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) on the basis of the severity of brain injury

- Whether there are 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

Point-of-Care Ultrasound as a Diagnostic Tool During Cardiac Arrest (SysRev)

Rationale for Review

A SysRev of the diagnostic accuracy of point-of-care ultrasound (POCUS) was prioritized by the ALS Task Force because ultrasound use during CPR continues to grow in popularity, often with the goal of identifying a reversible cause of arrest that can then be treated. This CoSTR focuses entirely on POCUS as a diagnostic tool and does not replace the 2021 CoSTR on POCUS as a prognostic tool during CPR.[87] The diagnostic SysRev was registered on PROSPERO (registration CRD42020205207),[88] and the full text of the CoSTR can be found online.[89]

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

- **Population:** Adults with cardiac arrest in any setting

- **Intervention:** A particular finding on POCUS during CPR

- **Comparator:** An external confirmatory test or process including some component other than POCUS

- **Outcome:** *Important*—A specific etiology or pathophysiologic state that may have led to cardiac arrest

- **Study design:** Randomized and nonrandomized trials, cohort studies (prospective and retrospective), and case control studies with data on both POCUS findings and an external reference standard to contribute to a contingency table (ie, true positive, false positive, false negative, true negative). Animal studies, ecological studies, case series, case reports, narrative reviews, abstracts, editorials, comments, letters to the editor, or unpublished studies were not included.

- **Time frame:** All years and all languages were included if there was an English abstract. The literature search was updated through October 6, 2021.

Consensus on Science

The overall certainty of evidence was rated as very low for diagnosis of all target conditions primarily because of risk of bias, inconsistency, and imprecision. Because of critical risk of bias across all included studies and a high degree of clinical heterogeneity, no meta-analyses could be performed and individual studies are difficult to interpret.

Only a single observational study[90] provided sufficient information to calculate sensitivity and specificity of POCUS for specific pathophysiologic states, and these results are summarized in Table 10.

Table 10. Sensitivity and Specificity of POCUS for 3 Potential Arrest Etiologies From a Single Study*[90]

Target condition	Participants, n	Certainty of evidence (GRADE)	Sensitivity (95% CI)	Specificity (95% CI)
Cardiac tamponade	48	Very low	1.00 (0.29–1.00)	1.00 (0.88–1.00)
Pulmonary embolism	48	Very low	1.00 (0.16–1.00)	0.97 (0.82–0.99)
Myocardial infarction	48	Very low	0.86 (0.57–0.98)	0.94 (0.71–0.99)

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; and POCUS, point-of-care ultrasound.
*The reference was autopsy and/or clinical adjudication in all cases.

For the target conditions of cardiac tamponade, pericardial effusion, pulmonary embolism, myocardial infarction, aortic dissection, and hypovolemia, 11 observational studies[91-101] with high risk of bias provided sufficient data to estimate individual positive predictive values only among small subsets of between 1 and 10 patients with OHCA, IHCA, or intra-operative cardiac arrest. Individual estimates of positive predictive value have very wide CIs and are difficult to interpret in the context of the very small subsets of subjects.

Treatment Recommendations

We suggest against routine use of point of care ultrasound during CPR to diagnose reversible causes of cardiac arrest (weak recommendation, very low–certainty evidence).

We suggest that if point of care ultrasound can be performed by experienced personnel without interrupting CPR, it may be considered as an additional diagnostic tool when clinical suspicion for a specific reversible cause is present (weak recommendation, very low–certainty evidence).

Any deployment of diagnostic point of care ultrasound during CPR should be carefully considered and weighed against the risks of interrupting chest compressions and misinterpreting the sonographic findings (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

In making these recommendations, the ALS Task Force discussed that the inconsistent definitions and terminology used for sonographic evidence of specific causes of cardiac arrest was the primary source of clinical heterogeneity and that the establishment of uniform definitions and terminology to describe sonographic findings of reversible causes of cardiac arrest is very important.

The identified studies all have high risk of bias related to selection bias and ascertainment bias. Verification bias (when availability or use of the reference standard is influenced by test positive or test negative status) was present in all but one of the included studies. We strongly encourage subsequent investigations of POCUS during cardiac arrest to use methodology that mitigates these risks of bias, including standardized definition of time intervals for imaging acquisition, assessment of image quality, and experience of the sonographer, among others.

The task force discussed that the diagnostic utility of POCUS is affected by the clinical context. For example, a postoperative cardiac surgery patient with cardiac arrest may have a higher pretest probability for specific causes such as cardiac tamponade, pulmonary embolism, or acute hemorrhage. Conversely, the diagnostic utility of POCUS may be more limited in the context of undifferentiated cardiac arrest in the out-of-hospital setting.

Evidence showing that POCUS may increase the length of pauses in chest compressions was discussed as a very important consideration, especially given the lack of evidence for benefit from use of POCUS.[102,103] Some studies suggest transesophageal echocardiography can eliminate this problem.[104-106]

The task force noted that POCUS findings that may indicate myocardial infarction or pulmonary embolism outside of cardiac arrest may be much less specific during CPR. For

example, wall motion abnormalities may result from the ischemia of a low-flow state or a preexisting infarct, as opposed to a de novo myocardial infarction. Not treating a reversible cause of cardiac arrest risks failure of the resuscitation attempt or more severe post–cardiac arrest injury. Treating an incorrect diagnosis suggested by POCUS risks iatrogenic injury or delayed identification of the true underlying cause.

Because of the resources involved and the use of POCUS in current clinical practice, the task force expects that most diagnostic applications of POCUS will occur in a hospital-based setting as opposed to the prehospital setting.

The prognostic utility of POCUS to predict clinical outcomes is covered in a separate PICOST.[89]

Task Force Knowledge Gaps

- The diagnostic accuracy of POCUS during cardiac arrest using methodology that sufficiently minimizes risk of bias, especially selection bias, ascertainment bias, and verification bias

- Uniform definitions and terminology to describe sonographic findings of reversible causes of cardiac arrest or the associated reference standards

- The inter-rater reliability of POCUS diagnostic findings during cardiac arrest

- Resource requirements, cost-effectiveness, equity, acceptability, or feasibility of POCUS use during CPR

- Whether use of POCUS during CPR changes patient outcomes

Use of Vasopressin and Corticosteroids During Cardiac Arrest (SysRev)

Rationale for Review

This topic was prioritized by the ALS Task Force for consideration following the

publication of a recent RCT[107] and a subsequent SysRev with individual patient data meta-

analysis, which was identified as suitable for adolopment.[108] The full text of the CoSTR can be

found online.[109]

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

- **Population:** Adults with cardiac arrest in any setting

- **Intervention:** Administration of the combination of vasopressin and corticosteroids during

  CPR

- **Comparator:** Not using vasopressin and corticosteroids during CPR

- **Outcome:**

  – Critical: Health-related quality of life; survival with favorable functional outcome at

    discharge, 30, 60, 90 or 180 days and/or 1 year; survival at discharge, 30, 60, 90 or 180

    days and/or 1 year

  – Important: ROSC

- **Study design:** RCTs were eligible for inclusion. Observational studies and unpublished

  studies (eg, conference abstracts, trial protocols) were excluded.

- **Time frame:** All years and all languages were included if there was an English abstract.

Consensus on Science

Three RCTs[107,110,111] were identified, all of which included patients with IHCA only.

In-Hospital Cardiac Arrest

One of the included trials,[107] which enrolled 501 patients, assessed health-related quality of life at 90-days measured by the EuroQol 5 Dimension 5 Level tool. Data were available from all 44 patients who survived to 90 days, and there was no difference in the EuroQol 5 Dimension 5 Level.

Results from the meta-analysis of the 3 included RCTs for other clinical outcomes are presented in Table 11.

Table 11. Meta-Analysis of Effect of Vasopressin and Corticosteroids on Clinical Outcomes

Outcomes (importance)	Participants, studies	Certainty of evidence (GRADE)	OR (95% CI)	Anticipated absolute effects
Favorable functional outcome at hospital discharge (critical)	869 patients, 3 RCTs[107,110,111]	Low	1.64 (0.99–2.72)	37 patients more/1000 (1 fewer–93 more)
Survival to discharge (critical)	869 patients, 3 RCTs[107,110,111]	Low	1.39 (0.90–2.14)	34 patients more/1000 (9 fewer–91 more)
ROSC (important)	869 patients, 3 RCTs[107,110,111]	Moderate	2.09 (1.54–2.84)	181 more/1000 (108 more–249 more)

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; OR, odds ratio; RCT, randomized controlled trials; and ROSC, return of spontaneous circulation.

Out-of-Hospital Cardiac Arrest

We did not find any evidence specific to OHCA. Therefore, all the results for this population were the same, with the evidence downgraded for indirectness for the OHCA population.

Treatment Recommendations

We suggest against the use of the combination of vasopressin and corticosteroids in addition to usual care for adult in-hospital cardiac arrest due to low confidence in effect estimates for critical outcomes (weak recommendation, low to moderate-certainty evidence).

We suggest against the use of the combination of vasopressin and corticosteroids in addition to usual care for adult out-of-hospital cardiac arrest (weak recommendation, very low– to low-certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

In making these recommendations, the ALS Task Force considered that the intervention (vasopressin and corticosteroids) given intra-arrest improved ROSC, but this did not clearly translate into an effect on other outcomes.

In all studies, the combination of vasopressin and corticosteroids was administered in addition to standard intra-arrest treatments, including epinephrine and defibrillation. The task force noted that the earlier 2 studies[110,111] reported improvements in outcomes beyond ROSC (eg, survival, favorable neurologic outcome), but these effects were not observed in the latest study.[107] The earlier 2 studies included post-ROSC corticosteroids in addition to the intra-arrest vasopressin and steroids, which was not the case in the more recent study. The earlier 2 studies were considered by the ILCOR ALS Task Force in 2015[112] to be not sufficiently generalizable (eg, high rate of asystolic cardiac arrest, low baseline survival rate) for the task force to make a treatment recommendation supporting the use of the combination of vasopressin and corticosteroids.

The task force noted that the incorporation of these drugs into ALS treatment would present practical challenges because the addition of new drugs would add complexity to current treatment protocols. This would particularly be the case in out-of-hospital settings and systems where corticosteroids are only available in powdered form, requiring reconstitution before use. This was thought not to be warranted at this time, given the low confidence in effect estimates

for any outcomes beyond ROSC, as well as the fact that only the earlier trials including post-ROSC steroids reported any difference in survival outcomes.

The task force noted that time to drug administration was longer in the trial when this was led by the cardiac arrest team[107] rather than dedicated research staff.[110,111] Time to drug administration would likely be markedly longer in the prehospital setting. We discussed the potential interaction between vasopressin and corticosteroids and the current uncertainty as to whether either drug alone or the combination was driving the observed effect on ROSC.

The potential value of an improvement in ROSC when there was no observed effect on longer-term outcomes was discussed. The task force has previously suggested some other interventions without a clear survival benefit (eg, amiodarone or lidocaine for refractory shockable rhythm). Those drugs, however, appear to have a survival benefit in some subgroups (ie, witnessed arrest), which was not clearly the case for vasopressin and steroids.

Task Force Knowledge Gaps

- Whether the combination of vasopressin and corticosteroids, in addition to current standard resuscitation, improves survival or favorable functional outcome

- Whether improvement in ROSC with the combination of vasopressin and corticosteroids is a result of the specific combination of drugs or if only one of the medications is producing the effect

- How timing of administration of the combination of vasopressin and corticosteroids during cardiac arrest modifies the effect

Post–Cardiac Arrest Coronary Angiography (SysRev)

Rationale for Review

A SysRev was conducted and a new CoSTR was generated on this topic for 2021.[87] The search was updated this year to incorporate a new RCT on this topic and to identify any other relevant studies since publication of the previous SysRev. The original review was registered on PROSPERO (registration CRD 42020160152).[113]

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

- **Population:** Unresponsive adults (>18 years of age) with ROSC after cardiac arrest

- **Intervention:** Emergent or early (2–6 hours) coronary angiography (CAG) with percutaneous coronary intervention (PCI) if indicated

- **Comparator:** Delayed CAG (within 24 hours)

- **Outcome:**

  - Critical: Survival to hospital discharge, functional survival to ICU or hospital discharge, survival at 30, 90, and 180 days, functional survival at 30, 90, and 180 days

  - Important: Survival at 24 hours, coronary artery bypass graft, successful PCI, PCI frequency and adverse events of brain damage, recurrent cardiac arrest, arrhythmias, pneumonia, bleeding, acute worsening renal failure, injury or replacement therapy, shock, sepsis

- **Study design:** RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion for the 2021 CoSTR. Unpublished studies (eg, conference abstracts, trial protocols), case series, and case

reports were excluded. For this 2022 update, only additional RCTs published since the prior search were included.

- **Time frame:** All years and all languages were included if there was an English abstract. The initial search was run on April 29, 2020. For the 2022 update, the search was re-run on January 7, 2022.

Consensus on Science

One new RCT and 1 secondary analysis of a previous RCT were identified.[114,115] This enabled additional meta-analyses of several critical outcomes for patients with no ST-segment elevation on a post-ROSC electrocardiogram, and these results are included here by subgroup of initial rhythm.

All Initial Rhythms and No ST-Segment Elevation

No statistically significant difference was noted in any of the critical outcomes comparing early CAG with late or no CAG. The updated results are presented in Table 12. Previously reported results from single studies are included in the full online CoSTR.[116]

Table 12. Meta-analysis Results for Effect of Early Versus Late or No CAG in Patients With Any Initial Rhythm and No ST-Segment Elevation After Cardiac Arrest

Outcomes (importance)	Participants, studies	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Functional survival at 30 days (critical)	629 patients, 2 RCTs[114,117]	Low	0.92 (0.66–1.29)	30 patients fewer/1000 (146 fewer–103 more)
Survival to 30 days (critical)	629 patients, 2 RCTs[114,117]	Low	0.96 (0.70–1.33)	18 patients fewer/1000 (174 fewer–135 more)
PCI frequency (important) Intention to treat analysis (all randomized patients)	629 patients, 2 RCTs[114,117]	High	1.37 (1.07–1.74)	94 more/1000 (20 more–174 more)
PCI frequency (important)	485 patients, 2 RCTs[114,117]		0.86 (0.68–1.07	62 fewer/1000 (143 fewer–28 more)

Outcomes (importance)	Participants, studies	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Per protocol analysis (only patients who received angiography)				

CAG indicates coronary angiography; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; PCI, percutaneous intervention; RCTs, randomized controlled trials; and RR, relative risk.

Shockable Initial Rhythm, No ST-Segment Elevation

The new RCT[114] enrolled patients with all initial rhythms but provided a subgroup

analysis of patients with initial shockable rhythm. A meta-analysis including the new data from

the RCT as well as new data from a long-term outcome analysis of a previous trial[115] is presented

in Table 13. Results from single studies and all results with no new data from the 2021 CoSTR

are available in the full online CoSTR.[116]

Table 13. Meta-analysis Results for Effect of Early Versus Late or No CAG in Patients With Initial Shockable Rhythm and No ST-Segment Elevation After Cardiac Arrest

Outcomes (importance)	Participants, studies	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Survival to hospital discharge/30 days (critical)	552 patients, 2 RCTs[114,118]	Low	0.96 (0.84–1.10)	25 patients fewer/1000 (112 fewer–55 more)
Quality of life per RAND-36 physical score (critical)	235 patients, 1 RCT[115]	Very low	No difference in mean values	Not applicable
Quality of life per RAND-36 mental score (critical)	235 patients, 1 RCT[115]	Very low	No difference in mean values	Not applicable

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; RAND-36, RAND Corporation 36-Item Short Form Survey; RCT, randomized controlled trial; RR, relative risk; MD, mean difference; IQR, interquartile range

All Initial Rhythms With ST-Segment Elevation

No new evidence was identified for this group. Previously reported evidence showed no

statistically significant difference in outcomes based on early angiography or no early

angiography. These results are presented in more detail in the online CoSTR.[116]

Adverse Events

New meta-analyses were performed that included the 1 additional RCT identified since the last review.[114] No significant differences were seen in any of the reported adverse outcomes, including ischemic stroke, intracranial bleeds, recurrent cardiac arrest, cardiac arrhythmias, pneumonia, acute pulmonary edema, bleeding, and acute kidney failure. Additional details, including meta-analysis results, are included in the online CoSTR.[116]

Treatment Recommendations

When coronary angiography is considered for comatose post-arrest patients without ST elevation, we suggest that either an early or a delayed approach for angiography is reasonable (weak recommendation, low-certainty evidence).

We suggest early coronary angiography in comatose post–cardiac arrest patients with ST-segment elevation (good practice statement).

Justification and Evidence-to-Decision Framework

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

This updated review used the search strategy from the 2021 CoSTR,[87] restricting the inclusion criteria to RCTs only. We found 1 new RCT[114] and 1 analysis of long-term outcomes from a previously included RCT.[115] The new RCT enabled additional meta-analyses for some critical outcomes, but the overall results, and therefore the treatment recommendations, remain unchanged.

Without ST-Segment Elevation

In making the above recommendations, the ALS Task Force weighed the fact that we did not find sufficient evidence to demonstrate improved outcomes with early angiography for post–

cardiac arrest patients without ST-segment elevation regardless of presenting cardiac arrest rhythm (shockable or nonshockable). Patients in cardiogenic shock postarrest were excluded from all studies, and there is unlikely to ever be clinical equipoise to support a randomized trial of delayed intervention in the shock cohort. There may be subgroups of patients without ST-segment elevation with high-risk features that would benefit from earlier CAG.

Importantly, this review examined early coronary angiography, compared with a combined control group of late coronary angiography and/or no coronary angiography. It may be that survival and functional survival may not be the right outcomes to measure harm or benefit from an intervention that adjusts the timing of PCI in postarrest patients. We know that most patients admitted to hospital after cardiac arrest do not die from cardiac complications but instead die as a result of neurologic injury. There are no significant differences in adverse event rates with either time interval.

