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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: 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 summary addresses the most recently published resuscitation evidence reviewed by International Liaison Committee on Resuscitation Task Force science experts. Topics covered by systematic reviews include cardiopulmonary resuscitation during transport; approach to resuscitation after drowning; passive ventilation; minimizing pauses during cardiopulmonary resuscitation; temperature management after cardiac arrest; use of diagnostic point-of-care ultrasound 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 likely rescuers of high-risk populations; effect of resuscitation team training; blended learning for life support training; training and recertification for resuscitation instructors; and recovery position for maintenance of breathing and prevention of cardiac arrest. Members from 6 task forces have assessed, discussed, and debated the quality of the evidence using Grading of Recommendations Assessment, Development, and Evaluation criteria and generated consensus treatment recommendations. Insights into the deliberations of the task forces are provided in the Justification and Evidence-to-Decision Framework Highlights sections, and priority knowledge gaps for future research are listed.

Key Words: AHA Scientific Statements ■ advanced life support ■ basic life support ■ cardiac arrest ■ first aid ■ infant, newborn ■ pediatrics ■ resuscitation

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 through more streamlined approaches, detailed later.

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 ≈27 818 times, and 238 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 when 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. Complete evidence-to-decision tables are included in Supplemental Appendix A. Last, 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 through the GRADE approach. Each analysis has been detailed in either a SysRev 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

Abbreviations and Acronyms

A-B-C	airway-breaths-compressions
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
C-A-B	compressions-airway-breaths
CAG	coronary angiography
CARES	Cardiac Arrest Registry to Enhance Survival
CoSTR	Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations
COVID-19	coronavirus disease 2019
CPAP	continuous positive airway pressure
CPC	Cerebral Performance Category
CPR	cardiopulmonary resuscitation
DNACPR	do not attempt cardiopulmonary resuscitation
EPALS	European Paediatric Advanced Life Support
EPILS	European Paediatric Immediate Life Support
ETC	European Trauma Course
EvUp	evidence update
GRADE	Grading of Recommendations Assessment, Development, and Evaluation
HBB	Helping Babies Breathe
IHCA	in-hospital cardiac arrest
ILCOR	International Liaison Committee on Resuscitation
NICU	neonatal intensive care unit
NLS	neonatal life support
NRP	Newborn Resuscitation Programs
NRT	neonatal resuscitation training
OHCA	out-of-hospital cardiac arrest
PALS	Pediatric Advanced Life Support
PCI	percutaneous coronary intervention
PEWS	pediatric early warning system
PICO	population, intervention, comparator, and outcome
PLS	pediatric life support
POCUS	point-of-care ultrasound
PPV	positive-pressure ventilation
PROSPERO	Prospective Register of Systematic Reviews
RCT	randomized controlled trial
RFM	respiratory function monitor
ROSC	return of spontaneous circulation
SGA	supraglottic airway
ScopRev	scoping review
SysRev	systematic review
TTM	targeted temperature management

supporting the intervention (predefined by the population, intervention, comparator, and outcome [PICO] question) as high, moderate, low, or very low. Randomized controlled trials (RCTs) 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, for 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 when the data do not enable absolute effect estimates to be determined, alternative measures of effect such as odds ratios are reported.

In some cases, a previously published SysRev that meets specific methodological criteria can be used to generate a CoSTR using the GRADE-adolopment process.[1] Adolopment combines adoption, adaptation, and development and avoids the unnecessary repetition of the SysRev process. It includes the same process of bias assessment and data extraction, with the existing SysRev used as a starting point. Searches are updated if needed, and studies published since the SysRev are added.

The task forces generate treatment recommendations after weighing the evidence and after 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 to 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 Supplemental 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 subjects 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 (POCUS) as a diagnostic tool during cardiac arrest (SysRev)
- Vasopressin and corticosteroids for cardiac arrest (SysRev)
- Post–cardiac arrest coronary angiography (CAG; SysRev Update)
- Vasopressors during cardiac arrest (EvUp)
- Cardiac arrest from pulmonary embolism (EvUp)

Pediatric Life Support

- Public-access devices (SysRev)
- Pediatric early warning systems (PEWSs; 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 after in-hospital cardiac arrest (IHCA; SysRev)
- BLS training for likely rescuers of high-risk populations (SysRev)
- Patient outcome and resuscitation team members attending advanced life support (ALS) 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 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 the first aid setting (EvUp)
- Pediatric tourniquet types for life-threatening extremity bleeding (EvUp)

Readers are encouraged to monitor the ILCOR website[2] 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 SysRev 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.[3]

PICO, Study Design, 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
- Outcome:
  A. Critical: Survival to hospital discharge with good neurological outcome, survival to hospital discharge
  B. Important: Return of spontaneous circulation (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. The literature search was updated to October 16, 2021.

Consensus on Science

Two RCTs, 1 observational study, and a very small pilot RCT were identified.[4–7] The overall certainty of evidence was rated as very low. All the individual studies were 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.[4,5] The observational study evaluated passive oxygen insufflation as part of a minimally interrupted CPR bundle (also including uninterrupted preshock and postshock chest compressions and early epinephrine administration).[6] The pilot RCT compared 9 patients who received chest compression–induced ventilation that included CPAP with 11 patients who received volume-controlled ventilation during CPR.[7] 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, studies, n	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Discharge with favorable outcome (critical)	1019 patients, 1 observational study[6]	Very low	1.03 (0.84–1.26)	3 patients more/1000 (15 fewer–25 more)
Survival to ICU discharge (critical)	791 patients, 2 RCTs[4,5]	Low	0.96 (0.31–2.85)	1 patient fewer/1000 (14 fewer–38 more)
Survival to admission (important)	791 patients, 2 RCTs[4,5]	Low	0.92 (0.64–1.24)	14 patients fewer/1000 (61 fewer–41 more)
ROSC (important)	791 patients, 2 RCTs[4,5]	Low	0.98 (0.85–1.12)	4 patients fewer/1000 (31 fewer–25 more)
ROSC (important)	1019 patients, 1 observational study[6]	Very low	0.85 (0.77–1.00)	45 patients fewer/1000 (69 fewer–0 more)
ROSC (important)	20 patients, 1 pilot RCT study[7]	Very low	0.85 (0.77–1.00)	45 patients fewer/1000 (69 fewer–0 more)

CPR indicates cardiopulmonary resuscitation; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; ICU, intensive care unit; 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 Supplemental Appendix A.

Passive ventilation may represent an alternative to intermittent positive-pressure ventilation (PPV). It may shorten interruptions in chest compressions for advanced airway management and may overcome the potential harm from PPV (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[4,5] that were included compared intermittent PPV through a tracheal tube with continuous insufflation of oxygen through a modified tracheal tube, that is, a Boussignac tube. The Boussignac tube used in these studies generates a constant tracheal pressure of ≈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[6] 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, the certainty of evidence was rated as very low primarily because of the risk of bias attributable to indirectness.

We acknowledge that when 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 SysRev was registered in PROSPERO (CRD42019154784). The full text of this CoSTR can be found on the ILCOR website.[8]

PICO, Study Design, 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)
- Outcome:
  A. Critical: Survival to hospital discharge with good neurological outcome and survival to hospital discharge
  B. 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. The literature search was updated to December 17, 2021.

Consensus on Science

Three RCTs[9–11] and 21 observational studies[12–32] were identified. The evidence identified was divided into 5 categories, and results are summarized in Table 2:

Table 2. Minimizing Pauses in Chest Compressions

Category	Studies	Certainty of evidence (GRADE)	Main findings
1. RCTs on interventions that affect pauses	3 RCTs[9–11]	Very low	New AED strategies resulted in higher CPR fractions and shorter preshock and postshock pauses but no differences in survival.[9,10] Continuous chest compression strategy resulted in higher CPR fractions and lower survival to hospital admission; there were no difference in survival to discharge.[11]
2. Studies comparing before and after or different systems' CPR fraction	6 observational studies[12–17]	Very low	One study evaluated incremental changes in various CPR quality metrics and outcomes over time and found that from 2006–2016 both CPR fraction and the proportion of survivors with favorable survival increased.[13] The other studies observing improved CPR fractions and perishock pauses did not observe significant improvements in survival.[12,14–17]
3. Associations between chest compression pauses and outcomes	5 observational studies[18–22]	Very low	Two studies found increased CPR fraction to be associated with improved survival,[18,19] whereas 2 did not.[20,21] The fifth study found increasing CPR fraction to be associated with improved ROSC.[22] One study found increasing perishock pause to be associated with lower survival,[20] whereas another did not.[21]
4a. Outcomes compared for chest compression pause categories: CPR fraction	7 observational studies[18,21–26]	Very low	One study showed higher favorable neurological outcome and survival to discharge in arrests with CPR fraction >80% compared with <80% in the subgroup with >20-min CPR duration but no differences in survival in the corresponding patient subgroups with 5- or 10-min CPR durations.[23] 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%).[24,25] One study observed lower ROSC with CPR fraction >80% compared with <80%.[26] There were no significant differences in outcomes in the remaining 3 studies.[18,21,22]
4b. Outcomes compared for chest compression pause categories: perishock pauses	4 observational studies[21,25,28,29]		Three studies observed higher survival in patients with shorter preshock pauses (<10 s) compared with longer preshock pauses (>10–20 s),[21,25,28,29] and 2 studies observed higher survival in patients with shorter perishock pauses (<20 s) compared with longer perishock pauses (>20–40 s).[25,28] One study did not find improved survival with preshock pause <10 s compared with >10 s.[21]
5. Pauses compared between survivors and nonsurvivors	8 observational studies[20,26–32]	Very low	One study observed higher CPR fractions during the first 5 min in nonsurvivors compared with survivors[20]; 1 study observed higher CPR fractions in patients with downtimes >15 min without ROSC[26]; 1 observed higher CPR fractions in patients with ROSC.[27] In the remaining 5 studies, no difference was observed.[28–32]

AED indicates automated external defibrillator; CPR, cardiopulmonary resuscitation; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; RCT, randomized controlled trial; and ROSC, return of spontaneous circulation.

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 in which outcomes were compared between groups in different chest compression pause categories
5. Observational studies in which 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. All the individual studies were at a critical risk of bias attributable 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.

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 Supplemental 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 creators. 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) makes 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 depend on both cardiac rhythm and the duration of the resuscitation attempt; therefore, an optimal target will 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 neurological function in animals treated with short, controlled pauses during initial CPR).[33,34] 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, we believe that it is reasonable to assume that there is a low risk of harm from a lack of chest compression pauses and that the possibility for desirable effects from fewer pauses outweighs this.

