1	ILCOR Summary Statement
2	2024 International Consensus on Cardiopulmonary Resuscitation and Emergency
3	Cardiovascular Care Science With Treatment Recommendations
4	
5	Summary From the Basic Life Support; Advanced Life Support; Pediatric Life Support;
6	Neonatal Life Support; Education, Implementation, and Teams; and First Aid Task Forces
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19	*This article represents the author's opinions and does not represent the official policy or
20	position of the Uniformed Services University, Defense Department, or US government.
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1 ABSTRACT

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

13

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

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

14 support, neonatal, first aid

Definition
electroencephalogram
Education, Implementation, and Teams
emergency medical services
Grading of Recommendations Assessment, Development, and Evaluation
intensive care unit
in-hospital cardiac arrest
International Liaison Committee on Resuscitation
individual patient data
interquartile range
mean arterial pressure
neonatal life support
network meta-analysis
number needed to treat
out-of-hospital cardiac arrest
Promoting Excellence and Reflective Learning in Simulation
population, intervention, comparator, outcome
population, intervention, comparator, outcome, study design, and time
frame
pediatric life support
Prospective Register of Systematic Reviews
rapid cycle deliberate practice
randomized controlled trials
return of circulation
return of spontaneous circulation
supraglottic airway
ST-segment elevation myocardial infarction
Treatment of Electroencephalographic Status Epilepticus After
Cardiopulmonary Resuscitation

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1 INTRODUCTION

2 This is the eighth in a series of annual International Liaison Committee on Resuscitation 3 (ILCOR) International Consensus on Cardiopulmonary Resuscitation and Emergency 4 Cardiovascular Care Science With Treatment Recommendations (CoSTR) summary publications 5 summarizing the ILCOR task forces' analyses of published resuscitation evidence since ILCOR 6 began the more continuous process of evidence evaluation in 2015. Summarizing the work from 7 the 6 task forces over the past year, this year's review includes 19 systematic reviews (SysRevs) 8 with new or updated treatment recommendations. Although only SysRevs can generate a full 9 CoSTR and new treatment recommendations, 14 scoping reviews (ScopRevs) and 29 evidence 10 updates (EvUps) are also included. Draft CoSTRs for all topics evaluated with SysRevs were posted on a rolling basis 11 12 between December 1, 2023, and January 24, 2024, on the ILCOR website.¹ Each draft CoSTR 13 includes the data reviewed and draft treatment recommendations, with public comments accepted 14 for 2 weeks after posting. In some cases, if requested, public comment was permitted for longer. 15 Task forces considered public feedback and provided responses. The 33 draft CoSTR statements 16 and ScopRevs were viewed ≈18,200 times, and 38 comments were provided. All CoSTRs are 17 now available online, adding to the existing CoSTR statements. 18 This summary statement contains the final wording of the treatment recommendations 19 and good practice statements as approved by the ILCOR task forces, but it differs in several 20 respects from the online CoSTRs. The language used to describe the evidence is not restricted to 21 standard Grading of Recommendations Assessment, Development, and Evaluation (GRADE) terminology,² making it more accessible to a wider audience, and in some cases only the high-22

23 priority outcomes are reported. The Justification and Evidence-to-Decision Framework

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

6 The CoSTRs are based on analysis of the data using the GRADE approach.² SysRevs are 7 conducted by expert systematic reviewers or by task force members, always with the 8 involvement of ILCOR content experts. The GRADE approach guides the rating of the certainty 9 of evidence that supports the intervention effects (predefined by the population, intervention, 10 comparator, outcome [PICO] question). Certainty is categorized as high, moderate, low, or very 11 low. Randomized controlled trials (RCTs) begin the analysis as high-certainty evidence, and 12 observational studies begin the analysis as low-certainty evidence. Certainty of evidence can be 13 downgraded for risk of bias, inconsistency, indirectness, imprecision, or publication bias; it can 14 be upgraded for a large effect, for a dose-response effect, or if any residual confounding would 15 be thought to decrease the detected effect.

16 The format for outcome data reporting varies by the data available but ideally includes 17 both relative risk and the absolute risk difference, both with 95% CI. The absolute risk difference 18 enables a more clinically useful assessment of the magnitude of the effect of an intervention and 19 enables calculation of the number needed to treat (NNT=1/RD). When the data do not enable 20 absolute effect estimates, alternative measures of effect such as odds ratios (ORs) are reported. 21 Treatment recommendations are generated by the task forces after evaluating the evidence and 22 after discussion. The strength of a recommendation does not depend solely on the certainty of 23 evidence but also on the likely clinical impact as determined by task force members.

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1 ILCOR's goal is to review at least 20% of all PICO questions each year so that the 2 CoSTRs reflect current and emerging science. Acknowledging that many PICO topics will not 3 have sufficient new evidence to warrant a SysRev, ILCOR implemented 2 additional levels of 4 evidence review in 2020. ScopRevs are undertaken when the amount and type of evidence on a 5 broader topic is unclear. Search strategies are similar in rigor to those of SysRevs, but ScopRevs 6 do not include bias assessments or meta-analyses. Although ILCOR does not create or alter 7 treatment recommendations without a SysRev, if the topic of a ScopRev is thought to be of 8 particular interest to the resuscitation community, good practice statements are often made. Good 9 practice statements are not evidence-based recommendations but represent expert opinion in 10 light of very limited data. The third and least rigorous form of evidence evaluation is the evidence update (EvUp), 11 12 in which a minimum of a PubMed search is carried out to screen for significant new data and 13 assess whether there has been sufficient new science to warrant a more extensive review and 14 updated CoSTR. EvUps can inform a decision about whether a SysRev should be undertaken but 15 are not used to generate new or updated treatment recommendations because they do not include 16 bias assessment, GRADE evidence evaluation, or meta-analysis. In this document, ScopRevs are

17 summarized in the relevant Task Force section, with references to the more complete online

18 review. EvUps are listed at the end of each task force section in table form, with information

19 including the prior treatment recommendation(s) related to the PICO question, how many new

20 studies were identified, key findings, and whether an updated SysRev is recommended.

21 Complete EvUps are provided in Appendix B.

22

The following topics are addressed in this CoSTR summary:

1	Basic Life Support
2	• Optimal surface for performing cardiopulmonary resuscitation (CPR) (Basic Life Support
3	[BLS] 2510: SysRev)
4	• Optimization of dispatcher-assisted recognition of out-of-hospital cardiac arrest (OHCA)
5	(BLS 2102: ScopRev)
6	• Optimization of dispatcher-assisted CPR (BLS 2113: ScopRev)
7	• Optimization of dispatcher-assisted automated external defibrillation (AED) retrieval and
8	use (BLS 2120: ScopRev)
9	• Feedback for CPR quality (BLS 2511: ScopRev)
10	• Ultraportable or pocket AEDs (BLS 2603: ScopRev)
11	• Compression-ventilation ratio (BLS 2202: EvUp)
12	• Hand positioning (BLS 2502: EvUp)
13	• CPR before defibrillation (BLS 2203: EvUp)
14	• Rhythm check during compressions (BLS 2211: EvUp)
15	• Head-up CPR (BLS 2503: EvUp)
16	• Public access defibrillation programs (BLS 2121: EvUp)
17	Advanced Life Support
18	• Post-cardiac arrest oxygenation and ventilation (Advanced Life Support [ALS] 3506 and
19	3516: SysRev)
20	• Post-cardiac arrest hemodynamics (ALS 3515: SysRev Adolopment)
21	• Post-cardiac arrest temperature control (ALS 3523, 3524, 3525: SysRev)
22	• Post-cardiac arrest seizure prophylaxis and management (ALS 3502 and 3503: SysRev)
23	• Extracorporeal CPR (ALS 3001: SysRev)

1	• Cardiac arrest during pregnancy (ALS 3401: ScopRev)
2	• Front of neck airway access (ALS 3606: ScopRev)
3	• Cardiac arrest related to asthma (ALS 3408: EvUp)
4	• Atropine for cardiac arrest (ALS 3206: EvUp)
5	• Use of advanced airway during cardiac arrest (ALS 3300, 3301, 3302, 3303, 3304:
6	EvUp)
7	• CPR-induced consciousness (ALS 3004: EvUp)
8	• Antiarrhythmics during and after cardiac arrest (ALS 3201, 3514: EvUp)
9	Pediatric Life Support
10	• Blood pressure targets following return of circulation after cardiac arrest (Pediatric Life
11	Support [PLS] 4190-01: SysRev)
12	• Effect of prophylactic antiseizure medication and treatment of seizures on outcome of
13	pediatric patients following cardiac arrest (PLS 4210-02: SysRev)
14	• Advanced airway interventions in pediatric cardiac arrest (PLS 4060-01: SysRev)
15	• Ventilation rate with advanced airway during pediatric cardiac arrest (PLS 4120-02:
16	SysRev)
17	• Management of pulmonary hypertension with cardiac arrest in infants and children in the
18	hospital setting (PLS 4160-11: ScopRev)
19	• Prearrest care of pediatric dilated cardiomyopathy or myocarditis (PLS 4030-19: EvUp)
20	• Ventilation rate in pediatric respiratory arrest with a perfusing rhythm present (post-
21	cardiac arrest) (PLS 4120-01: EvUp)

1	Neonatal Life Support	
2	• Cord management at birth for preterm infants (Neonatal Life Support [NLS] 5051:	
3	SysRev)	
4	• Effect of rewarming rate on outcomes for newborns who are unintentionally hypothermic	
5	after delivery (NLS 5700: SysRev)	
6	• Therapeutic hypothermia in limited resource settings (NLS 5701: SysRev)	
7	Education, Implementation and Teams	
8	• Cardiac arrest centers (Education, Implementation and Teams [EIT] 6301: SysRev)	
9	• Cognitive aids during resuscitation education (EIT 6400: SysRev)	
10	• Immersive technologies for resuscitation teaching (EIT 6405: SysRev)	
11	• Gamified learning compared with other forms of resuscitation learning (EIT 6412:	
12	SysRev)	
13	• Rapid cycle deliberate practice in resuscitation training (EIT 6414: SysRev)	
14	• Team competencies training for resuscitation (EIT 6415: SysRev)	
15	• CPR education tailored to specific populations (EIT 6108: ScopRev)	
16	• International facets of the Chain of Survival (EIT 6311: ScopRev)	
17	• Provider workload and stress during resuscitation (EIT 6401: ScopRev)	
18	• Scripted debriefing compared with nonscripted debriefing in resuscitation training (EIT	
19	6413: ScopRev)	
20	• Emergency medical services (EMS) experience and exposure (EIT 6104: EvUp)	
21	• Patient outcomes of team members attending a CPR course (EIT 6106: EvUp)	
22	• Willingness to provide CPR (EIT 6304: EvUp)	
23	• Implementation of guidelines in communities (EIT 6306: EvUp)	

1	• Debriefing of resuscitation performance (EIT 6307: EvUp)
2	• CPR feedback devices during training (EIT 6404: EvUp)
3	• Blended-learning approach for life support education (EIT 6409: EvUp)
4	• High-fidelity training for resuscitation (EIT 6410: EvUp)
5	First Aid
6	• Use of supplemental oxygen in first aid (First Aid [FA] 1649: ScopRev)
7	• Recognition of sepsis (FA 7180: ScopRev)
8	• Stroke recognition (FA 7170: EvUp)
9	• Oxygen in stroke (FA7031: EvUp)
10	• Dental avulsion (FA 7361: EvUp)
11	• Second dose of epinephrine for anaphylaxis (FA 7111: EvUp)
12	• Naloxone for opioid emergencies (FA 7442: EvUp)
13	• Exertion-related dehydration and rehydration (FA 7241: EvUp)
14	• Counter-pressure maneuvers for prevention of syncope (FA 7550: EvUp)
15	• Recovery position (FA 7040: EvUp)
16	Readers are encouraged to monitor the ILCOR website ³ to provide feedback on planned
17	SysRevs and to provide comments when additional draft reviews are posted.
18	References
19	1. International Liaison Committee on Resuscitation. Consensus on science with treatment
20	recommendations (CoSTR). Accessed February 2, 2024. Accessed. https://costr.ilcor.org/
21	2. Guyatt G, Oxman AD, Akl EA, Kunz R, Vist G, Brozek J, Norris S, Falck-Ytter Y,
22	Glasziou P, DeBeer H, Jaeschke R, Rind D, Meerpohl J, Dahm P, Schunemann HJ. GRADE

- 1 guidelines: 1. Introduction—GRADE evidence profiles and summary of findings tables. J Clin
- 2 Epidemiol. 2011;64:383-394. doi: 10.1016/j.jclinepi.2010.04.026
- 3 3. International Liaison Committee on Resuscitation. ILCOR website. Accessed February 2,
- 4 2024. Accessed. https://www.ilcor.org/home

1 BLS TASK FORCE

2 **Optimal Surface for Performing CPR (BLS 2510: SysRev)**

3 Rationale for Review

4 This topic was prioritized for review by the BLS Task Force because it had not been reviewed since 2019.^{1,2} Since the last systematic review (SysRev) of this topic,³ the task force 5 6 was concerned that the practice of moving patients from the bed to the floor to improve the 7 quality of CPR could delay CPR; thus, it was considered timely to update the SysRev completed for the 2020 CoSTR.^{1,2} The SysRev was registered before initiation (International Prospective 8 Register of Systematic Reviews [PROSPERO] CRD42017080475). The full online CoSTR can 9 be found on the ILCOR website.⁴ 10 Population, Intervention, Comparator, Outcome, Study Design, and Time Frame 11 12 Population: For adults or children in cardiac arrest (OHCA and in-hospital cardiac arrest 13 [IHCA]) Intervention: The performance of CPR using a hard surface (eg, backboard, floor, or 14 15 deflatable or specialist mattress) • Comparators: The performance of CPR on a regular mattress or other soft surface 16 Outcomes: Survival with a favorable neurological outcome at hospital discharge/30 days 17 (critical), survival at hospital discharge/30 days (critical), event survival (important), 18 19 return of spontaneous circulation (ROSC) (important), CPR quality (eg, compression depth, compression rate, compression fraction) (important) 20 21 Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series, 22 controlled before-and-after studies, cohort studies) were eligible for inclusion. 23 Unpublished studies (eg, conference abstracts, trial protocols) were excluded.

1	Randomized manikin simulation or cadaver studies were included only if insufficient	
2	human studies were identified. Studies were included regardless of language if an	
3	abstract in English was available.	
4	• Time frame: The dates searched were September 17, 2019 (date of the search for the	
5	previous SysRev), to February 5, 2024.	
6	Consensus on Science	
7	In addition to the 11 manikin simulation RCTs ⁵⁻¹⁵ identified in the previous review, ³ we	
8	identified 1 small observational study ¹⁶ and 6 additional manikin RCTs ¹⁷⁻²² addressing this	
9	population, intervention, comparator, outcome, study design, and time frame (PICOST) question.	
10	The overall certainty of evidence was rated as very low to low due to risk of bias and serious	
11	indirectness. No studies reported patient outcomes. The included studies were grouped by	
12	surfaces studied: backboard versus hospital mattress, floor versus hospital mattress, floor versus	
13	firm home mattress, and floor versus other surface types. The small observational study that	
14	compared a backboard with a hospital mattress used a single accelerometer for measurement, and	
15	the results were considered unreliable. ¹⁶ Results of the meta-analysis of data from the manikin	
16	simulation studies are given in Table 1.	
17 18	Table 1. Results of the Meta-Analysis of CPR Metrics From the Manikin Simulation Studies Examining Different Surfaces for CPR	

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

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

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

2 **Prior Treatment Recommendations (2020**^{1,2})

- 3 We suggest performing chest compressions on a firm surface when possible (weak
- 4 recommendation, very low-certainty evidence).
- 5 During in-hospital cardiac arrest, we suggest, where a bed has a CPR mode which

6 increases mattress stiffness, it should be activated (weak recommendation, very low-certainty of

7 evidence).

8 During in-hospital cardiac arrest, we suggest against moving a patient from a bed to floor

9 to improve chest compression depth (weak recommendation, very low-certainty of evidence).

10 During in-hospital cardiac arrest, we suggest in favor of either a backboard or no-

11 backboard strategy, to improve chest compression depth (conditional recommendation, very

- 12 low-certainty of evidence).
- 13 2024 Treatment Recommendations

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

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

- We suggest activation of the CPR mode to increase mattress stiffness if available for in hospital cardiac arrest (good practice statement).
- For health care systems that have already incorporated backboards into routine use during
 resuscitations, the evidence was considered insufficient to suggest against their continued use
 (weak recommendation, very low-certainty of evidence).

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

10 Justification and Evidence-to-Decision Framework Highlights

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

12 When performing chest compressions on a patient lying on a mattress, the force of the 13 chest compressions is dissipated through the compression of the chest and compression of the 14 surface beneath the patient. Mattress compression can be as high as 57% of total compression depth, with greater compression seen in softer mattresses.²³⁻²⁵ This can lead to reduced spinal-15 16 sternal displacement and a reduction in effective chest compression depth. It is known that effective compression depths can be achieved on soft surfaces if the CPR provider increases 17 18 overall compression depth to compensate for mattress compression.²⁶⁻²⁹ CPR feedback devices 19 that account for mattress compression (eg, the use of dual, and not single, accelerometers or 20 increasing compression depth targets) can help CPR providers to ensure adequate compression depth when CPR is performed on a mattress.^{7,29-31} 21

In making these recommendations, the task force considered the importance of highquality chest compressions and minimizing delays to the initiation of CPR and the lack of human

Greif – 5

1	data, including patient outcomes. Within the limitations of manikin studies, the available		
2	evidence indicates that using a backboard on a hospital mattress provides only a marginal depth		
3	benefit that is unlikely to be clinically significant. In considering whether to transfer a patient to		
4	the floor to improve compression depth, the task force considered the risks of harm (eg,		
5	interruption in CPR, risk of losing vascular access) to the patient and resuscitation team		
6	outweighed any small improvement in chest compression depth. The addition of 2 studies		
7	simulating out-of-hospital settings (where beds may be softer) and one where the CPR provider		
8	may be a single untrained rescuer led the task force to broaden the recommendations to include		
9	OHCA. The task force felt the indirect evidence on backboards was not sufficient to have		
10	backboards removed where they are currently used. However, users should be aware that		
11	mattress stiffness and backboard size and orientation influence the backboard's effectiveness. ³²⁻³⁵		
12	Knowledge Gaps		
13	Studies reporting clinical outcomes		
14	• Studies examining the logistical aspects of backboard deployment or moving a patient		
15	from a bed to the floor		
16	• Studies in both high- and low-resource settings where hospital bed or prehospital		
17	stretcher configurations may vary		
18	Optimization of Dispatcher-Assisted Recognition of OHCA (BLS 2102: ScopRev)		
19	Rationale for Review		
20	The 2020 CoSTR on dispatcher-assisted diagnosis of cardiac arrest recommended		
21	dispatch centers look for ways to optimize sensitivity. ^{1,2} These interventions have not been		
22	reviewed by ILCOR before. A ScopRev was conducted to understand factors related to DA		
23	recognition and to review the current state of evidence for interventions aiming to optimize		

1	recognition to inform the development of a PICOST for a SysRev. The full online CoSTR can be		
2	found on the ILCOR website. ³⁶		
3	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame		
4	• Population: Adults and children who are in cardiac arrest outside of a hospital.		
5	• Intervention: Factors and interventions that improve dispatcher-assisted recognition of		
6	cardiac arrest.		
7	• Outcomes: Dispatcher-assisted recognition of cardiac arrest defined as initiation of		
8	cardiac arrest-specific actions, such as instructions to perform CPR.		
9	• Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series,		
10	controlled before-and-after studies, cohort studies, qualitative) were eligible for inclusion.		
11	All relevant studies with an abstract in English were included.		
12	• Time frame: The search of Medline was performed on performed on June 2, 2023, from		
13	database inception to June 2, 2023.		
14	Summary of Evidence		
15	This ScopRev identified 60 relevant papers. ³⁷⁻⁹⁶ The included manuscripts described 4		
16	major categories and 18 subcategories: 2 major categories and 11 subcategories relate to factors		
17	found to influence DA recognition, and 2 major categories and 7 subcategories were		
18	interventions aiming to improve DA recognition (Table 2). The detailed findings within each		
19	theme are summarized in the full CoSTR on the ILCOR website. ³⁶		
20 21	Table 2. Categories and Subcategories of Factors Influencing Dispatcher-Assisted Recognition of OHCA		

Categories	Subcategories	
Factors 1	elated to dispatcher-assisted recognition	
Communication between	1. Caller's emotional state	
caller and dispatcher (n=16)	2. Caller's proximity to OHCA patient	

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

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

3 Task Force Insights

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

1	including bypassing breathing in the initial assessment and asking the caller to put their		
2	hand on the patient's stomach. No strategy showed better results than the commonly used		
3	2-questions strategies. Although several strategies were tested, there were no RCTs		
4	comparing different strategies.		
5	• The only randomized control trial in this review studied the effect of including an		
6	artificial intelligence model to improve recognition of OHCA. Although the model		
7	seemed to perform well, the study did not show an effect on dispatcher recognition of		
8	OHCA when using the model in the emergency dispatch center. The main problem		
9	appeared to be high false positive rates.		
10	• Based on this ScopRev, there is insufficient evidence to pursue a new SysRev on this		
11	topic.		
12	2 Knowledge Gaps		
13	• Sensitivity, specificity, and positive predictive values of different factors to improve		
14	dispatcher-assisted recognition of OHCA, as well as how studied variables affect time to		
15	recognition		
16	• How different protocols and strategies compare with each other in randomized trials		
17	• When dispatchers should deviate from the script in the dispatch protocol. There is an		
18	expectation or necessity for dispatchers to follow and not deviate from a script. However,		
19	deviation may be necessary in certain cases, and continuation of the script in these cases		
20	could lead to worse communication, lower rates of recognition of OHCA, or longer time		
21	to recognition. Studies to identify which cases may benefit from deviation of script are		
22	warranted.		
23	• How to optimize dispatcher-assisted recognition of pediatric OHCA		

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

2 Rationale for Review

3	The 2020 SysRev recommends CPR instructions be provided by dispatchers during the		
4	emergency call. ^{1,2} Although the certainty of evidence was rated as very low at that time,		
5	dispatcher-assisted CPR (DA-CPR) has been implemented widely,97-100 and the task force was		
6	aware of new evidence examining interventions aiming to optimize DA-CPR. A ScopRev was		
7	conducted to map this evidence and determine if it was sufficient to warrant a new SysRev of		
8	interventions to improve DA-CPR. Studies comparing compression-only CPR with standard		
9	CPR were excluded as this topic is covered in a separate ILCOR PICOST. ^{101,102} The full online		
10	CoSTR can be found on the ILCOR website. ¹⁰³		
11	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame		
12	• Population: Adults and children with out-of-hospital cardiac arrest where DA-CPR is		
13	implemented		
14	• Intervention: Interventions used in addition to DA-CPR		
15	Comparators: Nonmodified DA-CPR		
16	Outcomes: Any outcomes		
17	• Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series,		
18	controlled before-and-after studies, cohort studies) were eligible for inclusion.		
19	Unpublished studies (eg, conference abstracts, trial protocols), editorials, commentaries,		
20	animal studies, and SysRevs were excluded. If there were insufficient studies from which		
21	to draw a conclusion, case series could be included in the initial search. All relevant		
22	studies with an abstract in English were included.		