With ST-Segment Elevation

For comatose patients with ST-segment elevation, there is no randomized clinical evidence for the timing of CAG. The task force acknowledges that early CAG, and percutaneous intervention if indicated, is the current standard of care for patients with ST-segment elevation myocardial infarction who did not have a cardiac arrest. We found no compelling evidence to change this approach in patients with ST-segment elevation after cardiac arrest.

Knowledge Gaps

- Lack of a consistent definition for comparable time intervals to treatment for early compared with late angiography and PCI
- Whether early CAG improves survival/survival with favorable neurologic outcome for postarrest patients with ST-segment elevation

- Whether angiography, compared with no angiography, improves outcomes in postarrest patients

- Whether angiography and PCI may improve outcomes in the no ST-segment elevation cohort who present in shock

- Whether CAG changes outcomes after IHCA

- Evidence for longer term outcomes is limited

- Relatively few studies examining health related quality of life outcomes

- Whether newer or alternative endpoints such as functional or biochemical measures may show a benefit with timing of CAG in cardiac arrest patients

Topics Reviewed by EvUps

The topics reviewed by EvUps are summarized in Table 14, with the PICO number, existing treatment recommendation, number of relevant studies identified, key findings, and whether a SysRev was deemed worthwhile. Complete EvUps can be found in Appendix C.

Table 14. Topics Reviewed by EvUps

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
Vasopressors during cardiac arrest (ALS 659)	2019 CoSTR	We recommend administration of epinephrine during cardiopulmonary resuscitation (strong recommendation, low- to moderate-certainty evidence). For nonshockable rhythms (PEA/asystole), we recommend administration of epinephrine as soon as	0 (2 substudies of a prior RCT identified)	10	Studies support the effect of survival but uncertain effect on functional outcome. Observational studies continue to be limited by resuscitation time bias.	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		feasible during cardiopulmonary resuscitation (strong recommendation, very low–certainty evidence). For shockable rhythms (VF/pVT), we suggest administration of epinephrine after initial defibrillation attempts are unsuccessful during cardiopulmonary resuscitation (weak recommendation, very low–certainty evidence). We suggest against the administration of vasopressin in place of epinephrine during cardiopulmonary resuscitation (weak recommendation, very low–certainty evidence). We suggest against the addition of vasopressin to epinephrine during cardiopulmonary resuscitation (weak recommendation, low-certainty evidence).				
Cardiac arrest from PE (ALS 581)	2020 CoSTR	We suggest administering fibrinolytic drugs for cardiac arrest when PE is the suspected cause of cardiac arrest (weak recommendation, very low–certainty evidence).	0	4	Small studies that do not change management; there is a need for an EvUp focusing on	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		We suggest the use of fibrinolytic drugs or surgical embolectomy or percutaneous mechanical thrombectomy for cardiac arrest when PE is the known cause of cardiac arrest (weak recommendation, very low certainty of evidence). The role of extracorporeal life support (ECPR) techniques has been addressed in the 2019 ILCOR CoSTR. We suggest that ECPR may be considered as a rescue therapy for selected patients with cardiac arrest when conventional CPR is failing in settings in which it can be implemented (weak recommendation, very low–certainty evidence).			ECPR for cardiac arrest from PE.	

CoSTR indicates International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations; CPR, cardiopulmonary resuscitation; ECPR, extracorporeal cardiopulmonary resuscitation; EvUp, evidence update; ILCOR, International Liaison Committee on Resuscitation; PE, pulmonary embolism; PEA, pulseless electrical activity; PICO, population, intervention, comparator, outcome; pVT, pulseless ventricular tachycardia; RCT, randomized controlled trial; SysRev, systematic review; and VF, ventricular fibrillation.

PEDIATRIC LIFE SUPPORT

Public-Access Devices (SysRev)

Rationale for Review

This topic was chosen because of growing literature on the inclusion of children in public-access defibrillation programs, the increasing use of AEDs for children generally, and the wider availability of AEDs in the community. The review was conducted on behalf of both the PLS and BLS Task Forces (PROSPERO Registration CRD42017080475), and the full text of this CoSTR is available on the ILCOR website.[119]

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

- **Population:** Infants, children, and adolescents with nontraumatic out-of-hospital cardiac arrest

- **Intervention:** Application of, or shock delivery from, an AED by lay rescuers

- **Comparator:** Standard care by lay rescuer without AED application

- **Outcome:**

  - Critical: survival and functional outcome at hospital discharge

  - Important: ROSC. Other outcomes as available

- **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.

- **Time frame:** All years and all languages were included if there was an English abstract. The initial search was done on January 25, 2021, and updated on November 3, 2021.

Consensus on Science

The search identified 1163 unique articles, and 4 observational studies were included. Three papers[120-122] were from the Cardiac Arrest Registry to Enhance Survival (CARES) database in the United States. The data reported did not correspond to the PICOST question in a usable manner, although AED use was part of the analyses. Raw data provided by the CARES registry included the number of children who had a cardiac arrest, age groups of those children, the number who had an AED applied, and the outcomes at hospital discharge. From those numbers, the relative risk of survival if an AED was applied was calculated. Because there were several studies from the Japanese Fire and Disaster Management Agency with overlapping dates for data inclusion, the last article[123] (the most time-inclusive) was chosen to avoid duplication of data.

Given the age-dependent risk of a shockable rhythm and age-dependent chance of survival, we analyzed the data in 3 age groups: less than 1 year of age, 1 to 12 years of age, and 13 to 18 years of age. The overall certainty of evidence was rated as very low for all outcomes, and the risk of bias was too high to enable meta-analysis. Table 15 summarizes the relative risks for the critical outcomes of Cerebral Performance Category (CPC) 1 to 2 at 1 month, CPC 1 to 2 at hospital discharge, and hospital discharge and bystander CPR with AED.

Table 15. Summary of Outcomes for Children for Whom an AED Was Applied, Compared With Those With No AED Applied, by Age Group

Age, years	Hospital discharge RR (95% CI)	CPC 1 to 2 at hospital discharge RR (95% CI)	CPC 1 to 2 at 1 month RR (95% CI)
<1[120-122]	1.43 (0.22–9.37)	1.82 (0.28–11.96)	
1–12[120-122]	3.04 (2.18–4.25)	3.85 (2.69–5.5)	
13–18[120-122]	3.38 (2.74–4.16)	3.75 (2.97–4.72)	
0–17 years[121]	1.55 (1.12–2.12)	1.49 (1.11–1.97)	
6–17 years[123]			12.12 (4.97–17.12)

AED indicates automatic external defibrillator; CPC, Cerebral Performance Category; CPR, cardiopulmonary resuscitation; and RR, relative risk.

Treatment Recommendations

We suggest the use of an AED by lay rescuers for all children over age 1 year who have non-traumatic out-of-hospital cardiac arrest (weak recommendation, very low-certainty evidence).

We cannot make a recommendation for or against the use of an AED by lay rescuers for all children below age 1 year suffering non-traumatic out-of-hospital cardiac arrest.

Justification and Evidence-to-Decision Framework Highlights

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

For Children More Than 1 Year of Age

In making these recommendations, the PLS Task Force considered that in all of the included studies, only a small percentage of children had an AED applied or shock delivered. The evidence showed that 120 out of 7591 children from the CARES database had an AED applied and 220 out of 5899 children in the Japanese study had a shock delivered.[120-123] In making a weak recommendation, we considered the high relative risk and the relatively low number needed to treat for improved hospital discharge and favorable neurologic outcomes at hospital discharge or 30 days but recognized that relatively few patients had an AED applied. There may be significant selection bias in those children who had the AED applied. The rescuers who applied the AED may be those who had a greater skillset and, thus, provided higher-quality CPR. In addition to treating shockable rhythms, AEDs provide instructions about CPR, which may help lay rescuers to perform CPR even if a shock is not required and dispatch instructions are not available.

The task force did not evaluate outcomes with chest compressions only versus chest compressions with rescue breaths because of the few children who had AEDs applied. There was substantial discussion about the potential for harm in applying an AED by delaying CPR and increasing the number and duration of pauses. In making a final recommendation, we acknowledged that the data were from nonselected rescuers and those events likely occurred, but the relative risks were still significantly in favor of AED application.

For Children Less Than 1 Year of Age

The task force had a robust discussion about this treatment recommendation. In making no recommendation about the use of AEDs in children less than 1 year of age, the task force considered the lack of a significant difference in outcomes. However, few patients in this age group had an AED applied (12), and only 1 survived. This may have resulted in a type II error and, thus, the task force did not make any recommendation. The task force recognized that there is a small population of infants who do have shockable rhythms, mainly those with inherited arrhythmia syndromes or hypoxemia. These infants could benefit from AED application. In the absence of dispatch CPR instructions, AEDs assist lay rescuers by providing CPR instructions, which could increase survival in infants without shockable rhythms.

Knowledge Gaps

- Absence of RCTs of AED use in children
- The interaction between high-quality CPR and the effect of AED application. This is particularly important in light of the importance of rescue breaths with chest compressions in pediatric cardiac arrest.

- Whether AED application alters outcomes on the basis of the type of CPR provided, ie, potential delay in initiating chest compressions, chest compression–only CPR, or conventional CPR with compressions and rescue breathing

- Whether AED application affects survival/functional survival beyond 30 days

- Whether there are possible advantages to using the pediatric modifications for younger children, especially those less than 8 years of age or who weigh less than 25 kg

- Whether the application of an AED is beneficial beyond shock delivery, such as by directing the rescuer to the appropriate actions. The mechanisms of potential human factors and behavioral change are not understood.

Pediatric Early Warning Systems (PEWS) With or Without Rapid Response Teams (SysRev)

Rationale for Review

This SysRev was prompted by our scoping review of Pediatric Early Warning Scores conducted in 2020,[124] and was undertaken to review our current treatment recommendations for Pediatric Early Warning Systems (PEWS) (PROSPERO Registration CRD42021269579). PEWS encompass both the use of an early warning score and a protocolized response to that score. The full text of this CoSTR can be found on the ILCOR website.[125]

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

- **Population:** Infants, children, and adolescents in any inpatient setting

- **Intervention:** PEWS with or without rapid response teams or medical emergency teams

- **Comparator:** No PEWS or standard care (without a scoring system)

- **Outcome:**

– Critical: significant clinical deterioration event, including but not limited to (1) unplanned/crash tracheal intubation, (2) unanticipated fluid resuscitation and inotropic/vasopressor use, (3) CPR or extracorporeal membrane oxygenation, and (4) death in patients (all-cause mortality) without a do not attempt resuscitate order:

– Important: unplanned code events

- **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.

- **Time frame:** All years and all languages were included if there was an English abstract. Literature search was updated to June 26, 2021.

Consensus on Science

We identified 12 studies with 1 RCT[126] and 11 cohort studies[127-137] for inclusion in our SysRev (Table 16). The overall certainty of evidence was rated as very low (downgraded for very serious risk of bias and very serious imprecision) for all outcomes. Results are summarized in Table 16.

Table 16. Summary of the Effect of Use of PEWS Compared With No PEWS on Patient Outcomes

Outcomes	Number/type of studies	RR (95% CI)	Comments
Mortality (critical)	1 RCT[126]	1.24 (0.95–1.62)	There was no significant difference in mortality with no PEWS compared with PEWS. Pooled analysis demonstrated a trend for increased mortality when no PEWS was used compared with PEWS.
	9 cohort studies[127-135]	Pooled RR 1.17 (0.98–1.40)	
Cardiopulmonary arrest events (critical)	6 cohort studies[128-131,135,136]	Pooled IRR/RR, 1.22 (0.93–1.59)	There was a trend for increased cardiopulmonary arrest events with no PEWS compared with PEWS, but this was not statistically significant.
	1 RCT[126]	1.67 (1.34–2.08)	

Outcomes	Number/type of studies	RR (95% CI)	Comments
Significant deterioration events (critical)	5 cohort studies[127,128,132,133,137]	Pooled RR, 1.09 (0.84–1.42)	Pooled analysis of all studies demonstrated a non–statistically significant trend of increased significant clinical deterioration events with no PEWS compared with PEWS; limited by heterogeneity.
Unplanned code events (important)	4 cohort studies[129,131,132,134]	Pooled IRR/RR, 1.73 (1.01–2.96)	There was a statistically significant increase in unplanned code events when no PEWS was compared with PEWS.

IRR indicates incidence rate ratio; PEWS, pediatric early warning systems; RCT, randomized controlled trial; and RR, relative risk.

Treatment Recommendations

We suggest using pediatric early warning systems to monitor hospitalized children, with the aim of identifying those who may be deteriorating (weak recommendation, low-certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The full evidence-to-decision table is provided in Appendix A.

In making these recommendations, the PLS Task Force considered the following:

PEWS should be part of an overall clinical response system, with the task force placing a higher value on improving healthcare providers' ability to recognize and intervene for patients with deteriorating illness over the expense incurred by a healthcare system committing significant resources to implement these systems. The task force also noted that the complex process of optimizing patient care is likely to include both the implementation of PEWS and ongoing education for healthcare providers. The PLS Task Force agreed that the decision to use PEWS should be balanced between use of existing resources and capabilities of the healthcare setting to adapt to its use and the consequences of its use.

In the limited available evidence, there is equipoise about whether the use of PEWS significantly decreases in-hospital pediatric mortality, significant clinical deterioration, and cardiopulmonary arrest events. However, in systems with available resources that prioritize and value the potential to decrease the incidence of code events for inpatient pediatric patients, there was very weak evidence to support the use of PEWS in this context.

The task force recognized the significant limitations of the available evidence in its treatment recommendations but also the importance and the potential value of improving healthcare providers' ability to recognize and intervene for patients with deteriorating illness. For settings already using PEWS, local validation, site-specific adaptation of its use, and longitudinal evaluation of its effectiveness are important.

Task Force Knowledge Gaps

- Whether PEWS decrease pediatric cardiopulmonary arrest or improve mortality

- The relative contribution of PEWS and other practice changes aimed at quality improvement (including educational processes, documentation review with feedback systems, and modification of other factors thought to improve the delivery of care) to changes in patient outcomes. Controlled trials and quality improvement methodology is suggested for further studies.

- The effect of rapid response teams, alone and in combination with PEWS

- Whether the effect of PEWS and/or rapid response teams varies by setting and patient type (eg, emergency department, pediatric oncology patients, patients in higher- vs lower-resource settings)

- Prospective evaluations of different PEWS for predicting, identifying, and providing early intervention for patients at risk for different forms of decompensation, including primary respiratory, circulatory, and neurologic etiologies

- Effectiveness of various methods for PEWS implementation and staff training; data on feasibility, cost-effectiveness, equity, and acceptability of integrating PEWS into existing healthcare systems

Topics Reviewed by Evidence Updates

The topics reviewed by EvUps are summarized in Table 17, with the PICO number, existing treatment recommendation, number of relevant studies identified, key findings, and whether a SysRev was deemed worthwhile. Complete EvUps can be found in Appendix C.

Table 17. Summary of PLS 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?
Sequence of chest compressions and ventilations: C-A-B versus A-B-C (Peds 709)	2020 CoSTR	The confidence in effect estimates is so low that the panel decided a recommendation was too speculative.	0	0	No new studies were identified.	No
Chest compression–only CPR versus conventional CPR (Peds 414)	2020 EvUp 2017 CoSTR	We recommend that rescuers provide rescue breaths and chest compressions for pediatric IHCA and OHCA. If rescuers cannot provide rescue breaths, they should at least perform chest compressions (strong recommendation, low-quality evidence).	0	1	One published study supports our current recommendations.	No
Drugs for the treatment of bradycardia (PLS NEW)	2020 EvUp 2010 CoSTR	Epinephrine may be administered to infants and children with bradycardia and	0	3	Three papers were identified: 2 showed an	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?
		poor perfusion that is unresponsive to ventilation and oxygenation. It is reasonable to administer atropine for bradycardia caused by increased vagal tone or anticholinergic drug toxicity. There is insufficient evidence to support or refute the routine use of atropine for pediatric cardiac arrest.			association between epinephrine use and worse outcome while 1 showed no difference, although epinephrine use was not the objective for this study. The current evidence is not enough to change the current recommendations and, thus, should not prompt a review.	
Emergency transcutaneous pacing for bradycardia (PLS NEW)	2020 EvUp 2020 CoSTR	In selected cases of bradycardia caused by complete heart block or abnormal function of the sinus node, emergency transthoracic pacing may be lifesaving. Pacing is not helpful in children with bradycardia secondary to a postarrest hypoxic/ischemic myocardial insult or respiratory failure. Pacing was not shown to be effective in the treatment of asystole in children.	0	0	No new studies were identified.	No
Extracorporeal CPR for pediatric cardiac arrest (Peds 407)	2019 CoSTR	We suggest that ECPR may be considered as an intervention for selected infants and children (eg, cardiac populations) with IHCA refractory to conventional CPR in settings where	0	15	Fifteen studies were identified and, collectively, their findings did not provide sufficient evidence to change the	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?
		resuscitation systems allow ECPR to be well performed and implemented (weak recommendation, very low-certainty evidence). There is insufficient evidence in pediatric OHCA to formulate a treatment recommendation for the use of ECPR.			treatment recommendations from 2019.	
Intraosseous versus intravenous route of drug administration (PLS, part of nodal ALS 2046)	2020 CoSTR	Intraosseous cannulation is an acceptable route of vascular access in infants and children with cardiac arrest. It should be considered early in the care of critically ill children whenever venous access is not readily available.	0	2	There were 2 nonrandomized, observational studies. One reported worse outcomes with IO access while the other found no difference.	No
Sodium bicarbonate administration for children in cardiac arrest (PLS 388)	2020 EvUp\n\n2010 CoSTR	Routine administration of sodium bicarbonate is not recommended in the management of pediatric cardiac arrest.	0	0	No new studies were identified. A SysRev and meta-analysis were published, and this included 7 observational studies (2 prospective), published between 2006 and 2018. Results support our current recommendations.	No
Targeted temperature management*	2019 CoSTR	The PLS Task Force recommendations from 2020 for the pediatric population remain unchanged in 2021, with minor wording clarification of temperature targets:	0	8	No new RCTs were identified. There were 8 additional publications; however, 7 were secondary	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?
		We suggest that for infants and children who remain comatose following ROSC from OHCA or IHCA, active control of temperature be used to maintain a central temperature ≤37.5°C (weak recommendation, moderate-certainty evidence). There is inconclusive evidence to support or refute the use of induced hypothermia (32°C to 34°C) compared with active control of temperature at normothermia (36°C to 37.5°C) (or an alternative temperature) for children who achieve ROSC but remain comatose after OHCA or IHCA.			analyses of subgroups of the THAPCA RCT primary trial data for the OHCA, IHCA, or combined cohorts.	