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 ScopRev was completed for the 2020 CoSTR, and this topic was subsequently prioritized by the BLS Task Force. This SysRev was registered in PROSPERO (CRD42021240615). The full text of these CoSTRs can be found on the ILCOR website.[35]

PICO, Study Design, and Time Frame

- Population: Adults and children receiving CPR after out-of-hospital cardiac arrest (OHCA)
- Intervention: Transport with ongoing CPR
- Comparator: Completing CPR on scene (until ROSC or termination of resuscitation)
- Outcome:
  - A. Critical: Survival to hospital discharge with good neurological outcome and survival to hospital discharge
  - B. 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. The literature search was updated to June 15, 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 the following:

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

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).

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Table 3. Effect of Transport on CPR Quality

Category	Studies	Certainty of evidence (GRADE)	Main findings
Correct hand positioning	2 manikin studies[36,37]	Very low	Simulated helicopter rescue; 1 study with fewer correct compressions in flight,[37] 1 study with no difference[36]
Chest compression rate	5 observational studies[38–42] 4 manikin studies[36,43–45]	Very low	One study with slightly faster compressions during transport,[42] 2 showed increased variation,[40,42] 3 showed no difference.[38,39,41] Manikin studies had divergent results.[36,43–45]
Chest compression depth	4 observational studies[39–42] 4 manikin studies[36,43–45]	Very low	One study with deeper compressions[42] and 1 with more correct depth[41] during transport, 2 with no difference.[39,40] Manikin studies had divergent results.[36,43–45]
Pauses	1 manikin study[45]	Very low	Pauses during transport within guidelines[45]
Leaning on the chest/incomplete release	2 manikin studies[37,45]	Very low	Manikin studies with divergent results[37,45]
CPR fraction	4 observational studies[38–40,42] 2 manikin studies[43,45]	Very low	3 studies showed lower CPR fractions during transport,[38–40] 1 showed no difference.[40] Manikin studies had divergent results.[43,45]
Ventilation	2 observational studies[38,39]	Very low	One study with faster ventilations during transport,[39] 1 study with no difference[38]
Overall correct CPR	1 observational study[42] 1 manikin study[46]	Very low	High-quality CPR observed both before and during transport.[42] Fewer correct compressions on manikin during transport[46]

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

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, when 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 Supplemental 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 clinicians, pathogenesis, rhythm, response to treatment), logistic considerations (location of arrest, challenges of extrication, resources required, journey to hospital), patient and responder 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.

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.[47] 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, CAG, 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.
- There are no studies on the impact of the presence or absence of an advanced airway on the effect of transport on ventilation during CPR.

Table 4. Effect of Transport on Survival

Outcomes (importance)	Participants, Studies, n	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Discharge with favorable outcome (critical)	27 705 patients, 1 observational study[47]	Very low	0.39 (0.33–0.47)	2 patients fewer/1000 (2 fewer–3 fewer)
Survival to discharge (critical)	27 705 patients, 1 observational study[47]	Very low	0.46 (0.42–0.52)	5 patients fewer/1000 (4 fewer–5 fewer)
ROSC (important)	27 705 patients, 1 observational study[47]	Very low	0.41 (0.39–0.43)	23 patients fewer/1000 (22 fewer–24 fewer)

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

Table 5. 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.

BLS indicates Basic Life Support; and CPR, cardiopulmonary resuscitation.

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 SysRev was registered in PROSPERO (CRD42021259983). The full text of this CoSTR can be found on the ILCOR website.[48]

PICO, Study Design, and Time Frame

- Population: Adults and children in cardiac arrest after drowning
- Intervention: Resuscitation that incorporates a compression-first strategy (C-A-B)
- Comparator: Resuscitation that starts with ventilation (A-B-C)
- Outcome:
  A. Critical: Survival to hospital discharge with good neurological outcome and survival to hospital discharge
  B. 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. The literature search was updated to October 16, 2021.

Consensus on Science

Seven hundred 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 laypeople providing resuscitation for adults and children in cardiac arrest caused by drowning (good practice statement).

We recommend that health care 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 pathogenesis.

A similar rationale is commonly invoked in pediatric cardiac arrest in which hypoxia is a more common cause than primary cardiac events.[49] ILCOR reviewed the evidence for initial resuscitation strategy in pediatric cardiac arrest in both 2015 and 2020.[50,51] No human studies were identified, and the Pediatric Life Support (PLS) Task Force did not recommend either strategy as superior. Instead, the task force 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 RCTs 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.[52,53]

There is only indirect evidence to support a ventilation-first strategy in drowning. Another SysRev 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 ScopRev found that bystander CPR including ventilation was associated with better survival.[54] One retrospective observational study compared in-water resuscitation (ie, ventilation) with no ventilation for drowning victims in respiratory (and possibly cardiac) arrest. Survival

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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 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 >8 cm.	0	0	No new studies identified	No
BLS 342 Barrier devices	2005 CoSTR	Providers should take appropriate safety precautions when feasible and when resources are available to do so, especially if the subject is known to have a serious infection (for example, 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 were identified. 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 min to assess the cardiac rhythm (weak recommendation, low-certainty evidence).	0	0	No new studies identified	No
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, when invasive monitoring is available, there are insufficient data on the value of a pulse check while performing CPR. We therefore do not make a treatment recommendation for the value of a pulse check.	0	0	No new studies since 2021. Some relevant articles showing the effectiveness of ultrasound to check for circulation were identified.	No
BLS 349 Rescuer fatigue in CCO-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 laypeople 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

(*Continued*)

Table 6. Continued

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 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 OHCA. 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, very low–certainty evidence).	0	0	No new studies addressing this question were identified, but 2 simulation/training studies highlighting difficulties for lay rescuers in identifying correct hand position were identified.	No
BLS 359 Dispatch-assisted CCO-CPR vs conventional CPR	2019 CoSTR	We recommend that dispatchers provide CCO-CPR instructions to callers for adults with suspected OHCA (strong recommendation, low-certainty evidence).	0	0	No new studies identified	No
BLS 360 EMS CCO-CPR 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 PPV delivered without pausing chest compressions until a tracheal tube or supraglottic device has been placed (strong recommendation, high-certainty evidence). We 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 was identified. Median inspiratory tidal volume generated by manual chest compressions without ventilation was 20 mL (IQR, 13–28 mL), which was judged inadequate to provide adequate alveolar ventilation.	No
BLS 362 CV 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 before defibrillation	2020 CoSTR	We suggest a short period of CPR until the defibrillator is ready for analysis 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 ≈5 cm (2 in; strong recommendation, low-certainty evidence) while avoiding excessive chest compression depths (>6 cm [>2.4 in] in an average adult) during manual CPR (weak recommendation, low-certainty evidence).	0	2	PICOSTs BLS 343, 366, and 367 have been evaluated together to identify any evidence looking at the interplay among the 3 CPR metrics. Two new observational studies on rate and depth, but not recoil, since last ScopRev were identified. Findings were consistent with current guidelines.	No
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 among the 3 CPR metrics. Two new observational studies on rate and depth, but not recoil, since last ScopRev were identified. Findings were consistent with current guidelines.	No

(*Continued*)

Table 6. Continued

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 368 Foreign-body airway obstruction	2020 CoSTR	We suggest that backslaps 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 (>1 y of age) 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 health care providers use Magill forceps to remove a foreign-body airway obstruction in patients with OHCA resulting from foreign-body airway obstruction (weak 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).	0	1	A single new case series was identified that describes 8 cases of the use of a vacuum cleaner to clear foreign-body airway obstruction.	No
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 IHCA, we suggest that when a bed has a CPR mode that increases mattress stiffness, it should be activated (weak recommendation, very low–certainty evidence). During IHCA, we suggest against moving a patient from the bed to the floor to improve chest compression depth (weak recommendation, very low–certainty evidence). During IHCA, we suggest in favor of either a backboard or no-backboard strategy to improve chest compression depth (conditional recommendation, very low–certainty 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
BLS 372 In-hospital CCO-CPR vs conventional CPR	2017 CoSTR	Whenever tracheal intubation or an SGA is achieved during in-hospital CPR, we suggest that providers perform continuous compressions with PPV delivered without pausing chest compressions (weak recommendation, very low–certainty evidence).	0	0	No new studies identified	No

(*Continued*)

Table 6. Continued

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 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 were identified. 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 (for example, 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 temporizing measure in the exceptional circumstance of a witnessed, monitored IHCA (for example, in a cardiac catheterization laboratory) attributable 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).	0	0	No new studies identified	No
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-s inspiratory time and with a 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 Identified studies evaluated tidal volumes during mechanical ventilation and after ROSC.	No
BLS 547 Lay rescuer CCO-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 starting CPR with compressions rather than ventilation in adults with cardiac arrest (weak recommendation, very low–certainty evidence).	0	0	No new studies identified	No

(*Continued*)

Table 6. Continued

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 740 Dispatcher recognition of cardiac arrest	2020 CoSTR	We recommend that dispatch centers implement a standardized algorithm or standardized criteria to immediately determine whether 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.	1	6	One RCT was identified in which calls processed with machine learning recognized arrest 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.	Yes
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 before 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 were 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). We suggest that the usefulness of head-up CPR during CPR be assessed in clinical trials or research initiatives (weak recommendation, very low–certainty evidence).	0	0	No new studies identified Observational data exploring AMSA and $ETCO_2$ to guide defibrillation might be relevant for ALS.	No

AED indicates automated external defibrillator; ALS, advanced life support; AMSA, amplitude spectral area; BLS, basic life support; CCO-CPR, chest compression–only cardiopulmonary resuscitation; CoSTR, Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations; CPR, cardiopulmonary resuscitation; CV, compression-to-ventilation; EMS, emergency medical services; EvUp, evidence update; HBV, hepatitis B virus; IHCA, in-hospital cardiac arrest; IQR, interquartile range; OHCA, out-of-hospital cardiac arrest; PAD, public-access defibrillation; PICO, population, intervention, comparator, outcome; PICOST, population, intervention, comparator, outcomes, study design, timeframe; PPV, positive-pressure ventilation; RCT, randomized controlled trial; SARS, severe acute respiratory syndrome; ScopRev, scoping review; and SGA, supraglottic airway.

*Complete EvUps are in Supplemental Appendix B.

(87.5% versus 25%) and survival with favorable functional outcome (52.6% versus 7.4%) were higher in the in-water resuscitation cohort.[55] Another study describes significantly worse functional outcomes in children who drowned who experienced cardiac arrest compared with respiratory arrest only (81% versus 0%; $P<0.001$). Intervening with ventilation early in the arrest process before the heart has stopped (ie, addressing the hypoxic mechanism) may improve outcomes.[56]

The recommendation for a compression-first strategy (C-A-B) for lay rescuers prioritizes simplicity and cohesiveness in training recommendations for laypeople, 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 health care 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 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 Supplemental Appendix B.