1 • Time frame: The search of Embase, Medline, Cumulative Index to Nursing and Allied 2 Health Literature Database, and Cochrane Database of Systematic Reviews was performed on May 17, 2023, for the period 2000 to May 17, 2023. 3 4 Summary of Evidence 5 Thirty-one studies were included in this ScopRev: One was a nonrandomized implementation trial,¹⁰⁴ 16 were simulation studies (15 RCTs,¹⁰⁵⁻¹¹⁹ 1 nonrandomized 6 comparison¹²⁰) and 12 were observational studies reviewing real-world OHCAs from registries 7 or collected data^{75,120-130} or emergency call review.¹³¹ Two included studies used qualitative¹³² 8 and mixed methods.¹³³ Only 1 study focused on pediatric cardiac arrest.¹¹¹ Complete details of 9 10 the studies and findings are reported in the full CoSTR on the ILCOR website. The interventions examined were advanced dispatcher training $(n=3^{121-123})$, centralization 11 of the dispatch center ($n=2^{124,125}$), use of metronome or varied metronome rates ($n=2^{105,106}$). 12 change in CPR sequence and compression ratio $(n=1^{126})$, an animated audiovisual recording 13 $(n=1^{107})$, prerecorded instructions compared with conversational live instructions $(n=1^{108})$, 14 implementation of novel DA-CPR protocols (n=4^{75,104,109,127}), changes in terminology about 15 compressions (n=6^{110-112,120,128,131}; 1 pediatric), inclusion of "undress patient" instructions 16 $(n=1^{113})$, verbal encouragement $(n=1^{119})$, and use of video at the scene $(n=9^{114-118,129,130,132,133})$. 17 The implementation of novel DA-CPR protocols, prerecorded instructions, centralized 18 dispatch, advanced dispatcher training, use of metronomes and varying metronome rates and 19 20 instructions to undress the patient all have less than 3 papers published, and therefore, we are 21 unable to make any comment on their effectiveness at this point. 22 The studies that focus on simplifying the compression instruction language (ie, "Push as 23 hard as you can" versus "Push approximately 2 inches/5 cm") suggest an improvement in the

1	quality of CPR. ^{111,112,120,128} The studies that examined adding video to the emergency call,		
2	compared with audio-only calls, suggest an improvement in CPR practice (eg, hand positioning)		
3	and quality (eg, compression depth and rate). ^{114-118,130}		
4	Task Force Insights		
5	The task force discussed the review findings and noted the following:		
6	• The lack of high-quality evidence, studies in humans, and the significant heterogeneity		
7	between studies of the various interventions		
8	• Terminology changes in instructions may not be generalizable to other languages.		
9	• Almost half of the studies comparing video to audio were simulation studies.		
10	• Based on this ScopRev, there is insufficient evidence to pursue a new SysRev on this		
11	topic.		
12	Knowledge Gaps		
13	• High-quality prospective research in humans		
14	• Data on optimizing DA-CPR in pediatric cases		
15	Optimization of Dispatcher-Assisted AED Retrieval and Use (BLS 2120: ScopRev)		
16	Rationale for Review		
17	Bystander use of AEDs is associated with high survival rates from OHCA, ^{134,135} but use		
18	is currently infrequent. ¹³⁶ This topic was selected for review by the BLS Task Force because of		
19	the widespread use of dispatch instructions for the retrieval and use of an AED ^{100,137} and the need		
20	to optimize systems to improve the public's AED use. ^{138,139} Although there is no existing ILCOR		
21	treatment recommendation related to dispatcher-assisted AED (DA-AED) retrieval, the task		
22	force decided the current evidence required a ScopRev to fully explore the scope of the topic.		
23	The full online CoSTR can be found on the ILCOR website. ¹⁴⁰		

1	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
2	• Population: Adults and children with out-of-hospital cardiac arrest
3	• Intervention: DA-AED retrieval and use
4	• Outcomes: Any reported outcomes
5	• Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series,
6	controlled before-and-after studies, cohort studies), simulation studies, case series (>5
7	patients), trial protocols, and conference abstracts were included. All relevant studies
8	with an abstract in English were included.
9	• Time frame: The search of Embase, Medline, and Cochrane Central was performed on
10	April 14, 2023, from database inception to April 13, 2023.
11	Summary of Evidence
12	Sixteen studies were included in this ScopRev: 5 observational studies reviewing real-
13	world OHCAs ¹⁴¹⁻¹⁴⁵ and 11 simulation studies (6 RCTs, ¹⁴⁶⁻¹⁵¹ 1 nonrandomized trial, ¹⁵² and 4
14	observational ¹⁵³⁻¹⁵⁶).
15	There were no studies that examined patient outcomes. One observational study did
16	report improvement in survival with favorable neurological outcome in 1132 (of 1606) OHCAs
17	when a DA-CPR protocol included instructions to retrieve an AED, but the relative contribution
18	of the DA-AED instruction could not be determined from the data provided. ¹⁴³
19	In systems using DA-AED retrieval and use, 5 observational studies reported low rates of
20	AED retrieval (0.8%–5.8% ^{141,142,144}), pad application (0.4%–1.7% ^{142,144,145}), and shocks
21	delivered (2.4%–11% ^{141,143}). In one study, rates of bystander defibrillation were greater with
22	dispatcher instructions to retrieve an AED, compared with cases where no instructions were
23	given (11% versus 5%, unadjusted p<0.001). ¹⁴³ Another observational study reported confusion

and delays in the emergency call following a 3-part instruction to retrieve an AED.¹⁴¹ Callers 1 2 often had to ask the dispatcher to repeat the instruction, or they asked clarifying questions. 3 In simulation studies, time to first shock, when measured from the time the AED arrived, was longer when dispatcher assistance was provided than when there was no assistance.^{146,157} 4 5 However, when time to retrieve an AED was factored in, time to first shock was shorter.^{149,158} 6 AED competence scores were consistently higher with dispatcher assistance (or an analogous form of instruction).^{146,151,157,159,160} In a simulation study, the use of video instruction 7 enabled the correction of pad placement, which initially was done incorrectly by most 8 bystanders.¹⁶⁰ In another study the use of mobile phone video resulted in better performance than 9 verbal instruction alone,¹⁴⁶ but a second study demonstrated no difference.¹⁵⁹ The use of 10 prerecorded video instruction was inferior to real-time (verbal) dispatcher instruction.¹⁵¹ In 1 11 12 study, dispatchers facilitated the application of an AED in 5 out of 6 cases when the AED had been brought to the (simulated) patient's side, but the study participant did not attempt to use it 13 unprompted.¹⁶¹ 14 15 Task Force Insights There is limited published research in this area, particularly on the impact on patient 16 outcomes. 17 • Given the majority of OHCAs occur in the home, public-access AEDs are likely to be in 18 close proximity in only a minority of cases, and fewer still are likely able to be located, 19 20 retrieved, and attached to a patient in a meaningful time frame. Research is emerging on the user-friendliness of different AED brands.^{162,163} 21 There is a risk that by implementing dispatcher instructions to retrieve and use public-22 23 access AEDs, other aspects of the community response (eg, time to CPR, delay to

1	dispatcher CPR instructions, reduced CPR efficacy due to distraction or interruptions)
2	could be affected. These risks are likely to be greatest when there is a lone rescuer at the
3	scene.
4	The studies reviewed in the present ScopRev suggest there is currently insufficient
5	evidence to pursue a new SysRev on this topic. There were no previous treatment
6	recommendations on this topic. Given the widespread adoption of this intervention and interest
7	in this topic, the task force considered the available evidence and developed the following good
8	practice statements.
9	2024 Treatment Recommendations
10	EMS implementing dispatcher-assisted public-access AED systems should monitor and
11	evaluate the effectiveness of their system (good practice statement).
12	Once a cardiac arrest is recognized during the emergency call and CPR has been started,
13	dispatchers should ask if there is an AED (or defibrillator) immediately available at the scene
14	and ask the caller to update them when one arrives (good practice statement).
15	If an AED is not immediately available and if there is more than 1 rescuer present,
16	dispatchers should offer instructions to locate and retrieve an AED. Retrieval instructions should
17	be supported, where resources allow, by up-to-date registries about public-access AED locations
18	and accessibility (good practice statement).
19	Once an AED is available, dispatchers should offer instructions on its use (good practice
20	statement).
21	Task Force Knowledge Gaps
22	• High-quality evidence of the effect of dispatcher-assisted public-access AED use on
23	critical and important clinical (patient) outcomes

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

16 Feedback for CPR Quality (BLS 2511: ScopRev)

17 Rationale for Review

18 CPR feedback devices are intended to improve patient outcomes through improving the 19 quality of CPR. The 2020 CoSTR on feedback for CPR quality recommended the use of real-20 time audiovisual feedback and prompt devices during CPR when used as part of a 21 comprehensive quality improvement program.^{1,2} There were challenges with the 2020 ILCOR 22 review due to the exclusion of many studies because they combined the evaluation of feedback 23 with other quality improvement activities (eg, debriefing). The task force decided to perform a

1	ScopRev to understand if the wider literature, including studies with other interventions, may		
2	provide further insights into the effectiveness of feedback and improve the existing PICOST		
3	question. Additionally, the task force concluded that this review should focus on the provision of		
4	CPR by health professionals responding in a professional capacity, rather than by bystanders or		
5	lay responders. The detailed results are provided on the ILCOR website. ¹⁶⁴		
6	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame		
7	• Population: Adults and children (excluding neonates) who are in cardiac arrest in any		
8	setting who are resuscitated by health professionals responding in a professional capacity		
9	• Intervention: Real-time feedback and prompt devices regarding the mechanics of CPR		
10	quality (eg, rate and depth of compressions and/or ventilations)		
11	• Comparators: No feedback or prompt devices, or alternative devices		
12	• Outcomes: Any outcome or measure of CPR quality		
13	• Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series,		
14	controlled before-and-after studies, cohort studies) are eligible for inclusion		
15	• Time frame: PubMed, Embase, Cochrane, and Cumulative Index to Nursing and Allied		
16	Health Literature were searched from database inception to July 18, 2023. A grey		
17	literature search was performed in the Google search engine (July 18, 2023). All relevant		
18	studies with an abstract in English were included.		
19	Summary of Evidence		
20	Of the 55 studies included, we identified 10 SysRevs, ¹⁶⁵⁻¹⁷⁴ 5 RCTs, ¹⁷⁵⁻¹⁷⁹ 37		
21	observational studies, ¹⁸⁰⁻²¹⁵ 2 case series, ^{216,217} and 1 commentary. ²¹⁸ The patients included		
22	varied widely between studies. Only 3 studies included children, 209,211,219 and most of the		
23	evidence consisted of before-and-after studies.		

Greif-17

1	The use of metronomes was examined in 1 SysRev from 2014 ¹⁷⁴ and 6 observational		
2	studies (3 OHCA and 3 IHCA). ¹⁸⁰⁻¹⁸⁵ This evidence suggests an associated improvement in CP		
3	quality, but there are few data on patient outcomes and what outcome data are reported are not		
4	adjusted for confounding (Table 3).		
5	By including a wider range of published studies and studies examining audiovisual		
6	feedback with other system improvements, we identified 9 SysRevs, ¹⁶⁵⁻¹⁷³ 5 RCTs, ¹⁷⁵⁻¹⁷⁹ 31		
7	observational studies, ^{186-215,219} and 2 case series. ^{216,217} Evidence examining key outcomes with a		
8	non-feedback comparator group suggests improved CPR quality, but most studies reporting		
9	improved patient outcomes beyond ROSC included other interventions, such as high-		
10	performance CPR and postevent debriefing (Table 4). This evidence aligns with ILCOR's		
11	current treatment recommendation that feedback devices should be used as part of a		
12	comprehensive quality improvement program. ^{1,2}		
13	Task Force Insights		
14	• As this was a ScopRev, no formal assessment of the quality of the literature was		
15	performed. However, the lack of RCTs was noted and many of the studies published		
16	since the last review continue to have methodological issues (eg, lack of adjustment for		
17	confounders, small sample sizes, no patient outcomes reported).		
18	• EMS systems and hospitals in well-resourced settings have, or are implementing, quality		
19	improvement programs, including the use of feedback devices, to improve the quality of		
20	CPR. This implementation makes the study of isolated interventions, such as feedback		
21	devices, difficult to evaluate in observational research.		
22	• While 59 studies were included in the narrative synthesis, there was insufficient new		
23	evidence to recommend a SysRev using the expanded PICOST question. An update of		

1 the SysRev using the existing PICOST question is recommended, with subgroups based 2 on the different devices and separate review for health care professionals and lay people. 3 This ScopRev has revealed a substantial adjacent literature studying the implementation 4 of high-performance CPR and quality improvement programs, but it was not possible to 5 extract a specific association with real-time CPR feedback from these studies. It is 6 suggested that a new PICOST question is developed that examines the impact of these 7 programs on clinical outcomes for both OHCA and IHCA patients. 8 Knowledge Gaps

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

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

11 Table 3. Human Studies on Metronome Rate Guidance During CPR

Studies	Design issues	Results with use of feedback
Bolstridge 2016 ¹⁸⁰	Before/after study ^{180,181}	Significant increase: 2 before/after
Khorasani-Zadeh	Small sample size ¹⁸⁰	IHCA studies ^{180,181}
2020 ¹⁸¹		
CPR quality: chest compression fraction		
Chiang 2005 ¹⁸³	Before/after study ¹⁸³	No change: 1 before/after OHCA
	Small sample size ¹⁸³	study ¹⁸³

1 2

3

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

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

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

Studies	Design issues	Results with use of feedback
Kramer-Johansen 2006 ¹⁸⁹	Before/after study ^{186,189-191,195,197-199,201}	Significant increase: 5
Abella 2007 ¹⁸⁶	Abstract only ^{190,201}	before/after OHCA
Hostler 2011 ¹⁷⁶	Small sample size ^{195,197}	studies ^{189,191,197,198,201}
Bobrow 2013 ¹⁹¹	Significant missing data ^{176,190}	No change: 1 cluster OHCA
Crowe 2015 ¹⁹⁵ †		RCT ¹⁷⁶ ; 1 before/after IHCA
Riyapan 2019 ¹⁹⁷		study ¹⁸⁶¹⁹⁵ ; 3 before/after
Nehme 2021 ¹⁹⁹ *		OHCA studies ^{178,190,199}
Chandra 2022 ¹⁹⁰ †		
Lyngby 2022 ²⁰¹		
CPR quality: compression of	lepth	
Kramer-Johansen 2006 ¹⁸⁹	Before/after study ^{186,189-191,195,197-199,201}	Significant increase: 1
Abella 2007 ¹⁸⁶	Abstract only ^{190,201}	cluster OHCA RCT ¹⁷⁶ ; 7
Hostler 2011 ¹⁷⁶	Small sample size ^{195,197}	before/after OHCA
Bobrow 2013 ¹⁹¹	Significant missing data ^{176,190}	studies ^{189-191,195,197,198,201}
Crowe 2015 ¹⁹⁵ †		No change: 1 before/after
Riyapan 2019 ¹⁹⁷		IHCA study ¹⁸⁶
Nehme 2021 ¹⁹⁹ *		
Chandra 2022 ¹⁹⁰ †		
Lyngby 2022 ²⁰¹		
CPR quality: chest compres	ssion fraction	
Kramer-Johansen 2006 ¹⁸⁹	Before/after study ^{189,190,195,197-199,201}	Significant increase: 1
Hostler 2011 ¹⁷⁶	Abstract only ^{190,201}	cluster OHCA RCT ¹⁷⁶ ; 3
Crowe 2015 ¹⁹⁵ †	Small sample size ^{195,197}	before/after OHCA
Riyapan 2019 ¹⁹⁷	Significant missing data ^{176,190}	studies ^{190,199,201}
Lakomek 2020 ¹⁹⁸		No change: 4 before/after
Nehme 2021 ¹⁹⁹ *		OHCA studies ^{189,195,197,198}
Chandra 2022 ¹⁹⁰ †		
Lyngby 2022 ²⁰¹		

CPR indicates cardiopulmonary resuscitation; IHCA, in-hospital cardiac arrest; OHCA, out-of-hospital cardiac

arrest; and RCT, randomized controlled trials.

*High-performance training (audiovisual feedback, scenario-based training, checklist, team leader, and debriefing †Audiovisual feedback and debriefing

1 2 3 4

- 1 2 ‡High-performance CPR education, audiovisual feedback, and debriefing §High-performance CPR education and audiovisual feedback

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

Rationale for Review 4

5	Early defibrillation is associated with a large increase in survival from OHCA. ²²⁰⁻²²³ If
6	defibrillation occurs within 3 to 5 minutes of collapse, survival rates as high as 50% to 70% have
7	been reported. ^{222,223} EMS response times rarely enable delivery of defibrillation in such a short
8	time. ²²⁴ Recently, several companies have started advertising "ultraportable" or "pocket" AEDs
9	for personal use or equipping community volunteer responders to improve AED availability.
10	These devices may be limited in the number and the energy of the shocks they deliver (eg,
11	restricted to up to 20 shocks and a maximum of 85 J). This topic has not been reviewed before,
12	and given the interest in these devices, the task force thought a review of their effectiveness in
13	practice was timely. The detailed results are provided on the ILCOR website. ²²⁵
14	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
15	• Population: Adults and children in OHCA
16	• Intervention: The use of an ultraportable or pocket AED
17	• Outcomes: All outcomes were accepted
18	• Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series,
19	controlled before-and-after studies, cohort studies, conference abstracts, and trial
20	protocols) were eligible for inclusion. Studies that describe the use of mobile AEDs
21	associated with drone technology were excluded. All studies with an abstract in English
22	were included.
23	• Time frame: The search of Embase and Medline was performed on November 1, 2023,
24	for the period January 1, 2012, to October 31, 2023.

1 Summary of Evidence

- This review included 3 studies: a medico-economic simulation study,²²⁶ a study protocol 2
- of a cluster RCT,²²⁷ and an abstract with preliminary results of that cluster RCT.²²⁸ Key findings 3
- 4 from these studies are summarized in Table 5.
 - First author and Intervention / **Population** Findings year, study design comparator(s) Shaker 2022²²⁶; 600 000 simulated Small AED for rapid At a 1.6% SCA annual risk, economic analysis patients at low, treatment of SCA SMART strategy was moderate, and high (SMART) / No SMART associated with risk \$95 251/QALY (societal strategy for SCA perspective) and \$100 797/QALY (health care perspective). At a 3.5% SCA annual risk, SMART strategy was associated with \$53 925/QALY (societal perspective) and \$59 672/QALY (health care perspective). SMART prevented 1762 fatalities across risk strata (1.59% fatality relative risk reduction across groups). Todd 2023²²⁷; Sample size Community responder Primary outcome: Survival cluster RCT study calculation of 714 dispatched with to 30 days protocol (357 per arm) GoodSAM app equipped Aim to detect a 7% increase with an ultraportable in survival (9%–16%)
- 5 Table 5. Summary of Studies Reporting on Ultraportable or Pocket AEDs

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

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

4 Task Force Insights

5	•	Ultraportable or pocket AEDs are a new generation of defibrillators characterized by
6		small size, being lightweight and easy to carry on one's person, and affordable for
7		personal and home use.
8	•	We acknowledge that the development of ultraportable or pocket and more affordable
9		AEDs offers the unique opportunity to develop more efficient public access defibrillation
10	~	or community volunteer responder programs, increase home AED availability, and
11		therefore improve outcomes.
12	٠	Device registration with regulatory authorities alone does not provide evidence of device
13		performance in real-world settings. Because the success of defibrillation is related to
14		several factors, including shock energy, transthoracic impedance, defibrillator pad size
15		and anatomical location, diagnostic accuracy for shockable rhythms, and the duration the
1	person has been in cardiac arrest, further research is required to demonstrate the clinical	
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2	efficacy of pocket/ultraportable AEDs.	
3	• There is a lack of research in this area.	
4	There is currently insufficient evidence to recommend progression to a formal SysRev.	
5	2024 Treatment Recommendations (new)	
6	There is currently insufficient evidence on the clinical effectiveness of ultraportable or	
7	pocket AEDs to make a treatment recommendation.	
8	Knowledge Gaps	
9	• The effect of ultraportable or pocket AED use on critical and important clinical outcomes	
10	• A consensus on the definition of ultraportable AED	
11	• The clinical efficacy (ie, whether the devices work in optimal settings) or clinical	
12	effectiveness (real-world settings) of ultraportable AEDs	
13	• The performance of ultraportable AEDs compared with standard AEDs: Such research	
14	should address process measures (eg, time to defibrillation), evidence of efficacy (eg,	
15	termination of fibrillation, return of organized rhythm, ROSC) and clinical effectiveness	
16	(eg, survival with a favorable neurological outcome, survival to discharge).	
17	• The cost-effectiveness of ultraportable defibrillators in different contexts (eg, at home, by	
18	community volunteer responder programs, and in public locations)	
19	• How to best organize and maintain ultraportable defibrillators	

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

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

2 Table 6. BLS Topics Reviewed by Evidence Updates

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

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
Hand	2020	We suggest performing chest	0	0	No new studies.	No
positioning		compressions on the lower half of				
(BLS 2502)		the sternum on adults in cardiac				
		arrest (weak recommendation, very				
		low certainty evidence).				
Head-Up CPR	2021	We suggest against the routine use	0	2	High risk of bias. No	No
(BLS 2503)		of head-up CPR during CPR (weak			difference in outcomes	
		recommendation, very-low-			in propensity-matched	
		certainty evidence).			cohort.	
		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).				

BLS indicates basic life support; CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; PAD, public access defibrillation, PICO, 1 2

population, intervention, comparator, outcome; and RCT, randomized controlled trial.

1 **References**

2	1.	Olasveengen TM, Mancini ME, Perkins GD, Avis S, Brooks S, Castren M, Chung SP,
3		Considine J, Couper K, Escalante R, et al. Adult Basic Life Support: 2020 International
4		Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care
5		Science With Treatment Recommendations. Circulation. 2020;142:S41-S91. doi:
6		10.1161/CIR.00000000000892
7	2.	Olasveengen TM, Mancini ME, Perkins GD, Avis S, Brooks S, Castren M, Chung SP,
8		Considine J, Couper K, Escalante R, et al. Adult Basic Life Support: International
9		Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care
10		Science With Treatment Recommendations. Resuscitation. 2020;156:A35-A79. doi:
11		10.1016/j.resuscitation.2020.09.010
12	3.	Holt J, Ward A, Mohamed TY, Chukowry P, Grolmusova N, Couper K, Morley P,
13		Perkins GD. The optimal surface for delivery of CPR: A systematic review and meta-
14		analysis. Resuscitation. 2020;155:159-164. doi: 10.1016/j.resuscitation.2020.07.020
15	4.	Dewan M, Perkins G, Schachna E, Eastwood K, Smyth M, Olasveengen TM, Bray J, on
16		behalf of the International Liaison Committee on Resuscitation Basic Life Support Task
17		Force. Optimal surface for CPR: An Updated Systematic Review and Meta-analysis.
18		Consensus on Science with Treatment Recommendations [Internet] Brussels, Belgium:
19		International Liaison Committee on Resuscitation (ILCOR) Basic Life Support Task
20		Force, 2024 January 8. Available from: https://costr.ilcor.org/document/firm-surface-for-
21		cpr-an-updated-systematic-review-bls-2510.