A-B-C indicates airway-breaths-compressions; C-A-B, compressions-airway-breaths; CoSTR, International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations; CPR, cardiopulmonary resuscitation; ECPR, extracorporeal cardiopulmonary resuscitation; EvUp, evidence update; IHCA, in-hospital cardiac arrest; IO, intraosseous; OHCA, out-of-hospital cardiac arrest; PICO, population, intervention, comparator, outcome; PLS, pediatric life support; RCT, randomized controlled trial; ROSC, return of spontaneous circulation; SysRev, systematic review; THAPCA, Therapeutic Hypothermia After Pediatric Cardiac Arrest; and TTM, targeted temperature management.

*The International Liaison Committee on Resuscitation PLS Task Force issued "Post-Arrest Temperature Management in Children: Statement on Post Cardiac Arrest Temperature Management in Children" in November 2021,[138] following the CoSTR "Temperature Management in Adult Cardiac Arrest: Advanced Life Support Systematic Review" by the Advanced Life Support Task Force.[58]

NEONATAL LIFE SUPPORT

Maintaining Normal Temperature Immediately After Birth in Late Preterm and Term Infants (SysRev)

Rationale for Review

A previous SysRev conducted for ILCOR concluded that there was a dose-responsive association between hypothermia on admission to a neonatal unit or postnatal ward and increased risk of mortality and other adverse outcomes.[139] A systematic review estimated that hypothermia was common in infants born in hospitals (prevalence range, 32% to 85%) and homes (prevalence range, 11% to 92%), even in tropical environments.[140] A SysRev was initiated from a priority list from the ILCOR Neonatal Life Support (NLS) Task Force (PROSPERO; registration CRD42021270739).[Liley, 2022 ####] The full text of this review can be found on the ILCOR website.[141]

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

- **Population:** Late preterm and term newborn infants (≥34 weeks' gestation)

- **Intervention:** Increased room temperature 23.0°C or warmer, thermal mattress, plastic bag or wrap, hat, heating and humidification of gases used for resuscitation, radiant warmer (with or without servo control), early monitoring of temperature, warm bags of fluid, warmed swaddling/clothing, skin-to-skin care with a parent, or any combination of these interventions

- **Comparator:** Drying, without any of the above interventions, and comparisons between interventions

- **Outcome:**

  – Critical: Survival

- Important: Rate of normothermia on admission to neonatal unit or postnatal ward; rate of hypothermia and hyperthermia on admission to neonatal unit or postnatal ward; response to resuscitation (eg, need for assisted ventilation, highest F_{IO_2}). For this and all subsequent reviews, importance of outcomes was in accord with Strand et al[142] or by consensus of the task force for outcomes specific to each review. Additional outcomes are included in the full online CoSTR.[141] For the purposes of the review, the definitions in in Table 18 were used.[143]

Table 18. Temperature Terminology

Term	Body temperature	
Moderate hypothermia	$32.0°C–35.9°C$	Measured using a digital, mercury, or contactless thermometer (axillary, rectal, or other defined site), on admission to a postnatal ward or neonatal unit; or if admission temperature not reported, temperature measured between 30 and 60 min of age.
Cold stress	$36°C$ to $36.4°C$	
Hyperthermia	$>37.5°C$	

- **Study design:** RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies were excluded.

- **Time frame:** All years and all languages were included if there was an English abstract. The literature search was conducted to August 2, 2021.

Consensus on Science

The SysRev identified 35 studies (25 RCTs including 4625 participants[144-168] and 10 observational studies[169-178] including >3342 participants [number not reported in 1 study]). All RCTs had eligibility criteria that excluded some or all infants who were at high risk of needing resuscitation or who received resuscitation. The studies were conducted in high-, middle-, and

low-income countries, but few interventions were studied in all settings. None of the studies

included out-of-hospital births. Temperature outcomes were reported in a wide variety of ways,

constraining the meta-analysis. There were insufficient data to conduct any of the prespecified

subgroup analyses.

Comparison 1: Increased Room Temperature Compared With No Increased Room

Temperature for Late Preterm and Term Newborn Infants

The SysRev identified 1 cluster-RCT including 825 late preterm and term newborn

infants for this comparison.[151] All were born by caesarean section, so the study pertains

specifically to operating room temperatures and only temperatures of 20ºC and 23ºC were

compared. Data relating to the key critical and important outcomes for this comparison are

summarized in Table 19. Evidence for additional outcomes evaluated is included in the full

online CoSTR.[141]

Table 19. Increased Room Temperature Compared With No Increased Room Temperature for Late Preterm and Term Newborn Infants

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with room temperature 20ºC	RD with room temperature 23ºC
Normothermia on admission (important)	825 (1 RCT) Duryea et al,[151] 2016	Very low	1.26 (1.11–1.42)	449 per 1000	130 more infants per 1000 (55 more–209 more) were normothermic when 23ºC was used
Temperature on admission (important)	825 (1 RCT) Duryea et al,[151] 2016	Very low	Not applicable	Mean temperature 36.4°C	MD 0.3ºC higher (0.23ºC higher–0.37ºC higher) when 23ºC was used
Moderate hypothermia ($<36^0$C) (important)	825 (1 RCT) Duryea et al,[151] 2016	Very low	0.26 (0.16–0.42)	189 per 1000	140 fewer infants per 1000 (158 fewer–109 fewer) were moderately

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with room temperature 20ºC	**RD with room temperature 23ºC**
					hypothermic when 23ºC was used
Hyperthermia (>37.5ºC) (important)	825 (1 RCT) Duryea et al,[151] 2016	Very low	4.13 (0.88–19.32)	5 per 1000	15 more infants per 1000 (1 fewer–87 more) were hyperthermic when 23ºC was used

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; MD, mean difference; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

Comparison 2. Skin-to-Skin Care With a Parent Versus No Skin-to-Skin Care for Late

Preterm and Term Infants

The SysRev found 10 RCTs including 1668 late preterm and term newborn infants for this comparison.[147,149,153-156,159,162,163,165]

Data relating to key critical and important outcomes are shown in Table 20. Evidence for additional outcomes evaluated is included in the full online CoSTR.[141]

Table 20. Skin-to-Skin Care With a Parent Versus No Skin-to-Skin Care in Late Preterm and Term Newborn Infants

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with no skin-to-skin care	**RD with skin-to-skin care**
Survival to hospital discharge (critical)	203 (1 RCT) Ramani et al,[162] 2018	Very low	Insufficient events to determine the rate		
Normothermia on admission (important)	551 (3 RCTs) Ramani et al,[162] 2018 Safari et al,[163] 2018 Srivastava et al,[165] 2014	Very low	1.39 (0.91–2.12)	614 per 1000	239 more infants per 1000 (55 fewer–688 more) were normothermic when skin-to-skin care was used
Temperature on admission (important)	1048 (8 RCTs) Carfoot et al,[147] 2005	Very low	Not applicable	Mean temperature 36.5ºC	MD 0.32ºC higher (0.1ºC higher–0.54ºC

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with no skin-to-skin care	RD with skin-to-skin care
	Christensson et al,[149] 1992 Huang et al,[153] 2019 KoÇ et al,[155] 2017 Kollman et al,[156] 2017 Ramani et al,[162] 2018 Safari et al,[163] 2018 Srivastava et al,[165] 2014				higher) when skin-to-skin care was used
Hypoglycemia (Important)	100 (1 RCT) KoÇ et al,[155] 2017	Very low	0.16 (0.05–0.53)	326 per 1000	273 fewer infants per 1000 (309 fewer–153 fewer) were hypoglycemic when skin-to-skin care was used
Admission to NICU (Important)	512 (3 RCTs) Kollman et al,[156] 2017 Marín Gabriel et al,[159] 2010 Ramani et al,[162] 2018	Very low	0.34 (0.14–0.83)	70 per 1000	46 fewer infants per 1000 (60 fewer–12 fewer) were admitted to the NICU when skin-to-skin care was used

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; MD, mean difference; NICU, neonatal intensive care unit; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

Comparison 3. Plastic Bag or Wrap Compared With No Plastic Bag or Wrap for Late Preterm and Term Newborn Infants

The SysRev found 3 RCTs including 794 late preterm and term newborn infants for this comparison.[146,154,158,164] Data relating to key critical and important outcomes are shown in Table 21. Evidence for additional outcomes evaluated is included in the full online CoSTR.[141] Of note

this comparison included studies where infants had been dried or not dried prior to use of the

plastic bag or wrap.

Table 21. Plastic Bag or Wrap Compared With No Plastic Bag or Wrap for Late Preterm and Term Newborn Infants

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with standard care	RD with plastic bag or wrap plus standard care
Survival to hospital discharge (critical)	305 (2 RCTs) Leadford et al,[158] 2013 Shabeer et al,[164] 2018	Very low	0.95 (0.60–1.51)	981 per 1000	49 fewer infants per 1000 (392 fewer–500 more) died when a plastic bag or wrap was used
Normothermia on admission (important)	305 (2 RCTs) Leadford et al,[158] 2013 Shabeer et al,[164] 2018	Very low	1.50 (1.20–1.89)	406 per 1000	203 more infants per 1000 (81 more–3629 more) were normothermic when a plastic bag or wrap was used
Temperature on admission (important)	425 (3 RCTs) Cardona-Torres et al,[146] 2012 Leadford et al,[158] 2013 Shabeer et al,[164] 2018	Very low	Not applicable	Mean temperature 36.3ºC	MD 0.29ºC higher (0.2ºC higher–0.37ºC higher) when a plastic bag or wrap was used

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; MD; mean difference; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

Comparison 4. Plastic Bag or Wrap Combined With Skin-To-Skin Care Compared With Skin-To-Skin Care Alone for Late Preterm and Term Newborn Infants

The SysRev found 2 RCTs including 698 late preterm and term newborn infants for this

comparison.[145,167] Data relating to key critical and important outcomes are shown in Table 22.

Evidence for additional outcomes evaluated is included in the full online CoSTR.[141] This

comparison included studies where infants had been dried or not dried prior to use of the plastic

bag or wrap.

Table 22. Plastic Bag or Wrap Combined With Skin-to-Skin Care Compared With Skin-to-Skin Care Alone for Late Preterm and Term Newborn Infants

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with skin-to-skin care alone	RD with plastic bag or wrap plus skin-to-skin care
Survival to hospital discharge (critical)	271 (1 RCT) Belsches et al,[145] 2013	Low	All infants in both groups survived		
Normothermia on admission (important)	692 (2 RCTs) Belsches et al,[145] 2013 Travers et al,[167] 2021	Low	1.39 (1.08–1.79)	221 per 1000	86 more infants per 1000 more (18 more–174 more per 1000) were normothermic when a plastic bag or wrap was added
Temperature on admission (important)	692 (2 RCTs) Belsches et al, 2013[145] Travers et al, 2021[167]	Low	Not applicable	Mean body temperature 36.0ºC	MD 0.2ºC higher (0.1ºC higher–0.3ºC higher) when a plastic bag or wrap was added
Admission to NICU or special care unit (important)	275 (1 RCT) Belsches et al,[145] 2013	Low	0.26 (0.03–2.26)	29 per 1000	21 fewer infants per 1000 (28 fewer–36 more per 1000) were admitted to a NICU or special care unit when a plastic bag or wrap was added
Hyperthermia (>37.5°C) (important)	692 (2 RCTs) Belsches et al,[145] 2013 Travers et al,[167] 2021	Very low	1.02 (0.08–12.85)	3 per 1000	0 more infants per 1000 (3 fewer–34 more per 1000) were hyperthermic when a plastic bag or wrap was added

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; MD, mean difference; NICU, neonatal intensive care unit; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

For all other comparisons, no evidence-to-decision tables were developed, either because only single studies providing very low–certainty evidence were available or because no studies were found. Additional details on these comparisons are included in the online CoSTR.[141]

Treatment Recommendations

In late preterm and term newborn infants (≥34 weeks' gestation), we suggest the use of room temperatures of 23ºC compared to 20ºC at birth in order to maintain normal temperature (weak recommendation, very low–certainty evidence).

In late preterm and term newborn infants (≥34 weeks' gestation) at low risk of needing resuscitation, we suggest the use of skin-to-skin care with a parent immediately after birth rather than no skin-to-skin care to maintain normal temperature (weak recommendation, very low–certainty evidence).

In some situations where skin-to-skin care is not possible, it is reasonable to consider the use of a plastic bag or wrap, among other measures, to maintain normal temperature (weak recommendation, very low–certainty evidence).

In late preterm and term newborn infants ≥34 weeks' gestation, for routine use of a plastic bag or wrap in addition to skin-to-skin care immediately after birth compared with skin-to-skin care alone, the balance of desirable and undesirable effects was uncertain. Furthermore, the values, preferences, and cost implications of the routine use of a plastic bag or wrap in addition to skin-to-skin care are not known and, therefore, no treatment recommendation can be formulated.

Justification and Evidence-to-Decision Framework Highlights

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

In making these recommendations, the NLS Task Force considered that the review found evidence to support each of 3 interventions, without evidence of adverse effects. Each of these interventions was thought likely to be low in cost and feasible in many settings.

In many facilities, immediate newborn infant care (including resuscitation if needed) takes place in the delivery or operating room, and it may not be practicable to alter room temperatures for very preterm births and not others. Where a designated resuscitation room with separate temperature control is used, more individualised ambient temperature control may be feasible. Higher (>23°C) ambient temperatures have not been studied for late preterm and term infants. The adverse outcomes of maternal or neonatal hyperthermia could increase at higher ambient temperatures. Mortality may be increased among hyperthermic newborn infants,[179] and hypoxic ischemic encephalopathy may be exacerbated by hyperthermia.[180]

For skin-to-skin care, there is insufficient evidence to make a recommendation for newborn infants at high risk of needing resuscitation because of the inclusion criteria of available studies. There is a much larger evidence base supporting the use of skin-to-skin care in preterm and term infants for a variety of maternal and neonatal outcomes.[181,182] Studies report some barriers to use, but overall, skin-to-skin care is judged to be acceptable by both parents and caregivers.[183-185] Skin-to-skin care is likely to be cost-effective, acceptable, and feasible in high-, middle-, and low-income countries.

For routine use of a plastic bag or wrap for late preterm and term newborn infants 34 weeks' or greater gestation, the balance of desirable and undesirable effects was considered uncertain because of the potential for unmeasured undesirable effects. These could include that a plastic bag or wrap might be seen as an alternative or impediment to skin-to-skin care. When used in combination with warming devices, there could be risk of hyperthermia. Costs to clinical services could be high if they were used for a high proportion of late preterm and term infants. The environmental impact was also considered. Cultural values and maternal preferences in relation to this specific intervention are not known. Although the NLS Task Force agreed that

skin-to-skin care was preferred, a plastic bag or wrap may be reasonable when skin-to-skin care is not possible, especially for late preterm and low-birth-weight newborn infants, births in which ambient temperatures are low and cannot be increased, when alternative equipment (eg, radiant warmer, incubator, thermal mattress) is not available, or combinations of these circumstances.

The use of skin-to-skin care is likely to improve equity because of the low cost and feasibility for low- or middle-income countries. Room temperatures may or may not be easily adjustable in various settings. Where a room temperature of 23°C cannot be achieved, the importance of skin-to-skin care may be greater.

The overall balance of risks and benefits for the use of a plastic bag or wrap combined with skin-to-skin care was considered uncertain because there was concern plastic bags or wraps might impair the acceptability or safety of skin-to-skin care and, thereby, cause harm. As with the use of a plastic bag or wrap compared with standard care, costs may be a barrier, particularly in low-income countries, if the intervention was applied to a high proportion of births.

Task Force Knowledge Gaps

Additional gaps are included in the full online CoSTR.

- The balance of risks and benefits for each evidence-based intervention when combined with other interventions

- The best methods of maintaining normothermia in infants who received or were at high risk of receiving resuscitation

- The effectiveness of interventions for which no evidence was available or for which evidence was insufficient to make treatment recommendations, including the following:

    – Use of a thermal mattress, which may assume greater importance if a parent is unable to provide skin-to-skin care

- Caps made of various materials

- Use of heated, humidified gases for assisted ventilation

- Early monitoring of temperature versus no early monitoring of temperature

- The role of low- or moderately low–cost interventions such as prewarmed bags of intravenous fluid placed around the newborn infant or prewarmed swaddling and clothing

- The effect of maternal hypothermia or hyperthermia on newborn infants' temperatures

- Standardising the timing and method of recording temperature for all newborn infants would enhance the potential both for benchmarking and for meta-analysis of studies in future reviews.

Suctioning Clear Amniotic Fluid at Birth (SysRev)

Rationale for Review

To support air breathing at birth, oropharyngeal and/or nasopharyngeal suctioning has been a widespread practice for newborn infants. The 2010 CoSTR[186] and many subsequent guidelines have recommended selective use of upper airway suctioning, with use only if the airway appears obstructed or positive pressure ventilation (PPV) is required, and there has been increasing concern that there may be adverse effects of routine upper airway suctioning. A Scoping Review (NLS 596) found sufficient evidence to justify a SysRev.[187] A SysRev was initiated from a priority list from the ILCOR NLS Task Force; PROSPERO registration CRD42021286258.[Fawke, 2022 ####] The full text of this review can be found on the ILCOR website.[188]

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

- **Population:** Newborn infants who are born through clear (not meconium-stained) amniotic fluid

- **Intervention:** Initial suctioning of the mouth and nose

- **Comparator:** No initial suctioning

- **Outcome:**

    - Critical: Advanced resuscitation and stabilization interventions (intubation, chest compressions, epinephrine) in the delivery room

    - Important: Receipt of assisted ventilation; receipt and duration of oxygen supplementation; adverse effects of intervention (eg, apnea, bradycardia, injury, infection, low Apgar scores, dysrhythmia); unanticipated admission to the neonatal intensive care unit (NICU)[142]

- Study Design: RCTs and non-randomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, and cohort studies) were eligible for inclusion. Unpublished studies, case series, and animal studies were excluded.