ALS 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.[57] A SysRev was therefore conducted on behalf of the ALS Task Force (PROSPERO; CRD42020217954).[58] The complete CoSTR can be found online.[59]

PICO, Study Design, and Time Frame

For this PICO, study design, and time frame, 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 intracardiac 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 neurological/functional outcome at discharge/≥30 days
- Study design: Controlled trials in humans, including RCTs and nonrandomized trials (eg, pseudorandomized trials). Observational studies, ecological studies, case series, case reports, reviews, abstracts, editorials, comments, letters to the editor, and unpublished studies were excluded. Studies assessing cost-effectiveness were included for a descriptive summary.
- 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. Articles 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 to 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.

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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, n	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Survival to hospital discharge (critical)	2836 patients, 5 RCTs[60,61,63–65]	Low	1.12 (0.92–1.35)	55 patients more/1000 (37 fewer–161 more)
Favorable neurological outcome at discharge or 30 d (critical)	2139 patients, 3 RCTs[60,61,63]	Low	1.30 (0.83–2.03)	115 patients more/1000 (65 fewer–395 more)
Survival to 90 or 180 d (critical)	2776 patients, 5 RCTs[61–65]	Low	1.08 (0.89–1.30)	35 patients more/1000 (48 fewer–130 more)
Favorable neurological outcome at 90 or 180 d (critical)	2753 patients, 5 RCTs[61–65]	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 Temperature Control With Hypothermia

We identified 6 RCTs comparing the use of temperature control with hypothermia and temperature control with normothermia or fever prevention.[60–65] No differences were found across any outcome, and key results are presented in Table 7.

Use of Prehospital Cooling

We identified 10 RCTs[66–75] comparing the use of prehospital cooling with no prehospital cooling after OHCA, and no differences in critical outcomes were found (Table 8).

Specific Temperature Comparisons

A single large RCT,[76] 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.[77,78]

Duration of Cooling

A single RCT[79] including 451 patients found no statistically significant difference in survival or favorable neurological outcome at 6 months between 48 and 24 hours of temperature control with hypothermia.

Method of Temperature Control

Three RCTs[80–82] including a total of 523 patients found no difference in survival or favorable neurological 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 ≤37.5°C for patients who remain comatose after ROSC from cardiac arrest (weak recommendation, low-certainty evidence).

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

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

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

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

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

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 Supplemental Appendix A.

In making these recommendations, the ALS Task Force agreed that we should continue to recommend active temperature control to prevent fever in

Table 8. Key Outcomes From RCTs of Prehospital Cooling

Outcomes (importance)	Participants, studies, n	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Survival to hospital discharge (critical)	4808 patients, 10 RCTs[66–75]	Moderate	1.01 (0.92–1.11)	2 patients more/1000 (19 fewer–27 more)
Favorable neurological outcome at discharge (critical)	4666 patients, 9 RCTs[60,66–72,74,75]	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.

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

Outcomes (importance)	Participants, studies, n	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Favorable neurological outcome at 180 d (critical)	933 patients, 1 RCT[76]	Low	0.98 (0.86–1.13)	10 patients fewer/1000 (68 fewer–63 more)
Survival at 180 d (critical)	939 patients, 1 RCT[76]	Low	0.99 (0.88–1.12)	5 patients fewer/1000 (63 fewer–63 more)
Favorable neurological outcome at discharge (critical)	938 patients, 1 RCT[76]	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.

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 to the TTM and TTM2 RCTs. To provide additional clarity for interpreting future clinical trials, SysRevs, and CoSTRs, the Task Force proposes that 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 to be important, and the Task Force noted that in the TTM2 trial[61] pharmacological measures (acetaminophen), uncovering the patient, and lowering ambient temperature were used to maintain a temperature of ≤37.5°C (99.5°F) in the normothermia/fever prevention group. If the temperature was >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 patients with nonshockable cardiac arrest, the Hyperion trial[64] 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 included mainly 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 those in 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.
- 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.[83–85]
- The comparison between 33°C and 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 >33°C were not actively warmed.[61] In the Hyperion trial, patients allocated to normothermia whose temperature was <36.5°C at randomization were warmed at 0.25°C/h to 0.5°C/h and then maintained at 36.5°C to 37.5°C.[64]

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.[72]

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. Two recent SysRevs have conflicting conclusions.[86,87]

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 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

POCUS as a Diagnostic Tool During Cardiac Arrest (SysRev)

Rationale for Review

A SysRev of the diagnostic accuracy of 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.[88] The diagnostic SysRev was registered on PROSPERO (CRD42020205207) and the full text of the CoSTR can be found online.[89,90]

PICO, 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 cause or pathophysiological 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, and unpublished studies were not excluded.
- 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. As a result 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[91] provided sufficient information to calculate the sensitivity and specificity of POCUS for specific pathophysiological states, and these results are summarized in Table 10.

For the target conditions of cardiac tamponade, pericardial effusion, pulmonary embolism, myocardial infarction, aortic dissection, and hypovolemia, 11 observational studies[92–102] with a 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 intraoperative 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 POCUS during CPR to diagnose reversible causes of cardiac arrest (weak recommendation, very low–certainty evidence).

We suggest that if POCUS 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 POCUS during CPR should be carefully considered and weighed against the risks of interrupting chest compressions and misinterpreting the sonographic findings (good practice statement).

Table 10. Sensitivity and Specificity of POCUS for 3 Potential Arrest Causes From a Single Study*[91]

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 or clinical adjudication in all cases.

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 were 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 1 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 the use of POCUS.[103,104] Some studies suggest that transesophageal echocardiography can eliminate this problem.[105–107]

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 PICO Study Design, and Time Frame section.[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 interrater 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 after the publication of a recent RCT[108] and a subsequent SysRev with individual patient data meta-analysis, which was identified as suitable for adolopment.[109] The full text of the CoSTR can be found online.[110]

PICO, 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:
  A. Critical: Health-related quality of life; survival with favorable functional outcome at discharge, 30, 60, 90, or 180 days, or 1 year; and survival at discharge, 30, 60, 90, or 180 days or 1 year
  B. 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.

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

Outcomes (importance)	Participants, studies, n	Certainty of evidence (GRADE)	OR (95% CI)	Anticipated absolute effects
Favorable functional outcome at hospital discharge (critical)	869 patients, 3 RCTs[108,111,112]	Low	1.64 (0.99–2.72)	37 patients more/1000 (1 fewer–93 more)
Survival to discharge (critical)	869 patients, 3 RCTs[108,111,112]	Low	1.39 (0.90–2.14)	34 patients more/1000 (9 fewer–91 more)
ROSC (important)	869 patients, 3 RCTs[108,111,112]	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.

Consensus on Science

Three RCTs[108,111,112] were identified, all of which included patients with IHCA only.

In-Hospital Cardiac Arrest

One of the included trials,[108] 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 score.

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

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 IHCA because of 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 OHCA (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[111,112] reported improvements in outcomes beyond ROSC (eg, survival, favorable neurological outcome), but these effects were not observed in the later study.[108] 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[113] 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 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[108] rather than dedicated research staff.[111,112] 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 1 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.[88] 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 (CRD42020160152).[114]

PICO, Study Design, and Time Frame

- Population: Unresponsive adults (>18 years of age) with ROSC after cardiac arrest
- Intervention: Emergent or early (2–6 hours) CAG with percutaneous coronary intervention (PCI) if indicated
- Comparator: Delayed CAG (within 24 hours)
- Outcome:
  A. Critical: Survival to hospital discharge; functional survival to intensive care unit or hospital discharge; survival at 30, 90, and 180 days; functional survival at 30, 90, and 180 days
  B. 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 rerun on January 7, 2022.

Consensus on Science

One new RCT and 1 secondary analysis of a previous RCT were identified.[115,116] This enabled additional meta-analyses of several critical outcomes for patients with no ST-segment elevation on a post-ROSC ECG, 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.[118]

Shockable Initial Rhythm, No ST-Segment Elevation

The new RCT[115] 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 and new data from a long-term outcome analysis of a previous trial[116] 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.[118]

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.[118]

Adverse Events

New meta-analyses were performed that included the 1 additional RCT identified since the last review.[115] 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.[118]

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, n	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Functional survival at 30 d (critical)	629 patients, 2 RCTs[115,117]	Low	0.92 (0.66–1.29)	30 patients fewer/1000 (146 fewer–103 more)
Survival to 30 d (critical)	629 patients, 2 RCTs[115,117]	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[115,117]	High	1.37 (1.07–1.74)	94 more/1000 (20 more–174 more)
PCI frequency (important) Per-protocol analysis (only patients who received angiography)	485 patients, 2 RCTs[115,117]		0.86 (0.68–1.07	62 fewer/1000 (143 fewer–28 more)

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

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, n	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effects
Survival to hospital discharge/30 d (critical)	552 patients, 2 RCTs[115,119]	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[116]	Very low	No difference in mean values	Not applicable
Quality of life per RAND-36 mental score (critical)	235 patients, 1 RCT[116]	Very low	No difference in mean values	Not applicable

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; RAND-36, RAND Corp 36-Item Short Form Survey; RCT, randomized controlled trial; and RR, relative risk.

Treatment Recommendations

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

We suggest early CAG 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 Supplemental Appendix A.

This updated review used the search strategy from the 2021 CoSTR,[88] restricting the inclusion criteria to RCTs only. We found 1 new RCT[115] and 1 analysis of long-term outcomes from a previously included RCT.[116] 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 after arrest 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 who would benefit from earlier CAG.

It is important to note that this review examined early CAG compared with a combined control group of late CAG or no CAG. 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 of cardiac complications but instead die as a result of neurological 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.

Task Force 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 neurological 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
- Limited evidence for longer-term outcomes
- Relatively few studies examining health-related quality of life outcomes
- Whether newer or alternative end points such as functional or biochemical measures may show a benefit with timing of CAG in patients with cardiac arrest

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 Supplemental Appendix B.