1	5.	Tweed M, Tweed C, Perkins GD. The effect of differing support surfaces on the efficacy
2		of chest compressions using a resuscitation manikin model. Resuscitation. 2001;51:179-
3		183. doi: 10.1016/s0300-9572(01)00404-x
4	6.	Perkins GD, Benny R, Giles S, Gao F, Tweed MJ. Do different mattresses affect the
5		quality of cardiopulmonary resuscitation? Intensive Care Med. 2003;29:2330-2335. doi:
6		10.1007/s00134-003-2014-6
7	7.	Perkins GD, Smith CM, Augre C, Allan M, Rogers H, Stephenson B, Thickett DR.
8		Effects of a backboard, bed height, and operator position on compression depth during
9		simulated resuscitation. Intensive Care Med. 2006;32:1632-1635. doi: 10.1007/s00134-
10		006-0273-8
11	8.	Andersen LO, Isbye DL, Rasmussen LS. Increasing compression depth during manikin
12		CPR using a simple backboard. Acta Anaesthesiol Scand. 2007;51:747-750. doi:
13		10.1111/j.1399-6576.2007.01304.x
14	9.	Jantti H, Silfvast T, Turpeinen A, Kiviniemi V, Uusaro A. Quality of cardiopulmonary
15		resuscitation on manikins: on the floor and in the bed. Acta Anaesthesiol Scand.
16		2009;53:1131-1137. doi: 10.1111/j.1399-6576.2009.01966.x
17	10.	Sato H, Komasawa N, Ueki R, Yamamoto N, Fujii A, Nishi S, Kaminoh Y. Backboard
18		insertion in the operating table increases chest compression depth: a manikin study. J
19		Anesth. 2011;25:770-772. doi: 10.1007/s00540-011-1196-2
20	11.	Oh J, Chee Y, Song Y, Lim T, Kang H, Cho Y. A novel method to decrease mattress
21		compression during CPR using a mattress compression cover and a vacuum pump.
22		Resuscitation. 2013;84:987-991. doi: 10.1016/j.resuscitation.2012.12.027

1	12.	Fischer EJ, Mayrand K, Ten Eyck RP. Effect of a backboard on compression depth
2		during cardiac arrest in the ED: a simulation study. Am J Emerg Med. 2016;34:274-277.
3		doi: 10.1016/j.ajem.2015.10.035
4	13.	Putzer G, Fiala A, Braun P, Neururer S, Biechl K, Keilig B, Ploner W, Fop E, Paal P.
5		Manual versus Mechanical Chest Compressions on Surfaces of Varying Softness with or
6		without Backboards: A Randomized, Crossover Manikin Study. J Emerg Med.
7		2016;50:594-600 e591. doi: 10.1016/j.jemermed.2015.10.002
8	14.	Sanri E, Karacabey S. The Impact of Backboard Placement on Chest Compression
9		Quality: A Mannequin Study. Prehosp Disaster Med. 2019;34:182-187. doi:
10		10.1017/S1049023X19000153
11	15.	Ahn HJ, Cho Y, You YH, Min JH, Jeong WJ, Ryu S, Lee JW, Cho SU, Oh SK, Park JS,
12		et al. Effect of using a home-bed mattress on bystander chest compression during out-of-
13		hospital cardiac arrest. Hong Kong Journal of Emergency Medicine. 2021;28:37-42. doi:
14		10.1177/1024907919856485
15	16.	Picard C, Drew R, Norris CM, O'Dochartaigh D, Burnett C, Keddie C, Douma MJ.
16		Cardiac Arrest Quality Improvement: A Single-Center Evaluation of Resuscitations
17		Using Defibrillator, Feedback Device, and Survey Data. J Emerg Nurs. 2022;48:224-232
18		e228. doi: 10.1016/j.jen.2021.11.005
19	17.	Hasegawa T, Okane R, Ichikawa Y, Inukai S, Saito S. Effect of chest compression with
20		kneeling on the bed in clinical situations. Jpn J Nurs Sci. 2020;17:e12314. doi:
21		10.1111/jjns.12314
22	18.	Kingston T, Tiller NB, Partington E, Ahmed M, Jones G, Johnson MI, Callender NA.
23		Sports safety matting diminishes cardiopulmonary resuscitation quality and increases

1 rescuer perceived exertion. <i>PL</i>	LoS One. 2021;16:e0254800. doi:
---	---------------------------------

- 2 10.1371/journal.pone.0254800
- 3 19. Shimizu Y, Sadamori T, Saeki N, Mukai A, Doi M, Oue K, Yoshida M, Irifune M.
- 4 Efficacy of Chest Compressions Performed on Patients in Dental Chairs Versus on the
- 5 Floor. Anesth Prog. 2021;68:85-89. doi: 10.2344/anpr-68-01-07
- 6 20. Cuvelier Z, Houthoofdt R, Serraes B, Haentjens C, Blot S, Mpotos N. Effect of a
- 7 backboard on chest compression quality during in-hospital adult cardiopulmonary
- 8 resuscitation: A randomised, single-blind, controlled trial using a manikin model.
- 9 Intensive Crit Care Nurs. 2022;69:103164. doi: 10.1016/j.iccn.2021.103164
- 10 21. Torsy T, Deswarte W, Karlberg Traav M, Beeckman D. Effect of a dynamic mattress on
- 11 chest compression quality during cardiopulmonary resuscitation. *Nurs Crit Care*.
- 12 2022;27:275-281. doi: 10.1111/nicc.12631
- 13 22. Missel AL, Donnelly JP, Tsutsui J, Wilson N, Friedman C, Rooney DM, Neumar RW,
- 14 Cooke JM. Effectiveness of Lay Bystander Hands-Only Cardiopulmonary Resuscitation
- 15 on a Mattress versus the Floor: A Randomized Cross-Over Trial. *Ann Emerg Med.*

16 2023;81:691-698. doi: 10.1016/j.annemergmed.2023.01.012

- Lin Y, Wan B, Belanger C, Hecker K, Gilfoyle E, Davidson J, Cheng A. Reducing the
 impact of intensive care unit mattress compressibility during CPR: a simulation-based
- 19 study. Adv Simul (Lond). 2017;2:22. doi: 10.1186/s41077-017-0057-y
- 20 24. Noordergraaf GJ, Paulussen IW, Venema A, van Berkom PF, Woerlee PH, Scheffer GJ,
- 21 Noordergraaf A. The impact of compliant surfaces on in-hospital chest compressions:
- 22 effects of common mattresses and a backboard. *Resuscitation*. 2009;80:546-552. doi:
- 23 10.1016/j.resuscitation.2009.03.023

1	25.	Song Y, Oh J, Lim T, Chee Y. A new method to increase the quality of cardiopulmonary
2		resuscitation in hospital. Annu Int Conf IEEE Eng Med Biol Soc. 2013;2013:469-472.
3		doi: 10.1109/EMBC.2013.6609538
4	26.	Beesems SG, Koster RW. Accurate feedback of chest compression depth on a manikin on
5		a soft surface with correction for total body displacement. Resuscitation. 2014;85:1439-
6		1443. doi: 10.1016/j.resuscitation.2014.08.005
7	27.	Nishisaki A, Maltese MR, Niles DE, Sutton RM, Urbano J, Berg RA, Nadkarni VM.
8		Backboards are important when chest compressions are provided on a soft mattress.
9		Resuscitation. 2012;83:1013-1020. doi: 10.1016/j.resuscitation.2012.01.016
10	28.	Lee S, Oh J, Kang H, Lim T, Kim W, Chee Y, Song Y, Ahn C, Cho JH. Proper target
11		depth of an accelerometer-based feedback device during CPR performed on a hospital
12		bed: a randomized simulation study. Am J Emerg Med. 2015;33:1425-1429. doi:
13		10.1016/j.ajem.2015.07.010
14	29.	Ruiz de Gauna S, Gonzalez-Otero DM, Ruiz J, Gutierrez JJ, Russell JK. A Feasibility
15		Study for Measuring Accurate Chest Compression Depth and Rate on Soft Surfaces
16		Using Two Accelerometers and Spectral Analysis. Biomed Res Int. 2016;2016:6596040.
17		doi: 10.1155/2016/6596040
18	30.	Hellevuo H, Sainio M, Huhtala H, Olkkola KT, Tenhunen J, Hoppu S. The quality of
19		manual chest compressions during transporteffect of the mattress assessed by dual
20		accelerometers. Acta Anaesthesiol Scand. 2014;58:323-328. doi: 10.1111/aas.12245
21	31.	Oh J, Song Y, Kang B, Kang H, Lim T, Suh Y, Chee Y. The use of dual accelerometers
22		improves measurement of chest compression depth. Resuscitation. 2012;83:500-504. doi:
23		10.1016/j.resuscitation.2011.09.028

1	32.	Cheng A, Belanger C, Wan B, Davidson J, Lin Y. Effect of Emergency Department
2		Mattress Compressibility on Chest Compression Depth Using a Standardized
3		Cardiopulmonary Resuscitation Board, a Slider Transfer Board, and a Flat Spine Board:
4		A Simulation-Based Study. Simul Healthc. 2017;12:364-369. doi:
5		10.1097/SIH.0000000000245
6	33.	Cloete G, Dellimore KH, Scheffer C. Comparison of experimental chest compression
7		data to a theoretical model for the mechanics of constant peak displacement
8		cardiopulmonary resuscitation. Acad Emerg Med. 2011;18:1167-1176. doi:
9		10.1111/j.1553-2712.2011.01213.x
10	34.	Cloete G, Dellimore KH, Scheffer C, Smuts MS, Wallis LA. The impact of backboard
11		size and orientation on sternum-to-spine compression depth and compression stiffness in
12		a manikin study of CPR using two mattress types. Resuscitation. 2011;82:1064-1070.
13		doi: 10.1016/j.resuscitation.2011.04.003
14	35.	Perkins GD, Kocierz L, Smith SC, McCulloch RA, Davies RP. Compression feedback
15		devices over estimate chest compression depth when performed on a bed. Resuscitation.
16		2009;80:79-82. doi: 10.1016/j.resuscitation.2008.08.011
17	36.	Malta Hansen CJG, A.; Dicker, B.; Dassanayake, V.; Vaillancourt, C.; Dainty, K.;
18		Olasveengen, T.; Bray, J.; on behalf of the International Liaison Committee on
19		Resuscitation Basic Life Support Task Force,;. Optimization of Dispatcher-Assisted
20		Recognition of Out-of-Hospital Cardiac Arrest: a BLS Task Force Synthesis of a Scoping
21		Review. IConsensus on Science with Treatment Recommendations [Internet] Brussels,
22		Belgium: International Liaison Committee on Resuscitation (ILCOR) Basic Life Support
23		Task Force, 2024 January 8. Available from:

- https://costr.ilcor.org/document/optimization-of-dispatcher-assisted-da-recognition-of ohca-a-scoping-review-bls-2102-scr.
- 3 37. Alfsen D, Moller TP, Egerod I, Lippert FK. Barriers to recognition of out-of-hospital 4 cardiac arrest during emergency medical calls: a qualitative inductive thematic analysis. 5 Scand J Trauma Resusc Emerg Med. 2015;23:70. doi: 10.1186/s13049-015-0149-4 6 38. Chien CY, Chien WC, Tsai LH, Tsai SL, Chen CB, Seak CJ, Chou YS, Ma M, Weng 7 YM, Ng CJ, et al. Impact of the caller's emotional state and cooperation on out-ofhospital cardiac arrest recognition and dispatcher-assisted cardiopulmonary resuscitation. 8 9 Emerg Med J. 2019;36:595-600. doi: 10.1136/emermed-2018-208353 10 39. Missel AL, Dowker SR, Chiola M, Platt J, Tsutsui J, Kasten K, Swor R, Neumar RW, Hunt N, Herbert L, et al. Barriers to the Initiation of Telecommunicator-CPR during 9-1-11 12 1 Out-of-Hospital Cardiac Arrest Calls: A Qualitative Study. Prehosp Emerg Care. 13 2023:1-8. doi: 10.1080/10903127.2023.2183533 14 40. Richards CT, McCarthy DM, Markul E, Rottman DR, Lindeman P, Prabhakaran S, 15 Klabjan D, Holl JL, Cameron KA. A mixed methods analysis of caller-emergency 16 medical dispatcher communication during 9-1-1 calls for out-of-hospital cardiac arrest. 17 Patient Educ Couns. 2022;105:2130-2136. doi: 10.1016/j.pec.2022.03.004 18 41. Garza AG, Gratton MC, Chen JJ, Carlson B. The accuracy of predicting cardiac arrest by 19 emergency medical services dispatchers: the calling party effect. Acad Emerg Med. 20 2003;10:955-960. doi: 10.1111/j.1553-2712.2003.tb00651.x 21 42. Bang A, Herlitz J, Holmberg S. Possibilities of implementing dispatcher-assisted 22 cardiopulmonary resuscitation in the community. An evaluation of 99 consecutive out-of-

1		hospital cardiac arrests. Resuscitation. 2000;44:19-26. doi: 10.1016/s0300-
2		9572(99)00163-x
3	43.	Bang A, Ortgren PO, Herlitz J, Wahrborg P. Dispatcher-assisted telephone CPR: a
4		qualitative study exploring how dispatchers perceive their experiences. Resuscitation.
5		2002;53:135-151. doi: 10.1016/s0300-9572(01)00508-1
6	44.	Castren M, Kuisma M, Serlachius J, Skrifvars M. Do health care professionals report
7		sudden cardiac arrest better than laymen? Resuscitation. 2001;51:265-268. doi:
8		10.1016/s0300-9572(01)00422-1
9	45.	Bradley SM, Fahrenbruch CE, Meischke H, Allen J, Bloomingdale M, Rea TD.
10		Bystander CPR in out-of-hospital cardiac arrest: the role of limited English proficiency.
11		Resuscitation. 2011;82:680-684. doi: 10.1016/j.resuscitation.2011.02.006
12	46.	Perera N, Birnie T, Ngo H, Ball S, Whiteside A, Bray J, Bailey P, Finn J. "I'm sorry, my
13		English not very good": Tracking differences between Language-Barrier and Non-
14		Language-Barrier emergency ambulance calls for Out-of-Hospital Cardiac Arrest.
15		Resuscitation. 2021;169:105-112. doi: 10.1016/j.resuscitation.2021.10.035
16	47.	Riou M, Ball S, Williams TA, Whiteside A, Cameron P, Fatovich DM, Perkins GD,
17		Smith K, Bray J, Inoue M, et al. 'She's sort of breathing': What linguistic factors
18		determine call-taker recognition of agonal breathing in emergency calls for cardiac
19		arrest? Resuscitation. 2018;122:92-98. doi: 10.1016/j.resuscitation.2017.11.058
20	48.	Stangenes SR, Painter IS, Rea TD, Meischke H. Delays in recognition of the need for
21		telephone-assisted CPR due to caller descriptions of chief complaint. Resuscitation.
22		2020;149:82-86. doi: 10.1016/j.resuscitation.2020.02.013

1	49.	Tamminen J, Lyden E, Kurki J, Huhtala H, Kamarainen A, Hoppu S. Spontaneous trigger
2		words associated with confirmed out-of-hospital cardiac arrest: a descriptive pilot study
3		of emergency calls. Scand J Trauma Resusc Emerg Med. 2020;28:1. doi:
4		10.1186/s13049-019-0696-1
5	50.	Riou M, Ball S, Morgan A, Gallant S, Perera N, Whiteside A, Bray J, Bailey P, Finn J. 'I
6		think he's dead': A cohort study of the impact of caller declarations of death during the
7		emergency call on bystander CPR. Resuscitation. 2021;160:1-6. doi:
8		10.1016/j.resuscitation.2021.01.001
9	51.	Linderoth G, Hallas P, Lippert FK, Wibrandt I, Loumann S, Moller TP, Ostergaard D.
10		Challenges in out-of-hospital cardiac arrest - A study combining closed-circuit television
11		(CCTV) and medical emergency calls. Resuscitation. 2015;96:317-322. doi:
12		10.1016/j.resuscitation.2015.06.003
13	52.	Linderoth G, Moller TP, Folke F, Lippert FK, Ostergaard D. Medical dispatchers'
14		perception of visual information in real out-of-hospital cardiac arrest: a qualitative
15		interview study. Scand J Trauma Resusc Emerg Med. 2019;27:8. doi: 10.1186/s13049-
16		018-0584-0
17	53.	Blomberg SN, Folke F, Ersboll AK, Christensen HC, Torp-Pedersen C, Sayre MR,
18		Counts CR, Lippert FK. Machine learning as a supportive tool to recognize cardiac arrest
19		in emergency calls. Resuscitation. 2019;138:322-329. doi:
20		10.1016/j.resuscitation.2019.01.015
21	54.	Byrsell F, Claesson A, Ringh M, Svensson L, Jonsson M, Nordberg P, Forsberg S,
22		Hollenberg J, Nord A. Machine learning can support dispatchers to better and faster

1		recognize out-of-hospital cardiac arrest during emergency calls: A retrospective study.
2		Resuscitation. 2021;162:218-226. doi: 10.1016/j.resuscitation.2021.02.041
3	55.	Blomberg SN, Christensen HC, Lippert F, Ersboll AK, Torp-Petersen C, Sayre MR,
4		Kudenchuk PJ, Folke F. Effect of Machine Learning on Dispatcher Recognition of Out-
5		of-Hospital Cardiac Arrest During Calls to Emergency Medical Services: A Randomized
6		Clinical Trial. JAMA Netw Open. 2021;4:e2032320. doi:
7		10.1001/jamanetworkopen.2020.32320
8	56.	Nikolaj Blomberg S, Jensen TW, Porsborg Andersen M, Folke F, Kjaer Ersboll A, Torp-
9		Petersen C, Lippert F, Collatz Christensen H. When the machine is wrong.
10		Characteristics of true and false predictions of Out-of-Hospital Cardiac arrests in
11		emergency calls using a machine-learning model. Resuscitation. 2023;183:109689. doi:
12		10.1016/j.resuscitation.2023.109689
13	57.	Rafi S, Gangloff C, Paulhet E, Grimault O, Soulat L, Bouzille G, Cuggia M. Out-of-
14		Hospital Cardiac Arrest Detection by Machine Learning Based on the Phonetic
15		Characteristics of the Caller's Voice. Stud Health Technol Inform. 2022;294:445-449.
16		doi: 10.3233/SHTI220498
17	58.	Chan J, Rea T, Gollakota S, Sunshine JE. Contactless cardiac arrest detection using smart
18		devices. NPJ Digit Med. 2019;2:52. doi: 10.1038/s41746-019-0128-7
19	59.	Dami F, Rossetti AO, Fuchs V, Yersin B, Hugli O. Proportion of out-of-hospital adult
20		non-traumatic cardiac or respiratory arrest among calls for seizure. Emerg Med J.
21		2012;29:758-760. doi: 10.1136/emermed-2011-200234
22	60.	Besnier E, Damm C, Jardel B, Veber B, Compere V, Dureuil B. Dispatcher-assisted
23		cardiopulmonary resuscitation protocol improves diagnosis and resuscitation

1		recommendations for out-of-hospital cardiac arrest. Emerg Med Australas. 2015;27:590-
2		596. doi: 10.1111/1742-6723.12493
3	61.	Deakin CD, England S, Diffey D, Maconochie I. Can ambulance telephone triage using
4		NHS Pathways accurately identify paediatric cardiac arrest? Resuscitation.
5		2017;116:109-112. doi: 10.1016/j.resuscitation.2017.03.013
6	62.	Derkenne C, Jost D, Thabouillot O, Briche F, Travers S, Frattini B, Lesaffre X,
7		Kedzierewicz R, Roquet F, de Charry F, et al. Improving emergency call detection of
8		Out-of-Hospital Cardiac Arrests in the Greater Paris area: Efficiency of a global system
9		with a new method of detection. Resuscitation. 2020;146:34-42. doi:
10		10.1016/j.resuscitation.2019.10.038
11	63.	Fukushima H, Imanishi M, Iwami T, Kitaoka H, Asai H, Seki T, Kawai Y, Norimoto K,
12		Urisono Y, Nishio K, et al. Implementation of a dispatch-instruction protocol for
13		cardiopulmonary resuscitation according to various abnormal breathing patterns: a
14		population-based study. Scand J Trauma Resusc Emerg Med. 2015;23:64. doi:
15		10.1186/s13049-015-0145-8
16	64.	Gram KH, Praest M, Laulund O, Mikkelsen S. Assessment of a quality improvement
17		programme to improve telephone dispatchers' accuracy in identifying out-of-hospital
18		cardiac arrest. Resusc Plus. 2021;6:100096. doi: 10.1016/j.resplu.2021.100096
19	65.	Hardeland C, Olasveengen TM, Lawrence R, Garrison D, Lorem T, Farstad G, Wik L.
20		Comparison of Medical Priority Dispatch (MPD) and Criteria Based Dispatch (CBD)
21		relating to cardiac arrest calls. Resuscitation. 2014;85:612-616. doi:
22		10.1016/j.resuscitation.2014.01.029

1	66.	Hardeland C, Sunde K, Ramsdal H, Hebbert SR, Soilammi L, Westmark F, Nordum F,
2		Hansen AE, Steen-Hansen JE, Olasveengen TM. Factors impacting upon timely and
3		adequate allocation of prehospital medical assistance and resources to cardiac arrest
4		patients. Resuscitation. 2016;109:56-63. doi: 10.1016/j.resuscitation.2016.09.027
5	67.	Heward A, Damiani M, Hartley-Sharpe C. Does the use of the Advanced Medical
6		Priority Dispatch System affect cardiac arrest detection? <i>Emerg Med J.</i> 2004;21:115-118.
7		doi: 10.1136/emj.2003.006940
8	68.	Huang CH, Fan HJ, Chien CY, Seak CJ, Kuo CW, Ng CJ, Li WC, Weng YM. Validation
9		of a Dispatch Protocol with Continuous Quality Control for Cardiac Arrest: A Before-
10		and-After Study at a City Fire Department-Based Dispatch Center. J Emerg Med.
11		2017;53:697-707. doi: 10.1016/j.jemermed.2017.06.028
12	69.	Kuisma M, Boyd J, Vayrynen T, Repo J, Nousila-Wiik M, Holmstrom P. Emergency call
13		processing and survival from out-of-hospital ventricular fibrillation. Resuscitation.
14		2005;67:89-93. doi: 10.1016/j.resuscitation.2005.04.008
15	70.	Mao DR, Ee AZQ, Leong PWK, Leong BS, Arulanandam S, Ng M, Ng YY, Siddiqui FJ,
16		Ong MEH. Is your unconscious patient in cardiac arrest? A New protocol for telephonic
17		diagnosis by emergency medical call-takers: A national study. Resuscitation.
18		2020;155:199-206. doi: 10.1016/j.resuscitation.2020.08.009
19	71.	Michiels C, Clinckaert C, Wauters L, Dewolf P. Phone CPR and barriers affecting life-
20		saving seconds. Acta Clin Belg. 2021;76:427-432. doi: 10.1080/17843286.2020.1752454
21	72.	Moller TP, Andrell C, Viereck S, Todorova L, Friberg H, Lippert FK. Recognition of
22		out-of-hospital cardiac arrest by medical dispatchers in emergency medical dispatch

1 centres in two countries. *Resuscitation*. 2016;109:1-8. doi:

- 2 10.1016/j.resuscitation.2016.09.012
- 3 73. Nurmi J, Pettila V, Biber B, Kuisma M, Komulainen R, Castren M. Effect of protocol
 4 compliance to cardiac arrest identification by emergency medical dispatchers.
- 5 *Resuscitation*. 2006;70:463-469. doi: 10.1016/j.resuscitation.2006.01.016
- 6 74. Orpet R, Riesenberg R, Shin J, Subido C, Markul E, Rea T. Increasing bystander CPR:
 7 potential of a one question telecommunicator identification algorithm. *Scand J Trauma* 8 *Resusc Emerg Med.* 2015;23:39. doi: 10.1186/s13049-015-0115-1
- 9 75. Plodr M, Truhlar A, Krencikova J, Praunova M, Svaba V, Masek J, Bejrova D, Paral J.
- 10 Effect of introduction of a standardized protocol in dispatcher-assisted cardiopulmonary
- 11 resuscitation. *Resuscitation*. 2016;106:18-23. doi: 10.1016/j.resuscitation.2016.05.031
- 12 76. Sanko S, Kashani S, Lane C, Eckstein M. Implementation of the Los Angeles Tiered
- 13 Dispatch System is associated with an increase in telecommunicator-assisted CPR.