- **Time frame:** All years and all languages were included if an English abstract was available. Literature search was performed on September 21, 2021.

Consensus on Science

The SysRev identified 11 studies (9 RCTs including 1138 participants[189-197] and 2 observational studies[198,199]) for inclusion. The studies predominantly enrolled healthy, low-risk term newborn infants. For 2 of the RCTs[192,193] enrolling 280 participants, the task force had concerns about the reliability of the oxygen saturation and heart rate data. Therefore, results of

these studies have been excluded from the meta-analysis. In sensitivity analysis, exclusion of these studies did not change the overall outcome.

Data relating to the key critical and important outcomes for this comparison are summarized in Table 23. Evidence for additional outcomes that were evaluated is included in the full online CoSTR.[188]

Table 23. Suctioning Clear Amniotic Fluid at Birth

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with no suctioning	RD with suctioning
Assisted ventilation (important)	742 (3 RCTs) Bancalari et al,[189] 2019 Kelleher et al,[194] 2013 Modarres Nejad et al,[195] 2014	Very low	0.72 (0.40–1.31)	64 per 1000	18 fewer per 1000 (39 fewer–20 more)
Advanced resuscitation and stabilization interventions (important)	742 (3 RCTs) Bancalari et al,[189] 2019 Kelleher et al,[194] 2013 Modarres Nejad et al,[195] 2014	Very low	0.72 (0.40–1.31)	64 per 1000	18 fewer per 1000 (39 fewer–20 more)
Oxygen saturations at 5 min (important)	280 (3 RCTs) Bancalari et al,[189] 2019 Modarres Nejad et al,[195] 2014 Takahashi et al,[196] 2009	Very low	Not applicable	Mean oxygen saturation 84.2%	MD 0.26% lower (1.77% lower–1.26% higher)
HR at 5 min (important)	84 (1 RCT) Bancalari et al,[189] 2019	Very low	Not applicable	Mean HR 162/min without suctioning	MD 1.00/min lower (7.96/min lower–5.96/min higher)

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; HR, heart rate; MD, mean difference; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

For all predefined subgroup analyses, there were insufficient data available.

Treatment Recommendations

We suggest that suctioning of clear amniotic fluid from the nose and mouth should not be used as a routine step for newborn infants at birth (weak recommendation, very low–certainty evidence).

Airway positioning and suctioning should be considered if airway obstruction is suspected (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

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

The NLS Task Force found no justification to routinely use an intervention such as oral and nasal suctioning in the absence of demonstrated benefit. The participants in the included studies were predominantly healthy, term newborn infants, and there could be potential for unmeasured harm if suctioning caused delay in resuscitation for those who require it.

This systematic review recommendation does not apply to situations where there are concerns regarding airway obstruction.

Task Force Knowledge Gaps

- The role of suctioning of clear amniotic fluid at birth for newborn infants who are at high risk of needing respiratory support or more advanced resuscitation
- The role of suctioning of clear amniotic fluid at birth for preterm newborn infants
- Adherence to guidelines in relation to suctioning of the upper airway

Tactile Stimulation for Resuscitation Immediately After Birth (SysRev)

Rationale for Review

Tactile stimulation has been included in the initial steps of stabilization of the newborn infant in the treatment recommendations from ILCOR in 1999, 2006, 2010, 2015, and 2020[139,186,187,200,201] largely based on expert opinion. Because the effectiveness of tactile stimulation to facilitate breathing at birth has never been systematically evaluated by ILCOR, this PICO question was prioritized by the NLS Task Force for SysRev (PROSPERO; registration CRD42021227768).[202] The full text of this CoSTR can be found on the ILCOR website.[203]

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

- **Population:** Term or preterm newborn infants immediately after birth with absent, intermittent, or shallow respirations.

- **Intervention:** Any tactile stimulation performed within 60 seconds after birth and defined as one or more of the following: rubbing the chest/sternum; rubbing the back; rubbing the soles of the feet; flicking the soles of the feet; combination of these methods. This intervention should be done in addition to routine handling with measures to maintain temperature.

- **Comparison**: Routine handling with measures to maintain temperature, defined as care taken soon after birth, including positioning, drying and additional thermal care.

- **Outcome:**

    - Critical: Survival as reported by authors; neurodevelopmental outcomes

    - Important: Establishment of spontaneous breathing without PPV (yes or no); time to the first spontaneous breath or crying from birth; time to heart rate 100/min or greater from birth; intraventricular hemorrhage (only in preterm infants <34 weeks' gestation); oxygen

and/or respiratory support at admission to a neonatal special or intensive care unit;

admission to a neonatal special or intensive care unit for those not admitted by protocol

based on gestational age and/or birthweight[142]

- Potential subgroups were defined a priori: gestational age (<34 weeks', 34–36 6/7

  weeks', and ≥37 weeks' gestation), cord management (early cord clamping, delayed cord

  clamping, and cord milking), clinical settings (high and low resource), and method of

  stimulation (type, number and/or duration of stimuli).

- **Study design:** RCTs and nonrandomized studies (non-RCTs, interrupted time series,

  controlled before-and-after studies, and cohort studies) were eligible for inclusion.

  Unpublished studies (conference abstracts, trial protocols) and animal studies were excluded.

- **Time frame:** All years and all languages were included if there was an English abstract. The

  literature search was first done on December 6, 2020, with final update on September 17,

  2021.

Consensus on Science

The SysRev identified 2 observational studies.[204,205] The study by Baik-Schneditz et al

was not eligible for data analysis because of its critical risk of bias (mainly because of

confounding by indication).[204] Therefore, only the study by Dekker et al with 245 preterm

newborn infants was analyzed (Table 24).[205]

Table 24. Tactile Stimulation for Resuscitation of Newborn Infants Immediately After Birth

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with routine handling only	RD with tactile stimulation in addition to routine handling
Tracheal intubation in delivery room (important)	245 (1 observational study) Dekker et al,[205] 2018	Very low	0.41 (0.20–0.85)	177 per 1000	105 fewer per 1000 infants (142 fewer–27 fewer) were intubated when tactile stimulation was used

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; RD, risk difference; and RR, risk ratio.

No data were reported on other prespecified outcomes or by subgroups.

Treatment Recommendations

We suggest it is reasonable to apply tactile stimulation in addition to routine handling with measures to maintain temperature in newborn infants with absent, intermittent, or shallow respirations during resuscitation immediately after birth (weak recommendation, very low–certainty evidence).

Tactile stimulation should not delay the initiation of PPV for newborn infants who continue to have absent, intermittent, or shallow respirations after birth (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

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

The NLS Task Force based the treatment recommendation on several inferences. The very limited available data suggest a possible benefit to tactile stimulation in decreasing the need for tracheal intubation in preterm infants, but the certainty of evidence is very low. The results of the single study identified should be analyzed with caution because of indirectness (all 245

infants were put on CPAP before tactile stimulation, in contrast to the common practice of tactile stimulation before CPAP or PPV), possible selection bias (among 673 infants who were video-recorded immediately after birth, 245 (36%) were included in the study), and confounding (the clinical indication of tactile stimulation was retrospectively assessed and it could not be determined in 34% of the 585 tactile stimulation episodes). Additional observational studies showed that, in general, infants who received tactile stimulation responded with crying, grimacing, and body movements, although the methods of stimulation were variable and the outcomes analyzed were not exactly the same among the studies.[206-209] These studies could not be included in the SysRev because of the lack of control groups who did not receive tactile stimulation.

A single-center RCT compared single versus repetitive tactile stimulation in newborn preterm infants immediately after birth. Patients in the repetitive stimulation group had higher oxygen saturation levels and lower oxygen requirements at the start of transport to the NICU. This study could not be included in the SysRev because of the lack of control group who did not receive tactile stimulation. A single-center RCT compared back rubbing to foot flicking to provide tactile stimulation in preterm and term infants with birthweight greater than 1500g who did not cry at birth. There was no difference between both techniques in achieving effective crying to prevent the need for PPV.[210] This study could not be included in the SysRev because of the lack of a control group that did not receive tactile stimulation.

In studies that analyze a bundle of procedures to stimulate respiratory transition at birth in low-resource settings, tactile stimulation, together with upper airway suction, triggered the initiation of spontaneous respirations.[211,212] These studies could not be included in the SysRev

because of the inability to isolate the effects of tactile stimulation as well as the lack of a control group.

Despite the possible benefits outlined above, there are some concerns related to possible adverse effects of tactile stimulation in delaying the initiation of ventilation beyond 60 seconds after birth, which may then compromise the efficacy of the overall resuscitation.[208,210,213] In addition, there is a report of soft tissue trauma after tactile stimulation.[214]

Task Force Knowledge Gaps

For full list, see the complete CoSTR.[203]

- Effect of tactile stimulation on the main outcomes: breathing without PPV; time to the first spontaneous breath or crying from birth; and time to heart rate 100/min or greater from birth

- Effect of tactile stimulation on secondary outcomes: death in the delivery room, hospital death; neurodevelopmental outcomes; intraventricular hemorrhage only in preterm infants; oxygen and/or respiratory support at admission to a neonatal special unit or intensive care unit; and admission to a neonatal special or intensive care unit for those not admitted by protocol

- Effects of tactile stimulation in different gestational ages and with different cord management strategies

- Which patients benefit from tactile stimulation (all, patients with apnea, irregular breathing, or other)

- Indications for tactile stimulation

- Efficacy of different methods of tactile stimulation (rubbing, flicking, or other) and locations on the body

- Optimal duration and number of each stimulus

Delivery Room Heart Rate Monitoring to Improve Outcomes for Newborn Infants (SysRev)

Rationale for Review

Monitoring heart rate in the first minutes after birth was last reviewed by the NLS Task Force in 2015, at which time the focus was on which methods resulted in the most accurate measurement at the earliest time.[139] This SysRev focused on critical and important patient outcomes and was initiated from a priority list from the ILCOR NLS Task Force; PROSPERO; registration CRD42021283438. [Kawakami, 2022 ####] The full text of this review can be found on the ILCOR website.[215]

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

- **Population:** Newborn infants in the delivery room

- **Intervention:** Use of electrocardiogram (ECG), Doppler device, digital stethoscope, photoplethysmography, video plethysmography, dry electrode technology, or any other newer modalities

- **Comparator:** 1) Pulse oximeter with or without auscultation; 2) auscultation alone; 3) between intervention comparison

- **Outcome:**

  – Critical: Chest compressions or epinephrine (adrenaline) administration; death before hospital discharge

  – Important: Duration of PPV; tracheal intubation; time from birth to heart rate 100/min or greater as measured by ECG; resuscitation team performance; unanticipated admission to the NICU.[142]

- **Study design:** RCTs and non-randomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, and cohort studies) were eligible for inclusion. Unpublished studies and case series were excluded.

- **Time frame:** All years and all languages were included if there was an English abstract. The literature search was performed on October 29, 2021.

Consensus on Science

Comparison 1: ECG Versus Auscultation Plus Pulse Oximeter During Resuscitation of Newborn Infants

The SysRev identified 2 RCTs[216,217] involving 91 newborn infants and 1 cohort study[218] involving 632 newborn infants.

Data relating to the key critical and important outcomes for this comparison are summarized in Table 25. Evidence for additional outcomes evaluated is included in the full online CoSTR.[215]

Table 25. ECG Versus Auscultation Plus Pulse Oximeter During Resuscitation of Newborn Infants

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects(n)	
				Risk with auscultation plus pulse oximeter	RD with use of ECG plus auscultation plus pulse oximeter
Duration of PPV (important)	51 (1 RCT) Abbey et al,[216] 2021	Very low	N/A	Mean duration of PPV 196 s	MD 91 s shorter (78 s shorter–36 s longer) with addition of ECG
Tracheal intubation (important)	91 (2 RCTs) Abbey et al,[216] 2021 Katheria et al,[217] 2017	Low	1.34 (0.69–2.59)	244 per 1000	81 more infants per 1000 were intubated in the DR (74 fewer–384 more) with the addition of ECG

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects(n)	
				Risk with auscultation plus pulse oximeter	RD with use of ECG plus auscultation plus pulse oximeter
Tracheal intubation (important)	632 (1 observational study) Shah et al,[218] 2019	Low	0.75 (0.62–0.90)	475 per 1000	119 fewer infants per 1000 were intubated in the DR (181 fewer–48 fewer) with the addition of ECG
Chest compressions (important)	632 (1 observational study) Shah et al,[218] 2019	Low	2.14 (0.98–4.70)	30 per 1000	35 more infants per 1000 received chest compressions (1 fewer–113 more) received chest compressions) with the addition of ECG
Epinephrine (adrenaline) (critical)	632 (1 observational study) Shah et al,[218] 2019	Low	3.56 (0.42–30.3)	4 per 1000	10 more infants per 1000 received epinephrine (2 fewer–111 more) with the addition of ECG
Death before discharge (critical)	51 (1 RCT) Abbey et al,[216] 2021	Very low	0.96 (0.15–6.31)	77 per 1000	3 fewer infants per 1000 died (74 fewer–462 more) with the addition of ECG
Death before discharge (critical)	632 (1 observational study) Shah et al,[218] 2019	Low	0.96 (0.57–1.61)	87 per 1000	3 fewer infants per 1000 died (38 fewer–53 more) with the addition of ECG

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; ECG, electrocardiogram; DR, delivery room; MD, mean difference; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

No studies were found that provided outcomes relevant to this SysRev for other

modalities versus pulse oximetry and/or auscultation (Comparison 2) or for between-intervention

comparisons (Comparison 3).

Treatment Recommendations

Where resources permit, we suggest that the use of ECG for heart rate assessment of a newborn infant requiring resuscitation in the delivery room is reasonable (weak recommendation, low-certainty evidence).

Where ECG is not available, auscultation with pulse oximetry is a reasonable alternative for heart rate assessment, but the limitations of these modalities should be kept in mind (weak recommendation, low-certainty evidence).

There is insufficient evidence to make a treatment recommendation regarding the use of a digital stethoscope, audible or visible Doppler ultrasound, dry electrode technology, reflectance-mode green light photoplethysmography, or transcutaneous electromyography of the diaphragm for heart rate assessment of a newborn in the delivery room.

Auscultation with or without pulse oximetry should be used to confirm the heart rate when ECG is unavailable, not functioning, or when pulseless electrical activity is suspected (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The evidence-to-decision table is provided in Appendix A.

The treatment recommendations were informed by low-certainty evidence that, for most outcomes, did not demonstrate improvement or suggestion of harm for any critical or important outcome. The only exception was a lower proportion of infants intubated in the delivery room in an observational study,[218] a result that was not confirmed in the meta-analysis of 2 RCTs.[216,217] The potential advantages of rapid signal acquisition and continuous, accurate heart rate monitoring need to be weighed against the potential costs of equipment and training.

Task Force Knowledge Gaps

- Higher-certainty evidence regarding whether ECG or other modalities for heart rate assessment improve critical and important neonatal outcomes

- Impact of ECG or other modalities for heart rate measurement on resuscitation team performance

- Impact of ECG and other modalities for heart rate assessment on equity

- Cost-effectiveness of different modalities for heart rate assessment in the delivery room

- Whether the utility of various modalities varies by subgroups, including vigorous versus nonvigorous newborn infants, those who do or don't require tracheal intubation or more advanced resuscitation, by gestational age and weight, by method of umbilical cord management, and for pulseless electrical activity

CPAP Versus No CPAP for Term Respiratory Distress in the Delivery Room (SysRev)

Rationale for Review

CPAP has been included in the neonatal resuscitation algorithm to help infants with persistently labored breathing or cyanosis after the initial steps of resuscitation. For spontaneously breathing preterm newborn infants with respiratory distress requiring respiratory support in the delivery room, ILCOR has suggested initial use of CPAP rather than tracheal intubation and intermittent PPV.[187] Although it has become increasingly frequent to provide CPAP in the delivery room for late preterm and term infants, this practice has not been systematically evaluated by ILCOR and therefore this PICO was prioritized by the NLS Task Force (PROSPERO; registration CRD42021225812).[Shah, 2022 ####]

The full text of this CoSTR can be found on the ILCOR website.[219]

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

- **Population:** In spontaneously breathing newly born ≥34 weeks' gestation newborn infants with respiratory distress and/or low oxygen saturations during transition after birth

- **Intervention:** CPAP at different levels with or without supplemental oxygen

- **Comparison**: No CPAP with or without supplemental oxygen

- **Outcome:**

  − Critical: Chest compressions in the delivery room; death at hospital discharge; moderate to severe neurodevelopmental impairment (>18 months)

  − Important: Admissions to the NICU or higher level of care; receiving any positive pressure support in the NICU; receiving tracheal intubation in the delivery room; use and duration of respiratory support in NICU; air-leak syndromes including pneumothorax and pneumomediastinum; length of hospital stay[142]

- **Study design:** RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies, and simulation studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) and animal studies were excluded.

- **Time frame:** All years and all languages were included if an English abstract was available. The literature search was first performed on November 30, 2020, and updated on October 11, 2021.

Consensus on Science

The SysRev identified 2 RCTs[220,221] involving 323 newborn infants and 2 observational studies, 1 of which was divided in 2 publications[222-224], involving 8476 infants. Relevant data

from the author via electronic communications have been collated into 1 study for purpose of this meta-analysis.[222,223] Meta-analysis of RCT evidence is shown in Table 26. No evidence was identified for tracheal intubation, need for chest compressions in the delivery room and neurodevelopmental impairment.