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 CPR (strong recommendation, low- to moderate-certainty evidence). For nonshockable rhythms (PEA/asystole), we recommend administration of epinephrine as soon as feasible during CPR (strong recommendation, very low–certainty evidence). For shockable rhythms (VF/pVT), we suggest administration of epinephrine after initial defibrillation attempts are unsuccessful during CPR (weak recommendation, very low–certainty evidence). We suggest against the administration of vasopressin in place of epinephrine during CPR (weak recommendation, very low–certainty evidence). We suggest against the addition of vasopressin to epinephrine during CPR (weak recommendation, low-certainty evidence).	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
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). We suggest the use of fibrinolytic drugs, surgical embolectomy, or percutaneous mechanical thrombectomy for cardiac arrest when PE is the known cause of cardiac arrest (weak recommendation, very low–certainty evidence). The role of extracorporeal life support (ECPR) techniques was 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).	0	4	Small studies that do not change management; there is a need for an EvUp focusing on ECPR for cardiac arrest from PE.	No

ALS indicates advanced life support; CoSTR, 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 electric 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; CRD42017080475). The full text of this CoSTR is available on the ILCOR website.[120]

PICO, Study Design, and Time Frame

- Population: Infants, children, and adolescents with nontraumatic OHCA
- Intervention: Application of, or shock delivery from, an AED by lay rescuers
- Comparator: Standard care by lay rescuer without AED application
- Outcome:
  A. Critical: survival and functional outcome at hospital discharge
  B. 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 articles[121–123] were from the CARES (Cardiac Arrest Registry to Enhance Survival) database in the United States. The data reported did not correspond to the PICO study design and time frame question in a usable manner, although AED use was part of the analyses. Raw data provided by CARES 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 several studies from the Japanese Fire and Disaster Management Agency had overlapping dates for data inclusion, the last article[124] (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: <1, 1 to 12, 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) of 1 to 2 at 1 month, CPC of 1 to 2 at hospital discharge, and hospital discharge and bystander CPR with AED.

Treatment Recommendations

We suggest the use of an AED by lay rescuers for all children >1 year of age who have nontraumatic OHCA (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 <1 year of age with nontraumatic OHCA.

Justification and Evidence-to-Decision Framework Highlights

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

For Children >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 of 7591 children from the CARES database had an AED applied and that 220 of 5899 children in the Japanese study had a shock delivered.[121–124] 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 neurological outcomes at hospital discharge or 30 days, but we 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 skill set and thus provided higher-quality CPR. In addition to treating shockable rhythms, AEDs provide instructions on 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 <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 <1 year of age, the task force considered the lack of a significant difference in outcomes. However, few patients (12) in this age group had an AED applied, and only 1 survived. This may have resulted in a type II error; 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 congenital cyanotic cardiac disease. 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.

Task Force 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, that is, potential delay in the initiation of 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 of AED application for younger children, especially those <8 years of age or who weigh <25 kg
- Whether the application of an AED is beneficial beyond shock delivery such as by directing the rescuer to perform appropriate actions.

PEWSs With or Without Rapid Response Teams (SysRev)

Rationale for Review

This SysRev was prompted by our ScopRev of pediatric early warning scores conducted in 2020[125] and was undertaken to review our current treatment recommendations for PEWSs (PROSPERO; CRD42021269579). PEWSs 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.[126]

PICO, Study Design, and Time Frame

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

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

Age, y	Hospital discharge RR (95% CI)	CPC 1 to 2 at hospital discharge, RR (95% CI)	CPC 1 to 2 at 1 mo, RR (95% CI)
<1[121–123]	1.43 (0.22–9.37)	1.82 (0.28–11.96)	
1–12[121–123]	3.04 (2.18–4.25)	3.85 (2.69–5.5)	
13–18[121–123]	3.38 (2.74–4.16)	3.75 (2.97–4.72)	
0–17[122]	1.55 (1.12–2.12)	1.49 (1.11–1.97)	
6–17[124]			12.12 (4.97–17.12)

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

- Intervention: PEWSs with or without rapid response teams or medical emergency teams
- Comparator: No PEWS or standard care (without a scoring system)
- Outcome:
  A. 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-resuscitation order
  B. 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. The literature search was updated to June 26, 2021.

Consensus on Science

We identified 12 studies, 1 RCT[127] and 11 cohort studies,[128–138] 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.

Treatment Recommendations

We suggest using PEWSs 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 Supplemental Appendix A.

In making these recommendations, the PLS Task Force considered the following: PEWSs should be part of an overall clinical response system, with the task force placing a higher value on improving health care providers' ability to recognize and intervene for patients with deteriorating illness over the expense incurred by a health care 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 PEWSs and ongoing education for health care providers. The PLS Task Force agreed that the decision to use PEWSs should be balanced between the use of existing resources and the capabilities of the health care setting to adapt to its use and the consequences of its use.

Evidence is limited, and there is equipoise about whether the use of PEWSs significantly decreases in-hospital pediatric mortality, significant clinical deterioration, and cardiopulmonary arrest events. In the context of resource-limited health systems, the need to use health care resources judiciously is especially important. Although no definitive

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[127]	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 use of PEWS.
	9 cohort studies[128–136]	Pooled RR 1.17 (0.98–1.40)	
Cardiopulmonary arrest events (critical)	6 cohort studies[129–132,136,137]	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.
Significant deterioration events (critical)	1 RCT[127]	1.67 (1.34–2.08)	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.
	5 cohort studies[128,129,133,134,138]	Pooled RR, 1.09 (0.84–1.42)	
Unplanned code events (important)	4 cohort studies[130,132,133,135]	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 system; RCT, randomized controlled trial; and RR, relative risk.

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 vs 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 identified	No
CCO-CPR vs 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 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.	0	3	Three articles were identified: 2 showed an association between epinephrine use and worse outcome, and 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.	No
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 identified	No
ECPR for pediatric cardiac arrest (Peds 407)	2019 CoSTR	We suggest that ECPR may be considered as an intervention for selected infants and children (for example, cardiac populations) with IHCA refractory to conventional CPR in settings in which 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.	0	15	Fifteen studies were identified; collectively, their findings did not provide sufficient evidence to change the treatment recommendations from 2019.	No
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 intraosseous access, and the other found no difference.	No
Sodium bicarbonate administration for children in cardiac arrest (PLS 388)	2020 EvUp 2010 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, which included 7 observational studies (2 prospective), published between 2006 and 2018. Results support our current recommendations.	No

(*Continued*)

Table 17. Continued

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
TTM*	2019 CoSTR	The PLS Task Force recommendations from 2020 for the pediatric population remain unchanged in 2021, with minor wording clarification of temperature targets: We suggest that for infants and children who remain comatose after 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–34°C) compared with active control of temperature at normothermia (36°C–37.5°C; or an alternative temperature) for children who achieve ROSC but remain comatose after OHCA or IHCA.	0	8	No new RCTs were identified. There were 8 additional publications; however, 7 were secondary analyses of subgroups of the THAPCA RCT primary trial data for the OHCA, IHCA, or combined cohorts.	No

A-B-C indicates airway-breaths-compressions; C-A-B, compressions-airway-breaths; CCO-CPR, chest compression–only cardiopulmonary resuscitation; 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; OHCA, out-of-hospital cardiac arrest; Peds, pediatrics; 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,[139] following the CoSTR "Temperature Management in Adult Cardiac Arrest: Advanced Life Support Systematic Review" by the Advanced Life Support Task Force.[59]

benefits were found, the very weak evidence identified supports the use of PEWSs in systems with available resources that prioritize and value the potential to decrease the incidence of code events for inpatient children.

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 health care providers' ability to recognize and intervene for patients with deteriorating illness. For settings already using PEWSs, 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 PEWSs 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 are suggested for further studies.
- The effect of rapid response teams, alone and in combination with PEWSs
- Whether the effect of PEWSs and rapid response teams varies by setting and patient type (eg, emergency department, pediatric oncology patients, patients in higher- versus lower-resource settings)
- Prospective evaluations of different PEWSs for predicting, identifying, and providing early intervention for patients at risk for different forms of decompensation, including primary respiratory, circulatory, and neurological causes
- Effectiveness of various methods for PEWS implementation and staff training; data on feasibility, cost-effectiveness, equity, and acceptability of integrating PEWSs into existing health care systems

Topics Reviewed by EvUps

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 Supplemental Appendix B.

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.[140] A SysRev estimated that hypothermia was common in infants born in hospitals (prevalence range, 32%–85%)

Table 18. Temperature Terminology

Term	Body temperature, °C	
Moderate hypothermia	32.0–35.9	Measured with 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	36–36.4	
Hyperthermia	>37.5	

and homes (prevalence range, 11%–92%), even in tropical environments.[141] A SysRev was initiated from a priority list from the ILCOR Neonatal Life Support (NLS) Task Force (PROSPERO; CRD42021270739). The full text of this review can be found on the ILCOR website.[142]

PICO, Study Design, and Time Frame

- Population: Late preterm and term newborn infants (≥34 weeks' gestation)
- Intervention: Increased room temperature to ≥23.0°C, 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:
  A. Critical: Survival
  B. 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[143] or by consensus of the task force for outcomes specific to each review. Additional outcomes are included in the full online CoSTR.[142] For the purposes of the review, the definitions in Table 18 were used.[144]
- 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[145–169] and 10 observational studies[170–179] 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-resource 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.[152] All were born by caesarean section, so the study pertains specifically to operating room temperatures, and only temperatures of 20°C and 23°C 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.[142]

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 20°C	RD with room temperature 23°C
Normothermia on admission (important)	825 (1 RCT) Duryea et al,[152] 2016	Very low	1.26 (1.11–1.42)	449/1000	130 more infants/1000 (55 more–209 more) were normothermic when 23°C was used
Temperature on admission (important)	825 (1 RCT) Duryea et al,[152] 2016	Very low	Not applicable	Mean temperature 36.4°C	MD, 0.3°C higher (0.23°C higher–0.37°C higher) when 23°C was used
Moderate hypothermia (<36°C) (important)	825 (1 RCT) Duryea et al,[152] 2016	Very low	0.26 (0.16–0.42)	189/1000	140 fewer infants/1000 (158 fewer–109 fewer) were moderately hypothermic when 23°C was used
Hyperthermia (>37.5°C) (important)	825 (1 RCT) Duryea et al,[152] 2016	Very low	4.13 (0.88–19.32)	5/1000	15 more infants/1000 (1 fewer–87 more) were hyperthermic when 23°C 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.