14 *Resuscitation*. 2020;155:74-81. doi: 10.1016/j.resuscitation.2020.06.039

- 15 77. Sanko S, Feng S, Lane C, Eckstein M. Comparison of Emergency Medical Dispatch
- 16 Systems for Performance of Telecommunicator-Assisted Cardiopulmonary Resuscitation
- 17 Among 9-1-1 Callers With Limited English Proficiency. JAMA Netw Open.
- 18 2021;4:e216827. doi: 10.1001/jamanetworkopen.2021.6827
- 19 78. Stipulante S, Tubes R, El Fassi M, Donneau AF, Van Troyen B, Hartstein G, D'Orio V,
- 20 Ghuysen A. Implementation of the ALERT algorithm, a new dispatcher-assisted
- 21 telephone cardiopulmonary resuscitation protocol, in non-Advanced Medical Priority
- 22 Dispatch System (AMPDS) Emergency Medical Services centres. *Resuscitation*.
- 23 2014;85:177-181. doi: 10.1016/j.resuscitation.2013.10.005

1	79.	Travers S, Jost D, Gillard Y, Lanoe V, Bignand M, Domanski L, Tourtier JP, Paris Fire
2		Brigade Cardiac Arrest Work G. Out-of-hospital cardiac arrest phone detection: those
3		who most need chest compressions are the most difficult to recognize. Resuscitation.
4		2014;85:1720-1725. doi: 10.1016/j.resuscitation.2014.09.020
5	80.	Vaillancourt C, Charette M, Kasaboski A, Hoad M, Larocque V, Crete D, Logan S,
6		Lamoureux P, McBride J, Cheskes S, et al. Cardiac arrest diagnostic accuracy of 9-1-1
7		dispatchers: a prospective multi-center study. Resuscitation. 2015;90:116-120. doi:
8		10.1016/j.resuscitation.2015.02.027
9	81.	Vaillancourt C, Verma A, Trickett J, Crete D, Beaudoin T, Nesbitt L, Wells GA, Stiell
10		IG. Evaluating the effectiveness of dispatch-assisted cardiopulmonary resuscitation
11		instructions. Acad Emerg Med. 2007;14:877-883. doi: 10.1197/j.aem.2007.06.021
12	82.	Viereck S, Moller TP, Ersboll AK, Baekgaard JS, Claesson A, Hollenberg J, Folke F,
13		Lippert FK. Recognising out-of-hospital cardiac arrest during emergency calls increases
14		bystander cardiopulmonary resuscitation and survival. Resuscitation. 2017;115:141-147.
15		doi: 10.1016/j.resuscitation.2017.04.006
16	83.	Watkins CL, Jones SP, Hurley MA, Benedetto V, Price CI, Sutton CJ, Quinn T, Bangee
17		M, Chesworth B, Miller C, et al. Predictors of recognition of out of hospital cardiac arrest
18		by emergency medical services call handlers in England: a mixed methods diagnostic
19		accuracy study. Scand J Trauma Resusc Emerg Med. 2021;29:7. doi: 10.1186/s13049-
20		020-00823-9
21	84.	Roppolo LP, Westfall A, Pepe PE, Nobel LL, Cowan J, Kay JJ, Idris AH. Dispatcher
22		assessments for agonal breathing improve detection of cardiac arrest. Resuscitation.
23		2009;80:769-772. doi: 10.1016/j.resuscitation.2009.04.013

1	85.	Berdowski J, Beekhuis F, Zwinderman AH, Tijssen JG, Koster RW. Importance of the
2		first link: description and recognition of an out-of-hospital cardiac arrest in an emergency
3		call. Circulation. 2009;119:2096-2102. doi: 10.1161/CIRCULATIONAHA.108.768325
4	86.	Bang A, Herlitz J, Martinell S. Interaction between emergency medical dispatcher and
5		caller in suspected out-of-hospital cardiac arrest calls with focus on agonal breathing. A
6		review of 100 tape recordings of true cardiac arrest cases. Resuscitation. 2003;56:25-34.
7		doi: 10.1016/s0300-9572(02)00278-2
8	87.	Fukushima H, Panczyk M, Hu C, Dameff C, Chikani V, Vadeboncoeur T, Spaite DW,
9		Bobrow BJ. Description of Abnormal Breathing Is Associated With Improved Outcomes
10		and Delayed Telephone Cardiopulmonary Resuscitation Instructions. J Am Heart Assoc.
11		2017;6. doi: 10.1161/JAHA.116.005058
12	88.	Bohm K, Rosenqvist M, Hollenberg J, Biber B, Engerstrom L, Svensson L. Dispatcher-
13		assisted telephone-guided cardiopulmonary resuscitation: an underused lifesaving system.
14		Eur J Emerg Med. 2007;14:256-259. doi: 10.1097/MEJ.0b013e32823a3cd1
15	89.	Dami F, Heymann E, Pasquier M, Fuchs V, Carron PN, Hugli O. Time to identify cardiac
16		arrest and provide dispatch-assisted cardio-pulmonary resuscitation in a criteria-based
17		dispatch system. Resuscitation. 2015;97:27-33. doi: 10.1016/j.resuscitation.2015.09.390
18	90.	Crabb DB, Elmelige YO, Gibson ZC, Ralston DC, Harrell C, Cohen SA, Fitzpatrick DE,
19		Becker TK. Unrecognized cardiac arrests: A one-year review of audio from emergency
20		medical dispatch calls. Am J Emerg Med. 2022;54:127-130. doi:
21		10.1016/j.ajem.2022.01.068
22	91.	Fukushima H, Imanishi M, Iwami T, Seki T, Kawai Y, Norimoto K, Urisono Y, Hata M,
23		Nishio K, Saeki K, et al. Abnormal breathing of sudden cardiac arrest victims described

1		by laypersons and its association with emergency medical service dispatcher-assisted
2		cardiopulmonary resuscitation instruction. Emerg Med J. 2015;32:314-317. doi:
3		10.1136/emermed-2013-203112
4	92.	Lewis M, Stubbs BA, Eisenberg MS. Dispatcher-assisted cardiopulmonary resuscitation:
5		time to identify cardiac arrest and deliver chest compression instructions. Circulation.
6		2013;128:1522-1530. doi: 10.1161/CIRCULATIONAHA.113.002627
7	93.	Schwarzkoph M, Yin L, Hergert L, Drucker C, Counts CR, Eisenberg M. Seizure-like
8		presentation in OHCA creates barriers to dispatch recognition of cardiac arrest.
9		Resuscitation. 2020;156:230-236. doi: 10.1016/j.resuscitation.2020.06.036
10	94.	Eisenberg MS, Carter W, Hallstrom A, Cummins R, Litwin P, Hearne T. Identification of
11		cardiac arrest by emergency dispatchers. Am J Emerg Med. 1986;4:299-301. doi:
12		10.1016/0735-6757(86)90297-4
13	95.	Kim TH, Jung JH, Song KJ, Hong KJ, Jeong J, Lee SGW. Association between patient
14		age and pediatric cardiac arrest recognition by emergency medical dispatchers. $Am J$
15		Emerg Med. 2022;58:275-280. doi: 10.1016/j.ajem.2022.05.038
16	96.	Tzeng CF, Lu CH, Lin CH. Community Socioeconomic Status and Dispatcher-Assisted
17		Cardiopulmonary Resuscitation for Patients with Out-of-Hospital Cardiac Arrest. Int J
18		Environ Res Public Health. 2021;18. doi: 10.3390/ijerph18031207
19	97.	Govindarajan P, Lin L, Landman A, McMullan JT, McNally BF, Crouch AJ, Sasson C.
20		Practice variability among the EMS systems participating in Cardiac Arrest Registry to
21		Enhance Survival (CARES). Resuscitation. 2012;83:76-80. doi:
22		https://doi.org/10.1016/j.resuscitation.2011.06.026

1	98.	Lee SCL, Mao DR, Ng YY, Leong BS, Supasaovapak J, Gaerlan FJ, Son DN, Chia BY,
2		Do Shin S, Lin CH, et al. Emergency medical dispatch services across Pan-Asian
3		countries: a web-based survey. BMC Emerg Med. 2020;20:1. doi: 10.1186/s12873-019-
4		0299-1
5	99.	Tjelmeland IBM, Masterson S, Herlitz J, Wnent J, Bossaert L, Rosell-Ortiz F, Alm-Kruse
6		K, Bein B, Lilja G, Grasner JT, et al. Description of Emergency Medical Services,
7		treatment of cardiac arrest patients and cardiac arrest registries in Europe. Scand J
8		Trauma Resusc Emerg Med. 2020;28:103. doi: 10.1186/s13049-020-00798-7
9	100.	Beck B, Bray JE, Smith K, Walker T, Grantham H, Hein C, Thorrowgood M, Smith A,
10		Inoue M, Smith T, et al. Description of the ambulance services participating in the Aus-
11		ROC Australian and New Zealand out-of-hospital cardiac arrest Epistry. Emerg Med
12		Australas. 2016;28:673-683. doi: 10.1111/1742-6723.12690
13	101.	Olasveengen TM, de Caen AR, Mancini ME, Maconochie IK, Aickin R, Atkins DL, Berg
14		RA, Bingham RM, Brooks SC, Castren M, et al. 2017 International Consensus on
15		Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With
16		Treatment Recommendations Summary. Resuscitation. 2017;121:201-214. doi:
17		10.1016/j.resuscitation.2017.10.021
18	102.	Olasveengen TM, de Caen AR, Mancini ME, Maconochie IK, Aickin R, Atkins DL, Berg
19		RA, Bingham RM, Brooks SC, Castren M, et al. 2017 International Consensus on
20		Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With
21		Treatment Recommendations Summary. Circulation. 2017;136:e424-e440. doi:
22		10.1161/CIR.000000000000541

1	103.	Dainty KN DG, Vaillancourt C, Smyth M, Olasveengen T, Bray J on behalf of the
2		International Liaison Committee on Resuscitation Basic Life Support Task Force
3		Interventions used with Dispatcher-assisted CPR: A scoping review. [Internet] Brussels,
4		Belgium: International Liaison Committee on Resuscitation (ILCOR) Basic Life Support
5		Task Force, 2024 Jan 8 https://costr.ilcor.org/document/optimization-of-dispatcher-
6		assisted-cpr-instructions-a-scoping-review-bls-2113-scr.
7	104.	Ong MEH, Shin SD, Ko PC-I, Lin X, Ma MH-M, Ryoo HW, Wong KD, Supasaowapak
8		J, Lin C-H, Kuo C-W, et al. International multi-center real world implementation trial to
9		increase out-of-hospital cardiac arrest survival with a dispatcher-assisted cardio-
10		pulmonary resuscitation package (Pan-Asian resuscitation outcomes study phase 2).
11		Resuscitation. 2022;171:80-89. doi: 10.1016/j.resuscitation.2021.12.032
12	105.	Lee DH, Kim CW, Kim SE. The effect of the different methods indicating 100/min to
13		120/min using the metronome in dispatcher-assisted resuscitation. The American journal
14		of emergency medicine. 2014;32:1282-1283. doi: 10.1016/j.ajem.2014.07.009
15	106.	Park SO, Hong CK, Shin DH, Lee JH, Hwang SY. Efficacy of metronome sound
16		guidance via a phone speaker during dispatcher-assisted compression-only
17		cardiopulmonary resuscitation by an untrained layperson: a randomised controlled
18		simulation study using a manikin. <i>Emergency medicine journal : EMJ</i> . 2013;30:657-661.
19		doi: 10.1136/emermed-2012-201612
20	107.	Choa M, Park I, Chung HS, Yoo SK, Shim H, Kim S. The effectiveness of
21		cardiopulmonary resuscitation instruction: Animation versus dispatcher through a cellular
22		phone. Resuscitation. 2008;77:87-94. doi: 10.1016/j.resuscitation.2007.10.023

1	108.	Birkun A, Glotov M, Ndjamen HF, Alaiye E, Adeleke T, Samarin S. Pre-recorded
2		instructional audio vs. dispatchers' conversational assistance in telephone
3		cardiopulmonary resuscitation: A randomized controlled simulation study. World journal
4		of emergency medicine. 2018;9:165-171. doi: 10.5847/wjem.j.1920-8642.2018.03.001
5	109.	Rasmussen SE, Nebsbjerg MA, Krogh LQ, Bjørnshave K, Krogh K, Povlsen JA,
6		Riddervold IS, Grøfte T, Kirkegaard H, Løfgren B. A novel protocol for dispatcher
7		assisted CPR improves CPR quality and motivation among rescuers—A randomized
8		controlled simulation study. Resuscitation. 2017;110:74-80. doi:
9		10.1016/j.resuscitation.2016.09.009
10	110.	Brown TB, Saini D, Pepper T, Mirza M, Nandigam HK, Kaza N, Cofield SS. Instructions
11		to "put the phone down" do not improve the quality of bystander initiated dispatcher-
12		assisted cardiopulmonary resuscitation. Resuscitation. 2008;76:249-255. doi:
13		10.1016/j.resuscitation.2007.07.026
14	111.	Rodriguez SA, Sutton RM, Berg MD, Nishisaki A, Maltese M, Meaney PA, Niles DE,
15		Leffelman J, Berg RA, Nadkarni VM. Simplified dispatcher instructions improve
16		bystander chest compression quality during simulated pediatric resuscitation.
17		Resuscitation. 2014;85:119-123. doi: 10.1016/j.resuscitation.2013.09.003
18	112.	Trethewey SP, Vyas H, Evans S, Hall M, Melody T, Perkins GD, Couper K. The impact
19		of resuscitation guideline terminology on quality of dispatcher-assisted cardiopulmonary
20		resuscitation: A randomised controlled manikin study. Resuscitation. 2019;142:91-96.
21		doi: 10.1016/j.resuscitation.2019.07.016

1	113.	Eisenberg Chavez D, Meischke H, Painter I, Rea TD. Should dispatchers instruct lay
2		bystanders to undress patients before performing CPR? A randomized simulation study.
3		Resuscitation. 2013;84:979-981. doi: 10.1016/j.resuscitation.2012.12.010
4	114.	Bolle SR, Scholl J, Gilbert M. Can video mobile phones improve CPR quality when used
5		for dispatcher assistance during simulated cardiac arrest? Acta Anaesthesiologica
6		Scandinavica. 2009;53:116-120. doi: 10.1111/j.1399-6576.2008.01779.x
7	115.	Lee JS, Jeon WC, Ahn JH, Cho YJ, Jung YS, Kim GW. The effect of a cellular-phone
8		video demonstration to improve the quality of dispatcher-assisted chest compression-only
9		cardiopulmonary resuscitation as compared with audio coaching. Resuscitation.
10		2011;82:64-68. doi: 10.1016/j.resuscitation.2010.09.467
11	116.	Lee HS, You K, Jeon JP, Kim C, Kim S. The effect of video-instructed versus audio-
12		instructed dispatcher-assisted cardiopulmonary resuscitation on patient outcomes
13		following out of hospital cardiac arrest in Seoul. Scientific reports. 2021;11:15555-
14		15555. doi: 10.1038/s41598-021-95077-5
15	117.	Yang C-W, Wang H-C, Chiang W-C, Hsu C-W, Chang W-T, Yen Z-S, Ko PC-I, Ma
16		MH-M, Chen S-C, Chang S-C. Interactive video instruction improves the quality of
17		dispatcher-assisted chest compression-only cardiopulmonary resuscitation in simulated
18		cardiac arrests. Critical care medicine. 2009;37:490-495. doi:
19		10.1097/CCM.0b013e31819573a5
20	118.	Peters M, Stipulante S, Cloes V, Mulder A, Lebrun F, Donneau A-F, Ghuysen A. Can
21		Video Assistance Improve the Quality of Pediatric Dispatcher-Assisted Cardiopulmonary
22		Resuscitation? Pediatric emergency care. 2022;38:e451-e457. doi:
23		10.1097/PEC.00000000002392

1	119.	Hwang BN, Lee EH, Park HA, Park JO, Lee CA. Effects of positive dispatcher
2		encouragement on the maintenance of bystander cardiopulmonary resuscitation quality.
3		Medicine. 2020;99:e22728. doi: 10.1097/MD.000000000022728
4	120.	Mirza M, Brown TB, Saini D, Pepper TL, Nandigam HK, Kaza N, Cofield SS.
5		Instructions to "push as hard as you can" improve average chest compression depth in
6		dispatcher-assisted cardiopulmonary resuscitation. Resuscitation. 2008;79:97-102. doi:
7		10.1016/j.resuscitation.2008.05.012
8	121.	Harjanto S, Na MXB, Hao Y, Ng YY, Doctor N, Goh ES, Leong BS-H, Gan HN, Chia
9		MYC, Tham LP, et al. A before-after interventional trial of dispatcher-assisted cardio-
10		pulmonary resuscitation for out-of-hospital cardiac arrests in Singapore. Resuscitation.
11		2016;102:85-93. doi: 10.1016/j.resuscitation.2016.02.014
12	122.	Park GJ, Song KJ, Shin SD, Hong KJ, Kim TH, Park YM, Kong J. Clinical effects of a
13		new dispatcher-assisted basic life support training program in a metropolitan city.
14		Medicine. 2022;101:e29298. doi: 10.1097/MD.000000000029298
15	123.	Tsunoyama T, Nakahara S, Yoshida M, Kitamura M, Sakamoto T. Effectiveness of
16		dispatcher training in increasing bystander chest compression for out-of-hospital cardiac
17		arrest patients in Japan. Acute Medicine & Surgery. 2017;4:439-445. doi:
18		10.1002/ams2.303
19	124.	Lerner EB, Farrell BM, Colella MR, Sternig KJ, Westrich C, Cady CE, Liu JM. A
20		centralized system for providing dispatcher assisted CPR instructions to 9-1-1 callers at
21		multiple municipal public safety answering points. Resuscitation. 2019;142:46-49. doi:
22		10.1016/j.resuscitation.2019.07.010

1	125.	Ro YS, Shin SD, Lee SC, Song KJ, Jeong J, Wi DH, Moon S. Association between the
2		centralization of dispatch centers and dispatcher-assisted cardiopulmonary resuscitation
3		programs: A natural experimental study. Resuscitation. 2018;131:29-35. doi:
4		10.1016/j.resuscitation.2018.07.034
5	126.	Bray JE, Deasy C, Walsh J, Bacon A, Currell A, Smith K. Changing EMS dispatcher
6		CPR instructions to 400 compressions before mouth-to-mouth improved bystander CPR
7		rates. Resuscitation. 2011;82:1393 doi: 10.1016/j.resuscitation.2011.06.018
8	127.	Stipulante S, Tubes R, El Fassi M, Donneau A-F, Van Troyen B, Hartstein G, D'Orio V,
9		Ghuysen A. Implementation of the ALERT algorithm, a new dispatcher-assisted
10		telephone cardiopulmonary resuscitation protocol, in non-Advanced Medical Priority
11		Dispatch System (AMPDS) Emergency Medical Services centres. Resuscitation.
12		2014;85:177-181. doi: 10.1016/j.resuscitation.2013.10.005
13	128.	Leong PWK, Leong BS-H, Arulanandam S, Ng MXR, Ng YY, Ong MEH, Mao DRH.
14		Simplified instructional phrasing in dispatcher-assisted cardiopulmonary resuscitation -
15		when 'less is more'. Singapore medical journal. 2021;62:647-652. doi:
16		10.11622/smedj.2020080
17	129.	Lee SY, Song KJ, Shin SD, Hong KJ, Kim TH. Comparison of the effects of audio-
18		instructed and video-instructed dispatcher-assisted cardiopulmonary resuscitation on
19		resuscitation outcomes after out-of-hospital cardiac arrest. Resuscitation. 2020;147:12-
20		20. doi: 10.1016/j.resuscitation.2019.12.004
21	130.	Linderoth G, Lippert F, Østergaard D, Ersbøll AK, Meyhoff CS, Folke F, Christensen
22		HC. Live video from bystanders' smartphones to medical dispatchers in real

1		emergencies. BMC Emergency Medicine. 2021;21:101. doi: 10.1186/s12873-021-00493-
2		5
3	131.	Riou M, Ball S, Whiteside A, Bray J, Perkins GD, Smith K, O'Halloran KL, Fatovich
4		DM, Inoue M, Bailey P, et al. 'We're going to do CPR': A linguistic study of the words
5		used to initiate dispatcher-assisted CPR and their association with caller agreement.
6		Resuscitation. 2018;133:95-100. doi: 10.1016/j.resuscitation.2018.10.011
7	132.	Johnsen E, Bolle SR. TO SEE OR NOT TO SEE-Better dispatcher-assisted CPR with
8		video-calls? A qualitative study based on simulated trials. Resuscitation. 2008;78:320-
9		326. doi: 10.1016/j.resuscitation.2008.04.024
10	133.	Kim H-J, Kim J-H, Park D. Comparing audio- and video-delivered instructions in
11		dispatcher-assisted cardiopulmonary resuscitation with drone-delivered automatic
12		external defibrillator: a mixed methods simulation study. PeerJ. 2021;9:e11761-e11761.
13		doi: 10.7717/peerj.11761
14	134.	Holmberg MJ, Vognsen M, Andersen MS, Donnino MW, Andersen LW. Bystander
15		automated external defibrillator use and clinical outcomes after out-of-hospital cardiac
16		arrest: A systematic review and meta-analysis. Resuscitation. 2017;120:77-87. doi:
17		papers3://publication/doi/10.1016/j.resuscitation.2017.09.003
18	135.	Bækgaard JS, Viereck S, Møller TP, Ersbøll AK, Lippert F, Folke F. The Effects of
19		Public Access Defibrillation on Survival After Out-of-Hospital Cardiac Arrest: A
20		Systematic Review of Observational Studies. Circulation. 2017;136:954-965. doi:
21		papers3://publication/doi/10.1161/CIRCULATIONAHA.117.029067
22	136.	Nishiyama C, Kiguchi T, Okubo M, Alihodzic H, Al-Araji R, Baldi E, Beganton F,
23		Booth S, Bray J, Christensen E, et al. Three-year trends in out-of-hospital cardiac arrest

1		across the world: Second report from the International Liaison Committee on
2		Resuscitation (ILCOR). Resuscitation. 2023;186:109757. doi:
3		10.1016/j.resuscitation.2023.109757
4	137.	Luger M, Edlinger M, Bohm K, Maurer A, Truhlar A, Baubin M. European Resuscitation
5		Council Dispatch Centre Survey (EDiCeS). A survey on telephone-assisted
6		cardiopulmonary resuscitation. Resuscitation. 2015;96:74. doi:
7		https://doi.org/10.1016/j.resuscitation.2015.09.176
8	138.	Brooks SC, Clegg GR, Bray J, Deakin CD, Perkins GD, Ringh M, Smith CM, Link MS,
9		Merchant RM, Pezo-Morales J, et al. Optimizing outcomes after out-of-hospital cardiac
10		arrest with innovative approaches to public-access defibrillation: A scientific statement
11		from the International Liaison Committee on Resuscitation. Resuscitation. 2022;172:204-
12		228. doi: 10.1016/j.resuscitation.2021.11.032
13	139.	Brooks SC, Clegg GR, Bray J, Deakin CD, Perkins GD, Ringh M, Smith CM, Link MS,
14		Merchant RM, Pezo-Morales J, et al. Optimizing Outcomes After Out-of-Hospital
15		Cardiac Arrest With Innovative Approaches to Public-Access Defibrillation: A Scientific
16		Statement From the International Liaison Committee on Resuscitation. Circulation.
17		2022;145:e776-e801. doi: 10.1161/CIR.0000000000001013
18	140.	Smith CMS, L.; Whiting, J.; Smyth, M.; Olasveengen, T.; Bray, J.; on behalf of the
19		International Liaison Committee on Resuscitation Basic Life Support Task Force.,;.
20		Dispatcher instructions for public-access AED retrieval and/or use. A scoping review.
21		Consensus on Science with Treatment Recommendations [Internet] Brussels, Belgium:
22		International Liaison Committee on Resuscitation (ILCOR) Basic Life Support Task

	Force, 2024 January 8. https://costr.ilcor.org/document/optimization-of-dispatcher-
	assisted-public-access-aed-retrieval-and-use-a-scoping-review-bls-2120.
141.	Perera N, Ball S, Birnie T, Morgan A, Riou M, Whiteside A, Perkins GD, Bray J,
	Fatovich DM, Cameron P, et al. "Sorry, what did you say?" Communicating defibrillator
	retrieval and use in OHCA emergency calls. Resuscitation. 2020;156:182-189. doi:
	10.1016/j.resuscitation.2020.09.006
142.	Gardett I, Broadbent M, Scott G, Clawson JJ, Olola C. Availability and Use of an
	Automated External Defibrillator at Emergency Medical Dispatch. Prehosp Emerg Care.
	2019;23:683-690. doi: 10.1080/10903127.2018.1559565
143.	Kaneko T, Tanaka H, Uezono K. Dispatcher-assisted cardiopulmonary resuscitation
	improves the neurological outcomes of out-of-hospital cardiac arrest victims: a
	retrospective analysis of prehospitalization records in Kumamoto City. Crit Care Shock.
	2019;22:9-15.
144.	Agerskov M, Nielsen AM, Hansen CM, Hansen MB, Lippert FK, Wissenberg M, Folke
	F, Rasmussen LS. Public Access Defibrillation: Great benefit and potential but
	infrequently used. Resuscitation. 2015;96:53-58. doi:
	papers3://publication/doi/10.1016/j.resuscitation.2015.07.021
145.	Deakin CD, Shewry E, Gray HH. Public access defibrillation remains out of reach for
	most victims of out-of-hospital sudden cardiac arrest. Heart. 2014;100:619-623. doi:
	papers3://publication/doi/10.1136/heartjnl-2013-305030
146.	Bang JY, Cho Y, Cho GC, Lee J, Kim IY. Can Mobile Videocall Assist Laypersons' Use
	of Automated External Defibrillators? A Randomized Simulation Study and Qualitative
	Analysis. Biomed Res Int. 2020;2020:4069749. doi: 10.1155/2020/4069749
	 141. 142. 143. 144. 144. 144. 145. 146.