Table 26. CPAP at Different Levels With or Without Supplemental Oxygen Versus No CPAP With or Without Supplemental Oxygen for Respiratory Distress in the Delivery Room for Late Preterm and Term Newborn Infants

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with no CPAP provided for respiratory distress in the DR	RD with CPAP provided for respiratory distress in the DR
NICU admissions (important)	323 (2 RCTs) Celebi et al,[220] 2016 Osman et al,[221] 2019	Very low	0.28 (0.11–0.67)	129 per 1000	94 fewer per 1000 late preterm and term newborn infants (115 fewer–44 fewer) were admitted to the NICU when CPAP was used
Air-leak syndromes (important)	8476 (3 observational studies) Hishikawa et al,[223] 2015 Hishikawa et al,[222] 2016 Smithhart et al,[224] 2019	Very low	4.92 (4.13–5.87)	34 per 1000	133 more per 1000 late preterm and term newborn infants (106 more–166 more) developed air-leak syndrome when CPAP was used
NICU respiratory support (important)	323 (2 RCTs) Celebi et al,[220] 2016 Osman et al,[221] 2019	Very low	0.18 (0.06–0.6)	97 per 1000	79 fewer per 1000 late preterm and term newborn infants (91 fewer–39 fewer) needed NICU respiratory support when CPAP was used
Death before discharge from hospital (critical)	323 (2 RCTs) Celebi et al,[220] 2016 Osman et al,[221] 2019	Very low	0.30 (0.01–6.99)	6 per 1000	5 fewer per 1000 late preterm and term newborn infants (6 fewer–39 more) died before discharge from the hospital when CPAP was used

CPAP indicates continuous positive airway pressure; DR, delivery room; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; NICU, neonatal intensive care unit; PPV, positive pressure ventilation; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

Treatment Recommendations

For spontaneously breathing late preterm and term newborn infants in the delivery room with respiratory distress, there is insufficient evidence to suggest for or against routine use of CPAP compared with no CPAP.

Justification and Evidence-to-Decision Framework Highlights

The evidence-to-decision table is provided in Appendix A.

In making this recommendation, the NLS Task Force acknowledges that the use of CPAP in the delivery room has been recommended for infants with persistent signs of respiratory distress, labored breathing, or cyanosis after the initial steps of resuscitation. This was mainly extrapolated from evidence in preterm patients. The benefits and risks in late preterm and term newborn infants had not been systematically reviewed before this review. The 2 RCTs included only 323 subjects, who were all delivered by cesarean section.[220,221] One RCT enrolled 259 newborns and used prophylactic CPAP.[220] Within the observational studies, a positive association between the use of CPAP and the presence of air-leak syndromes was identified (1 nested cohort study included only newborn infants admitted to the NICU). Therefore, in concluding that no recommendation could be made, the task force integrated the values placed on avoidance of potential harm, as noted by the positive association between CPAP use and air-leak syndromes, and potential benefit, as noted by the reduction in NICU admission among infants born by cesarean section.

Knowledge Gaps

- Large multicenter RCTs evaluating the effect of delivery room CPAP for late preterm and term newborns with respiratory distress are needed.

- The effect of CPAP in the delivery room for late preterm and term infants delivered vaginally

- The impact of labor on outcomes when CPAP is used for respiratory distress in the delivery room

- The effect of CPAP among different populations: late preterm versus term and post-term newborn infants

- The effect of CPAP after any previous positive pressure support (PPV or sustained inflation)

- Whether effects of CPAP differ with or without the use of supplemental oxygen

- The effect of the modes of support: interfaces (facemask versus nasal prongs, cannula versus alternative airway), devices (T-piece versus flow-inflating bag); and level of CPAP support: high CPAP (>6 cm H_2O) versus low CPAP (4–6 cm H_2O).

Supraglottic Airways for Neonatal Resuscitation (SysRev)

Rationale for Review

Given the importance of effective PPV for resuscitation of newborn infants and the limitations of using either a face mask or endotracheal tube, the NLS Task Force prioritized evaluation of SGAs for PPV. In 2015, the NLS Task Force conducted a SysRev focused on using an SGA compared with endotracheal intubation as the secondary device for PPV if initial ventilation with a face mask failed. For this review, the task force aimed to compare the use of an SGA with a face mask as the initial device for administering PPV during resuscitation immediately after birth and to determine if use of an SGA would decrease the probability of failing to improve with initial PPV. Additional randomized trials comparing an SGA with a face mask as the initial device for PPV have been published since the previous review. Thus, a SysRev was undertaken (PROSPERO; registration CRD42021230722). [Yamada, 2022 ####]

The full text of this CoSTR can be found on the ILCOR website.[225]

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

- **Population:** Newborn infants 34 0/7 weeks' or more gestation receiving intermittent PPV during resuscitation immediately after birth

- **Intervention:** SGA

- **Comparator:** Face mask

- **Outcome:**

  - Critical: Chest compressions or epinephrine (adrenaline) administration during initial resuscitation; survival to hospital discharge; neurodevelopmental impairment at 18 months of age or older (abnormal motor, sensory, or cognitive function or low educational achievement at ≥18 months of age using an appropriate, standardized test or examination)

  - Important: Failure to improve with the device; tracheal intubation during initial resuscitation; time to heart rate greater than 100/min during initial resuscitation; duration of PPV during initial resuscitation; time to cessation of PPV; soft tissue injury (as defined by authors); admission to the NICU; air leak during the initial hospital stay (presence of pneumothorax, pneumomediastinum, pulmonary interstitial emphysema, or pneumopericardium) [142]

    Potential subgroups (late preterm vs term and cuffless vs cuffed supraglottic airway) were defined a priori.

- **Study design:** RCTs, quasi-RCTs, and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Quasi-RCTs were included with RCTs in meta-analyses. Unpublished studies (eg, conference

abstracts, trial protocols) were excluded. Outcomes from observational studies were assessed

if there were fewer than 2 included RCTs/quasi-RCTs or if the certainty of evidence from

RCTs/quasi-RCTs was scored very low.

- **Time frame:** All years and all languages were included if there was an English abstract. The

  literature search was updated to December 9, 2021.

Consensus on Science

The SysRev identified 5 RCTs[226-230] and 1 quasi-RCT[231] involving a total of 1857

newborn infants, and 2 retrospective cohort studies[232,233] involving 218 newborn infants. An

additional study[234] reported secondary outcomes from a subset of newborn infants enrolled in an

included RCT.[227] Meta-analysis results are shown in Table 27. For additional outcomes please

see the full CoSTR.[225]

Table 27. Meta-analysis of RCTs for SGA Compared With Face Mask for PPV During Resuscitation Immediately After Birth

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with face mask	RD with SGA
Failure to improve with device (important)	1823 (6 RCTs) Feroze et al,[226] 2008 Pejovic et al,[227] 2020 Pejovic et al,[228] 2018 Singh et al,[229] 2005 Trevisanuto et al,[230] 2015 Zhu et al, [231] 2011	Moderate	0.24 (0.17–0.36)	138 per 1000	105 fewer per 1000 infants (114 fewer–88 fewer) had failure to improve when an SGA was used
Endotracheal intubation during resuscitation (important)	1715 (4 RCTs) Pejovic et al,[227] 2020 Singh et al,[229] 2005 Trevisanuto et al,[230] 2015 Zhu et al,[231] 2011	Low	0.34 (0.20–0.56)	62 per 1000	41 fewer per 1000 infants (49 fewer–27 fewer) had endotracheal intubation during resuscitation when an SGA was used
Chest compressions during resuscitation (critical)	1346 (3 RCTs) Pejovic et al,[227] 2020 Singh et al,[229] 2005	Low	0.97 (0.56–1.65)	39 per 1000	1 fewer per 1000 infants (17 fewer–26 more) had chest compressions

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with face mask	RD with SGA
	Trevisanuto et al,[230] 2015				during resuscitation when an SGA was used
Epinephrine (adrenaline) administration during resuscitation (critical)	192 (2 RCTs) Singh et al, 2005[229] Trevisanuto et al,[230] 2015	Low	0.67 (0.11–3.87)	31 per 1000	10 fewer per 1000 infants (28 fewer–90 more) had epinephrine (adrenaline) administration during resuscitation when an SGA was used
Time to heart rate >100/min (important)	46 (1 RCT) Pejovic et al,[234] 2021	Low		The mean time was 78 s	MD 66 s lower (31 s lower–100 s lower) when an SGA was used
Duration of PPV (important)	610 (4 RCTs) Pejovic et al,[228] 2018 Singh et al,[229] 2005 Trevisanuto et al,[230] 2015 Zhu et al, [231] 2011	Low	NA	The mean time was 62 s	MD 18 s lower (24 s lower–36 s lower) when an SGA was used
Admission to neonatal intensive care (important)	1314 (4 RCTs) Pejovic et al,[227] 2020 Pejovic et al,[228] 2018 Singh et al,[229] 2005 Trevisanuto et al, [230] 2015	Very low	0.97 (0.94–1.00)	847 per 1000	25 fewer per 1000 infants (51 fewer–0 fewer) when an SGA was used
Air leak (important)	192 (2 RCTs) Singh et al, 2005[229] Trevisanuto et al, 2015[230]	Very low	Not estimable (no events)	0 per 1000	0 fewer per 1000 infants (30 fewer–30 more) when an SGA was used
Soft tissue injury (important)	1724 (4 RCTs) Pejovic et al, 2020[227] Singh et al, 2005[229] Trevisanuto et al, 2015[230] Zhu et al, 2011[231]	Low	1.05 (0.15–7.46)	2 per 1000	0 fewer per 1000 infants (2 fewer–15 more) when an SGA was used
Survival to hospital discharge (critical)	50 (1 RCT) Singh et al,[229] 2005	Low	1.00 (0.93–1.08)	1000 per 1000	0 fewer per 1000 infants (40 fewer–20 more) when an SGA was used

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; NA, not applicable; NICU, neonatal intensive care unit; PPV, positive pressure ventilation; RCT, randomized controlled trial; RD, risk difference; MD, mean difference; RR, risk ratio; and SGA, supraglottic airway.

Subgroup Analyses

No data were reported to perform prespecified subgroup analyses by gestational age (term versus late preterm). For the planned subgroup analysis based on device design (i-Gel™ versus other device), failure to improve with the device was the only outcome with sufficient data to analyze, and there was no evidence of an interaction ($P= 0.29$, $I_2=10\%$).

Treatment Recommendations

Where resources and training permit, we suggest that a supraglottic airway may be used in place of a face mask for newborn infants 34 0/7 weeks' or more gestation receiving intermittent positive pressure ventilation during resuscitation immediately after birth (weak recommendation, low-certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The evidence-to-decision table is provided in Appendix A.

In making these recommendations, the NLS Task Force acknowledged several issues. SGAs compared with face masks may be more effective in achieving successful resuscitation of late preterm and term newborn infants who receive PPV immediately after birth. Although *failure to improve with device* was variously defined by authors and often included cross-over to the alternative device, there was a strong inverse association between the use of an SGA and risk of tracheal intubation. This may reflect a greater likelihood of achieving effective ventilation with use of an SGA. Nevertheless, given that the interventions were not blinded and the ability to intubate in the largest trial was dependent on physician availability, there are risks of differential co-interventions and other biases. Furthermore, optimal information size was not achieved for any of the critical or important prespecified outcomes except duration of PPV. Consequently,

further trials are needed before stronger recommendations can be made about use of SGAs as the initial device for PPV.

Balancing factors in the task force recommendation include the training required for SGA insertion and the safety of the SGA compared with face mask ventilation. Although the training provided was incompletely documented in several studies[226,229,231] and no study compared the effectiveness of different training programs, the success rate for insertion was high despite apparently short-duration training with a manikin. In the largest trial,[227] participating midwives received brief didactic training for insertion of a cuffless supraglottic device as part of a Helping Babies Breathe course and were required to demonstrate 3 successful insertions in a manikin before participating in the study. Only 2 RCTs[229,230] indicated that successful insertion in a newborn infant was a prerequisite to study participation. Although the individual studies had limited power to establish the safety of the SGA, the task force was encouraged by the relatively large number of newborn infants reported across all studies and the small number of adverse events.

Costs and cost-effectiveness have not been studied. In 4 of the included studies[227,228,230,231] the authors indicated that the device was provided as part of the study. The availability of resources and economic considerations will influence decisions regarding use of an SGA or face mask. Given the large number of infants worldwide who receive PPV after birth, it is important to evaluate the cost-effectiveness of the SGA as the initial device for PPV.

Task Force Knowledge Gaps

For a complete list, please see the online CoSTR.[225]

- Training requirements to achieve and maintain competency with SGA insertion, including different types of devices

- Effectiveness and safety of SGAs as the initial device for PPV in high-resource settings

- Effectiveness and safety of SGAs compared with face masks during chest compressions

- Effectiveness and safety of different SGA designs

- Effectiveness and safety of SGAs for PPV among newborn infants less than 34 weeks' gestation

Respiratory Function Monitoring During Neonatal Resuscitation at Birth (SysRev)

Rationale for Review

Respiratory function monitors (RFMs) have the potential to improve the outcomes of assisted ventilation during resuscitation of newborn infants by helping resuscitation teams avoid excessive (harmful to the lungs and brain) or insufficient (ineffective) tidal volumes during resuscitation. Inappropriate tidal volumes can be caused by mask leak, airway obstruction, or ventilation pressures that are too high or too low for the mechanical characteristics of the individual infant's lungs. A SysRev conducted for ILCOR in 2015[139] found only 1 small eligible study.[235] Because the NLS Task Force was aware that further studies had been published, a SysRev was prioritized (PROSPERO; registration CRD42021278169).[Fuerch, 2022 ####] The full text of this review can be found on the ILCOR website.[236]

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

- **Population:** Newborn infants receiving respiratory support at birth

- **Intervention:** Display of an RFM

- **Comparator:** No display of an RFM

- **Outcome:**

  - Critical: Death before discharge, severe intraventricular hemorrhage

- – Important: Response to and characteristics of the resuscitation; achieving desired tidal

    volumes; percentage maximum mask leak; intubation in the delivery room;

    pneumothorax; bronchopulmonary dysplasia; duration of respiratory support during

    neonatal intensive care[142]

- **Study design:** RCTs, quasi-RCTs, and non-randomized studies (non-RCTs, interrupted time

    series, controlled before-and-after studies, cohort studies) were eligible for inclusion.

    Unpublished studies were excluded.

- **Time frame:** All years and all languages were included if there was an English abstract. The

    literature search was updated to December 31, 2021.

Consensus on Science

The SysRev identified 3 RCTs,[235,237,238] involving 443 newborns.

Data relating to the key critical and important outcomes for this comparison are

summarized in Table 28. Evidence for additional outcomes evaluated is included in the full

online CoSTR.[236]

Table 28. Use of an RFM During Neonatal Resuscitation at Birth

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with standard care	RD with use of standard care plus an RFM
Tracheal intubation in the delivery room (important)	443 (3 RCTs) Schmölzer et al,[235] 2012 Van Zanten et al,[237] 2021 Zeballos Sarrato et al,[238] 2019	Very low	0.90 (0.55–1.48)	353 per 1000	40 fewer infants per 1000 (220 fewer–130 more) were intubated in the DR when an RFM was used
Achieving desired tidal volumes (important)	337 (2 RCTs) Schmölzer et al,[235] 2012 Van Zanten et al,[237] 2021	Low	0.96 (0.69–1.34)	301 per 1000	10 fewer infants per 1000 (110 fewer–80 more) achieved the desired tidal volume in

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with standard care	RD with use of standard care plus an RFM
					the DR when an RFM was used
Pneumothorax (important)	393 (2 RCTs) Van Zanten et al,[237] 2021 Zeballos Sarrato et al,[238] 2019	Low	0.54 (0.26–1.13)	94 per 1000	40 fewer infants per 1000 (90 fewer–10 more) had a pneumothorax when an RFM was used
Death before hospital discharge (critical)	442 (3 RCTs) Schmölzer et al,[235] 2012 Van Zanten et al,[237] 2021 Zeballos Sarrato et al, 2019[238]	Low	1.00 (0.66–1.52)	165 per 1000	0 fewer infants per 1000 (70 fewer–70 more) died when an RFM was used
Severe IVH (critical)	287 (1 RCT) Van Zanten et al,[237] 2021	Low	0.96 (0.38–2.42	60 per 1000	0 fewer infants per 1000 (60 fewer–50 more) developed severe IVH when an RFM was used
IVH (all grades) (important)	393 (2 RCTs) Van Zanten et al,[237] 2021 Zeballos Sarrato et al,[238] 2019	Low	0.69 (0.49–0.96)	318 per 1000	100 fewer infants per 1000 (180 fewer–10 fewer) developed IVH (all grades) when an RFM was used
BPD (important)	393 (2 RCTs) Van Zanten et al,[237] 2021 Zeballos Sarrato et al,[238] 2019	Low	0.85 (0.7–1.04)	527 per 1000	80 fewer infants per 1000 (180 fewer–20 more) developed BPD when an RFM was used

BPD indicates bronchopulmonary dysplasia; DR, delivery room; GRADE; Grading of Recommendations Assessment, Development, and Evaluation; IVH, intraventricular hemorrhage; PPV, positive pressure ventilation; RCT, randomized controlled trial; RD, risk difference, RFM, respiratory function monitor; and RR, risk ratio.

Treatment Recommendations

There is insufficient evidence to make a recommendation for or against the use of a respiratory function monitor in newborn infants receiving respiratory support at birth (low-certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The NLS Task Force concluded that a treatment recommendation could not be made because there was low confidence in effect estimates, and most could not rule out either clinical benefit or harm. Although intraventricular hemorrhage (all grades) was significantly reduced, there was no effect demonstrated for severe intraventricular hemorrhage. The finding had low certainty, was one of numerous secondary outcomes for the study that most influenced the pooled difference, and was the only finding of the study that suggested benefit of RFM use.[237] Information on costs of purchasing RFM devices and of training in their use was not available but would need to be justified by evidence of improvement in outcomes.