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,[163] 2018	Very low	Insufficient events to determine the rate		
Normothermia on admission (important)	551 (3 RCTs) Ramani et al,[163] 2018 Safari et al,[164] 2018 Srivastava et al,[166] 2014	Very low	1.39 (0.91–2.12)	614/1000	239 more infants/1000 (55 fewer–688 more) were normothermic when skin-to-skin care was used
Temperature on admission (important)	1048 (8 RCTs) Carfoot et al,[148] 2005 Christensson et al,[150] 1992 Huang et al,[154] 2019 KoÇ and Kaya,[156] 2017 Kollmann et al,[157] 2017 Ramani et al,[163] 2018 Safari et al,[164] 2018 Srivastava et al,[166] 2014	Very low	Not applicable	Mean temperature, 36.5°C	MD, 0.32°C higher (0.1°C higher–0.54°C higher) when skin-to-skin care was used
Hypoglycemia (important)	100 (1 RCT) KoÇ and Kaya,[156] 2017	Very low	0.16 (0.05–0.53)	326/1000	273 fewer infants/1000 (309 fewer–153 fewer) were hypoglycemic when skin-to-skin care was used
Admission to NICU (important)	512 (3 RCTs) Kollmann et al,[157] 2017 Marín Gabriel et al,[160] 2010 Ramani et al,[163] 2018	Very low	0.34 (0.14–0.83)	70/1000	46 fewer infants/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 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.[148,150,154–157,160,163,164,166]

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.[142]

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

The SysRev found 4 RCTs including 730 late preterm and term newborn infants for this comparison.[147,155,159,165] 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.[142] Of note, this comparison included studies in which infants had been dried or not dried before the use of the plastic bag or wrap.

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.[146,168] 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.[142] This comparison included studies in which infants had been dried or not dried before the use of the plastic bag or wrap.

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.[142]

Treatment Recommendations

In late preterm and term newborn infants (≥34 weeks' gestation), we suggest the use of room temperatures of 23°C compared with 20°C 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 in which 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,

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,[159] 2013 Shabeer et al,[165] 2018	Very low	0.95 (0.60–1.51)	981/1000	49 fewer infants/1000 (392 fewer–500 more) died when a plastic bag or wrap was used
Normothermia on admission (important)	305 (2 RCTs) Leadford et al,[159] 2013 Shabeer et al,[165] 2018	Very low	1.50 (1.20–1.89)	406/1000	203 more infants/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,[147] 2012 Leadford et al,[159] 2013 Shabeer et al,[165] 2018	Very low	Not applicable	Mean temperature, 36.3°C	MD, 0.29°C higher (0.2°C higher–0.37°C 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.

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,[146] 2013	Low	All infants in both groups survived		
Normothermia on admission (important)	692 (2 RCTs) Belsches et al,[146] 2013 Travers et al,[168] 2021	Low	1.39 (1.08–1.79)	221/1000	86 more infants/1000 more (18 more–174 more/1000) were normothermic when a plastic bag or wrap was added
Temperature on admission (important)	692 (2 RCTs) Belsches et al,[146] 2013 Travers et al,[168] 2021	Low	Not applicable	Mean body temperature, 36.0°C	MD, 0.2°C higher (0.1°C higher–0.3°C higher) when a plastic bag or wrap was added
Admission to NICU or special care unit (important)	275 (1 RCT) Belsches et al,[146] 2013	Low	0.26 (0.03–2.26)	29/1000	21 fewer infants/1000 (28 fewer–36 more/1000) were admitted to an NICU or special care unit when a plastic bag or wrap was added
Hyperthermia (>37.5°C) (important)	692 (2 RCTs) Belsches et al,[146] 2013 Travers et al,[168] 2021	Very low	1.02 (0.08–12.85)	3/1000	0 more infants/1000 (3 fewer–34 more/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.

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; therefore, no treatment recommendation can be formulated.

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision tables are provided in Supplemental 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. When a designated resuscitation room with separate temperature control is used, more individualized 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 newborn infants with hyperthermia,[180] and hypoxic ischemic encephalopathy may be exacerbated by hyperthermia.[181]

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.[182,183] Studies report some barriers to use, but overall, skin-to-skin care is judged to be acceptable by both parents and caregivers.[184–186] 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' 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 they are 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, for births in which ambient temperatures are low and cannot be increased, when alternative equipment (eg, radiant warmer, incubator, thermal mattress) is not available, or with 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. When 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 that 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:
  - A. Use of a thermal mattress, which may assume greater importance if a parent is unable to provide skin-to-skin care
  - B. Caps made of various materials
  - C. Use of heated, humidified gases for assisted ventilation
  - D. Early monitoring of temperature versus no early monitoring of temperature
  - E. 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
  - F. The effect of maternal hypothermia or hyperthermia on newborn infants' temperatures
  - G. Standardizing the timing and method of recording temperature for all newborn infants, which 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 or nasopharyngeal suctioning has been a widespread practice for newborn infants. The 2010 CoSTR[187] and many subsequent guidelines have recommended selective use of upper airway suctioning, with use only if the airway appears obstructed or PPV is required, and there has been increasing concern that there may be adverse effects of routine upper airway suctioning. A ScopRev (NLS 596) found sufficient evidence to justify a SysRev.[188] A SysRev was initiated from a priority list from the ILCOR NLS Task Force (PROSPERO; CRD42021286258). The full text of this review can be found on the ILCOR website.[189]

PICO, 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:
  - A. Critical: Advanced resuscitation and stabilization interventions (intubation, chest compressions, epinephrine) in the delivery room
  - B. 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)[143]
- 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, case series, and animal studies were excluded.

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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,[190] 2019 Kelleher et al,[195] 2013 Modarres Nejad et al,[196] 2014	Very low	0.72 (0.40–1.31)	64/1000	18 fewer/1000 (39 fewer–20 more)
Advanced resuscitation and stabilization interventions (important)	742 (3 RCTs) Bancalari et al,[190] 2019 Kelleher et al,[195] 2013 Modarres Nejad et al,[196] 2014	Very low	0.72 (0.40–1.31)	64/1000	18 fewer/1000 (39 fewer–20 more)
Oxygen saturations at 5 min (important)	280 (3 RCTs) Bancalari et al,[190] 2019 Modarres Nejad et al,[196] 2014 Takahashi,[197] 2009	Very low	Not applicable	Mean oxygen saturation, 84%	MD, 0.26% lower (1.77% lower–1.26% higher)
HR at 5 min (important)	84 (1 RCT) Bancalari et al,[190] 2019	Very low	Not applicable	Mean HR, 162 bpm without suctioning	MD, 1.00 bpm lower (7.96 bpm lower–5.96 bpm 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.

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

Consensus on Science

The SysRev identified 11 studies (9 RCTs including 1138 participants[190–198] and 2 observational studies[199,200]) for inclusion. The studies enrolled predominantly healthy, low-risk term newborn infants. For 2 of the RCTs[193,194] 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.[189]

For all predefined subgroup analyses, insufficient data were 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 Supplemental 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 no benefit was found. There could also be potential for unmeasured harm if routine suctioning caused delay in resuscitation for those who require it.

This SysRev recommendation does not apply to situations when there are concerns about 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[140,187,188,201,202] largely on the basis of 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; CRD42021227768).[203] The full text of this CoSTR can be found on the ILCOR website.[204]

PICO, Study Design, and Time Frame

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

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,[206] 2018	Very low	0.41 (0.20–0.85)	177/1000	105 fewer/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.

- Intervention: Any tactile stimulation performed within 60 seconds after birth and defined as 1 or more of the following: rubbing the chest/sternum, rubbing the back, rubbing the soles of the feet, flicking the soles of the feet, or a combination of these methods. This intervention should be done in addition to routine handling with measures to maintain temperature.
- Comparator: Routine handling with measures to maintain temperature, defined as care taken soon after birth, including positioning, drying, and additional thermal care
- Outcome:
  A. Critical: Survival as reported by authors; neurodevelopmental outcomes
  B. Important: Establishment of spontaneous breathing without PPV (yes or no); time to the first spontaneous breath or crying from birth; time to a heart rate of ≥100 bpm from birth; intraventricular hemorrhage (only in preterm infants with <34 weeks' gestation); oxygen or respiratory support at admission to a neonatal special care unit or NICU; admission to a neonatal special care unit or NICU for those not admitted by protocol on the basis of gestational age or birth weight[143]
  C. Potential subgroups were defined a priori: gestational age (<34, 34–36 6/7, 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, 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 the final update on September 17, 2021.

Consensus on Science

The SysRev identified 2 observational studies.[205,206] The study by Baik-Schneditz et al[205] was not eligible for data analysis because of its critical risk of bias (mainly because of confounding by indication). Therefore, only the study by Dekker et al[206] with 245 preterm newborn infants was analyzed (Table 24).

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

Treatment Recommendations

We suggest that it is reasonable to apply tactile stimulation in addition to routine handling with measures to maintain temperature in newborn infants with absent, intermittent, or shallow respirations during resuscitation immediately after birth (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 Supplemental 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.[207–210] 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 with 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 a 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 birth weight >1500 g who did not cry at birth. There was no difference between the 2 techniques in achieving effe ctive crying to prevent the need for PPV.[211] This study could not be included in the SysRev because of the lack of a control group who 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.[212,213] These studies could not be included in the SysRev because of the inability to isolate the effects of tactile stimulation and 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.[209,211,214] In addition, there is a report of soft tissue trauma after tactile stimulation.[215]

Task Force Knowledge Gaps

The complete CoSTR provide a full list.[204]

- Effect of tactile stimulation on the main outcomes: Breathing without PPV; time to the first spontaneous breath or crying from birth; and time to a heart rate of ≥100 bpm 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 or respiratory support at admission to a neonatal special unit or NICU; and admission to a neonatal special unit or NICU 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, patients with apnea, those with 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.[140] This SysRev focused on critical and important patient outcomes and was initiated from a priority list from the ILCOR NLS Task Force (PROSPERO; CRD42021283438). The full text of this review can be found on the ILCOR website.[216]

PICO, Study Design, and Time Frame

- Population: Newborn infants in the delivery room
- Intervention: Use of 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:
  - A. Critical: Chest compressions or epinephrine (adrenaline) administration; death before hospital discharge
  - B. Important: Duration of PPV; tracheal intubation; time from birth to a heart rate of ≥100 bpm as measured by ECG; resuscitation team performance; unanticipated admission to the NICU.[143]
- 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 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[217,218] involving 91 newborn infants and 1 cohort study[219] 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.[216]

No studies were found that provided outcomes relevant to this SysRev for other modalities versus pulse oximetry or auscultation (Comparison 2) or for between-intervention comparisons (Comparison 3).

Treatment Recommendations

When 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).