1	147.	Ecker R, Rea TD, Meischke H, Schaeffer SM, Kudenchuk P, Eisenberg MS. Dispatcher
2		assistance and automated external defibrillator performance among elders. Acad Emerg
3		Med. 2001;8:968-973. doi: papers3://publication/uuid/275C498E-E077-40BE-AD77-
4		3E46023597A5
5	148.	Harve H, Jokela J, Tissari A, Saukko A, Räsänen P, Okkolin T, Pettilä V, Silfvast T. Can
6		untrained laypersons use a defibrillator with dispatcher assistance? Acad Emerg Med.
7		2007;14:624-628. doi: papers3://publication/doi/10.1197/j.aem.2007.03.1353
8	149.	Neves Briard J, Grou-Boileau F, El Bashtaly A, Spenard C, de Champlain F, Homier V.
9		Automated External Defibrillator Geolocalization with a Mobile Application, Verbal
10		Assistance or No Assistance: A Pilot Randomized Simulation (AED G-MAP). Prehosp
11		Emerg Care. 2019;23:420-429. doi: 10.1080/10903127.2018.1511017
12	150.	Riyapan S, Lubin J. Emergency dispatcher assistance decreases time to defibrillation in a
13		public venue: a randomized controlled trial. Am J Emerg Med. 2016;34:590-593. doi:
14		papers3://publication/doi/10.1016/j.ajem.2015.12.015
15	151.	Yang H, Praise K. Study on the ability to use automatic external defibrillators by students
16		[translated title] Korean J Emerg Med Ser. 2017;21:63-69.
17	152.	Kim HJ, Kim JH, Park D. Comparing audio- and video-delivered instructions in
18		dispatcher-assisted cardiopulmonary resuscitation with drone-delivered automatic
19		external defibrillator: a mixed methods simulation study. Peer J. 2021;9:e11761. doi:
20		10.7717/peerj.11761
21	153.	Johnson AM, Cunningham CJ, Zégre-Hemsey JK, Grewe ME, DeBarmore BM, Wong E,
22		Omofoye F, Rosamond WD. Out-of-Hospital Cardiac Arrest Bystander Defibrillator
23		Search Time and Experience With and Without Directional Assistance: A Randomized

	Simulation Trial in a Community Setting. Simul Healthc. 2022;17:22-28. doi:
	10.1097/sih.00000000000582
154.	Maes F, Marchandise S, Boileau L, le Polain de Waroux J-B, Scavée C. Evaluation of a
	new semiautomated external defibrillator technology: a live cases video recording study.
	Emerg Med J. 2015;32:481-485. doi: papers3://publication/doi/10.1136/emermed-2013-
	202962
155.	Sanfridsson J, Sparrevik J, Hollenberg J, Nordberg P, Djärv T, Ringh M, Svensson L,
	Forsberg S, Nord A, Andersson-Hagiwara M, et al. Drone delivery of an automated
	external defibrillator – a mixed method simulation study of bystander experience. Scand
	J Trauma Resusc Emerg Med. 2019;27:40.
156.	You JS, Park S, Chung SP, Park JW. Performance of cellular phones with video
	telephony in the use of automated external defibrillators by untrained laypersons. Emerg
	<i>Med J.</i> 2008;25:597-600.
157.	Ecker R, Rea TD, Meischke H, Schaeffer SM, Kudenchuk P, Eisenberg MS. Dispatcher
	assistance and automated external defibrillator performance among elders. Academic
	emergency medicine : official journal of the Society for Academic Emergency Medicine.
	2001;8:968-973. doi: papers3://publication/uuid/275C498E-E077-40BE-AD77-
	3E46023597A5
158.	Riyapan S, Lubin J. Emergency dispatcher assistance decreases time to defibrillation in a
	public venue: a randomized controlled trial. The American journal of emergency
	medicine. 2016;34:590-593. doi: papers3://publication/doi/10.1016/j.ajem.2015.12.015
159.	Kim HJ, Kim JH, Park D. Comparing audio- and video-delivered instructions in
	dispatcher-assisted cardiopulmonary resuscitation with drone-delivered automatic
	 154. 155. 156. 157. 158. 159.

1		external defibrillator: a mixed methods simulation study. PeerJ. 2021;9:e11761. doi:
2		10.7717/peerj.11761
3	160.	You JS, Park S, Chung SP, Park JW. Performance of cellular phones with video
4		telephony in the use of automated external defibrillators by untrained laypersons.
5		Emergency Medicine Journal. 2008;25:597-600.
6	161.	Maes F, Marchandise S, Boileau L, le Polain de Waroux J-B, Scavée C. Evaluation of a
7		new semiautomated external defibrillator technology: a live cases video recording study.
8		Emergency medicine journal : EMJ. 2015;32:481-485. doi:
9		papers3://publication/doi/10.1136/emermed-2013-202962
10	162.	Hansen MV, Lofgren B, Nadkarni VM, Lauridsen KG. Impact of different methods to
11		activate the pediatric mode in automated external defibrillators by laypersons - A
12		randomized controlled simulation study. Resusc Plus. 2022;10:100223. doi:
13		10.1016/j.resplu.2022.100223
14	163.	Abelairas-Gomez C, Carballo-Fazanes A, Chang TP, Fijacko N, Rodriguez-Nunez A. Is
15		the AED as intuitive as we think? Potential relevance of "The Sound of Silence" during
16		AED use. Resusc Plus. 2022;12:100323. doi: 10.1016/j.resplu.2022.100323
17	164.	Masterson SN, T.; Ikeyama, T.; Nehme, Z.; Considine, J.; Olasveengen, T.; Bray, J.; on
18		behalf of the International Liaison Committee on Resuscitation Basic Life Support Task
19		Force,;. Real-Time Feedback for Cardiopulmonary Resuscitation Task Force Synthesis of
20		a Scoping Review Consensus on Science with Treatment Recommendations [Internet]
21		Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Basic
22		Life Support Task Force, 2024 January 8.

1	165.	Yeung J, Meeks R, Edelson D, Gao F, Soar J, Perkins GD. The use of CPR
2		feedback/prompt devices during training and CPR performance: A systematic review.
3		Resuscitation. 2009;80:743-751. doi: 10.1016/j.resuscitation.2009.04.012
4	166.	Kirkbright S, Finn J, Tohira H, Bremner A, Jacobs I, Celenza A. Audiovisual feedback
5		device use by health care professionals during CPR: a systematic review and meta-
6		analysis of randomised and non-randomised trials. Resuscitation. 2014;85:460-471. doi:
7		10.1016/j.resuscitation.2013.12.012
8	167.	Ko YC, Hsieh MJ, Ma MH, Bigham B, Bhanji F, Greif R. The effect of system
9		performance improvement on patients with cardiac arrest: A systematic review.
10		Resuscitation. 2020;157:156-165. doi: 10.1016/j.resuscitation.2020.10.024
11	168.	Miller AC, Scissum K, McConnell L, East N, Vahedian-Azimi A, Sewell KA, Zehtabchi
12		S. Real-time audio-visual feedback with handheld nonautomated external defibrillator
13		devices during cardiopulmonary resuscitation for in-hospital cardiac arrest: A meta-
14		analysis. Int J Crit Illn Inj Sci. 2020;10:109-122. doi: 10.4103/ijciis.ijciis_155_20
15	169.	Lyngby RM, Händel MN, Christensen AM, Nikoletou D, Folke F, Christensen HC,
16		Barfod C, Quinn T. Effect of real-time and post-event feedback in out-of-hospital cardiac
17		arrest attended by EMS - A systematic review and meta-analysis. Resusc Plus.
18		2021;6:100101. doi: 10.1016/j.resplu.2021.100101
19	170.	Ng QX, Han MX, Lim YL, Arulanandam S. A Systematic Review and Meta-Analysis of
20		the Implementation of High-Performance Cardiopulmonary Resuscitation on Out-of-
21		Hospital Cardiac Arrest Outcomes. J Clin Med. 2021;10. doi: 10.3390/jcm10102098
22	171.	Lv GW, Hu QC, Zhang M, Feng SY, Li Y, Zhang Y, Zhang YY, Wang WJ. Effect of
23		real-time feedback on patient's outcomes and survival after cardiac arrest: A systematic

	review and meta-analysis. Medicine (Baltimore). 2022;101:e30438. doi:
	10.1097/md.000000000030438
172.	Wang SA, Su CP, Fan HY, Hou WH, Chen YC. Effects of real-time feedback on
	cardiopulmonary resuscitation quality on outcomes in adult patients with cardiac arrest:
	A systematic review and meta-analysis. Resuscitation. 2020;155:82-90. doi:
	10.1016/j.resuscitation.2020.07.024
173.	Schultz RB, B.; Bhanji F.; Lang, E. Plenary Oral Presentations. CJEM. 2015;17:S41-S42.
	doi: 10.1017/cem.2015.50
174.	Targett C, Harris T. Towards evidence-based emergency medicine: Best BETs from the
	Manchester Royal Infirmary. BET 3: Can metronomes improve CPR quality? Emerg Med
	J. 2014;31:251-254. doi: 10.1136/emermed-2014-203617.3
175.	Bohn A, Weber TP, Wecker S, Harding U, Osada N, Van Aken H, Lukas RP. The
	addition of voice prompts to audiovisual feedback and debriefing does not modify CPR
	quality or outcomes in out of hospital cardiac arresta prospective, randomized trial.
	Resuscitation. 2011;82:257-262. doi: 10.1016/j.resuscitation.2010.11.006
176.	Hostler D, Everson-Stewart S, Rea TD, Stiell IG, Callaway CW, Kudenchuk PJ, Sears
	GK, Emerson SS, Nichol G. Effect of real-time feedback during cardiopulmonary
	resuscitation outside hospital: prospective, cluster-randomised trial. <i>Bmj</i> . 2011;342:d512.
	doi: 10.1136/bmj.d512
177.	Vahedian-Azimi A, Rahimibashar F, Miller AC. A comparison of cardiopulmonary
	resuscitation with standard manual compressions versus compressions with real-time
	audiovisual feedback: A randomized controlled pilot study. Int J Crit Illn Inj Sci.
	2020;10:32-37. doi: 10.4103/ijciis.ijciis_84_19
	 172. 173. 174. 175. 176. 177.

1	178.	Goharani R, Vahedian-Azimi A, Farzanegan B, Bashar FR, Hajiesmaeili M, Shojaei S,
2		Madani SJ, Gohari-Moghaddam K, Hatamian S, Mosavinasab SMM, et al. Real-time
3		compression feedback for patients with in-hospital cardiac arrest: a multi-center
4		randomized controlled clinical trial. J Intensive Care. 2019;7:5. doi: 10.1186/s40560-
5		019-0357-5
6	179.	Vahedian-Azimi A, Hajiesmaeili M, Amirsavadkouhi A, Jamaati H, Izadi M, Madani SJ,
7		Hashemian SM, Miller AC. Effect of the Cardio First Angel [™] device on CPR indices: a
8		randomized controlled clinical trial. Crit Care. 2016;20:147. doi: 10.1186/s13054-016-
9		1296-3
10	180.	Bolstridge J, Delaney HM, Matos RI. Use of a Metronome to Improve Quality of In-
11		Hospital Cardiopulmonary Resuscitation. Circulation. 2016;134:A18583-A18583.
12	181.	Khorasani-Zadeh A, Krowl LE, Chowdhry AK, Hantzidiamantis P, Hantzidiamantis K,
13		Siciliano R, Grover MA, Dhamoon AS. Usefulness of a metronome to improve quality of
14		chest compressions during cardiopulmonary resuscitation. Proc (Bayl Univ Med Cent).
15		2020;34:54-55. doi: 10.1080/08998280.2020.1805840
16	182.	Rainey K, Birkhoff S. Turn the Beat On: An Evidenced-Based Practice Journey
17		Implementing Metronome Use in Emergency Department Cardiac Arrest. Worldviews
18		Evid Based Nurs. 2021;18:68-70. doi: 10.1111/wvn.12486
19	183.	Chiang WC, Chen WJ, Chen SY, Ko PC, Lin CH, Tsai MS, Chang WT, Chen SC, Tsan
20		CY, Ma MH. Better adherence to the guidelines during cardiopulmonary resuscitation
21		through the provision of audio-prompts. Resuscitation. 2005;64:297-301. doi:
22		10.1016/j.resuscitation.2004.09.010

1	184.	Fletcher D, Galloway R, Chamberlain D, Pateman J, Bryant G, Newcombe RG. Basics in
2		advanced life support: a role for download audit and metronomes. Resuscitation.
3		2008;78:127-134. doi: 10.1016/j.resuscitation.2008.03.003
4	185.	Kennedy J, Machado K, Maynard C, Walker RG, Sayre MR, Counts CR. Metronome use
5		improves achievement of a target compression rate in out-of-hospital cardiac arrest: A
6		retrospective analysis. Resusc Plus. 2023;15:100417. doi: 10.1016/j.resplu.2023.100417
7	186.	Abella BS, Edelson DP, Kim S, Retzer E, Myklebust H, Barry AM, O'Hearn N, Hoek
8		TL, Becker LB. CPR quality improvement during in-hospital cardiac arrest using a real-
9		time audiovisual feedback system. Resuscitation. 2007;73:54-61. doi:
10		10.1016/j.resuscitation.2006.10.027
11	187.	Couper K, Kimani PK, Abella BS, Chilwan M, Cooke MW, Davies RP, Field RA, Gao F,
12		Quinton S, Stallard N, et al. The System-Wide Effect of Real-Time Audiovisual
13		Feedback and Postevent Debriefing for In-Hospital Cardiac Arrest: The Cardiopulmonary
14		Resuscitation Quality Improvement Initiative. Crit Care Med. 2015;43:2321-2331. doi:
15		10.1097/ccm.00000000001202
16	188.	Davis DP, Graham PG, Husa RD, Lawrence B, Minokadeh A, Altieri K, Sell RE. A
17		performance improvement-based resuscitation programme reduces arrest incidence and
18		increases survival from in-hospital cardiac arrest. Resuscitation. 2015;92:63-69. doi:
19		10.1016/j.resuscitation.2015.04.008
20	189.	Kramer-Johansen J, Myklebust H, Wik L, Fellows B, Svensson L, Sørebø H, Steen PA.
21		Quality of out-of-hospital cardiopulmonary resuscitation with real time automated
22		feedback: a prospective interventional study. Resuscitation. 2006;71:283-292. doi:
23		10.1016/j.resuscitation.2006.05.011
1	190.	Chandra SH, E.P.; Kolb, L.; Myers, L.; White, R.D.;. Effect of real-time automated and
----	------	---
2		delayed summative feedback on CPR quality in adult out-of-hospital cardiac arrest: A
3		prospective multicenter controlled clinical trial. Academic Emergency Medicine.
4		2011;18:S145-146. doi: 10.1111/j.1553-2712.2011.01073.x
5	191.	Bobrow BJ, Vadeboncoeur TF, Stolz U, Silver AE, Tobin JM, Crawford SA, Mason TK,
6		Schirmer J, Smith GA, Spaite DW. The influence of scenario-based training and real-
7		time audiovisual feedback on out-of-hospital cardiopulmonary resuscitation quality and
8		survival from out-of-hospital cardiac arrest. Ann Emerg Med. 2013;62:47-56.e41. doi:
9		10.1016/j.annemergmed.2012.12.020
10	192.	Leis CC, González VA, Hernandez RDE, Sanchez O, Martin JLM, Hermosa EJM,
11		TORRES EC. Feedback on chest compression quality variables and their relationship to
12		rate of return of spontaneous circulation. Emergencias. 2013;25:99-104.
13	193.	Sainio M, Kämäräinen A, Huhtala H, Aaltonen P, Tenhunen J, Olkkola KT, Hoppu S.
14		Real-time audiovisual feedback system in a physician-staffed helicopter emergency
15		medical service in Finland: the quality results and barriers to implementation. Scand J
16		Trauma Resusc Emerg Med. 2013;21:50. doi: 10.1186/1757-7241-21-50
17	194.	Freese J, Menegus M, Rabrich J, Slesinger T, Silverman R, Keller N, Dillworth J, Isaacs
18		D, Ben-Eli D. Addition of Real-Time CPR Feedback Improves Immediate Outcomes for
19		Out-of-Hospital Cardiac Arrest. Circulation. 2014;130:A72-A72.
20	195.	Crowe C, Bobrow BJ, Vadeboncoeur TF, Dameff C, Stolz U, Silver A, Roosa J, Page R,
21		LoVecchio F, Spaite DW. Measuring and improving cardiopulmonary resuscitation
22		quality inside the emergency department. Resuscitation. 2015;93:8-13. doi:
23		10.1016/j.resuscitation.2015.04.031

1	196.	Hopkins CL, Burk C, Moser S, Meersman J, Baldwin C, Youngquist ST. Implementation
2		of Pit Crew Approach and Cardiopulmonary Resuscitation Metrics for Out-of-Hospital
3		Cardiac Arrest Improves Patient Survival and Neurological Outcome. J Am Heart Assoc.
4		2016;5. doi: 10.1161/JAHA.115.002892
5	197.	Riyapan S, Naulnark T, Ruangsomboon O, Chaisirin W, Limsuwat C, Prapruetkit N,
6		Chakorn T, Monsomboon A. Improving quality of chest compression in Thai emergency
7		department by using real-time audio-visual feedback cardio-pulmonary resuscitation
8		monitoring. Journal of the Medical Association of Thailand. 2019;102.
9	198.	Lakomek F, Lukas RP, Brinkrolf P, Mennewisch A, Steinsiek N, Gutendorf P, Sudowe
10		H, Heller M, Kwiecien R, Zarbock A, et al. Real-time feedback improves chest
11		compression quality in out-of-hospital cardiac arrest: A prospective cohort study. PLoS
12		One. 2020;15:e0229431. doi: 10.1371/journal.pone.0229431
13	199.	Nehme Z, Ball J, Stephenson M, Walker T, Stub D, Smith K. Effect of a resuscitation
14		quality improvement programme on outcomes from out-of-hospital cardiac arrest.
15		Resuscitation. 2021;162:236-244. doi: 10.1016/j.resuscitation.2021.03.007
16	200.	Alqudah Z, Smith K, Stephenson M, Walker T, Stub D, Nehme Z. The impact of a high-
17		performance cardiopulmonary resuscitation protocol on survival from out-of-hospital
18		cardiac arrests witnessed by paramedics. Resusc Plus. 2022;12:100334. doi:
19		10.1016/j.resplu.2022.100334
20	201.	Lyngby RM, Folke F, Oelrich RM, Nikoletou D, Quinn T. 338 Cardio-pulmonary-
21		resuscitation quality in out-of-hospital cardiac arrest – effect of real-time feedback. BMJ
22		Open. 2022;12:A17. doi: https://doi.org/10.1136/bmjopen-2022-EMS.38

1	202.	Olasveengen TM, Tomlinson AE, Wik L, Sunde K, Steen PA, Myklebust H, Kramer-
2		Johansen J. A failed attempt to improve quality of out-of-hospital CPR through
3		performance evaluation. Prehosp Emerg Care. 2007;11:427-433. doi:
4		10.1080/10903120701536628
5	203.	Pearson DA, Darrell Nelson R, Monk L, Tyson C, Jollis JG, Granger CB, Corbett C,
6		Garvey L, Runyon MS. Comparison of team-focused CPR vs standard CPR in
7		resuscitation from out-of-hospital cardiac arrest: Results from a statewide quality
8		improvement initiative. Resuscitation. 2016;105:165-172. doi:
9		10.1016/j.resuscitation.2016.04.008
10	204.	Couper K, Mason AJ, Gould D, Nolan JP, Soar J, Yeung J, Harrison D, Perkins GD. The
11		impact of resuscitation system factors on in-hospital cardiac arrest outcomes across UK
12		hospitals: An observational study. Resuscitation. 2020;151:166-172. doi:
13		10.1016/j.resuscitation.2020.04.006
14	205.	Lukas RP, Gräsner JT, Seewald S, Lefering R, Weber TP, Van Aken H, Fischer M, Bohn
15		A. Chest compression quality management and return of spontaneous circulation: a
16		matched-pair registry study. Resuscitation. 2012;83:1212-1218. doi:
17		10.1016/j.resuscitation.2012.03.027
18	206.	Picard C, Drew R, Norris CM, O'Dochartaigh D, Burnett C, Keddie C, Douma MJ.
19		Cardiac Arrest Quality Improvement: A Single-Center Evaluation of Resuscitations
20		Using Defibrillator, Feedback Device, and Survey Data. J Emerg Nurs. 2022;48:224-
21		232.e228. doi: 10.1016/j.jen.2021.11.005
22	207.	Park JH, Shin SD, Ro YS, Song KJ, Hong KJ, Kim TH, Lee EJ, Kong SY.
23		Implementation of a bundle of Utstein cardiopulmonary resuscitation programs to

1		improve survival outcomes after out-of-hospital cardiac arrest in a metropolis: A before
2		and after study. Resuscitation. 2018;130:124-132. doi:
3		10.1016/j.resuscitation.2018.07.019
4	208.	Pfeiffer S, Duval-Arnould J, Wenger J, Lauridsen K, Hunt E, Haskell S, Atkins D,
5		Knight L, Cheng A, Gilfoyle E. 345: CPR coach role improves depth, rate, and return of
6		spontaneous circulation. Critical Care Medicine. 2018;46:155.
7	209.	Sutton RM, Niles D, French B, Maltese MR, Leffelman J, Eilevstjonn J, Wolfe H,
8		Nishisaki A, Meaney PA, Berg RA, et al. First quantitative analysis of cardiopulmonary
9		resuscitation quality during in-hospital cardiac arrests of young children. Resuscitation.
10		2014;85:70-74. doi: 10.1016/j.resuscitation.2013.08.014
11	210.	Kern KB, Sanders AB, Raife J, Milander MM, Otto CW, Ewy GA. A study of chest
12		compression rates during cardiopulmonary resuscitation in humans. The importance of
13		rate-directed chest compressions. Arch Intern Med. 1992;152:145-149.
14	211.	Berg RA, Sanders AB, Milander M, Tellez D, Liu P, Beyda D. Efficacy of audio-
15		prompted rate guidance in improving resuscitator performance of cardiopulmonary
16		resuscitation on children. Acad Emerg Med. 1994;1:35-40.
17	212.	Niles D, Nysaether J, Sutton R, Nishisaki A, Abella BS, Arbogast K, Maltese MR, Berg
18		RA, Helfaer M, Nadkarni V. Leaning is common during in-hospital pediatric CPR, and
19		decreased with automated corrective feedback. Resuscitation. 2009;80:553-557. doi:
20		10.1016/j.resuscitation.2009.02.012
21	213.	Fried DA, Leary M, Smith DA, Sutton RM, Niles D, Herzberg DL, Becker LB, Abella
22		BS. The prevalence of chest compression leaning during in-hospital cardiopulmonary
23		resuscitation. Resuscitation. 2011;82:1019-1024. doi: 10.1016/j.resuscitation.2011.02.032