Task Force Knowledge Gaps

- Human factor assessment (eg, the design of RFM displays to ensure teams can make best use of displayed data during resuscitation, without distraction from other critical tasks)

- Development of low-cost devices for use in lower-resourced settings

- Training requirements to achieve and maintain competency in the acquisition and accurate interpretation of data derived from RFM during neonatal resuscitation

- Cost-effectiveness for the use of RFM (versus no RFM) during neonatal resuscitation

- Standardized definitions of respiratory function outcomes (eg, what comprises clinically significant mask leak or optimal versus suboptimal tidal ventilation during resuscitation)

EDUCATION, IMPLEMENTATION, AND TEAMS

Prearrest Prediction of Survival After IHCA (SysRev)

Rationale for Review

Only 15% to 30% of patients with IHCA will survive to hospital discharge, and some of these patients will survive with unfavorable functional outcome.[239] The ability to predict which patients are likely, or unlikely, to benefit from CPR is important to patients and caregivers. This SysRev aimed to determine whether any prearrest clinical prediction rules can predict the chance of surviving an IHCA, with or without favorable functional outcome.

The review was registered at PROSPERO: CRD42021268005. The full text of this CoSTR is available on the ILCOR website.[240]

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

- **Population:** Hospitalized adults and children experiencing an IHCA

- **Intervention:** Any prearrest clinical prediction rule

- **Comparator:** No clinical prediction rule

- **Outcome:**

  - Critical: survival to hospital discharge or to 30 days, survival with favorable neurological outcome

  - Important: ROSC

- **Study design:** RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies, case series where n ≥5) were included. Unpublished results (eg, trial protocols), commentaries, editorials, reviews, and conference abstracts were excluded.

- **Time frame:** All years and all languages were included if there was an English abstract. The search was updated to January 13, 2022.

Consensus on Science

This review identified 23 studies[241-263] investigating 13 different prearrest prediction rules for survival after IHCA. We did not conduct any meta-analyses because the included studies were all based on historical (retrospective) cohort studies and judged to have very serious risk of bias and because the evidence was considered very low certainty for all available scores. Table 29 summarizes the studies for the prearrest morbidity score (PAM), and Table 30 summarizes the prognosis after resuscitation (PAR) score, aiming to predict survival to hospital discharge.

Table 29. Predictive Values of Historical Cohort Studies Using the PAM Score to Predict Survival to Hospital Discharge (Presented With 95% CI)

Study	Cutoff	Sensitivity (95% CI)	Specificity (95% CI)	NPV (95% CI)	PPV (95% CI)
Ebell et al,[247] 1997	PAM >8	100 (90.0–100)	1.8 (0.9–3.1)	100 (71.5–100)	5.4 (3.8–7.5)
O'Keeffe et al,[257] 1994	PAM >8	100 (86.3–100)	2.0 (0.6–4.5)	100 (47.8–100)	9.1 (6.0–13.2)
Bowker et al,[241] 1999	PAM >6	100 (92.5–100)	12.9 (8.7–18.1)	100 (87.7–100)	19.9 (15.0–25.6)
Ohlsson et al,[256] 2014	PAM >7	96.6 (88.1–99.6)	10.9 (7.2–15.7)	92.6 (75.7–99.1)	21.5 (16.7–27.0)
George et al,[248] 1989	PAM >8	100 (89.7–100)	22.6 (15.1–31.8)	100 (85.8–100)	29.3 (21.2–38.5)
Cohn et al,[243] 1993	PAM >8	100 (92.0–100)	25.0 (12.7–41.2)	100 (69.2–100)	59.5 (47.4–70.4)

NPV indicates negative predictive value; PAM, prearrest morbidity; and PPV, positive predictive value.

Table 30. Predictive Values of Historical Cohort Studies Using the PAR Score to Predict Survival to Hospital Discharge (Presented With 95% CI)

Study	Cutoff	Sensitivity (95% CI)	Specificity (95% CI)	NPV (95% CI)	PPV (95% CI)
Ebell et al,[247] 1997	PAR >8	82.9 (66.4–93.4)	20.1 (17.0–23.5)	95.4 (90.3–98.3)	5.5 (3.7–7.8)
O'Keeffe et al,[257] 1994	PAR >5	100 (86.3–100)	22.8 (17.8–28.4)	100 (93.9–100)	11.1 (7.3–16.0)
Bowker et al,[241] 1999	PAR >7	100 (94.7–100)	14.3 (9.7–20.0)	100 (87.7–100)	28.8 (23.1–35.0)

Study	Cutoff	Sensitivity (95% CI)	Specificity (95% CI)	NPV (95% CI)	PPV (95% CI)
Ohlsson et al,[256] 2014	PAR >10	98.3 (90.8–100)	10.5 (6.8–15.2)	96.0 (79.6–99.9)	21.8 (16.9–27.2)

NPV indicates negative predictive value; PAR, prognosis after resuscitation; and PPV, positive predictive value.

Other smaller studies report prediction of survival to hospital discharge using the Modified Early Warning Score,[262] the National Early Warning Score,[251,260] the Clinical Frailty Scale,[253] a neuronal network,[244] and the Acute Physiology and Chronic Health III score.[247] Details for these are available in the CoSTR on the ILCOR website.[240]

The Good Outcome Following Attempted Resuscitation (GO-FAR) score, which aims to predict survival with a CPC of 1, has been evaluated in several studies. These results are presented in Table 31. One additional study[252] reported a negative predictive value of 87.0 (95% CI, 73.7–95.1) and a sensitivity of 94.1 (95% CI, 87.6–97.8) for the GO-FAR score to predict survival to hospital discharge (details are available on the ILCOR website[240]).

Table 31. Predictive Values of Historical Cohort Studies Using the GO-FAR Score to Predict Survival to Hospital Discharge With a CPC of 1 (Presented With 95% CIs)

Study	Cutoff	Sensitivity (95% CI)	Specificity (95% CI)	NPV (95% CI)	PPV (95% CI)
Ebell et al,[246] 2013	≥24	99.3 (99.0–99.5)	10.4 (10.1–10.7)	99.2 (98.9–99.5)	11.4 (11.1–11.7)
Piscator et al,[258] 2018	≥24	99.3 (96.1–100.)	9.7 (6.9–13.1)	97.4 (86.2–99.4)	28.9 (24.9–33.1)
Rubins et al,[261] 2019	≥24	95.7 (88.0–99.1)	17.1 (13.2–21.6)	95.0 (86.1–99.0)	19.5 (15.5–24.1)
Cho et al,[242] 2020	≥24	99.4 (96.6–100)	11.4 (9.4–13.8)	99.0 (94.4–100)	17.6 (15.2–20.3)
Thai et al,[263] 2019	≥24	99.2 (99.0–99.4)	8.2 (7.9–8.4)	98.4 (97.9–98.7)	16.1 (15.8–16.4)
Ohlsson et al,[255] 2016	≥24	97.8 (88.2–99.9)	10.3 (6.8–14.9)	96.2 (80.4–99.9)	16.9 (12.5–22.0)

CPC indicates Cerebral Performance Category; GO-FAR, Good Outcome Following Attempted Resuscitation; NPV, negative predictive value; and PPV, positive predictive value.

Two classification and regression tree models (versions 1 and 2) aimed to predict survival

with a CPC of 1, whereas the GO-FAR 2 score and the Prediction of Outcome for In-Hospital

Cardiac Arrest (PIHCA) score investigated prediction of survival with CPC 2 or less. These

results are presented in Table 32.

Table 32. Predictive Values of Historical Cohort Studies Using Scores Other Than the GO-FAR Score to Predict Survival to Hospital Discharge With Favorable Neurological Outcome (Presented With 95% CIs)

Study	Model	Sensitivity (95% CI)	Specificity (95% CI)	NPV (95% CI)	PPV (95% CI)
Ebell et al,[245] 2013	CART 1	96.0 (94.9–96.9)	24.1 (23.3–24.8)	97.8 (97.2–98.3)	14.6 (13.9–15.3)
Guilbault et al,[250] 2017	CART 1	95.6 (84.9–99.5)	28.5 (22.9–34.6)	97.2 (90.2–99.7)	19.9 (14.8–25.9)
Ebell et al,[245] 2013	CART 2	94.1 (92.9–95.2)	30.9 (30.1–31.7)	97.5 (97.0–98.0)	15.5 (14.8–16.2)
Guilbault et al,[250] 2017	CART 2	95.6 (84.9–99.5)	36.4 (30.3–42.8)	97.8 (92.2–99.7)	21.8 (16.3–28.3)
George et al,[249] 2020	GO-FAR 2	98.9 (98.6–99.1)	6.7 (6.4–6.9)	95.7 (94.9–96.4)	21.8 (21.4–22.2)
Piscator et al,[259] 2019	PIHCA	99.4 (96.8–100)	8.4 (6.0–11.3)	97.4 (86.5–99.9)	29.4 (25.7–33.2)

CART indicates classification and regression tree model; GO-FAR, Good Outcome Following Attempted Resuscitation; NPV, negative predictive value; PIHCA, Prediction of Outcome for In-Hospital Cardiac Arrest; and PPV, positive predictive value.

In summary, none of the scores were able to reliably predict survival on the basis of

patient factors before an IHCA, and no studies were found on the clinical implementation of such

a score.

Treatment Recommendations

We recommend against using any currently available prearrest prediction rule as a sole reason to not resuscitate an adult with in-hospital cardiac arrest (strong recommendation, very low–certainty evidence).

We are unable to make a recommendation about using prearrest prediction rules to facilitate do-not-attempt CPR (DNACPR) discussions with adult patients, pediatric patients, or their substitute decision-maker, as there are no studies investigating the clinical implementation of such a score for this indication.

We are unable to provide any recommendation for pediatric patients as no studies on children were identified.

Justification and Evidence-to-Decision Framework Highlights

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

In making this recommendation, the task force valued a perfect negative predictive value (ie, no chance of classifying a survivor as a nonsurvivor). None of the existing prearrest prediction rules were able to reliably predict no chance of survival to hospital discharge or survival with favorable functional outcome. The task force also noted that most studies predicting survival to hospital discharge (eg, the PAM or PAR score) were based on cohorts before 2000, when survival rates were lower. The PAM score and the PAR scores did not perform consistently across cohorts.

Some studies were based on selected patient cohorts or patients from a single center, raising concerns about generalizability. All studies were based on historical cohorts, and concern for bias and unaccounted-for confounding was high. As there were no prospective studies identified on clinical implementation of a prearrest prediction model to facilitate DNACPR

discussions, it is unknown whether the clinical implementation of such a score would influence the rate of DNACPR discussions, the rate of DNACPR orders, survival outcomes, or patient perspectives.

All scores predicting survival with favorable neurological outcome included variables such as hypotension, respiratory insufficiency, or sepsis before the arrest that may change during the hospital admission. Thus, there are concerns about applicability of these models.

The GO-FAR score identifies the chance of survival with good neurological outcome (ie, CPC of 1), although patients and relatives may value survival with a CPC of greater than 1.

Scores that can predict a very low chance of survival with favorable functional outcome may be used to facilitate DNACPR discussions with patients, although the score may not be able to predict no chance of survival or survival with favorable neurological outcome.

Task Force Knowledge Gaps

- Assessment of clinical decision tools to predict ROSC and long-term outcomes beyond hospital discharge or quality-of-life outcomes

- Assessment of clinical decision tools for prearrest prediction of IHCA survival for children

- We did not identify any score predicting survival with favorable neurological outcome that did not include physiological deterioration before cardiac arrest, which may be difficult to apply prospectively.

- Prospective validation studies or randomized trials of in-hospital prearrest clinical prediction rules to be used for DNACPR discussions and/or making DNACPR orders

- How the use of clinical decision tools affects resuscitation practices, cost-benefit, or survival outcomes

BLS Training for High-Risk Populations (SysRev)

Rationale for Review

This topic was last reviewed in 2015.[264,265] The Education, Implementation, and Teams

Task Force prioritized this question because there have been several high-quality studies since

the last review, and existing evidence suggests that likely rescuers are unlikely to seek training

on their own but are willing to receive training.[266-268] The review was registered at PROSPERO:

CRD42021233811, and the full text of this CoSTR is on the ILCOR website.[269]

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

- **Population:** For adults and children at high risk of OHCA

- **Intervention:** BLS training of likely rescuers

- **Comparator:** No training

- **Outcome:**

  - Patient outcomes:

    - Critical: Favorable neurological outcome at hospital discharge or to 30 days, survival

      at hospital discharge or to 30 days

    - Important: ROSC, rates of bystander CPR (subsequent use of skills), bystander CPR

      quality during an OHCA (any available CPR metrics), and rates of AED use

      (subsequent use of skills)

  - Educational outcomes:

    - Critical: CPR quality and correct AED use at the end of training and within 12

      months of training

- Important: CPR and AED knowledge at the end of training and within 12 months after training; confidence and willingness to perform CPR at the end of training and within 12 months after training, and CPR training of others

- **Study design:** RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies (including conference abstracts, trial protocols) were excluded.

- **Time frame:** All years and all languages were included if there was an English abstract. Literature search was updated to October 15, 2021.

Consensus on Science

The SysRev performed as part of the 2015 ILCOR review[264,265] identified 32 studies relating to BLS training in likely rescuers (eg, family or caregivers) of high-risk OHCA groups.[270-301]

One study[295] from the 2015 review was not relevant for the revised outcomes in this update and was not included in this updated review.

In our updated search, we found 12 new studies published since the 2015 review.[302-313]

The 12 new studies included likely rescuers of patients with cardiac disease,[303-311,313] drug use disorder,[302] pulmonary disease,[311] or an acute life-threatening event.[312] Similar to the 2015 reviewed studies, these new studies used varying methods for BLS training, control groups, and assessment of outcomes and were too heterogeneous for a meta-analysis of any outcome to be performed.

Only 2 of the new studies examined the subsequent use of BLS skills and patient outcomes.[302,312] Overall, there remain too few witnessed OHCA events and rates of loss to follow-up that are too high for us to be confident in the effect of

training.[270,275,278,280,283,290,291,296,297,302,312] Most of the old and new studies assessing educational

outcomes demonstrated improvements in BLS skills and knowledge immediately after

training.[271,273,276,277,284,287-289,292,293,299-301,304-307,309-313]

In assessing long-term outcomes, there was some degradation in some BLS skills

compared with immediately posttraining but an improvement in skills and knowledge compared

with baseline.[272,304,306,307,309,312] Training immediately increased willingness[272,278,282,285-287,294,298,305,307] and confidence[271,305-307,309] to provide CPR if needed. Those trained were also

likely to share training with other family members and friends when provided with materials (eg,

BLS training kits with a manikin).[271,272,285,286,304,305,307,308]

Treatment Recommendations

We recommend BLS training for likely rescuers of populations at high-risk of out-of-

hospital cardiac arrest (strong recommendation, low-to-moderate–certainty evidence).

We recommend health care professionals encourage and direct likely rescuers of

populations at high risk of cardiac arrest to attend BLS training (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

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

In making this recommendation, the Education, Implementation, and Teams Task Force

placed higher value on the improvements in competency in BLS skills, the improvements in

confidence and willingness to perform BLS, the multiplier effect of trained individuals training

others, the high proportion of OHCAs that occur in the home and the potential benefits of such

patients receiving BLS from a family member or caregiver, the fact that BLS training doesn't

increase anxiety in trainees,[266] and that these groups are unlikely to undertake training on their

own.[266]

Given these facts, we considered it important to recommend that healthcare professionals encourage and direct these groups to attend BLS training even though they may not take up training.[281] We also placed lesser value on the associated costs and the potential that performance of some skills may not be to guideline standard and may not be retained without refresher CPR training.

Task Force Knowledge Gaps

- The long-term impact of training on patient outcomes

- The best methods for training and retraining to achieve high attendance and skill retention

- Whether healthcare providers suggesting the need for BLS training, rather than providing training, influences likely rescuers to seek and obtain training

Patient Outcome and Resuscitation Team Members Attending Advanced Life Support Courses (EvUp/SysRev/Adolopment)

Rationale for Review

Attendance at an advanced life support course comes at a cost—both financial and in time—to participants and their institutions. It is, therefore, important to show whether such participation has a meaningful impact upon patient outcomes. In 2020, we recommended the provision of accredited adult advanced life support training for healthcare providers (weak recommendation, very low–certainty evidence). The purpose of this SysRev is to update the evidence for adult advanced life support training and to expand the search to participants of other advanced life support courses covering patients of all ages.

The review was registered at PROSPERO: CRD42021253673. The full text of this CoSTR is available on the ILCOR website.[314]

Course types, titles, and abbreviations used in this CoSTR:

- Adult advanced life support courses: Advanced Life Support (ALS), Advanced Cardiovascular Life Support (ACLS)

- Pediatric advanced life support courses: Pediatric Advanced Life Support (PALS), European Paediatric Advanced Life Support (EPALS), European Paediatric Intermediate Life Support (EPILS)

- Neonatal resuscitation training (NRT): Newborn Resuscitation Programs (NRP), Neonatal Life Support (NLS), Advanced Resuscitation of the Newborn Infant (ARNI)

- Helping Babies Breathe (HBB) Course

- Advanced Trauma Life Support (ATLS®) Course

- European Trauma Course (ETC)

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

- **Population:** Patients of any age requiring IHCA resuscitation

- **Intervention:** Prior participation of 1 or more members of the resuscitation team in an accredited advanced life support course (eg, ALS, ACLS, PALS, EPALS, EPILS, NRT [including NRP, HBB, NLS, ARNI])

- **Comparator:** No such participation

- **Outcome:** Critical: ROSC, survival to hospital discharge or to 30 days, survival to 1 year, and survival with favorable neurological outcome; NRT (in addition): stillbirth rate, neonatal and perinatal mortality

- **Study design:** RCTs, nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies, and case series where n ≥5), and reviews were

included. Unpublished reports (eg, trial protocols), commentary, editorials, studies looking at the impact of individual components of courses (eg, airway, drug therapy, defibrillation), studies relating to BLS and first aid courses, dedicated trauma courses (eg, ATLS®, ETC), and studies relating to OHCA were excluded.