When ECG is not available, auscultation with pulse oximetry is a reasonable alternative for heart rate assessment, but the limitations of these modalities

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,[217] 2021	Very low	Not applicable	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,[217] 2021 Katheria et al,[218] 2017	Low	1.34 (0.69–2.59)	244/1000	81 more infants/1000 were intubated in the DR (74 fewer–384 more) with the addition of ECG
Tracheal intubation (important)	632 (1 observational study) Shah et al,[219] 2019	Low	0.75 (0.62–0.90)	475/1000	119 fewer infants/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,[219] 2019	Low	2.14 (0.98–4.70)	30/1000	35 more infants/1000 received chest compressions (1 fewer–113 more) with the addition of ECG
Epinephrine (adrenaline) (critical)	632 (1 observational study) Shah et al,[219] 2019	Low	3.56 (0.42–30.3)	4/1000	10 more infants/1000 received epinephrine (2 fewer–111 more) with the addition of ECG
Death before discharge (critical)	51 (1 RCT) Abbey et al,[217] 2021	Very low	0.96 (0.15–6.31)	77/1000	3 fewer infants/1000 died (74 fewer–462 more) with the addition of ECG
Death before discharge (critical)	632 (1 observational study) Shah et al,[219] 2019	Low	0.96 (0.57–1.61)	87/1000	3 fewer infants/1000 died (38 fewer–53 more) with the addition of ECG

DR indicates delivery room; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; MD, mean difference; PPV, positive-pressure ventilation; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

should be kept in mind (weak recommendation, low-certainty evidence).

There is insufficient evidence to make a treatment recommendation for 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 or not functioning or when pulseless electric activity is suspected (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The evidence-to-decision table is provided in Supplemental 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 when electrocardiographic monitoring was used,[219] a result that was not confirmed in the meta-analysis of 2 RCTs.[217,218] 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 for 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 do not require tracheal intubation or more advanced resuscitation, by gestational age and weight, by method of umbilical cord management, and for pulseless electric 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.[188] Although providing CPAP in the delivery room for late preterm and term infants has become increasingly frequent, this practice has not been systematically evaluated by ILCOR. Therefore, this PICO was prioritized by the NLS Task Force (PROSPERO; CRD42021225812).[219]

The full text of this CoSTR can be found on the ILCOR website.[220]

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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,[221] 2016 Osman et al,[222] 2019	Very low	0.28 (0.11–0.67)	129/1000	94 fewer/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,[224] 2015 Hishikawa et al,[223] 2016 Smithhart et al,[225] 2019	Very low	4.92 (4.13–5.87)	34/1000	133 more/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,[221] 2016 Osman et al,[222] 2019	Very low	0.18 (0.06–0.6)	97/1000	79 fewer/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,[221] 2016 Osman et al,[222] 2019	Very low	0.30 (0.01–6.99)	6/1000	5 fewer/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; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

PICO, Study Design, and Time Frame

- Population: In spontaneously breathing newborn infants with ≥34 weeks' gestation with respiratory distress or low oxygen saturations during transition after birth
- Intervention: CPAP at different levels with or without supplemental oxygen
- Comparator: No CPAP with or without supplemental oxygen
- Outcome:
  A. Critical: Chest compressions in the delivery room; death at hospital discharge; moderate to severe neurodevelopmental impairment (>18 months)
  B. Important: Admissions to the NICU or higher level of care; receipt of any positive-pressure support in the NICU; receipt of 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[143]
- 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[221,222] involving 323 newborn infants and 2 observational studies, 1 of which was divided into 2 publications,[223–225] involving 8476 infants. Relevant data from the author through electronic communications have been collated into 1 study for the purpose of this meta-analysis.[223,224] 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.

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 Supplemental 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 extrapolated mainly 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, all delivered by cesarean section.[221,222] One RCT enrolled 259 newborns and used prophylactic CPAP.[221] 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.

Task Force Knowledge Gaps

- Large multicenter RCTs evaluating the effect of delivery room CPAP for late preterm and term newborns with respiratory distress
- 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 postterm newborn infants
- The effect of CPAP after any previous positive-pressure support (PPV or sustained inflation)
- Whether effects of CPAP differ with and without the use of supplemental oxygen
- The effect of the modes of support: interfaces (face mask versus nasal prongs, cannula versus alternative airway) and 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).

SGAs 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 whether the use of an SGA would increase the probability of improving 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; CRD42021230722).[225a]

The full text of this CoSTR can be found on the ILCOR website.[226]

PICO, Study Design, and Time Frame

- Population: Newborn infants ≥34 0/7 weeks' gestation receiving intermittent PPV during resuscitation immediately after birth
- Intervention: SGA
- Comparator: Face mask
- Outcome:
  A. Critical: Chest compressions or epinephrine (adrenaline) administration during initial resuscitation; survival to hospital discharge; neurodevelopmental impairment at ≥18 months of age (abnormal motor, sensory, or cognitive function or low educational achievement at ≥18 months of age with the use of an appropriate, standardized test or examination)
  B. Important: Failure to improve with the device; tracheal intubation during initial resuscitation; time to a heart rate >100 bpm 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).[143]
  C. Potential subgroups (late preterm versus term and cuffless versus cuffed SGA) 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 <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[227–231] and 1 quasi-RCT[232] involving a total of 1857 newborn infants and 2 retrospective cohort studies[233,234] involving 218 newborn infants. An additional study[235] reported secondary outcomes from a subset of newborn infants enrolled in an included RCT.[228] Meta-analysis results are shown in Table 27. Additional outcomes are given in the full CoSTR.[226]

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 an SGA may be used in place of a face mask for newborn

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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,[227] 2008 Pejovic et al,[228] 2020 Pejovic et al,[229] 2018 Singh,[230] 2005 Trevisanuto et al,[231] 2015 Zhu et al,[232] 2011	Moderate	0.24 (0.17–0.36)	138/1000	105 fewer/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,[228] 2020 Singh,[230] 2005 Trevisanuto et al,[231] 2015 Zhu et al,[232] 2011	Low	0.34 (0.20–0.56)	62/1000	41 fewer/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,[228] 2020 Singh,[230] 2005 Trevisanuto et al,[231] 2015	Low	0.97 (0.56–1.65)	39/1000	1 fewer/1000 infants (17 fewer–26 more) had chest compressions during resuscitation when an SGA was used
Epinephrine (adrenaline) administration during resuscitation (critical)	192 (2 RCTs) Singh,[230] 2005 Trevisanuto et al,[231] 2015	Low	0.67 (0.11–3.87)	31/1000	10 fewer/1000 infants (28 fewer–90 more) had epinephrine (adrenaline) administration during resuscitation when an SGA was used
Time to heart rate >100 bpm (important)	46 (1 RCT) Pejovic et al,[235] 2021	Low		Mean time, 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,[229] 2018 Singh,[230] 2005 Trevisanuto et al,[231] 2015 Zhu et al,[232] 2011	Low	Not applicable	Mean time, 62 s	MD, 18 s lower (24 s lower–36 s lower) when an SGA was used
Admission to NICU (important)	1314 (4 RCTs) Pejovic et al,[228] 2020 Pejovic et al,[229] 2018 Singh,[230] 2005 Trevisanuto et al,[231] 2015	Very low	0.97 (0.94–1.00)	847/1000	25 fewer/1000 infants (51 fewer–0 fewer) when an SGA was used
Air leak (important)	192 (2 RCTs) Singh,[230] 2005 Trevisanuto et al,[231] 2015	Very low	Not estimable (no events)	0/1000	0 fewer/1000 infants (30 fewer–30 more) when an SGA was used
Soft tissue injury (important)	1724 (4 RCTs) Pejovic et al,[228] 2020 Singh,[230] 2005 Trevisanuto et al,[231] 2015 Zhu et al,[232] 2011	Low	1.05 (0.15–7.46)	2/1000	0 fewer/1000 infants (2 fewer–15 more) when an SGA was used
Survival to hospital discharge (critical)	50 (1 RCT) Singh,[230] 2005	Low	1.00 (0.93–1.08)	1000/1000	0 fewer/1000 infants (40 fewer–20 more) when an SGA was used

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; MD, mean difference; NICU, neonatal intensive care unit; PPV, positive-pressure ventilation; RCT, randomized controlled trial; RD, risk difference; RR, risk ratio; and SGA, supraglottic airway.

infants of ≥34 0/7 weeks' gestation receiving intermittent PPV 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 Supplemental 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 crossover 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 the use of an SGA. Nevertheless, given that the interventions were not blinded and that the ability to intubate in the largest trial was dependent on physician availability, there are risks of differential cointerventions 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 the 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[227,230,232] 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,[228] participating midwives received brief didactic training for insertion of a cuffless supraglottic device as part of a Helping Babies Breathe (HBB) course and were required to demonstrate 3 successful insertions in a manikin before participating in the study. Only 2 RCTs[230,231] 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,[228,229,231,232] the authors indicated that the device was provided as part of the study. The availability of resources and economic considerations will influence decisions about the 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

The online CoSTR provides a complete list.[226]

- 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 of <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 (potentially 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[140] found only 1 small eligible study.[236] Because the NLS Task Force was aware that further studies had been published, a SysRev was prioritized (PROSPERO; CRD42021278169). The full text of this review can be found on the ILCOR website.[237]

PICO, 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:
  A. Critical: Death before discharge, severe intraventricular hemorrhage
  B. 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[143]
- Study design: RCTs, quasi-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 updated to December 31, 2021.

Consensus on Science

The SysRev identified 3 RCTs[236,238,239] 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.[237]

Treatment Recommendations

There is insufficient evidence to make a recommendation for or against the use of an RFM 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

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,[236] 2012 Van Zanten et al,[238] 2021 Zeballos Sarrato et al,[239] 2019	Very low	0.90 (0.55–1.48)	353/1000	40 fewer infants/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,[236] 2012 Van Zanten et al,[238] 2021	Low	0.96 (0.69–1.34)	301/1000	10 fewer infants/1000 (110 fewer–80 more) achieved the desired tidal volume in the DR when an RFM was used
Pneumothorax (important)	393 (2 RCTs) Van Zanten et al,[238] 2021 Zeballos Sarrato et al,[239] 2019	Low	0.54 (0.26–1.13)	94/1000	40 fewer infants/1000 (90 fewer–10 more) had a pneumothorax when an RFM was used
Death before hospital discharge (critical)	442 (3 RCTs) Schmölzer et al,[236] 2012 Van Zanten et al,[238] 2021 Zeballos Sarrato et al,[239] 2019	Low	1.00 (0.66–1.52)	165/1000	0 fewer infants/1000 (70 fewer–70 more) died when an RFM was used
Severe IVH (critical)	287 (1 RCT) Van Zanten et al,[238] 2021	Low	0.96 (0.38–2.42	60/1000	0 fewer infants/1000 (60 fewer–50 more) developed severe IVH when an RFM was used
IVH (all grades; important)	393 (2 RCTs) Van Zanten et al,[238] 2021 Zeballos Sarrato et al,[239] 2019	Low	0.69 (0.49–0.96)	318/1000	100 fewer infants/1000 (180 fewer–10 fewer) developed IVH (all grades) when an RFM was used
BPD (important)	393 (2 RCTs) Van Zanten et al,[238] 2021 Zeballos Sarrato et al,[239] 2019	Low	0.85 (0.7–1.04)	527/1000	80 fewer infants/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; RCT, randomized controlled trial; RD, risk difference, RFM, respiratory function monitor; and RR, risk ratio.

confidence in effect estimates, and most could not rule out either clinical benefit or harm. Although intraventricular hemorrhage (all grades) was significantly reduced, no effect was 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.[238] Costs of purchasing RFM devices and of training in their use had no information 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 that teams can make best use of displayed data during resuscitation without distraction from other critical tasks)
- Development of low-cost devices for use in low-resource 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 makes up 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.[240] 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.[241]

PICO, Study Design, and Time Frame

- Population: Hospitalized adults and children experiencing an IHCA
- Intervention: Any prearrest clinical prediction rule
- Comparator: No clinical prediction rule

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,[248] 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 and Ebell,[258] 1994	PAM >8	100 (86.3–100)	2.0 (0.6–4.5)	100 (47.8–100)	9.1 (6.0–13.2)
Bowker and Stewart,[242] 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,[257] 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,[249] 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,[244] 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.