1	214.	Setälä P, Virkkunen I, Kämäräinen A, Huhtala H, Virta J, Yli-Hankala A, Hoppu S.
2		Nothing beats quality-controlled manual chest compressions: End-tidal carbon dioxide
3		changes between manual cardiopulmonary resuscitation and with active compression-
4		decompression device. Resuscitation. 2015;96:70-71.
5	215.	Koch M, Mueller M, Warenits AM, Holzer M, Spiel A, Schnaubelt S. Carotid Artery
6		Ultrasound in the (peri-) Arrest Setting-A Prospective Pilot Study. J Clin Med. 2022;11.
7		doi: 10.3390/jcm11020469
8	216.	Cho GC. Skin and soft tissue damage caused by use of feedback-sensor during chest
9		compressions. In: <i>Resuscitation</i> . Ireland; 2009:600; discussion 601.
10	217.	Sainio M, Sutton RM, Huhtala H, Eilevstjønn J, Tenhunen J, Olkkola KT, Nadkarni VM,
11		Hoppu S. Association of arterial blood pressure and CPR quality in a child using three
12		different compression techniques, a case report. Scand J Trauma Resusc Emerg Med.
13		2013;21:51. doi: 10.1186/1757-7241-21-51
14	218.	Beaulac G, Teran F, Lecluyse V, Costescu A, Belliveau M, Desjardins G, Denault A.
15		Transesophageal Echocardiography in Patients in Cardiac Arrest: The Heart and Beyond.
16		Can J Cardiol. 2023;39:458-473. doi: 10.1016/j.cjca.2022.12.027
17	219.	Sutton RM, Maltese MR, Niles D, French B, Nishisaki A, Arbogast KB, Donoghue A,
18		Berg RA, Helfaer MA, Nadkarni V. Quantitative analysis of chest compression
19		interruptions during in-hospital resuscitation of older children and adolescents.
20		Resuscitation. 2009;80:1259-1263. doi: 10.1016/j.resuscitation.2009.08.009
21	220.	Nakashima T, Noguchi T, Tahara Y, Nishimura K, Yasuda S, Onozuka D, Iwami T,
22		Yonemoto N, Nagao K, Nonogi H, et al. Public-access defibrillation and neurological

1		outcomes in patients with out-of-hospital cardiac arrest in Japan: a population-based
2		cohort study. Lancet. 2019;394:2255-2262. doi: 10.1016/s0140-6736(19)32488-2
3	221.	Kitamura T, Kiyohara K, Iwami T. Public-Access Defibrillation in Japan. N Engl J Med.
4		2017;376:e12. doi: 10.1056/NEJMc1700160
5	222.	Caffrey SL, Willoughby PJ, Pepe PE, Becker LB. Public use of automated external
6		defibrillators. N Engl J Med. 2002;347:1242-1247. doi: 10.1056/NEJMoa020932
7	223.	Valenzuela TD, Roe DJ, Nichol G, Clark LL, Spaite DW, Hardman RG. Outcomes of
8		rapid defibrillation by security officers after cardiac arrest in casinos. N Engl J Med.
9		2000;343:1206-1209. doi: 10.1056/nejm200010263431701
10	224.	Gold LS, Fahrenbruch CE, Rea TD, Eisenberg MS. The relationship between time to
11		arrival of emergency medical services (EMS) and survival from out-of-hospital
12		ventricular fibrillation cardiac arrest. Resuscitation. 2010;81:622-625. doi:
13		10.1016/j.resuscitation.2010.02.004
14	225.	Debaty GD, K.; Norii, T.; Perkins, G.D.; Olasveengen, T.; Bray, J.; on behalf of the
15		International Liaison Committee on Resuscitation Basic Life Support Task Force.
16		Effectiveness of ultra-portable or pocket automated external defibrillator Consensus on
17		Science with Treatment Recommendations [Internet] Brussels, Belgium: International
18		Liaison Committee on Resuscitation (ILCOR) Basic Life Support Task Force, 2024
19		January 8. https://costr.ilcor.org/document/effectiveness-of-ultra-portable-or-pocket-
20		automated-external-defibrillators-a-scoping-review-bls-2603-scr.
21	226.	Shaker MS, Abrams EM, Oppenheimer J, Singer AG, Shaker M, Fleck D, Greenhawt M,
22		Grove E. Estimation of Health and Economic Benefits of a Small Automatic External
23		Defibrillator for Rapid Treatment of Sudden Cardiac Arrest (SMART): A Cost-

1 Effectiveness Analysis. *Front Cardiovasc Med.* 2022;9:771679. doi:

- 2 10.3389/fcvm.2022.771679
- 3 227. Todd V, Dicker B, Okyere D, Smith K, Howie G, Smith T, Stub D, Ray M, Stewart R,
- 4 Scott T, et al. The First Responder Shock Trial (FIRST): Can We Improve Cardiac Arrest
- 5 Survival by Providing Community Responders With Ultraportable Automated External
- 6 Defibrillators? *Heart, Lung and Circulation.* 2023;32. doi: 10.1016/j.hlc.2023.04.240
- 7 228. Todd V, Dicker B, Okyere D, Smith K, Howie G, Smith T, Stub D, Ray M, Stewart R,
- 8 Scott T, et al. The First Responder Shock Trial (FIRST): Can We Improve Cardiac Arrest
- 9 Survival by Providing Community Responders With Ultraportable Automated External
- 10 Defibrillators? *Heart, Lung and Circulation.* 2023;32:S88. doi:
- 11 10.1016/j.hlc.2023.04.240

1	ADVANCED	LIFE	SUPPORT
1	ADVANCED		SULLOKI

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

3 Rationale for Review

4	This review was conducted by the ALS Task Force in collaboration with the BLS Task
5	Force. Oxygenation and ventilation are important components of post-cardiac arrest
6	management. This topic was last updated with a SysRev for the 2020 CoSTR (PROSPERO
7	registration CRD42022371007). ¹⁻³ Since the last review of this topic, the task forces were aware
8	of new clinical trials, prompting an update of the SysRev. The complete CoSTR can be found
9	online. ⁴
10	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
11	• Population: Unresponsive adults with sustained ROSC after cardiac arrest in any setting
12	(in-hospital or out-of-hospital)
13	• Intervention: An oxygenation or ventilation strategy targeting a specific SpO ₂ , PaO ₂ ,
14	and/or PaCO ₂
15	• Comparators: Treatment without specific targets or with an alternate target to the
16	intervention
17	• Outcomes:
18	- Critical: Survival or survival with a favorable neurological outcome at hospital
19	discharge/30 days or longer
20	- Other outcomes will depend on the available data and subsequent outcome prioritization
21	by the ILCOR ALS Task Force
22	• Study designs: Controlled trials, including RCTs, and nonrandomized trials (eg,
23	pseudorandomized trials) were included. Observational studies, animal studies,

- 1 ecological studies, case series, case reports, reviews, abstracts, editorials, comments,
- 2 letters to the editor, and unpublished studies were excluded. All languages were included
- 3 if there was an English abstract or full-text article.
- Time frame: From August 22, 2019 (date of search of the prior review), to June 30, 2023
- 5 Consensus on Science
- 6 Five new RCTs including adult patients were identified.⁵⁻⁹ These studies add to the

7 previous SysRev, which included 7 RCTs.^{2,10-16} Studies used a variety of specific oxygen and

8 carbon dioxide strategies or targets, as defined in Table 7.

Study outhor year	Lower oxygen and higher	Higher oxygen and lower	
Study author, year	carbon dioxide strategies	carbon dioxide strategies	
Kuisma, 2006 ¹⁵	2–4 L/min O ₂	>10 L/min O ₂	
Bray, 2018 ¹⁴	O ₂ saturation goal 90%–94%	O ₂ saturation goal 98%–100%	
Thomas, 2019 ¹¹	O2 saturation goal 94%–98%	100% FIO2	
Bernard, 2022 ⁵	O ₂ saturation goal 90%–94%	O ₂ saturation goal 98%–100%	
Jakkula, 2018 ¹⁰	PaO ₂ of 10–15 kPa (75–113	PaO ₂ 20–25 kPa (150–188	
	mm Hg)	mm Hg)	
Young, 2020 ¹³	O ₂ saturation goal 90%–97%	Standard care	
Schmidt, 2022 ⁸	PaO ₂ of 9–10 kPa (68–75	PaO ₂ 13–15 kPa (98–105	
	mm Hg)	mm Hg)	
Semler, 2022 ⁷	O ₂ saturation goal 88%–96%	O ₂ saturation goal 96%–100%	
Crescioli, 2023 ⁹	PaO ₂ 60 mm Hg (8 kPa)	PaO ₂ 90 mm Hg (12 kPa)	

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

	Lower oxygen and higher	Higher oxygen and lower	
Study author, year	carbon dioxide strategies	carbon dioxide strategies	
Jakkula, 2018 ¹⁰	PaCO ₂ 5.8–6.0 kPa (44–45	PaCO ₂ 4.5–4.7 kPa (34–35	
	mm Hg)	mm Hg)	
Eastwood, 2016 ¹²	PaCO ₂ 50–55 mm Hg (6.7–7.3	PaCO ₂ 35–45 mm Hg (4.7–6.0	
Eastwood, 2023 ⁶	kPa)	kPa)	

1

Key results for both oxygen and carbon dioxide comparisons are presented in Table 8 and

2 Table 9. Overall, there was no consistent evidence of benefit or harm from the different oxygen

3 and carbon dioxide strategies investigated.

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

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

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

1 2 ARD indicates absolute risk difference; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; ICU, intensive care unit; RCT, randomized controlled trial; and RR, relative risk.

Table 9. Summary of Findings From Studies Comparing Higher Carbon Dioxide Values 3 With Lower Carbon Dioxide Values 4

Outcome (importance)	Participants, n (studies)	Certainty of evidence, GRADE	RR (95% CI)	ARD (95% CI)
Moderate hypercapnia compared with normocapnia or low-normal PaCO ₂ after		mal PaCO ₂ after		
		ROSC		
Survival to	1866 (3	Moderate	0.95 (0.82,	30 fewer per 1000
hospital discharge	RCTs) ^{6,10,12}		1.10)	patients (108 fewer
(critical)				to 60 more)

Outcome (importance)	Participants, n (studies)	Certainty of evidence, GRADE	RR (95% CI)	ARD (95% CI)
Survival to 6	1648 (1 RCT) ⁶	Moderate	0.96 (0.88,	22 fewer per 1000
months (critical)			1.05)	patients (65 fewer
				to 27 more)
Survival with	1751 (3	Moderate	0.96 (0.85,	19 fewer per 1000
favorable	RCTs) ^{6,10,12}		1.10)	patients (70 fewer
neurological				to 46 more)
outcome at 6				
months (critical)				

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

3 Prior Treatment Recommendations (2020)^{1,3}

4	We suggest the use of 100% inspired oxygen until the arterial oxygen saturation or the
5	partial pressure of arterial oxygen can be measured reliably in adults with ROSC after cardiac
6	arrest in any setting (weak recommendation, very low-certainty evidence).
7	We recommend avoiding hypoxemia in adults with ROSC after cardiac arrest in any
8	setting (strong recommendation, very low-certainty evidence).
9	We suggest avoiding hyperoxemia in adults with ROSC after cardiac arrest in any setting
10	(weak recommendation, low-certainty evidence).
11	There is insufficient evidence to suggest for or against targeting mild hypercapnia
12	compared with normocapnia in adults with ROSC after cardiac arrest.
13	We suggest against routinely targeting hypocapnia in adults with ROSC after cardiac
14	arrest (weak recommendation, low-certainty evidence).

1 2024 Treatment Recommendations

2 Oxygen Targets

3	We recommend the use of 100% inspired oxygen until the arterial oxygen saturation or
4	the partial pressure of arterial oxygen can be measured reliably in adults with ROSC after cardiac
5	arrest in the prehospital setting (strong recommendation, moderate-certainty evidence) and in-
6	hospital setting (strong recommendation, low-certainty evidence).
7	We recommend avoiding hypoxemia in adults with ROSC after cardiac arrest in any
8	setting (strong recommendation, very low-certainty evidence).
9	We suggest avoiding hyperoxemia in adults with ROSC after cardiac arrest in any setting
10	(weak recommendation, low-certainty evidence).
11	Following reliable measurement of arterial oxygen values, we suggest targeting an
12	oxygen saturation of 94% to 98% or a partial pressure of arterial oxygen of 75 to 100 mm Hg
13	(\approx 10–13 kPa) in adults with ROSC after cardiac arrest in any setting (good practice statement).
14	When relying on pulse oximetry, health care professionals should be aware of the
15	increased risk of inaccuracy that may conceal hypoxemia in patients with darker skin
16	pigmentation (good practice statement).
17	Carbon Dioxide Targets
18	We suggest targeting normocapnia (a partial pressure of carbon dioxide of 35–45 mm Hg
19	or \approx 4.7–6.0 kPa) in adults with ROSC after cardiac arrest (weak recommendation, moderate-
20	certainty evidence).
21	Justification and Evidence-to-Decision Framework Highlights
22	The complete evidence-to-decision table is provided in Appendix A2.

1 Oxygen Targets

2	• The task forces discussed that avoiding oxygen titration until blood oxygen values are
3	accurately measured is especially important in the prehospital setting, where arterial
4	blood gas analysis is rarely available and peripheral blood oxygen saturation may be
5	difficult to obtain consistently. The largest RCT in the prehospital setting suggested that
6	early titration to a lower oxygen target is harmful. ⁵ The task forces discussed whether the
7	evidence favored avoiding any titration of oxygen in the out-of-hospital setting because
8	most patients in the control arm of the EXACT trial (Reduction of Oxygen After Cardiac
9	Arrest) received 100% oxygen without titration. However, most thought that once
10	reliable measurement of oxygenation was available, the evidence only supported not
11	titrating to a lower target range of 90% to 94%.
12	• In making the recommendation to avoid hypoxemia, the task forces concluded that the
13	physiologic basis for hypoxia being harmful justifies its avoidance and that detection of
14	hypoxemia may be the best surrogate for true hypoxia.
15	• The suggestion to avoid hyperoxemia is based on very low-certainty to moderate-
16	certainty evidence that showed either harm (in observational studies included in the 2020
17	SysRev) or no benefit (in RCTs) from hyperoxemia. It is important to consider that the
18	higher oxygen groups in RCTs generally did not reach the very high PaO2 values (300-
19	400 mm Hg) associated with harm in some observational studies.
20	• The variability in oxygenation targets across RCTs and observational studies makes it
21	difficult to identify an evidence-based optimal range. However, the task forces
22	recognized the need for more precise guidance than that provided previously and agreed

1

2

that targeting an oxygen saturation of 94% to 98% or a PaO_2 target of 75 to 100 mm Hg (10–13 kPa) is reasonable.

While studies evaluating the accuracy of pulse oximetry in people with different degrees 3 of skin pigmentation were not part of this SysRev, the SysRev team and task forces were 4 5 aware of and considered several such studies that have found a slightly higher risk of 6 occult hypoxemia (pulse oximetry reading of >90% saturation, while arterial oxygen saturation by blood gas is <88%) in people with dark skin.¹⁷⁻¹⁹ While none of these 7 studies were done in cardiac arrest patients, the task forces concluded that it was 8 important to make medical professionals treating cardiac arrest patients aware of this 9 10 issue because this knowledge could inform decision-making about whether to titrate supplemental oxygen. The task forces, therefore, provided a good practice statement to 11 12 highlight this issue.

13 Carbon Dioxide Targets

14 The evidence from RCTs and observational studies is inconsistent. RCTs have failed to 15 show any effect from different CO₂ targets. Considering the lack of evidence for benefit 16 or harm from targeting CO₂ values above or below the normal range, the task forces 17 deemed it reasonable to target normocapnia, generally defined as a PaCO₂ of 35 to 45 mm Hg, in both RCTs and observational studies. Notably, the task forces are aware of 18 unpublished data from one RCT⁵ as well observational studies not included in this 19 review,²⁰⁻²³ suggesting that ETCO₂ values may not accurately reflect PaCO₂ values, which 20 21 may be an important consideration in the prehospital setting. As with all critically ill 22 patients, there may be specific scenarios in which CO₂ values may need to be higher or

1	lower than normal to compensate for other illnesses (eg, severe lung injury or metabolic
2	acidosis).
3	• The task forces discussed whether cardiac arrest patients with baseline chronic lung
4	disease and chronic CO ₂ retention might respond differently to different CO ₂ targets;
5	however, no evidence addressing this subgroup was found.
6	Knowledge Gaps
7	• The optimal oxygen target for post-cardiac arrest patients
8	• Whether there is a threshold at which hypoxemia and hyperoxemia become harmful
9	• The optimal duration for specific oxygen strategies
10	• The optimal CO ₂ target for post–cardiac arrest patients
11	• Whether there is a threshold at which hypocapnia and hypercapnia become harmful
12	• The accurate correlation of ETCO ₂ with PaCO ₂ values
13	• The effects of manipulating PaCO ₂ on cerebral blood flow in post-cardiac arrest patients
14	• How PaCO ₂ targets should be adjusted in patients with chronic CO ₂ retention
15	• Whether arterial blood gas analysis should be adjusted to 37 °C or to a patient's current
16	temperature
17	Post-Cardiac Arrest Hemodynamics (ALS 3515: SysRev Adolopment)
18	Rationale for Review
19	The topic of hemodynamic goals after cardiac arrest was previously reviewed by the ALS
20	Task Force in 2015, ^{24,25} and an EvUp was conducted in 2020. ^{1,3} In the previous recommendation,
21	consideration of hemodynamic goals was suggested, but there was insufficient evidence to
22	recommend a specific target. New RCTs have been published on this topic, and the task force
23	decided a SysRev was warranted. A recently published SysRev with individual patient data

Greif-77

1	meta-analysis, which included a meta-analysis of the effect of targeting a mean arterial pressure
2	(MAP) higher or lower than 70 mm Hg, was identified; this review was deemed of sufficient
3	quality to be used for adolopment. ²⁶ The complete CoSTR can be found online. ²⁷
4	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
5	• Population: Adults with sustained ROSC after cardiac arrest
6	• Intervention: Targeting a MAP of 71 mm Hg or higher
7	• Comparator: Targeting a MAP of 70 mm Hg or lower
8	• Outcomes:
9	- Critical: Survival or good functional outcome defined as a modified Rankin Scale score
10	of 1 to 3 or a score of 1 to 2 on the Cerebral Performance Category scale at 90 to 180
11	days
12	- Important: Intensive care unit mortality, new arrhythmia resulting in hemodynamic
13	compromise or cardiac arrest while in the intensive care unit (ICU)
14	• Study designs: RCTs were eligible for inclusion. All years and all languages were
15	included as long as there was an English abstract. Observational studies and unpublished
16	studies (eg, conference abstracts, trial protocols) were excluded.
17	• Time frame: The literature search was conducted in October 2022 and updated in August
18	2023.
19	Consensus on Science
20	The SysRev identified 4 RCTs of 1065 patients comparing lower and higher MAP targets
21	after ROSC. ²⁸⁻³¹ The included RCTs provided low-certainty evidence (downgraded for risk of
22	bias and indirectness) of no benefit from a higher MAP compared with a lower MAP target for
23	the critical outcomes of mortality at 180 days (relative risk [RR], 1.08 [95% CI, 0.92-1.26]) and

Greif-78

1	good functional outcome at 180 days (RR, 0.99 [95% CI, 0.84–1.16]). Similarly, there was no
2	benefit for the outcomes of ICU mortality (RR, 1.09 [95% CI, 0.81-1.46]) or new arrhythmia
3	resulting in hemodynamic compromise or cardiac arrest during ICU stay (RR, 1.04 [95% CI,
4	0.77–1.40]).
5	Prior Treatment Recommendations (2015) ^{24,25}
6	We suggest hemodynamic goals (eg, MAP, systolic blood pressure) be considered during
7	postresuscitation care and as part of any bundle of postresuscitation interventions (weak
8	recommendation, low-certainty evidence).
9	There is insufficient evidence to recommend specific hemodynamic goals; such goals
10	should be considered on an individual patient basis and are likely to be influenced by post-
11	cardiac arrest status and pre-existing comorbidities (weak recommendation, low-certainty
12	evidence).
13	2024 Treatment Recommendations
14	There is insufficient scientific evidence to recommend a specific blood pressure goal after
15	cardiac arrest. Therefore, we suggest a mean arterial blood pressure of at least 60 to 65 mm Hg in
16	patients after out-of-hospital (moderate-certainty to low-certainty evidence) and IHCA (low-
17	certainty to very low-certainty evidence).
18	Justification and Evidence-to-Decision Framework Highlights
19	The complete evidence-to-decision table is provided in Appendix A2.
20	In making these updated recommendations, the ALS Task Force considered the
21	following:
22	
22	• The 4 RCTs conducted since the prior review provide significant new evidence but have
22	• The 4 RCTs conducted since the prior review provide significant new evidence but have not yet identified an optimal BP strategy.