- **Time frame:** Publications from all years (except for ALS, which included studies after March 2018, as previous studies were included in another already published systematic review) and all languages were included if there was an English abstract. Search was conducted on October 18, 2021

Consensus on Science

This review identified 18 studies covering the adult ALS Course (n=1),[315] NRT courses (n=11),[316-326] and the HBB Course (n=6).[327-332] In addition, 2 review articles were identified, 1 of which covered NRT[333] and the other covered HBB.[334] Evidence was of very low certainty (downgraded for risk of bias and inconsistency).

Adult Advanced Life Support Courses (ALS, ACLS)

The 2020 CoSTR was based on an adolopment of a SysRev.[335] This EvUp for that review included the newly identified study.[315] This retrospective descriptive study from India assessed the impact on patient outcomes of nursing staff attending an American Heart Association course. The study reported outcomes for ROSC and survival to hospital discharge. The updated results from the previous CoSTR with the data from this study were ROSC (odds ratio 1.66; 95% CI, 1.24–2.21) and survival to hospital discharge and to 30 days (odds ratio 2.48; 95% CI, 1.21–5.09). This supported the conclusions from the previous ILCOR CoSTR.

Neonatal Resuscitation Training

One SysRev was identified[333] covering all NRT approaches. No additional studies were identified through our search. This SysRev satisfied the "A Measurement Tool to Assess Systematic Reviews-2" criteria for adolopment, as defined by the ILCOR Adolopment Process document.[336] Data were extracted and analyzed for hospital-based studies only, and results are presented in Table 33. All included studies were of pre- or post-design and from low- to middle-resource settings. Despite clinical and statistical heterogeneity, all analyses showed a consistent treatment effect for this training.

Table 33. NRT Outcomes From Hospital-Only Studies

Outcome	Studies, n	Participants, n	RR	95% CI
All stillbirths	9[212,322,329,337-340]*	1 334 307	0.88	0.82–0.94
Fresh stillbirths	6[212,322,328,329]*	231 455	0.71	0.54–0.93
1-day neonatal mortality	5[212,328,341]*	216 373	0.58	0.38–0.90
7-day neonatal mortality	5[328,338,341-343]	296 300	0.78	0.63–0.97
28-day mortality	6[320,322,328,329,337,344]	1 090 594	0.89	0.65–1.22
Perinatal mortality	4[328,337,338]†	1 178 446	0.78	0.70–0.87

NRT indicates neonatal resuscitation training; and RR, relative risk.

*Data from 1 unpublished study included.

†Data from 2 unpublished studies included.

Helping Babies Breathe

One SysRev of the HBB Course was identified,[334] which also met criteria for adolopment. All of the included studies were from low-resource areas. The review found moderate evidence for a decrease in intrapartum-related stillbirth and 1-day neonatal mortality rate after implementing the HBB training and resuscitation method. One additional study was identified in our search, which concluded that HBB may be effective in a local first-level referral hospital in Mali.[330]

Treatment Recommendations

We recommend the provision of accredited advanced life support training (ACLS, ALS) for healthcare providers who provide advanced life support care for adults (strong recommendation, very low–certainty evidence).

We recommend the provision of accredited courses in neonatal resuscitation training (NRT, NRP) and HBB for healthcare providers who provide advanced life support 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 adverse effects.

Justification and Evidence-to-Decision Framework Highlights

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

In making this recommendation, the Education, Implementation, and Teams Task Force recognizes that the evidence in support of this recommendation comes from studies providing very low–certainty evidence on a range of courses run in different resource settings around the world over a long period. Despite this, the studies show a consistent treatment effect for this training with potential for many lives saved. The provision of NRT and HBB training is feasible in low- and middle-resource settings.

Task Force Knowledge Gaps

- The trainee characteristics and training/recertification frequency required to sustain the existing effect on patient outcomes

- The impact of other advanced life support courses (eg, pediatric) on patient outcomes

- The impact of blended-learning approaches

- The impact of modifications necessitated by the COVID-19 pandemic

Blended Learning for Life Support Education (SysRev)

Rationale for Review

Blended learning is an educational approach that combines face-to-face and online approaches.[345] Recently, the impact of the COVID-19 pandemic on the feasibility of face-to-face interactions and teaching has been profound, making the use of technology to facilitate learning a necessity rather than an option.[346-349] The 2020 CoSTR strongly recommended "providing the option of eLearning as part of a blended-learning approach to reduce face-to-face training time in advanced life support courses (very low– to low-certainty evidence)."[350] This SysRev is designed to evaluate the impact of blended learning on all accredited life support courses. The study was registered with PROSPERO on August 20, 2021 (registration number CRD42021274392).[351]

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

- **Population:** Participants undertaking an accredited life support course (eg, BLS, advanced life support courses, ATLS®)

- **Intervention:** Blended-learning approach

- **Comparator:** Non–blended learning approach (online or face-to-face only)

- **Outcome:** Critical: knowledge acquisition (end of course, 6 months, 1 year), skills acquisition (end of course, 6 months, 1 year), participant satisfaction (end of course), patient survival, and implementation outcomes (cost, time needed)

- **Study design:** RCTs, nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies, and case series where n ≥5), and manikin studies

were included. Unpublished reports (eg, trial protocols), commentary, editorial, and reviews were excluded.

- **Time frame:** Publications from all years from 2000 onward and all languages were included if there was an English abstract. Search was conducted on August 6, 2021.

Consensus on Science

Most studies used face-to-face only as the control group, with only 2 BLS studies having online learning only as a control group.[352,353]

There was a mix of interventions in the BLS group, with some adding online content to standardized face-to-face courses,[352-356] and some substituting didactic content with online content leaving an amended face-to-face element.[357-363] In the advanced life support group, all except 1 study[364] evaluated online learning as a substitute for didactic elements. The ATLS® study evaluated online learning as a substitute for didactic elements.[365]

Basic Life Support

A total of 14 studies were included, addressing both BLS knowledge and BLS skills after the intervention.[352-363,366,367] Results were mixed, with some studies finding a benefit with blended learning, and some studies finding no difference. Only one study found a statistically significant benefit for knowledge[359] and for skills[360] with face-to-face only. For BLS knowledge and skills retention, there was no significant difference up to 12 months after intervention.

For the outcome of attitudes, there was evidence of positive attitudes to all forms of training.[353,355,362,363]

For the outcome of costs, the single cost analysis study found a notable financial benefit for teaching BLS via a blended-learning approach.[366]

Adult Advanced Life Support

The review included 8 studies.[364,368-374] For the outcome of advanced life support knowledge (postintervention), 2 studies found significantly higher scores in the blended-learning group,[368,374] whilst the remainder of the studies found no significant difference between the groups.[364,369,373] There was no significant difference between groups for 1 study at 7 months.[369]

For the outcome of advanced life support skills (postintervention), 1 pilot study[373] found significantly higher scores in the control group; however, a subsequent study of the revised version of the same course found significantly higher scores in the blended-learning group.[374] The remainder of the studies found no significant difference between the groups.[364,368,369,371]

Attitudes were diverse: 3 studies found a preference for blended learning,[364,368,371] and 2 studies found a preference for face-to-face learning.[369,372]

Two studies found a notable financial benefit for teaching advanced life support via a blended-learning approach.[370,373]

Advanced Trauma Life Support

One study found that a blended-learning approach involving the substitution of didactic elements with online learning for the American College of Surgeons' ATLS® Course was better than face-to-face, but only in terms of knowledge outcomes.[365] Overall pass rates were better, but there was no specific description of the breakdown of skills performance as opposed to knowledge outcomes in determining the final result, so a conclusion about skills training cannot be made.

Treatment Recommendations

We recommend a blended learning as opposed to non-blended approach for life support training where resources and accessibility permit its implementation (strong recommendation, very low–certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

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

In making this recommendation, the Education, Implementation, and Teams Task Force considered that a blended learning approach is grounded in a strong framework from educational theory, and has been shown to result in similar or better educational outcomes for participants of life support training. A blended learning approach enables ongoing training in life support skills for those in remote locations, lower-resource settings, and in times of pandemic, but may not be feasible in areas where access to online learning is limited or unavailable. Blended learning enables consistent messaging about content, which can be particularly beneficial for pre-course preparation, and it reduces participant and stakeholder costs.

The task force agreed that non-blended learning approaches (ie, face-to-face only or online only) are an acceptable alternative where resources or accessibility do not permit the implementation of a blended learning approach. Most of the studies used face-to-face only as the control group, with very limited evidence for online only as the control group. Blended learning approaches decrease the duration of face-to-face training required, although time is still needed to complete the online component.

Task Force Knowledge Gaps

- The elements of instructional delivery that are associated with better educational outcomes

- Whether certain levels of blended learning (ie, how much, what exactly, when used) are more beneficial than others

- Whether there is a difference in outcomes between approaches where online learning is added to established face-to-face content or where it substitutes for elements of the face-to-face contact

- Whether blended learning life support education leads to better patient outcomes

- Whether certain subgroups of participants (eg, first time versus recertification) have better educational outcomes from a blended learning approach

- How blended learning compares with online-only learning

Faculty Development Approaches for Life Support Courses (ScopRev)

Rationale for Review

A cornerstone to improve survival after cardiac arrest is continuous education in resuscitation delivery for laypersons and healthcare professionals. To do so, regional resuscitation councils have implemented resuscitation courses and training programs for their instructors within their faculty development programs to teach standardized resuscitation for their accredited courses. This ScopRev was conducted to identify the types of available evidence on the topic of faculty development programs for life support courses and is summarized here. The full text of this ScopRev is available on the ILCOR website.[375]

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

- **Population:** Instructors of accredited life support courses, including BLS, PBLS, ALS, PALS, and NRP

- **Intervention:** Any faculty development approach to improve instructional competence in accredited life support courses

- **Comparator:** No such approach or any other faculty development approach

- **Outcome:**

  - Clinical outcomes of patients resuscitated by students of the instructors: Critical: favorable neurologic outcome, survival to discharge, short-term survival, ROSC, sustained ROSC, and survival to admission

  - Educational outcomes:

    - Critical: skill performance of students of the instructors in actual resuscitation.

    - Important: knowledge, instructional skills, and attitudes of instructors at the end of instructor training course; knowledge, instructional skills, and attitudes of instructors some period of time after the end of the instructor training course; confidence of instructors to teach students at the end of the instructor training course and some period of time after course completion; and knowledge, skill performance, attitudes, willingness, and confidence of students of the instructors immediately at the end of the provider course or some period of time after course completion

- **Study design:** RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies, case-control studies), unpublished studies (eg, conference abstracts, trial protocols), letters, editorials, comments, case series, and case reports were eligible for inclusion. Interventions with nonaccredited life support courses, or life support training included as part of a curriculum in other medical educational courses, were excluded.

- **Time frame:** All years and all languages were included if there was an English abstract. Literature search updated to December 31, 2021.

Summary of Evidence

Of the initial search yield of 13 291 records, 20 studies,[376-395] including 5 conference abstracts,[379,385,389,390,395] 1 short communication,[393] and 14 full-length articles,[376-378,380-384,386-388,391,392,394] were included. Interventions were grouped into 4 categories, and studies are summarized in Table 34.

1. Instructor qualification/training, n=9[379,382,383,386-388,390,391,394]

2. Assessment tools, n=3[376,389,395]

3. Teaching skills enhancement, n=3[378,381,385]

4. Additional course for instructors, n=5[377,380,384,392,393]

Table 34. Interventions to Improve Instructional Competence

Category	Intervention	Results
1. Instructor qualification/training		
Internet-based AHA CIC[382]	Comparing internet-based AHA CIC with traditional classroom-based AHA CIC	There was no difference in pretest and posttest practical scores. Candidates in the online group had significantly higher adjusted posttest scores.
Train-the-trainer courses[379,383,386,390,391]	Instructor course with train-the-trainer model, sending the "trained trainers" to deliver further resuscitation training	Train-the-trainer programs may be effective in improving resuscitation knowledge and skills and are important for developing local expertise.
System-wide instructor training program[388]	Retrospective analysis of 24 pediatric and neonatal CPR instructor courses certified by the Spanish Paediatric and Neonatal Resuscitation Group, held between 1999 and 2019	A specific pediatric and neonatal CPR instructor course is an adequate method for sustainable training of health professionals to teach pediatric resuscitation.
Modified instructor course with lectures, instruction practice, and self-developed resuscitation scenarios[394]	New instructor course compared with conventional training	There was improved confidence in teaching neonatal CPR when participating in the new course.

Category	Intervention	Results
Web-based questionnaire survey for instructors[387]	Web-based survey with a 29-item Competence Importance Performance scale	Several important factors for the competence of instructors were identified.
2. Assessment tools		
Assessment for chest compression with real-time compression feedback[376]	Real-time compression feedback	There were improved chest compression performance skills with real-time feedback, without comparable improvement in chest compression assessment skills in video review.
Assessment for chest compression with self-learning[395]	Recorded chest compressions by motion-capture camera	There was improved ability of novice instructors to assess chest compressions after self-training, but it does not equal that of experienced instructors.
Delivery of BLS training using fully-body sensor-equipped manikins[389]	Use of sensor-equipped manikins for accredited instructors asked to deliver BLS training	Instructors felt the manikins were useful and felt confident when delivering the course, and that may be beneficial to a trainer's perception.
3. Teaching skills enhancement		
Different feedback method[378]	Learning conversation structured methods of feedback delivery in BLS training, compared with the sandwich technique (ie, positive feedback—negative feedback—positive feedback)	Using learning conversation structured methods by instructors was preferred over using the sandwich technique by instructors, and may give instructors more confidence.
Using standardized script by novice instructors to facilitate team debriefing[381]	Use of scripted debriefing by novice instructors and/or simulator physical realism affects knowledge and performance in simulated cardiopulmonary arrests.	The use of a standardized script to debrief by novice instructors improved students' knowledge acquisition and team leader behavioral performance during subsequent simulated cardiopulmonary arrests.
Tape recording and a later critical viewing of a lecture[385]	Record the lecture provided by BLS/AED or ALS instructor candidates with a tape, a later video review, and oral self-assessment.	The opinion of all participants was positive when they were asked about comparing their subjective impressions with the objective viewing.
4. Additional course for instructors		
Educational program to teach ACLS instructors to evaluate team leader performance[384]	Educational program to review commonly observed errors and to identify critical errors	Trained instructors identified more critical errors and gave more correct grade assignments.
ATP[392,393]	ATP as additional training, focusing on decision-making in equivocal situations	Trained instructors were less prone to incorrectly giving failing scores to candidates.[393] Instructors

Category	Intervention	Results
		with additional training were significantly more confident at assessing.[392]
Neonatal resuscitation workshop[377]	2-day neonatal resuscitation workshop	There were significant improvements in participants' perceptions of their teaching ability.
Clinical teacher training course/workshop (enhance teaching skills and methods) [380]	2-day BLS and emergency medicine teacher training program	Students taught by untrained teachers performed better in some domains. Teaching quality was rated significantly better by students of untrained teachers.

ACLS, advanced cardiovascular life support; AED, automated external defibrillator; AHA, American Heart Association; ALS, advanced life support; ATP, assessment training program; BLS, basic life support; CIC, core instructor course; and CPR, cardiopulmonary resuscitation.

Task Force Insights

This ScopRev on faculty development approaches to improve instructional competence in life support courses was summarized in 4 themes: instructor qualification/training, assessment tools, teaching skills enhancement, and additional courses for instructors. Many studies only described implementations of regional instructor programs but did not report outcomes and were excluded. Some organizations used their specific train-the-trainer courses, and it seems that these models may be effective in these specific contexts, but different systems make comparisons nearly impossible.

Instructors' assessment of chest compressions was not as good as expected; therefore, feedback devices and training programs sharpening their assessment skills were suggested.[376,384,392,393,395] Of the articles with additional training programs that were included, 4 out of 5 had a positive effect on instructors' teaching competencies and evaluation ability.[377,384,392,393] However, new teaching strategies may not have the expected effects, which emphasizes the need for rigorous evaluation of any changes to training practices.[380]

Specific debriefing and feedback methods were suggested for instructors teaching life support courses, which may increase instructors' confidence.[378] Most resuscitation training

studies analyzed the learning outcomes of course participants but rarely assessed instructors. Future research on faculty development of resuscitation instructors should include assessment of core instructor competencies as an outcome of interest.

We did not identify any recertification program for instructors, although continuous lifelong learning to retain the teaching skills is crucial for instructors. One reason for suboptimal instructor performance might be lack of effective retraining or recertification programs.

Treatment Recommendations

There was no treatment recommendation on faculty development programs for resuscitation course instructors previously. This ScopRev has not identified sufficient evidence to support a new SysRev, and no treatment recommendation was generated.

Based on this ScopRev and expert opinion from the task force members, faculty development for resuscitation course instructors remains an important element contributing to improved teaching and the learners' outcomes in accredited life support courses. However, no clear picture of the most appropriate and most effective faculty development programs could be identified from the studies reviewed. Different approaches need to consider the local training environment and resource availability, as well as instructors' needs to maximize learning outcomes of such programs. The best ways to maintain and assess instructor competency whilst concurrently maximizing cost-effectiveness needs to be established.

The task force encourages resuscitation councils to implement faculty development programs for their teaching staff of their accredited resuscitation courses.

Task Force Knowledge Gaps

- The most appropriate life support instructor training strategy
- The best methods for objective measurement of core competence of instructors

- Strategies to build up an effective recertification or retraining program for life support course instructors

- Which feedback method or debriefing strategy is effective and how to teach instructors to use a debriefing method successfully in life support instructor training

- Whether continuous assessment and feedback to instructors from others, such as senior instructors or course directors, improves instructor competence and learning outcomes for the course participants

- The effect on patient outcome of instructor training

Topics Reviewed by EvUps

In Table 35, EvUps are listed with the PICO number, existing treatment recommendation, number of relevant studies identified, key findings, and information about whether a SysRev was deemed worthwhile. Complete EvUps can be found in Appendix C.