- Outcome:
  A. Critical: survival to hospital discharge or to 30 days, survival with favorable neurological outcome
  B. Important: ROSC
- Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies, case series in which 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[242–264] 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, and Table 30 summarizes the prognosis after resuscitation score, aiming to predict survival to hospital discharge.

Other smaller studies report prediction of survival to hospital discharge using the Modified Early Warning Score,[263] the National Early Warning Score,[252,261] the Clinical Frailty Scale,[254] a neuronal network,[245] and the Acute Physiology and Chronic Health III score.[248] Details for these are available on the CoSTR on the ILCOR website.[241]

The Good Outcome Following Attempted Resuscitation 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[253] 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 Good Outcome Following Attempted Resuscitation score to predict survival to hospital discharge (details are available on the ILCOR website[241]).

Two classification and regression tree models (versions 1 and 2) aimed to predict survival with a CPC of 1, whereas the Good Outcome Following Attempted Resuscitation 2 score and the Prediction of Outcome for In-Hospital Cardiac Arrest score investigated prediction of survival with a CPC of ≤2. These results are presented in Table 32.

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 not to resuscitate an adult with IHCA (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 because 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 because no studies on children were identified.

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,[248] 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 and Ebell,[258] 1994	PAR >5	100 (86.3–100)	22.8 (17.8–28.4)	100 (93.9–100)	11.1 (7.3–16.0)
Bowker and Stewart,[242] 1999	PAR >7	100 (94.7–100)	14.3 (9.7–20.0)	100 (87.7–100)	28.8 (23.1–35.0)
Ohlsson et al,[257] 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.

Table 31. Predictive Values of Historical Cohort Studies Using the Good Outcome Following Attempted Resuscitation Score to Predict Survival to Hospital Discharge With a CPC 1 (Presented With 95% CIs)

Study	Cutoff	Sensitivity (95% CI)	Specificity (95% CI)	NPV (95% CI)	PPV (95% CI)
Ebell et al,[247] 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,[259] 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,[262] 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,[243] 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 and Ebell,[264] 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,[256] 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; NPV, negative predictive value; and PPV, positive predictive value.

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Supplemental 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 prearrest morbidity or prognosis after resuscitation score) were based on cohorts before 2000, when survival rates were lower. The prearrest morbidity score and the prognosis after resuscitation 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. Because no prospective studies were 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, 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 the applicability of these models.

The Good Outcome Following Attempted Resuscitation 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 >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
- Assessment of scores predicting survival with favorable neurological outcome that do 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 or making DNACPR orders
- How the use of clinical decision tools affects resuscitation practices, cost-benefit, or survival outcomes

Table 32. Predictive Values of Historical Cohort Studies Using Scores Other Than the Good Outcome Following Attempted Resuscitation 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,[246] 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,[251] 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,[246] 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,[251] 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,[250] 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,[260] 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.

BLS Training for Likely Rescuers of High-Risk Populations (SysRev)

Rationale for Review

This topic was last reviewed in 2015.[265,266] 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.[267–269] The review was registered at PROSPERO (CRD42021233811). The full text of this CoSTR is on the ILCOR website.[270]

PICO, Study Design, and Time Frame

- Population: Adults and children at high risk of OHCA
- Intervention: BLS training of likely rescuers
- Comparator: No training
- Outcome:
  A. Patient outcome:
    - 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)

  B. Educational outcome:
    - 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. The literature search was updated to October 15, 2021.

Consensus on Science

The SysRev performed as part of the 2015 ILCOR review[265,266] identified 32 studies relating to BLS training in likely rescuers (eg, family or caregivers) of high-risk OHCA groups.[273–304]

One study[298] 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.[305–316]

The 12 new studies included likely rescuers of patients with cardiac disease,[306–314,316] drug use disorder,[305] pulmonary disease,[314] or an acute life-threatening event.[315] Similar to the 2015 reviewed studies, these new studies used various 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.[305,315] 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.[273,278,281,283,286,293,294,299,300,305,315] Most of the old and new studies assessing educational outcomes demonstrated improvements in BLS skills and knowledge immediately after training.[274,276,279,280,287,290–292,295,296,302–304,307–310,312–316]

In the assessment of long-term outcomes, there was some degradation in some BLS skills compared with immediately after training but an improvement in skills and knowledge compared with baseline.[275,307,309,310,312,315] Training immediately increased willingness[275,281,285,288–290,297,301,308,310] and confidence[274,308–310,312] 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).[274,275,288,289,307,308,310,311]

Treatment Recommendations

We recommend BLS training for likely rescuers of populations at high risk of OHCA (strong recommendation, low- to moderate-certainty evidence).

We recommend that 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 Supplemental 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 does not increase anxiety in trainees,[267] and that these groups are unlikely to undertake training on their own.[267]

Given these facts, we considered it important to recommend that health care professionals encourage and direct these groups to attend BLS training although they may not take up training.[284] 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 health care 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 ALS Courses (EvUp/SysRev/Adolopment)

Rationale for Review

Attending an ALS course comes at a cost—both financial and in terms of time—to participants and their institutions. It is therefore important to show whether such participation has a meaningful impact on patient outcomes. In 2020, we recommended the provision of accredited adult ALS training for health care providers (weak recommendation, very low–certainty evidence). The purpose of this SysRev is to update the evidence for adult ALS training and to expand the search to participants of other ALS 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.[317]

Course types, titles, and acronyms used in this CoSTR are as follows:

- Adult ALS courses: ALS, Advanced Cardiovascular Life Support (ACLS)
- Pediatric ALS courses: Pediatric ALS (PALS), European Paediatric ALS (EPALS), European Paediatric Intermediate Life Support (EPILS)
- Neonatal resuscitation training (NRT): Newborn Resuscitation Programs (NRPs), NLS, Advanced Resuscitation of the Newborn Infant (ARNI)
- HBB course
- Advanced Trauma Life Support (ATLS) course
- European Trauma Course (ETC)

PICO, Study Design, and Time Frame

- Population: Patients of any age requiring IHCA resuscitation
- Intervention: Prior participation of ≥1 members of the resuscitation team in an accredited ALS 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 in which 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, studies on 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 because previous studies were included in another published SysRev) and all languages were included if there was an English abstract. The literature search was conducted on October 18, 2021.

Consensus on Science

This review identified 18 studies covering the adult ALS course (n=1),[318] NRT courses (n=11),[319–329] and the HBB course (n=6).[330–335] In addition, 2 review articles were identified: 1 covered NRT[336] and the other covered HBB.[337] Evidence was of very low certainty (downgraded for risk of bias and inconsistency).

Adult ALS Courses (ALS, ACLS)

The 2020 CoSTR was based on an adolopment of a SysRev.[338] This EvUp for that review included the newly identified study.[318] 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[336] 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.[339] Data were extracted and analyzed for hospital-based studies only, and results are presented in Table 33. All included studies were of before-and-after design and from low- to middle-resource settings. Despite clinical and statistical heterogeneity, all analyses showed a consistent treatment effect for this training.

Helping Babies Breathe

One SysRev of the HBB course was identified,[337] 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

Table 33. NRT Outcomes From Hospital-Only Studies

Outcome	Studies, n	Participants, n	RR	95% CI
All stillbirths	9[213,325,332,340–343*]	1 334 307	0.88	0.82–0.94
Fresh stillbirths	6[213,325,331,332*]	231 455	0.71	0.54–0.93
1-d neonatal mortality	5[213,331,344*]	216 373	0.58	0.38–0.90
7-d neonatal mortality	5[331,341,344–346]	296 300	0.78	0.63–0.97
28-d mortality	6[323,325,331,332,340,347]	1 090 594	0.89	0.65–1.22
Perinatal mortality	4[331,340,341†]	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.

stillbirth and 1-day neonatal mortality rate after implementation of 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.[333]

Treatment Recommendations

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

We recommend the provision of accredited courses in NRT (NRT, NRP) and HBB for health care providers who provide ALS care for newborns and babies (strong recommendation, very low–certainty evidence).

We have made a discordant recommendation (strong recommendation despite very low–certainty evidence) because we have placed a very high value on an uncertain but potentially life-preserving benefit, and the intervention is not associated with prohibitive adverse effects.

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Supplemental 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. Although no evidence for pediatric training courses was identified, it is unlikely that the effect would differ from that seen with adult and neonatal courses. 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 ALS courses (eg, pediatric) on patient outcomes
- The impact of blended-learning approaches on patient outcomes
- The impact on resuscitation training of modifications necessitated by the coronavirus disease 2019 (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.[348] 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.[349–352] 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 ALS courses (very low– to low-certainty evidence)."[353] 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 (CRD42021274392).[354] The full text of the CoSTR is available on the ILCOR website.[355]

PICO, Study Design, and Time Frame

- Population: Participants undertaking an accredited life support course (eg, BLS, ALS 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 in which n ≥5), and manikin studies were included. Unpublished reports (eg, trial protocols), commentary, editorial, and reviews were excluded.