1	• While no specific mean arterial BP strategy has been found to be beneficial in cardiac
2	arrest trials, the task force thought it was important to provide more specific guidance
3	than had been previously provided. The threshold of 65 mm Hg was agreed upon because
4	this threshold is the accepted standard in other forms of critical illness, and there is no
5	evidence to deviate from that practice in postarrest patients. Observational data suggest
6	that the lowest MAP not associated with a worse outcome after cardiac arrest is about 60
7	to 70 mm Hg, ³²⁻³⁴ and the "Surviving Sepsis Campaign: International Guidelines for
8	Management of Sepsis and Septic Shock" recommends targeting a MAP of >65 mm Hg
9	in patients with septic shock. ³⁵
10	• No statistically significant benefit or harm from targeting a higher MAP was found for
11	any critical outcome.
12	• All RCT studies conducted thus far focused on patients with a likely cardiac cause of the
13	arrest and a high likelihood of a favorable outcome.
14	• Whether a higher MAP target, such as 80 to 100 mm Hg, may be beneficial for some
15	patients has not been determined by trials to date. The task force acknowledged that this
16	is part of clinical practice at some cardiac arrest centers. The current treatment
17	recommendation purposefully does not prescribe an upper limit for MAP targets because
18	it is unknown.
19	Knowledge Gaps
20	• Optimal BP management in patients with cardiac arrest of noncardiac etiology or with
21	IHCA and who have thus far not been included in trials
22	• What blood pressure to target in the prehospital setting

1	• The current evidence can exclude a relative positive or negative treatment effect of
2	targeting a higher MAP of higher than 25% but not lower; this difference may be
3	unrealistic, and there may be a need for larger trials.
4	• Whether the effect of MAP on outcome is different in certain subgroups of patients, such
5	as those with chronic hypertension
6	• Whether targeting a higher BP could be beneficial in patients with deranged cerebral
7	autoregulation
8	• Whether increasing MAP influences cerebral or coronary blood flow
9	• Whether MAP, as opposed to some other proxy for organ perfusion (lactate clearance,
10	urinary output, capillary refill), is the optimal bedside therapeutic target
11	• The optimal strategy to achieve a target MAP after cardiac arrest, which may include the
12	use of intravenous fluids (fluid type and volume), specific vasopressors or combinations
13	of vasopressors, and use of mechanical support
14	Post–Cardiac Arrest Temperature Control (ALS 3523, 3524, 3525: SysRev)
15	Rationale for Review
16	Since publication of the prior SysRev, ³⁶ the task force has been aware of new clinical
17	trials examining temperature control in comatose post-cardiac arrest patients and, therefore,
18	updated the SysRev (PROSPERO registration of original review CRD42020217954). The
19	SysRev covered the following 6 different aspects of temperature management: (1) use of
20	hypothermic temperature control, (2) timing, (3) specific temperature, (4) duration of
21	temperature control, (5) method of temperature control, and (6) rate of rewarming. The full
22	CoSTR can be found online. ³⁷

1	Popul	ation, Intervention, Comparator, Outcome, Study Design, and Time Frame
2	•	Population: Adults with cardiac arrest in any setting (in-hospital or out-of-hospital)
3	•	Interventions:
4	_	Intervention 1: Temperature control (temperature control studies targeting hypothermia at
5		32–34 °C in the SysRev)
6	_	Intervention 2: Temperature control induction before a specific time point (eg,
7		prehospital or intracardiac arrest)
8	_	Intervention 3: Temperature control at a specific temperature (eg, 33 °C)
9	_	Intervention 4: Temperature control for a specific duration (eg, 48 hours)
10	_	Intervention 5: Temperature control with a specific method (eg, external)
11	_	Intervention 6: Temperature control with a specific rewarming rate
12	•	Comparators:
13	_	Comparator 1: No temperature control (temperature control studies targeting
14		normothermia or fever prevention included in the SysRev)
15	_	Comparator 2: Temperature control induction after that specific time point
16	_	Comparator 3: Temperature control at a different specific temperature (eg, 36 °C)
17	_	Comparator 4: Temperature control at a different specific duration (eg, 24 hours)
18	_	Comparator 5: Temperature control with a different specific method (eg, internal)
19	_	Comparator 6: Temperature control with a different specific rewarming rate or no
20		specific rewarming rate
21	•	Outcomes:
22	_	Critical: Survival and survival with a favorable neurological outcome at hospital
23		discharge and 30 days and longer

1	• Study designs: Controlled trials in humans, including RCTs and nonrandomized trials
2	(eg, pseudorandomized trials), were included. Observational studies, ecological studies,
3	case series, case reports, reviews, abstracts, editorials, comments, letters to the editor, and
4	unpublished studies were excluded. Studies assessing cost-effectiveness were included
5	for a descriptive summary. Unpublished studies (eg, conference abstracts, trial protocols)
6	were excluded. All languages were included if there was an English abstract.
7	• Time frame: The original literature search was performed on October 30, 2020, and
8	updated for clinical trials on June 17, 2021. The literature search was conducted on May
9	31, 2023, for the updated SysRev and on June 3, 2023, for ongoing clinical trials.
10	Consensus on Science
11	Note on Terminology
12	The term targeted temperature management has been updated as below for clarity.
13	• Hypothermic temperature control = active temperature control with the target temperature
14	below the normal range
15	• Normothermic temperature control = active temperature control with the target
16	temperature in the normal range
17	• Fever prevention temperature control = monitoring temperature and actively preventing
18	and treating temperature above the normal range
19	• No temperature control = no protocolized active temperature control strategy
20	This updated search yielded 6 new trials investigating different aspects of post-cardiac
21	arrest temperature control, adding to the 32 trials identified in the previous review. Comparisons
22	included temperature control versus no temperature control, timing of temperature control,
23	specific temperature targets, durations of temperature control, methods of temperature control,

- 1 and rates of rewarming. Key results are summarized in Table 10. Overall, there was no
- 2 difference between hypothermic temperature control and normothermic temperature control or
- 3 between other specific temperatures studied or different durations or methods of temperature
- 4 control.
- 5 Table 10. Summary of Findings of Trials on Postarrest Temperature Control

Outcome (importance)	Participants, n (studies)	Certainty of evidence, GRADE	RR (95% CI)	ARD (95% CI)
Hypothermia (32–3	4 °C) compared wi	th normothermia	or fever preve	ntion
Survival to hospital	3074 (6 RCTs) ³⁸⁻	Low	1.07 (0.91-	32 more per 1000
discharge (critical)	43		1.25)	patients (41 fewer to
				114 more)
Survival with	2377 (4	Low	1.16 (0.81-	59 more per 1000
favorable	RCTs) ^{38,39,42,43}		1.66)	patients (70 fewer to
neurological				243 more)
outcome at hospital				
discharge or 30				
days (critical)				
Survival to 90 or	3014 (6 RCTs) ³⁹⁻	Low	1.06 (0.91,	25 more per 1000
180 days (critical)	44		1.23)	patients (38 fewer to
				97 more)
Survival with	2991 (6 RCTs) ³⁹⁻	Low	1.16 (0.92,	57 more per 1000
favorable	44		1.47)	patients (28 fewer to
neurological				166 more)
outcome at 90 or				
180 days (critical)				
33 °C compared wit	th 36 °C			
Survival with	938 (1 RCT) ⁴⁵	Low	0.96 (0.83,	18 fewer per 1000
favorable			1.11)	patients (78 fewer to
neurological				50 more)

Outcome (importance)	Participants, n (studies)	Certainty of evidence, GRADE	RR (95% CI)	ARD (95% CI)
outcome at hospital				
discharge (critical)				
Survival with	990 (2 RCTs) ^{45,46}	Low	1.01 (0.88,	4 more per 1000
favorable			1.15)	patients (42 fewer to
neurological				53 more)
outcome at 180				
days (critical)				
Duration of cooling	(12–24 h compared	d with 36 h of ten	perature cont	rol or 48 h
compared with 24 h	ı*)			
Survival at 1 month	173 (1 RCT) ⁴⁷	Very low	1.03 (0.89,	24 more per 1000
(critical)			1.18)	patients (88 fewer to
	,			145 more)
Favorable	173 (1 RCT) ⁴⁷	Very low	0.95 (0.75,	31 fewer per 1000
neurological			1.21)	patients (156 fewer
outcome at 1 month				to 131 more)
(critical)				
*Survival at 6	351 (1 RCT) ⁴⁸	Low	1.10 (0.96,	66 more per 1000
months (critical)			1.27)	patients (26 fewer to
				178 more)
*Favorable	351 (1 RCT) ⁴⁸	Low	1.08 (0.93,	51 more per 1000
neurological			1.25)	patients (45 fewer to
outcome at 6				159 more)
months (critical)				
Method of temperat	ture control (endow	ascular compare	d with surface	cooling)
Survival to hospital	523 (3 RCTs) ⁴⁹⁻⁵¹	Low	1.14 (0.93,	56 more per 1000
discharge or 28			1.38)	patients (28 fewer to
days (critical)				152 more)

Outcome (importance)	Participants, n (studies)	Certainty of evidence, GRADE	RR (95% CI)	ARD (95% CI)
Favorable	523 (3 RCTs) ⁴⁹⁻⁵¹	Low	1.22 (0.95,	64 more per 1000
neurological			1.56)	patients (15 fewer to
outcome at hospital				163 more)
discharge or 28				
days (critical)				
Rewarming rate (0.	25 °C/h compared	with 0.50 °C/h)		
Survival at 90 days	50 (1 RCT) ⁵²	Low	0.88 (0.56,	77 fewer per 1000
(critical)			1.38)	patients (282 fewer
				to 243 more)
Favorable	50 (1 RCT) ⁵²	Low	1.00 (0.59,	0 fewer per 1000
neurological			1.70)	patients (213 fewer
outcome at 90 days				to 364 more)
Duration of fever p	revention after init	ial temperature of	control	l
Survival at 90 days	789 (1 RCT) ⁵³	Low	0.99 (0.90,	7 fewer per 1000
(critical)			1.08)	patients (80 fewer to
				56 more)
Favorable	789 (1 RCT) ⁵³	Low	0.98 (0.89,	14 fewer per 1000
neurological			1.08)	patients (74 fewer to
outcome at 90 days				54 more)
(critical)				

1 2 ARD indicates absolute risk difference; GRADE, Grading of Recommendations Assessment, Development, and

Evaluation; RCT, randomized controlled trial; and RR, relative risk.

2024 Treatment Recommendations and Good Practice Statements (Unchanged) 3

We suggest actively preventing fever by targeting a temperature ≤37.5 °C for patients 4

5 who remain comatose after ROSC from cardiac arrest (weak recommendation, low-certainty

evidence). 6

1	Whether subpopulations of cardiac arrest patients may benefit from targeting
2	hypothermia at 32 °C to 34 °C remains uncertain.
3	Comatose patients with mild hypothermia after ROSC should not be actively warmed to
4	achieve normothermia (good practice statement).
5	We recommend against the routine use of prehospital cooling with rapid infusion of large
6	volumes of cold intravenous fluid immediately after ROSC (strong recommendation, moderate-
7	certainty evidence).
8	We suggest surface or endovascular temperature control techniques when temperature
9	control is used in comatose patients after ROSC (weak recommendation, low-certainty
10	evidence).
11	When a cooling device is used, we suggest using a temperature control device that
12	includes a feedback system based on continuous temperature monitoring to maintain the target
13	temperature (good practice statement).
14	Prior Good Practice Statement on Duration of Fever Prevention (2022 ^{54,55})
15	We suggest active prevention of fever for at least 72 hours in post-cardiac arrest patients
16	who remain comatose (good practice statement).
17	2024 Good Practice Statement on Duration of Fever Prevention
18	We suggest active prevention of fever for 36 to 72 hours in post-cardiac arrest patients
19	who remain comatose (good practice statement).
20	Justification and Evidence-to-Decision Framework Highlights
21	The complete evidence-to-decision table is provided in Appendix A2.

1 Hypothermia Compared With Normothermia or Prevention of Fever

2 All members of the task force agreed to continue to recommend active temperature 3 control in post-cardiac arrest patients, although the evidence for this is limited. The task force acknowledged that the SysRev found no difference in overall outcomes 4 5 between patients treated with hypothermia and normothermia or fever prevention. 6 The majority of the task force favored fever prevention temperature control for comatose 7 patients after ROSC as opposed to hypothermic temperature control, on the basis of the SysRevs and because this intervention requires fewer resources and had fewer side 8 9 effects than hypothermic temperature control. Several members, however, wanted to 10 leave open the option to use hypothermic temperature control (33 °C). Reasons for this include findings of a single trial suggesting benefit in those with a nonshockable initial 11 12 rhythm⁴¹ and the relatively few data in patients with cardiac arrest of a noncardiac etiology. 13 14 The task force discussed the possibility that earlier cooling and achieving the target 15 temperature sooner might still be beneficial. Trials to date have largely not been able to achieve this. 16 Although there was no direct evidence in our SysRevs, the task force maintained the 17 18 existing good practice statement supporting the avoidance of active warming of patients 19 who have passively become mildly hypothermic after ROSC (eg, 32-36 °C) because 20 there was concern that this may be a harmful intervention. 21 Prehospital Cooling 22 Our treatment recommendation for prehospital cooling is unchanged from our 2015 23 recommendation. No new studies were identified.

1	• We found no evidence that any method of prehospital cooling improved outcomes, and
2	the rapid infusion of large amounts of cold fluid immediately after achieving ROSC in
3	the prehospital setting could be harmful. Any potential harm from this therapy may relate
4	specifically to the prehospital setting, where there may be less control over the
5	environment, fewer personnel, and reduced monitoring capabilities.
6	• We have not made a treatment recommendation about intra-arrest cooling for OHCA.
7	Cooling Devices
8	• There was consensus that temperature should be continually monitored by the cooling
9	device, when such a device is used, so that a stable temperature is maintained.
10	• Two SysRevs conflict on whether surface or endovascular cooling is preferable. One
11	showed that intravascular cooling is associated with improved neurological outcome, ⁵⁶
12	while the other found no association with survival or neurological outcomes. ⁵⁷
13	Duration of Temperature Control
14	• Our previous treatment recommendation was a good practice statement based on trials
15	controlling temperature for at least 72 hours in those patients who remained sedated or
16	comatose. One trial showed no difference between 24 and 48 hours of hypothermia, ⁴⁸ and
17	another found no difference between 12 to 24 and 36 hours of hypothermia. ⁴⁷
18	• This updated review includes an additional trial comparing temperature control for a total
19	duration of 36 hours versus 72 hours that found no difference in outcomes. ⁵³ The same
20	trial included temperature control with a surface cooling device at one site and an
21	intravenous cooling device at the other site. Whether results are applicable to temperature
22	control without a device or different cooling devices is unknown.

1	• The task force was not able to reach consensus on a treatment recommendation on
2	duration of temperature control or fever prevention. After discussion about the lack of
3	consistency in the interventions and comparators across the available studies, the task
4	force agreed that there was not enough trial evidence to support a recommendation
5	specifically on how long to prevent fever. All task force members agreed on the good
6	practice statement, which accommodates a range of duration that is supported by the
7	limited data and by expert opinion.
8	Rewarming
9	• The task force discussed that, although there is no evidence that active rewarming is
10	harmful, expert opinion is that it is generally unwarranted and can be avoided.
11	Knowledge Gaps
12	• Data on no temperature control versus fever prevention temperature control (little data
13	available)
14	• The effect of temperature control after extracorporeal cardiopulmonary resuscitation
15	(ECPR)
16	• The effect of temperature control after IHCA (only 1 trial and one trial subgroup
17	available)
18	• Whether there is a therapeutic window within which hypothermic temperature control is
19	effective in the clinical setting
20	• If a therapeutic window exists, whether there are clinically feasible cooling strategies that
21	can rapidly achieve therapeutic target temperatures within the therapeutic window
22	• Whether the clinical effectiveness of hypothermia is dependent on providing the
23	appropriate dose (target temperature and duration) based on the severity of brain injury

1	• Whether there are unidentified subsets of post-cardiac arrest patients who would benefit
2	from hypothermic temperature control as currently practiced
3	• Whether temperature control using a cooling device with feedback is more effective than
4	temperature control without a feedback-controlled cooling device
5	Post–Cardiac Arrest Seizure Prophylaxis and Treatment (ALS 3502 and 3503: SysRev)
6	Rationale for Review
7	This topic was last updated in 2020. ^{1,3} This was a nodal SysRev between the ALS and
8	Pediatric Life Support Task Forces based on the knowledge of new evidence examining the
9	treatment of seizures after cardiac arrest. The nodal review included both adults and children.
10	Readers should refer to the pediatric life support section for pediatric-specific recommendations
11	on this topic. The SysRev was registered on PROSPERO (CRD42023460746 and
12	CRD42023463581), and the full CoSTR can be found online. ⁵⁸
13	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
14	• Population: Adults or children in any setting (in-hospital or out-of-hospital) with cardiac
15	arrest and ROSC
16	• Intervention: One strategy for prophylactic antiseizure medication or seizure treatment
17	• Comparators: Another strategy or no prophylactic antiseizure medication or seizure
18	treatment
19	• Outcomes:
20	- Critical: Survival or survival with favorable neurological/functional outcome at
21	discharge, 30 days, 60 days, 180 days, or 1 year
22	• Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series,
23	controlled before-and-after studies, cohort studies) were eligible for inclusion.

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1	Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All
2	relevant publications in any language were included if there was an English abstract.
3	• Time frame: All years; search conducted on September 11, 2023
4	Consensus on Science
5	Prophylactic Antiseizure Medication
6	No new studies were identified since the prior review. For the critical outcome of
7	survival with favorable neurological outcome at discharge, 30 days, or longer, 2 RCTs including
8	562 patients investigated prophylactic antiseizure medication and provided very low-certainty
9	evidence of no benefit for survival or neurologic outcome. ^{59,60} Agents used for prophylaxis
10	included thiopentone, ⁵⁹ magnesium, diazepam, and the combination of magnesium and
11	diazepam, ⁶⁰ all compared with placebo. A nonrandomized clinical trial of 107 patients provided
12	very low-certainty evidence of no improvement in neurological outcome at hospital discharge or
13	survival with thiopentone compared with historic controls. ⁶¹
14	Treatment of Seizures
15	No RCTs or nonrandomized studies addressed the effect of treatment of clinical seizures
16	in post-cardiac arrest patients compared with no seizure treatment. One RCT provided low-
17	certainty evidence on the effect of treatment of rhythmic and periodic electroencephalogram
18	(EEG) patterns in comatose patients after cardiac arrest, compared with no treatment, finding no
19	difference in favorable neurological outcome (Cerebral Performance Category 1-2) at 3 months
20	with administration of antiseizure medications compared with standard care (RR, 1.23 [95% CI,
21	0.48–3.15]; or 19 more per 1000 patients, [95% CI, from 43 fewer to 179 more]). ⁶² There was
22	also no difference in survival.

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1	Prior Treatment Recommendations (2020)
2	We suggest against seizure prophylaxis in adult post-cardiac arrest survivors (weak
3	recommendation, very low-certainty evidence).
4	We suggest treatment of seizures in adult post-cardiac arrest survivors (weak
5	recommendation, very low-certainty evidence). ^{1,3}
6	2024 Treatment Recommendations
7	We suggest against the use of prophylactic antiseizure medication in post-cardiac arrest
8	adults (weak recommendation, very low-certainty evidence).
9	We suggest treatment of clinically apparent and electrographic (EEG) seizures in post-
10	cardiac arrest adults (good practice statement).
11	We suggest treatment of rhythmic and periodic EEG patterns that are on the ictal-
12	interictal continuum in comatose post-cardiac arrest adults (weak recommendation, low-
13	certainty evidence).
14	Justification and Evidence-to-Decision Framework Highlights
15	The complete evidence-to-decision table is provided in Appendix A2.
16	Prophylactic Antiseizure Medication
17	No new evidence has emerged on this topic since the prior review. The task force decided
18	to clarify the language slightly but saw no reason for substantive change. The task force
19	considered the evidence that the administration of prophylactic antiseizure medication in other
20	forms of acute brain injury is not associated with improved outcomes and that most prophylactic
21	antiseizure medications can have significant side effects. Finally, the task force acknowledged
22	that most comatose post-cardiac arrest patients routinely receive sedatives like propofol or
23	benzodiazepines, which are known to have antiseizure effects. However, the task force identified

- 1 no controlled studies that examined whether different sedation strategies or choices of sedation
- 2 drugs had an impact on the incidence of post-cardiac arrest seizures.
- 3 Seizure Treatment
- 4 The task force discussed the importance of consistent definitions when investigating this
- 5 topic and creating treatment recommendations. Terms and definitions established by the
- 6 American Clinical Neurophysiology Society are used in the discussion below and should be
- 7 employed consistently in trials (Table 11).⁶³

8 Table 11. ACNS Standardized Critical Care EEG Terminology 2021 for Electrographic 9 and Electroclinical Seizures

Category	Definition
Electrographic seizure	• Epileptiform discharges averaging >2.5 Hz for ≥10 s (>25
	discharges in 10 s)
	or
	• Any pattern with definite evolution as defined above and
	lasting ≥10 s
Electroclinical seizure	Any EEG pattern with either
	• Definite clinical correlate time-locked to the pattern (of any
	duration)
	or
	• EEG and clinical improvement with a parenteral (typically IV)
	antiseizure medication
Electroclinical status	An electroclinical seizure for
epilepticus	• ≥ 10 continuous min
	0 <i>1</i> *
	• A total duration of $\geq 20\%$ of any 60-min period of recording <i>or</i>

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

ACNS indicates American Clinical Neurophysiology Society; ECSE, electroclinical status epilepticus; EEG,

¹ 2 3 electroencephalogram; IV, intravenous; PD, periodic discharge; RDA, rhythmic delta activity; SE, status epilepticus; and SW, spike wave.

1		Other points of discussion included
2	•	Correct categorization of EEG findings requires the skilled interpretation of video EEG.
3	•	Untreated clinical seizure activity may cause additional brain injury, and, thus, treatment
4		of clinical seizures is recommended despite the lack of high-certainty evidence.
5	•	Rhythmic and periodic EEG patterns that do not meet criteria for electrographic seizures
6		are of unclear significance in patients who are comatose after cardiac arrest. It is not clear
7		if they represent a marker of an injured brain or if treatment may improve outcomes.
8	•	In the TELSTAR trial (Treatment of Electroencephalographic Status Epilepticus After
9		Cardiopulmonary Resuscitation), the majority (\approx 80%) of the EEG patterns were
10		generalized periodic discharges of 0.5 to 2.5 Hz without evolution. Whether such EEG
11		patterns deserve treatment is unknown, and no difference was seen in the trial. Post hoc
12		subgroup analysis of TELSTAR suggested a possible beneficial effect in the small
13		subgroup with electrographic seizures but not for treatment of periodic discharges. ⁶²
14	•	Indirect evidence from case series suggests sedatives such as propofol are effective in
15		suppressing clinical seizures and electrographic seizures. A retrospective study provides
16		some evidence that conventional antiseizure medications (specifically valproate and
17		levetiracetam) also have an effect in suppressing epileptiform activity in the EEG. ⁶⁴
18	•	There is no direct evidence of undesirable effects of antiseizure medications in comatose
19		post-cardiac arrest patients, although use of sedating agents may delay awakening.
20	•	The benefit of continuous EEG compared with intermittent EEG was not specifically
21		reviewed. Continuous EEG monitoring is labor intensive and likely to add significant
22		cost to patient care. The cost-effectiveness of this approach is controversial and may
23		depend substantially on the setting. The CERTA study (Continuous EEG Randomized

1	Trial in Adults) evaluated continuous versus intermittent EEG in critically ill adults with
2	impaired consciousness, and approximately one third of the subjects had been
3	resuscitated from cardiac arrest. ⁶⁵ No difference was found in outcome (6-month
4	mortality), although more seizures were detected and more frequent changes to
5	antiseizure medications were made in the continuous EEG group.
6	Knowledge Gaps
7	• Whether antiseizure medications affect the outcome of post-cardiac arrest patients with
8	either rhythmic and periodic EEG patterns or clinical seizures
9	• The optimal timing, duration, dosing, and choice of antiseizure medications for seizure
10	treatment in comatose post-cardiac arrest patients
11	• The utility and cost-effectiveness of continuous EEG versus intermittent EEG monitoring
12	in the diagnosis and treatment of seizures in comatose postarrest patients
13	• The threshold for treating rhythmic and periodic EEG activity
14	• The value of using volatile anesthetics to treat refractory status epilepticus in post-
15	cardiac arrest patients
16	Extracorporeal Cardiopulmonary Resuscitation (ALS 3001: SysRev)
17	Rationale for Review
18	The task force was aware of new research published on the use of ECPR, and the
19	decision was made to update our previous SysRev (PROSPERO registration
20	CRD42022341077). ^{66,67} This SysRev update was a joint effort between the ALS and Pediatric
21	Life Support Task Forces. For evidence related to pediatric cardiac arrest, refer to the Pediatric
22	Life Support section of this summary. The full CoSTR can be found online. ⁶⁸
1	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
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2	• Population: Adults (>18 years) with cardiac arrest in any setting (out-of-hospital or in-
3	hospital)
4	• Intervention: ECPR, including extracorporeal membrane oxygenation or
5	cardiopulmonary bypass during cardiac arrest
6	Comparators: Manual or mechanical cardiopulmonary resuscitation
7	Outcome: Any clinical outcome
8	• Study designs: RCTs were included. Observational studies, animal studies, ecological
9	studies, case series, case reports, reviews, abstracts, editorials, comments, letters to the
10	editor, and unpublished studies were excluded. Studies assessing cost-effectiveness were
11	included for a descriptive overview. Studies exclusively assessing the use of
12	extracorporeal life support for cardiac or respiratory failure after sustained ROSC were
13	excluded. Studies assessing extracorporeal circulation for deep hypothermia (or other
14	conditions) were included only if cardiac arrest was documented. All languages were
15	included if there was an English abstract or an English full-text article.
16	• Time frame: From June 21, 2022 (date of the search for the previous review), to May 10,
17	2023
18	Consensus on Science
19	A single new RCT was identified. ⁶⁹ This adds to the 3 RCTs identified in the previous
20	review. ^{67,70-72} Given the existence of 4 RCTs and the critical risk of bias of the observational
21	studies identified in prior reviews, only evidence from RCTs was considered.
22	The overall certainty of evidence was rated as low for OHCA and as very low for IHCA
23	(downgraded further because all evidence was in OHCA) for all outcomes. Because of a high

- 1 degree of heterogeneity between the randomized trials, no meta-analyses were performed. Key
- 2 results are summarized in Table 12.