Table 35. EIT Topics Reviewed by EvUps

Topic/PICO	Year(s) last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
Willingness to provide CPR (EIT 626)	2020 ScopRev 2010 CoSTR	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 continue compression-only CPR.	0	12 (9 are related to the COVID-19 pandemic)	Three observational studies identified factors associated with willingness to perform CPR described earlier. Six studies during the COVID-19 pandemic period found that bystander CPR rate decreased, and 5 studies showed a significant decrease in the rate of using bystander AED or PAD.	No

Topic/PICO	Year(s) last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		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.				
Team and leadership training (EIT 631)	2020 CoSTR	We suggest that specific team and leadership training be included as part of ALS training for healthcare providers (weak recommendation, very low–certainty evidence).	1	8	Published new evidence associates teamwork or leader performance with clinical performance, as measured by surrogate patient outcomes (adherence to resuscitation and other clinical practice guidelines, avoidance of errors, time to definitive therapies). No new evidence demonstrates an effect of team training on patient outcomes and survival.	No
Rapid response systems in adults (EIT 638)	2020 CoSTR	We suggest that hospitals consider the introduction of a rapid response system (rapid response team/medical emergency team) to reduce the incidence of IHCA and in-hospital mortality (weak recommendation, low-quality evidence).	0	11	No new randomized studies were found. The findings from 11 nonrandomized studies were mixed, and the majority suffer from high risk of bias. Two studies found no effect of rapid response teams on patient outcome, whereas the other observational studies showed positive effect, mostly in reduction of cardiac arrest or hospital mortality.	No
Community initiatives to promote BLS implementation (EIT 641)	2020 ScopRev 2015 CoSTR	We recommend implementation of resuscitation guidelines within organizations that provide care for patients in cardiac arrest in any setting (strong recommendation, very - low-quality evidence).	0	2	The 2 new observational studies confirm improvements from strategies driven by community initiatives promoting BLS described in the last ScopRev.	No
Debriefing of resuscitation performance	2020 EIT CoSTR;	**EIT 645:** We suggest data-driven, performance-focused debriefing of rescuers after	0	3	We did not find substantial new evidence supporting debriefing in adults. One observational study found	No

Topic/PICO	Year(s) last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
(EIT 645 and NLS 1562)	NLS ScopRev	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). **NLS 1562:** There was no previous treatment recommendation on the topic. This ScopRev did not identify sufficient evidence to prompt a SysRev.			short-term improvements with debriefing in neonates. Several knowledge gaps were found and described in the EvUp (eg, short- and long-term outcomes, debriefing facilitator training, emotional and psychological side effects of debriefing).	
Spaced versus massed learning (EIT 1601)	2020 CoSTR	For learners undertaking resuscitation courses, we suggest that spaced learning (training or retraining distributed over time) may be used instead of massed learning (training provided at one single time point) (weak recommendation, very low certainty of evidence).	3	5	The n=3 new randomized trials showed a tendency toward spaced learning but no clear picture on long-term outcome. Included nonrandomized studies were highly heterogeneous in outcome measures, type of resuscitation courses, and participants but overall showed a positive effect of spaced learning.	No

AED indicates automated external defibrillator; ALS, advanced life support; BLS, basic life support; CoSTR, International 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; IHCA, in-hospital cardiac arrest; ILCOR, International Liaison Committee on Resuscitation; NLS, neonatal life support; OHCA, out-of-hospital cardiac arrest; PAD, public-access defibrillation; PICO, population, intervention, comparator, outcome; RCT, randomized controlled trial; ScopRev, scoping review; and SysRev, systematic review.

FIRST AID TASK FORCE

The Recovery Position for Maintenance of Adequate Ventilation and the Prevention of Cardiac Arrest (SysRev)

Rationale for Review

This topic was prioritized by the First Aid Task Force after a scoping review using a reworded PICOST question in 2020. The original PICOST wording from 2015 sought to compare a lateral, side-lying recovery position with a supine position in adults who are breathing and unresponsive in an out-of-hospital setting. The revised PICOST wording now clarifies the population of interest as adults and children with a reduced level of responsiveness of nontraumatic etiology and who do not require resuscitative interventions. The SysRev was undertaken with involvement of content experts from the First Aid and Basic Life Support Task Forces (PROSPERO 2021 CRD42021248358). The full text of this CoSTR can be found online.[396]

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

- **Population:** Adults and children in the first aid setting who have a reduced level of responsiveness of nontraumatic etiology and do not require resuscitative interventions

- **Intervention:** Specific positioning (recovery positioning [ie, various semi-prone, lateral recumbent, side-lying, or three-quarters prone positions of the body])

- **Comparator:** Supine or other position

- **Outcome:** *Critical*—survival, incidence of cardiac arrest, delayed detection of apnea and cardiac arrest. *Important*—need for airway management, incidence of aspiration, hypoxia,

likelihood of cervical spine injury, complications (venous occlusion, arterial insufficiency, arm discomfort/pain, discomfort/pain, aspiration pneumonia)

- **Study design:** RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) and case series were included. Reports including a minimum of 5 cases were eligible for inclusion. Animal, healthy volunteer, and cadaver research were excluded. Unpublished studies (eg, conference abstracts, trial protocols) and editorials were excluded, although case reports published in letter form were included. Scoping reviews and SysRevs were included for discussion and to assure no primary papers were missed, but data were not extracted from these reviews.

- **Time frame:** All years and all languages were included if there was an English abstract. Literature search updated to November 17, 2021.

Consensus on Science

An updated search performed in 2021 identified 3 prospective observational studies enrolling 450 adults and 553 children[397-399] and 4 case series with a total of 251 patients (under 10% were children).[400-403] No comparative studies were identified evaluating critical outcomes, including survival, incidence of cardiac arrest, or delayed detection of apnea and cardiac arrest. Meta-analysis was not possible because of the lack of comparative studies, critical risk of bias, and high degree of heterogeneity.

A 1999 observational study of 205 acutely poisoned patients reported on those with suspected aspiration pneumonia and the body position they were found in.[397] Prone and semi-recumbent positions were associated with a decreased rate of suspected aspiration pneumonia (*P*<0.05). No significant difference was found in the incidence of pulmonary infiltrates between left lateral decubitus, right lateral decubitus, and supine body positions.

A 2016 observational study of 553 pediatric emergency department patients with loss of consciousness reported on the use of the recovery position by caregivers in 145 of 553 patients (26.2%). Use of the recovery position was associated with a decreased admission rate (adjusted odds ratio, 0.28 [95% CI, 0.17–0.48]; *P*<0.0001).[398]

A 2020 prospective observational study of 200 people with OHCA and receiving bystander intervention reported that 64 people (32%) were found by emergency medical services in a supine position suitable for providing chest compressions.[399] Another 37 patients (18.5%) were found in a recovery position. No significant difference in favorable functional outcome was observed between patients in the recovery position compared with those placed in a position suitable for chest compression.

Of the 4 case series identified, 3 series with a total of 244 patients described the body position of persons with sudden unexpected death in epilepsy.[401-403] All 3 case series reported a prone position in most patients with sudden death in epilepsy. A fourth case series reported 7 cases of OHCA in which the patients were judged by bystanders to be unresponsive but breathing normally and placed into a recovery position. The authors noted that subsequent loss of breathing was not detected and CPR was not started.[400]

Treatment Recommendations

When providing first aid to a person with a decreased level of 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 supine and reassessed (good practice statement).

Persons found in positions associated with aspiration and positional asphyxia such as facedown, prone, or in neck and torso flexion positions should be repositioned supine for reassessment (good practice statement).

Technical Remarks

Resuscitative interventions may include opening an airway, rescue breathing, chest compressions, and the application of an automated external defibrillator.

Various recovery positions have been described, and there remains little evidence to suggest an optimal position. The recommended recovery position (lateral recumbent positioning with arm nearest the first aid provider at a right angle to the body and elbow bent with palm up and far knee flexed), remains unchanged from the 2015 CoSTR.[404,405]

Justification and Evidence-to-Decision Framework Highlights

Please see Appendix A for the complete evidence-to-decision table.

Although the evidence to support a treatment recommendation was limited and of very low certainty, the first aid task force recognizes that the opioid crisis in North America has led to many individuals requiring first aid and use of the recovery position. The task force discussed at length the potential benefits from use of a recovery position versus the risks of harm.

One case series[400] described potential missed OHCA in persons placed into a recovery position. Other evidence was identified that did not meet inclusion criteria for this review in which healthy volunteers used breath holding to simulate apnea. It was suggested that placing persons in the recovery position may impair the detection of cardiac arrest and that supine

positioning with a head tilt–chin lift should be adopted instead.[406,407] The first aid task force

noted that it remains unknown how well the head tilt–chin lift was performed in the study or if it

can be maintained for prolonged periods by first aid providers. Moreover, the observation of the

subject may be more complete when they are supine, but a patent airway and unobstructed

breathing may be easier to obtain in the recovery position. The potential difficulty of training lay

providers to be able to accurately identify *normal* breathing and responsiveness in real-life

settings was also considered.

The task forces agreed that, in situations when a sole first aid responder is unable to

remain with a casualty and monitor their responsiveness and breathing, the use of a recovery

position is appropriate. Likewise, a recovery position would be useful in the setting of a sole

responder caring for a person who is in a supine position and requires ongoing airway

maintenance that will prevent the responder from calling for help or providing other immediate

first aid, such as administering naloxone for suspected opioid overdose. The potential impact of

body habitus on airway patency and ventilation in supine versus recovery positions was

discussed. For example, a supine position in an obese person with diminished level of

responsiveness may be associated with greater risk of airway obstruction and inadequate

ventilation. The limited included evidence showing an association between use of a recovery

position and a decreased admission rate further supports the use of a recovery position in

children with a decreased level of responsiveness, although a semi-recumbent position or prone

position was associated with lower rates of suspected aspiration pneumonia. Finally, we

acknowledge that positional asphyxia can occur in a person with a diminished level of

responsiveness in multiple positions. This may include when the torso is lateral and the neck

flexed or rotated down, when a seated person falls/flexes forward at the waist (face down), and

when the face is occluded by soft bedding or material. Case series and an analysis of deaths in patients with epilepsy who are lying in a prone position support the good practice statement to reposition persons found face down, prone, or in a flexed position to a supine position for reassessment.

On balance, the task forces recommend the use of a recovery position as having the potential to benefit most individuals who have a decreased level of responsiveness in the first aid setting. However, because a person's condition can deteriorate and possibly progress to cardiac arrest after being placed into a recovery position, the task forces introduced 2 new good practice statements, emphasizing the importance of careful monitoring and the need to change the position of the patient if assessment is impaired. This need for continuous or regular monitoring of respiratory status and responsiveness while someone is in the recovery position should be included in education and training courses.

Task Force Knowledge Gaps

- The role of positioning in assessment of patient breathing and responsiveness, as well as the ability to monitor a person for deterioration
- A study in which emergency call-takers randomize callers to receive instructions to place individuals with nontraumatic decreased level of responsiveness in either the recovery position or the supine position with assessment of clinical outcomes such as ability to monitor airway, breathing, and responsiveness
- The best position for assessing and maintaining airway patency relative to individual characteristics such as obesity or a history of obstructive sleep apnea, opioid use disorder, or seizure disorder

- How to ensure adequacy of the training of first aid and basic life support responders in the assessment of breathing and responsiveness so they can accurately identify normal breathing and responsiveness

Topics Reviewed by Evidence Updates

The topics reviewed by evidence updates (EvUps) are summarized in Table 36, with the PICO number, existing treatment recommendation, number of relevant studies identified, key findings, and whether a SysRev was deemed worthwhile. Complete EvUps can be found in Appendix C.

Table 36. Topics Reviewed by EvUps

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
Oral dilution for caustic substance ingestion (FA 202)	2010 CoSTR	Administration of a diluent in first aid may be considered if a caustic substance has been ingested, if advised to do so by a healthcare provider. (weak recommendation, very low–certainty evidence	1	0	Animal study of alkali injury of esophagus; irrigation with kefir and distilled water compared with distilled water alone; no difference in histopathological outcomes at 7 days	No
Recognition of anaphylaxis (FA 503)	2020 ScopRev; 2010 CoSTR	First aid providers should not be expected to recognize the signs and symptoms of anaphylaxis without repeated episodes of training and encounters with victims of anaphylaxis.	0	8	Survey studies focused on training in the use of epinephrine autoinjectors and recognition of anaphylaxis and reported on improved confidence in recognizing anaphylaxis and administering	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
					epinephrine or on reasons for hesitation/non-use of epinephrine autoinjectors.	
Compression wraps for acute closed ankle joint injury (FA 511)	2020 CoSTR	We suggest either application of a compression bandage or no application of a compression bandage for adults with an acute closed ankle joint injury (weak recommendation, very low–certainty evidence). Due to a lack of identified evidence, we are unable to recommend for or against use of a compression bandage for closed joint injuries besides the ankle.	0	0		No
Open chest wound dressings (FA 525)	2015 CoSTR	We suggest against the application of an occlusive dressing or device by first aid providers to individuals with an open chest wound (weak recommendation, very low–quality evidence).	0	0	3 animal studies of vented chest seals identified but excluded	No
Bronchodilators for acute asthma exacerbation (FA 534)	2015 CoSTR	When an individual with asthma is experiencing difficulty breathing, we suggest that trained first aid providers assist the individual with administration of a bronchodilator (weak recommendation, very low–quality evidence).	0	0	One review of SysRevs concluded that, among children with asthma, exacerbations treated in the emergency department, short-acting β-agonists	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
					delivered by metered-dose inhaler decrease hospital admission in younger children and emergency department length of stay in older children.	
Optimal duration of cooling of burns with water (FA 770)	2021 CoSTR	We recommend the immediate active cooling of thermal burns using running water as a first aid intervention for adults and children (strong recommendation, very low–certainty evidence). Because no difference in outcomes could be demonstrated with the different cooling durations studied, a specific duration of cooling cannot be recommended. Young children with thermal burns that are being actively cooled with running water should be monitored for signs and symptoms of excessive body cooling (good practice statement).	0	0		No
Preventive interventions for presyncope (FA 798)	2019 CoSTR	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	0	0		No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		(strong recommendation, low- 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).				
Single-stage scoring systems for concussion (FA 799)	2020 ScopRev 2015 CoSTR	No recommendation. We acknowledge the role that a simple, validated, single-stage concussion scoring system could play in the first aid provider's recognition and referral of victims of suspected head injury. However, review of the available literature shows no evidence regarding the application of such scoring systems by the first aid provider. **2021 best practice statement:** It is critically important that concussion is recognized and managed appropriately. In the absence of a validated, simple, single-stage concussion scoring system, the first aid assessment for a person with a possible concussion should be	0	0	A best practice statement was added in 2021 as shown.	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		based upon the typical signs and symptoms of concussion.				
Cooling techniques for exertional hyperthermia and heatstroke (FA 1545)	2020 CoSTR	For adults with exertional hyperthermia or exertional heat stroke, we recommend immediate active cooling using whole body (neck down) water immersion techniques (1°C–26°C [33.8°F–78.8°F) until a core body temperature of less than 39°C (102.2°F) is reached (weak recommendation, very low–certainty evidence). We recommend that when water immersion is not available, any other active cooling technique be initiated (weak recommendation, very low-certainty evidence). We recommend immediate cooling using any active or passive technique available that provides the most rapid rate of cooling (weak recommendation, very low–certainty evidence). For adults with nonexertional heat stroke, we cannot make a recommendation for or against any specific cooling technique	0	2	2 SysRevs identified, no change in treatment recommendations.	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		compared with an alternative cooling technique (no recommendation, very low–certainty evidence). For children with exertional or nonexertional heat stroke, we cannot make a recommendation for or against any specific cooling technique compared with an alternative cooling technique (no recommendation, very low–certainty evidence).				
First aid use of supplemental oxygen for acute stroke (FA 1549)	2020 CoSTR	For adults with suspected acute stroke, we suggest against the routine use of supplemental oxygen in the first aid setting compared with no use of supplemental oxygen (weak recommendation, low- to moderate-certainty evidence).	0	0		No
Methods of glucose administration for hypoglycemia in the first aid setting (FA 1585)	2018 CoSTR	We recommend the use of oral glucose (swallowed) for individuals with suspected hypoglycemia who are conscious and able to swallow (strong recommendation, very low–certainty evidence). We suggest against buccal glucose administration compared with oral	0	0		No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		glucose administration for individuals with suspected hypoglycemia who are conscious and able to swallow (weak recommendation, very low–certainty evidence). If oral glucose (eg, tablet) is not immediately available, we suggest a combined oral + buccal glucose (eg, glucose gel) administration for individuals with suspected hypoglycemia who are conscious and able to swallow (weak recommendation, very low–certainty evidence). We suggest the use of sublingual glucose administration for suspected hypoglycemia for children who may be uncooperative with the oral (swallowed) glucose administration route (weak recommendation, very low–certainty evidence).				
Pediatric tourniquet types for life-threatening extremity bleeding (new)	2020 CoSTR	We suggest the use of a manufactured windlass tourniquet for the management of life-threatening extremity bleeding in children (weak recommendation, very low–certainty evidence).	0	0		No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review, n	Observational studies since last review, n	Key findings	Sufficient data to warrant SysRev?
		We are unable to recommend for or against the use of other tourniquet types in children because of lack of evidence. For infants and children with extremities that are too small to allow the snug application of a tourniquet before activating the circumferential tightening mechanism, we recommend the use of direct manual pressure with or without the application of a hemostatic trauma dressing (good practice statement).				

EvUp indicates evidence update; FA, first aid; PICO, population, intervention, comparator, outcome; RCT, randomized controlled trial; ScopRev, scoping review; and SysRev, systematic review.

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