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- Time frame: Publications from all years from 2000 onward and all languages were included if there was an English abstract. The literature 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.[356,357]

There was a mix of interventions in the BLS group, with some adding online content to standardized face-to-face courses[276,356,357,359,360] and some substituting didactic content with online content, leaving an amended face-to-face element.[361–367] In the ALS group, all except 1 study[368] evaluated online learning as a substitute for didactic elements. The ATLS study evaluated online learning as a substitute for didactic elements.[369]

Basic Life Support

A total of 14 studies were included, addressing both BLS knowledge and BLS skills after the intervention.[276,356,357,359–367,370,371] Results were mixed, with some studies finding a benefit with blended learning and some studies finding no difference. Only 1 study found a statistically significant benefit for knowledge[363] and for skills[364] with a face-to-face approach 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 for all forms of training.[357,359,366,367]

For the outcome of costs, the single cost analysis study found a notable financial benefit for teaching BLS through a blended-learning approach.[370]

Adult ALS

The review included 8 studies.[368,372–378] For the outcome of ALS knowledge (after the intervention), 2 studies found significantly higher scores in the blended-learning group,[372,378] whereas the remainder of the studies found no significant difference between the groups.[368,373,377] There was no significant difference between groups for 1 study at 7 months.[373]

For the outcome of ALS skills (after the intervention), 1 pilot study[377] 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.[378] The remainder of the studies found no significant difference between the groups.[368,372,373,375]

Attitudes were diverse: 3 studies found a preference for blended learning,[368,372,375] and 2 studies found a preference for face-to-face learning.[373,376]

Two studies found a notable financial benefit for teaching ALS through a blended-learning approach.[374,377]

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 the face-to-face approach, but only in terms of knowledge outcomes.[369] 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 when 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 Supplemental 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 and 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 precourse 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 when resources or accessibility does 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 when online learning is added to established face-to-face content or when 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 laypeople and health care 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.[379] The full text of this ScopRev is available on the ILCOR website.[380]

PICO, 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:
  A. Clinical outcomes of patients resuscitated by students of the instructors: Critical—favorable neurological outcome, survival to discharge, short-term survival, ROSC, sustained ROSC, and survival to admission
  B. 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 the instructors' students immediately after 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. The literature search was updated to December 31, 2021.

Summary of Evidence

Twenty studies,[381–400] including 5 conference abstracts,[384,390,394,395,400] 1 short communication,[398] and 14 full-length articles,[381–383,385–389,391–393,396,397,399] were included. Interventions were grouped into 4 categories, and studies are summarized in Table 34.

1. Instructor qualification/training, n=9[384,387,388,391–393,395,396,399]
2. Assessment tools, n=3[381,394,400]
3. Teaching skills enhancement, n=3[383,386,390]
4. Additional course for instructors, n=5[382,385,389,397,398]

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.[381,389,397,398,400] Of the articles with additional training programs that were included, 4 of 5 had a positive effect on instructors' teaching competencies and evaluation ability.[382,389,397,398] However, new teaching strategies may not have the expected effects, which emphasizes the need for rigorous evaluation of any changes to training practices.[385]

Specific debriefing and feedback methods were suggested for instructors teaching life support courses, which may increase instructors' confidence.[383] 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

Table 34. Interventions to Improve Instructional Competence

Category	Intervention	Results
Instructor qualification/training		
Internet-based AHA CIC[387]	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[384,388,391,395,396]	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[393]	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[399]	New instructor course compared with conventional training	There was improved confidence in teaching neonatal CPR when participating in the new course.
Web-based questionnaire survey for instructors[392]	Web-based survey with a 29-item Competence Importance Performance scale	Several important factors for the competence of instructors were identified.
Assessment tools		
Assessment for chest compression with real-time compression feedback[381]	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[400]	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[394]	Use of sensor-equipped manikins for accredited instructors asked to deliver BLS training	Instructors felt that the manikins were useful and felt confident when delivering the course, and that may be beneficial to a trainer's perception.
Teaching skills enhancement		
Different feedback method[383]	Learning conversation structured methods of feedback delivery in BLS training, compared with the sandwich technique (that is, 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[386]	Use of scripted debriefing by novice instructors or simulator physical realism affects knowledge and performance in simulated cardiopulmonary arrests.	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[390]	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.
Additional course for instructors		
Educational program to teach ACLS instructors to evaluate team leader performance[389]	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[397,398]	ATP as additional training, focusing on decision making in equivocal situations	Trained instructors were less prone to incorrectly giving failing scores to candidates.[398] Instructors with additional training were significantly more confident at assessing.[397]
Neonatal resuscitation workshop[382]	2-d neonatal resuscitation workshop	There were significant improvements in participants' perceptions of their teaching ability.
Clinical teacher-training course/workshop (enhance teaching skills and methods)[385]	2-d 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 indicates 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.

previously. This ScopRev has not identified sufficient evidence to support a new SysRev, and no treatment recommendation was generated.

From 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

Table 35. Education, Implementation, and Teams 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 CCO-CPR. EMS dispatchers should provide CPR instructions to callers who report cardiac arrest. When providing CPR instructions, EMS dispatchers should include recognition of gasping and abnormal breathing.	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
Team and leadership training (EIT 631)	2020 CoSTR	We suggest that specific team and leadership training be included as part of ALS training for health care providers (weak recommendation, very low–certainty evidence).	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 a 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 (EIT 645 and NLS 1562)	2020 EIT CoSTR; NLS ScopRev	EIT 645: We suggest data-driven, performance-focused debriefing of rescuers after IHCA for both adults and children (weak recommendation, very low–certainty evidence). We suggest data-driven, performance-focused debriefing of rescuers after OHCA in both adults and children (weak recommendation, very low–certainty evidence). NLS 1562: There was no previous treatment recommendation on the topic. This ScopRev did not identify sufficient evidence to prompt a SysRev.	0	3	We did not find substantial new evidence supporting debriefing in adults or children. One observational study found short-term improvements with debriefing in neonates. Several knowledge gaps were found and described in the EvUp (for example, short- and long-term outcomes, debriefing facilitator training, emotional and psychological side effects of debriefing).	No
Spaced vs 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 1 single time point; weak recommendation, very low–certainty evidence).	3	5	The 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; CCO-CPR, chest compression–only cardiopulmonary resuscitation; CoSTR, International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations; COVID-19, coronavirus disease 2019; CPR, cardiopulmonary resuscitation; EIT, Education, Implementation, and Teams; EMS, emergency medical services; EvUp, evidence update; IHCA, in-hospital cardiac arrest; 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.

availability, as well as instructors' needs, to maximize learning outcomes of such programs. The best ways to maintain and assess instructor competency while concurrently maximizing cost-effectiveness need 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 improve 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 Supplemental Appendix B.

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 ScopRev using a reworded PICO study design and time frame question in 2020. The original PICO study design and time frame 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 PICO study design and time frame wording now clarify the population of interest as adults and children with a reduced level of responsiveness of nontraumatic origin 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).[401] The full text of this CoSTR can be found online.[402]

PICO, Study Design, and Time Frame

- Population: Adults and children in the first aid setting who have a reduced level of responsiveness of nontraumatic origin and do not require resuscitative interventions
- Intervention: Specific positioning (recovery positioning [ie, various semiprone, lateral recumbent, side-lying, or three-quarters prone positions of the body])
- Comparator: Supine or other position
- Outcome:
  A. Critical: Survival, incidence of cardiac arrest, delayed detection of apnea and cardiac arrest.
  B. 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 was excluded. Unpublished studies (eg, conference abstracts, trial protocols) and editorials were excluded, although case reports published in letter form were included. ScopRevs and SysRevs were included for discussion and to ensure that no primary articles 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. The literature search was 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[403–405] and 4 case series with a total of 251 patients (<10% were children).[406–409] 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 those with suspected aspiration pneumonia and the body position in which they were found.[403] Prone and semirecumbent 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 among left lateral decubitus, right lateral decubitus, and supine body positions.

A 2016 observational study of 553 patients in the pediatric emergency department with loss of consciousness reported 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]; $P<0.0001$).[404]

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.[405] 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 individuals with sudden unexpected death in epilepsy.[407–409] 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.[406]

Treatment Recommendations

When providing first aid to a person with a decreased level of responsiveness of nontraumatic origin 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).

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

Technical Remarks

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

Various recovery positions have been described, and little evidence remains 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.[410,411]

Justification and Evidence-to-Decision Framework Highlights

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

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[406] described potential missed OHCA in individuals 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 individuals 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.[412,413] 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 the subject is 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 a 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 semirecumbent position or prone position was associated with lower rates of suspected aspiration pneumonia. Last, we acknowledge that positional

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 FA may be considered if a caustic substance has been ingested, if advised to do so by a health care 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 d	No
Recognition of anaphylaxis (FA 503)	2020 ScopRev; 2010 CoSTR	FA 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 epinephrine or on reasons for hesitation/nonuse of epinephrine autoinjectors.	No
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). Because of 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 FA providers to individuals with an open chest wound (weak recommendation, very low–quality evidence).	0	0	Three animal studies of vented chest seals were 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 FA 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 delivered by metered-dose inhaler decrease hospital admission in younger children and emergency department length of stay in older children.	No
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 FA 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 counterpressure maneuver by individuals with acute symptoms of presyncope attributable to vasovagal or orthostatic causes in the FA setting (strong recommendation, low- and very low–certainty evidence). We suggest that lower body physical counterpressure maneuvers are preferable to upper body and abdominal physical counterpressure maneuvers (weak recommendation, very low–certainty evidence).	0	0		No

(*Continued*)

Table 36. Continued

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?
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 FA provider's recognition and referral of victims of suspected head injury. However, review of the available literature shows no evidence on the application of such scoring systems by the FA provider. 2022 good 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 FA assessment for a person with a possible concussion should be based on the typical signs and symptoms of concussion.	0	0	A good practice statement was added in 2022 as shown.	No
Cooling techniques for exertional hyperthermia and heatstroke (FA 1545)	2020 CoSTR	For adults with exertional hyperthermia or exertional heatstroke, 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 <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 heatstroke, we cannot make a recommendation for or against any specific cooling technique compared with an alternative cooling technique (no recommendation, very low–certainty evidence). For children with exertional or nonexertional heatstroke, we cannot make a recommendation for or against any specific cooling technique compared with an alternative cooling technique (no recommendation, very low–certainty evidence).	0	2	Two SysRevs were identified; no change in treatment recommendations.	No
FA 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 FA 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 FA 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 glucose administration for individuals with suspected hypoglycemia who are conscious and able to swallow (weak recommendation, very low–certainty evidence). If oral glucose (for example, tablet) is not immediately available, we suggest a combined oral+buccal glucose (for example, 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).	0	0		No

(*Continued*)

Table 36. Continued

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?
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). We are unable to recommend for or against the use of other tourniquet types in children because of a 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).	0	0		No

EvUp indicates evidence update; FA, first aid; PICO, population, intervention, comparator, outcome; RCT, randomized controlled trial; ScopRev, scoping review; and SysRev, systematic review.

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 is 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 were lying in a prone position support the good practice statement to reposition individuals 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 the person is 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 the 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 BLS responders in the assessment of breathing and responsiveness so that they can accurately identify normal breathing and responsiveness

Topics Reviewed by EvUps

The topics reviewed by 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 Supplemental Appendix B.

ARTICLE INFORMATION

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*Modest.

†Significant.

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*Modest.

†Significant.

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