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

Author,	n	Survival to discharge/30 d, n (%)		ARD (95%	Favorable outcome [*] at dis (%	functional scharge/30 d, n %) ARD (95%		Favorable functional outcome [*] at 6 mo, n (%)		ARD (95%
year		ECPR strategy	Standard care	CI), 70	ECPR strategy	Standard care	C1), 70	ECPR strategy	Standard care	ĊI), %
Yannopou	30	6/14 (43)	1/15 (7)	36 (7.4 to	3/14 (21)	0	21 (0 to 43)	6/14 (43)	0	43 (17 to
los, 2020 ⁷⁰				65)						69)
Hsu,	15	0	1/3 (33)	-33 (-87 to	0	0	0	NA	NA	NA
202171				20)						
Belohlave	264	52/124 (42)	43/132 (33)	9.4 (-2.4 to	38/124 (31)	24/132 (18)	13 (2 to 23)	39/124	29/132 (22)	10 (-1.3
k, 2022 ⁷²				21)				(32)		to 20)
Suverein,	134	14/70 (20)	13/64 (20)	-0.3 (-14 to	14/70 (20)	10/62 (16)	3.9 (-9.2 to	14/70 (20)	10/63 (16)	4.1 (-8.9
2023 ⁶⁹				13)			17)			to 17)

Favorable functional outcome defined as mRS score of 0 to 3 or CPC score of 1 to 2.
 ARD indicates absolute risk difference; CPC, Cerebral Performance Category; ECPR,

ARD indicates absolute risk difference; CPC, Cerebral Performance Category; ECPR, extracorporeal cardiopulmonary resuscitation; mRS, modified Rankin

5 Scale; and NA, not applicable.

1 Prior Treatment Recommendations (2023)

2	We suggest that ECPR may be considered as a rescue therapy for selected patients with
3	OHCA when conventional CPR is failing to restore spontaneous circulation in settings in which
4	this can be implemented (weak recommendation, low-certainty evidence).
5	We suggest that ECPR may be considered as a rescue therapy for selected patients with
6	IHCA when conventional CPR is failing to restore spontaneous circulation in settings in which
7	this can be implemented (weak recommendation, very low-certainty evidence).
8	2024 Treatment Recommendations
9	We suggest that extracorporeal cardiopulmonary resuscitation (ECPR) may be considered
10	as a rescue therapy for selected adults with out-of-hospital cardiac arrest when conventional
11	cardiopulmonary resuscitation is failing to restore spontaneous circulation in settings where this
12	can be implemented (weak recommendation, low-certainty evidence).
13	We suggest extracorporeal cardiopulmonary resuscitation (ECPR) may be considered as a
14	rescue therapy for selected adults with in-hospital cardiac arrest when conventional
15	cardiopulmonary resuscitation is failing to restore spontaneous circulation in settings where this
16	can be implemented (weak recommendation, very low-certainty evidence).
17	Justification and Evidence-to-Decision Framework Highlights
18	The complete evidence-to-decision table is provided in Appendix A2.
19	• In making this weak recommendation, we note that this patient population (ie, patients in
20	whom conventional CPR is failing during cardiac arrest) has an extremely high mortality
21	rate, particularly when refractory to standard advanced cardiac life support. Therefore,
22	the potential for benefit and value of this intervention remains despite the overall low
23	certainty of the evidence.

1	• The published randomized trials use highly selected patients for ECPR and not the
2	general population of all cardiac arrest cases. The trial by Yannopoulos et al ⁷⁰ enrolled
3	OHCA patients with an initial shockable rhythm and randomized patients upon hospital
4	arrival, whereas the trials by Hsu et al ⁷¹ and Belohlavek et al ⁷² enrolled OHCAs with any
5	initial rhythm and randomized patients in the prehospital setting. The trial by Suverein et
6	al ⁶⁹ enrolled OHCA patients with an initial shockable rhythm and randomized most
7	patients in the prehospital setting (63% in the ECPR group and 66% in the conventional
8	CPR group). Guidelines for clinical practice should ideally apply to similar populations,
9	although the optimal population remains undefined. For this reason, the findings of
10	individual trials should be interpreted cautiously in the context of the trial setting and
11	population.
12	• We acknowledge that ECPR is a complex intervention that requires considerable
13	resources and training that are not universally available but also acknowledge the value
14	of an intervention that may be successful in individuals for whom usual CPR techniques
15	have failed. In addition, ECPR can sustain perfusion while another intervention, such as
16	coronary angiography or percutaneous coronary intervention, can be performed.
17	Knowledge Gaps
18	• There are few, and no large, randomized trials of ECPR versus standard care
19	• The optimal patient population who may benefit from ECPR
20	• The optimal time to initiate ECPR in cases of refractory cardiac arrest
21	• Whether ECPR for OHCA should be initiated in the prehospital or in-hospital setting
22	• The optimal techniques for providing safe and timely ECPR
23	• The optimal post-cardiac arrest care strategy for patients resuscitated using ECPR

- Whether there are population-specific differences in performing ECPR for in-hospital
 cardiac arrest and OHCA
- Whether there are differences in quality of life between survivors of ECPR and standard
 CPR
- 5 The cost-effectiveness of ECPR
- 6 Cardiac Arrest During Pregnancy (ALS 3401: ScopRev)
- 7 *Rationale for Review*
- Cardiac arrest during pregnancy is a rare but catastrophic event. Physiologic changes 8 during pregnancy and concerns about both maternal and fetal survival bring additional 9 10 considerations to resuscitation of a pregnant patient. The task force was aware that the evidence 11 available was insufficient for a SysRev and meta-analysis to be possible but thought a review of 12 this topic was a high priority, and this ScopRev was thus completed. The full report of this ScopRev, including detailed tables describing the individual studies, can be found online.⁷³ 13 14 Population, Intervention, Comparator, Outcome, Study Design, and Time Frame 15 • Population: Pregnant or up to 1-year postpartum patients in cardiac arrest in any setting 16 (in-hospital or out-of-hospital) Intervention: Any specific intervention(s) 17 Comparators: Standard care or usual resuscitation practice 18
- Outcomes:
- 20 Maternal
- 21 Critical: Survival and favorable functional outcome at hospital discharge, 30 days, 60
- days, 180 days, or 1 year
- 23 Important: ROSC

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-	Neonatal
	Critical: Survival and favorable functional outcome at hospital discharge, 30 days, 60
	days, 180 days, or 1 year
	Important: ROSC
•	Study designs: RCTs and nonrandomized studies (non-RCTs, interrupted time series,
	controlled before-and-after studies, cohort studies, simulation/manikin and animal
	studies), case series with ≥ 20 patients, and descriptive studies without a comparator
	group were eligible for inclusion. Gray literature, social media, and non-peer-reviewed
	studies, unpublished studies, conference abstracts, and trial protocols were eligible for
	inclusion. All languages were included if there was an English abstract or an English full-
	text article.
•	Time frame: From August 2014 (date of prior review) to September 2023
Summ	nary of Evidence
	This ScopRev identified 8 heterogeneous studies describing several interventions for
cardia	c arrest during pregnancy.74-81 The studies are substantially limited by lack of granularity,
small	sample sizes, indirect measures of interventional effects, and high degrees of bias and
confor	unding.
	Studies are described in detail in the data tables in the online ScopRev. ⁷³ The studies
identif	fied concentrated on 3 interventions: (1) left-lateral uterine displacement with supine
positio	oning for resuscitation, (2) perimortem or resuscitative delivery, and (3) extracorporeal life
suppor	rt.
	Indirect data from a porcine model demonstrated significantly higher coronary perfusion
pressu	res during resuscitation with supine positioning with left-lateral uterine displacement
	Summ cardia small confou identif positio suppos

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1 compared with left-lateral tilt positioning (perfusion pressure of 20 mm Hg compared with 5 mm Hg, P < 0.05).⁷⁶ Five observational studies reported data supporting performing perimortem 2 3 cesarean or resuscitative delivery when ROSC does not occur early during resuscitation of cardiac arrest in a pregnant person with a uterine size >20 weeks' gestation.⁷⁷⁻⁸¹ The median 4 5 number of minutes from collapse to cesarean delivery in survivors and nonsurvivors varied 6 across studies, but shorter times from arrest to delivery were associated with improved maternal 7 and neonatal outcomes. Two studies suggested that extracorporeal life support may improve 8 pregnancy and peripartum outcomes for both the pregnant person and fetus in the setting of cardiac arrest, despite the potential of bleeding and clotting complications.^{74,75} 9

10 Task Force Insights

The task force prioritized this topic because of the ongoing burden of mortality during 11 12 pregnancy (estimated at 287 000 deaths globally in 2020, with mortality increasing in some countries, such as the United States).^{82,83} The prevalence of cardiac arrest during hospitalizations 13 14 for delivery in the United States from 2017 to 2019 rose to 1/9000, previously reported as 1/12 000 in 2014 using the US National Inpatient Sample database.⁸⁴ Cardiac arrest is the final 15 16 common pathway of several pathophysiologic conditions leading to death during pregnancy, 17 including hemorrhage, cardiomyopathy, hypertensive complications, embolic events, and sepsis. 18 Management of cardiac arrest is complex because it requires accommodation of the 19 physiological changes of pregnancy. Randomized trials are challenging to perform during 20 pregnancy, and the evidence on this topic is limited. For these reasons, the task force decided to 21 summarize the emerging research and identify specific knowledge gaps. The limited data did not 22 support a full SysRev or making any changes to existing treatment recommendations, but 2 good 23 practice statements were made.

1	2024 Treatment Recommendations (Unchanged) and Good Practice Statements (New)
2	We suggest delivery of the fetus by perimortem cesarean delivery for women in cardiac
3	arrest in the second half of pregnancy (weak recommendation, very low-certainty evidence).
4	There is insufficient evidence to define a specific time interval by which delivery should
5	begin.
6	High-quality usual resuscitation care and therapeutic interventions that target the most
7	likely cause(s) of cardiac arrest remain important in this population.
8	There is insufficient evidence to make a recommendation about the use of left-lateral tilt
9	and/or uterine displacement during CPR in the pregnant patient.
10	ECPR may be considered as a rescue therapy for selected cardiac arrest patients during
11	pregnancy or in the postpartum period when conventional CPR fails and in settings in which it
12	can be implemented (good practice statement).
13	This good practice statement does not replace the ALS treatment recommendation for use
14	of ECPR in general.
15	Institution readiness and resuscitation education are required to accommodate the unique
16	physiologic challenges of cardiac arrest during pregnancy (good practice statement).
17	Knowledge Gaps
18	• How to improve outcomes of cardiac arrest during pregnancy
19	• Optimal approach to airway management in cardiac arrest in pregnancy, including
20	placement of an advanced airway, tracheal intubation, and use of video laryngoscopy
21	• Optimal management of OHCA during pregnancy, including issues of transport and
22	consequent delays in perimortem or resuscitative delivery
23	• How to select patients most likely to benefit from, and not be harmed by, ECPR

1	Emergency Front of Neck Airway Access During Cardiac Arrest (ALS 3606: ScopRev)
2	Rationale for Review
3	This topic was selected for review by the ALS Task Force due to ongoing uncertainty
4	regarding optimal strategies for emergency airway management in cardiac arrest when standard
5	approaches to basic and advanced airway management fail. The full report of this ScopRev can
6	be found online. ⁸⁵
7	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
8	• Population: Adult patients in cardiac arrest in any setting in which adequate ventilation
9	cannot be rapidly achieved by using basic or advanced airway management strategies
10	• Intervention: Front-of-neck airway access attempt
11	• Comparators: Ongoing attempts at basic or advanced airway management strategies
12	Outcome: Any clinical outcome
13	• Study designs: RCTs, nonrandomized studies (eg, interrupted time series, controlled
14	before-and-after studies and cohort studies), and case series with at least 5 patients were
15	included. Animal studies, case series or reports with fewer than 5 patients, editorials,
16	protocols, review papers, and letters were excluded.
17	• Time frame: From inception to November 2, 2023
18	Summary of Evidence
19	Our search identified a single RCT ⁸⁶ and 68 observational studies from prehospital, in-
20	hospital, and military settings. ⁸⁷⁻¹⁵⁴ No studies specifically focused on cardiac arrest.
21	The RCT compared emergency cricothyrotomy and emergency percutaneous dilational

tracheostomy in 169 patients (9 with cardiac arrest) with failed airway management in the

1	emergency department. ⁸⁶ The success rate of percutaneous cricothyrotomy (95.3%) was similar
2	to that of percutaneous dilational tracheostomy (97.6%) (P=0.45).
3	The observational studies documented a median 11.4 front-of-neck access attempts per
4	study (interquartile range [IQR], 2.9-31.5). Most studies were trauma specific or a mix of trauma
5	and medical emergencies and occurred in a mix of prehospital, in-hospital, and military settings.
6	The most common emergency front-of-neck airway intervention was surgical cricothyroidotomy
7	Incidence of front-of-neck airway access attempts varied markedly across studies, from
8	0.06 to 436 attempts per 1000 patients. The variability was predominantly driven by the
9	denominator chosen in each study (eg, all intubation attempts or all cases of failed intubation).
10	Success rates were typically high, with most studies reporting success rates of >70%. Outcomes
11	varied markedly across studies. In cardiac arrest patients, rates of ROSC ranged from 0% to
12	64%. The evidence on complications was challenging to interpret because reporting was
13	inconsistent.
14	Task Force Insights
15	The task force discussed the review findings and noted the following:
16	• None of the available evidence directly addressed the review question.
17	• There were no studies that specifically examined patients in cardiac arrest, such that the
18	incidence of front-of-neck airway access attempts in the cardiac arrest population is
19	uncertain.
20	• The success rate of emergency front-of-neck airway access attempts was generally high.
21	• Clinical outcomes across studies varied markedly.
22	• The available evidence does not enable the task force to make comparisons across
23	different front-of-neck airway access strategies.

1	• The context of cardiac arrest (eg, ongoing chest compressions, unreliability of pulse
2	oximetry or other strategies to monitor oxygenation) may make it particularly challenging
3	to rapidly identify a failure to achieve adequate ventilation and adequate oxygenation.
4	• The task force recognized that the generation of high-quality data that directly address the
5	review question would be challenging.
6	2024 Good Practice Statement (New)
7	In adults in cardiac arrest, when standard airway management strategies (eg,
8	oropharyngeal airway and bag-mask, supraglottic airway, or tracheal tube) have failed, it is
9	reasonable for appropriately trained rescuers to attempt front-of-neck airway access using a
10	cricothyroidotomy technique (good practice statement).
11	Knowledge Gaps
12	• The incidence or success rate of emergency front-of-neck airway access attempts in the
13	adult cardiac arrest population
14	• The optimal timing for emergency front-of-neck airway access in adults in cardiac arrest
15	• Clinical outcomes of adults in cardiac arrest for whom emergency front-of-neck airway
16	access is attempted
17	• The optimal technique for achieving front-of-neck airway access
18	ALS Topics Reviewed by EvUps
19	ALS topics reviewed by EvUps are summarized in Table 13. Complete EvUps can be

20 found in Appendix B2.

1 Table 13. ALS Topics Reviewed With EvUps

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

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		If an advanced airway is used, we			ranging from glottic view	
		suggest a supraglottic airway or			to hospital survival).	
		tracheal intubation for adults with			Two randomized trials	
		out-of-hospital cardiac arrest in			compared proprietary	
		settings with a high tracheal			laryngoscopy tools against	
		intubation success rate (weak			direct laryngoscopy in	
		recommendation, very low-			small cohorts. In general,	
		certainty evidence).			findings favored the	
		If an advanced airway is used, we			proprietary tools over	
		suggest a supraglottic airway or			direct laryngoscopy.	
		tracheal intubation for adults with			Seven observational	
		in-hospital cardiac arrest (weak			studies, all limited by risk	
		recommendation, very low-			of bias, found an	
		certainty evidence).			association between early	
					advanced airway	
					placement and better	
					outcomes (patients who	
					did not receive an	
	1		1	1	1	<u> </u>

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

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
Cardiac	2010	There is insufficient evidence to	0	1 guideline		No
arrest		suggest any routine change to		paper		
associated		cardiac arrest resuscitation				
with asthma		treatment algorithms for patients				
(ALS 3408)		with cardiac arrest caused by				
		asthma.				
Antiarrhythm	2018	We suggest the use of amiodarone	0	20	Observational studies and	Yes for
ics during		or lidocaine in adults with shock	6 secondary		the secondary analyses of	beta
and after		refractory VF/pVT (weak	analyses of		prior RCTs generally	blockers
cardiac arrest		recommendation, low-quality	ROC-ALPS		favor amiodarone or	and
(ALS 3201,		evidence).	RCT		lidocaine over placebo,	procainami
3514)					supporting the current	de; No for
		We suggest against the routine use			treatment	other
		of magnesium in adults with shock-			recommendations.	agents
		refractory VF/pVT (weak				
		recommendation, very low-quality			Studies supported early	
		evidence).			administration of	
					antiarrhythmics during	
					cardiac arrest as survival	

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

ALS indicates advanced life support; CPR, cardiopulmonary resuscitation; CPRIC, CPR-induced consciousness; EvUp, evidence update; mCPR, mechanical

CPR; PICO, population, intervention, comparator, outcome; PTSD, posttraumatic stress disorder; RCT, randomized controlled trial; and SysRev, systematic review.

1 2 3

1 **References**

2	1. Berg KM, Soar J, Andersen LW, Bottiger BW, Cacciola S, Callaway CW, Couper K,
3	Cronberg T, D'Arrigo S, Deakin CD, Donnino MW, Drennan IR, Granfeldt A, Hoedemaekers
4	CWE, Holmberg MJ, Hsu CH, Kamps M, Musiol S, Nation KJ, Neumar RW, Nicholson T,
5	O'Neil BJ, Otto Q, de Paiva EF, Parr MJA, Reynolds JC, Sandroni C, Scholefield BR, Skrifvars
6	MB, Wang TL, Wetsch WA, Yeung J, Morley PT, Morrison LJ, Welsford M, Hazinski MF,
7	Nolan JP, Adult Advanced Life Support C. Adult Advanced Life Support: 2020 International
8	Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science
9	With Treatment Recommendations. Circulation. 2020;142:S92-S139. doi:
10	10.1161/CIR.00000000000893
11	2. Holmberg MJ, Nicholson T, Nolan JP, Schexnayder S, Reynolds J, Nation K, Welsford
12	M, Morley P, Soar J, Berg KM, Adult Pediatric Advanced Life Support Task Forces at the
13	International Liaison Committee on R. Oxygenation and ventilation targets after cardiac arrest: A
14	systematic review and meta-analysis. Resuscitation. 2020;152:107-115. doi:
15	10.1016/j.resuscitation.2020.04.031
16	3. Soar J, Berg KM, Andersen LW, Bottiger BW, Cacciola S, Callaway CW, Couper K,
17	Cronberg T, D'Arrigo S, Deakin CD, Donnino MW, Drennan IR, Granfeldt A, Hoedemaekers
18	CWE, Holmberg MJ, Hsu CH, Kamps M, Musiol S, Nation KJ, Neumar RW, Nicholson T,
19	O'Neil BJ, Otto Q, de Paiva EF, Parr MJA, Reynolds JC, Sandroni C, Scholefield BR, Skrifvars
20	MB, Wang TL, Wetsch WA, Yeung J, Morley PT, Morrison LJ, Welsford M, Hazinski MF,
21	Nolan JP, Adult Advanced Life Support C. Adult Advanced Life Support: 2020 International
22	Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with

1 Treatment Recommendations. *Resuscitation*. 2020;156:A80-A119. doi:

2 10.1016/j.resuscitation.2020.09.012

3 4. Holmberg MJ, Ikeyama T, Garg R, Drennan I, Lavonas E, Bray J, Olasveengen T, Berg 4 KM; on behalf of the Advanced Life Support and Basic Life Support Task Forces. Oxygenation 5 and ventilation targets after cardiac arrest: an updated systematic review and meta-analysis: 6 Consensus on Science With Treatment Recommendations. Accessed February 8, 2024. 7 https://costr.ilcor.org/document/oxygen-and-carbon-dioxide-targets-in-patients-with-return-of-8 spontaneous-circulation-after-cardiac-arrest-als-sr 9 5. Bernard SA, Bray JE, Smith K, Stephenson M, Finn J, Grantham H, Hein C, Masters S, 10 Stub D, Perkins GD, Dodge N, Martin C, Hopkins S, Cameron P, Investigators E. Effect of 11 Lower vs Higher Oxygen Saturation Targets on Survival to Hospital Discharge Among Patients 12 Resuscitated After Out-of-Hospital Cardiac Arrest: The EXACT Randomized Clinical Trial. JAMA. 2022;328:1818-1826. doi: 10.1001/jama.2022.17701 13 14 6. Eastwood G, Nichol AD, Hodgson C, Parke RL, McGuinness S, Nielsen N, Bernard S, 15 Skrifvars MB, Stub D, Taccone FS, Archer J, Kutsogiannis D, Dankiewicz J, Lilja G, Cronberg 16 T, Kirkegaard H, Capellier G, Landoni G, Horn J, Olasveengen T, Arabi Y, Chia YW, Markota 17 A, Haenggi M, Wise MP, Grejs AM, Christensen S, Munk-Andersen H, Granfeldt A, Andersen GO, Qvigstad E, Flaa A, Thomas M, Sweet K, Bewley J, Backlund M, Tiainen M, Iten M, Levis 18 19 A, Peck L, Walsham J, Deane A, Ghosh A, Annoni F, Chen Y, Knight D, Lesona E, Tlayjeh H, 20 Svensek F, McGuigan PJ, Cole J, Pogson D, Hilty MP, During JP, Bailey MJ, Paul E, Ady B, 21 Ainscough K, Hunt A, Monahan S, Trapani T, Fahey C, Bellomo R, Investigators TS. Mild 22 Hypercapnia or Normocapnia after Out-of-Hospital Cardiac Arrest. N Engl J Med. 2023;389:45-23 57. doi: 10.1056/NEJMoa2214552

1	7. Semler MW, Casey JD, Lloyd BD, Hastings PG, Hays MA, Stollings JL, Buell KG,
2	Brems JH, Qian ET, Seitz KP, Wang L, Lindsell CJ, Freundlich RE, Wanderer JP, Han JH,
3	Bernard GR, Self WH, Rice TW, Investigators P, the Pragmatic Critical Care Research G.
4	Oxygen-Saturation Targets for Critically Ill Adults Receiving Mechanical Ventilation. N Engl J
5	Med. 2022;387:1759-1769. doi: 10.1056/NEJMoa2208415
6	8. Schmidt H, Kjaergaard J, Hassager C, Molstrom S, Grand J, Borregaard B, Roelsgaard
7	Obling LE, Veno S, Sarkisian L, Mamaev D, Jensen LO, Nyholm B, Hofsten DE, Josiassen J,
8	Thomsen JH, Thune JJ, Lindholm MG, Stengaard Meyer MA, Winther-Jensen M, Sorensen M,
9	Frydland M, Beske RP, Frikke-Schmidt R, Wiberg S, Boesgaard S, Lind Jorgensen V, Moller
10	JE. Oxygen Targets in Comatose Survivors of Cardiac Arrest. N Engl J Med. 2022;387:1467-
11	1476. doi: 10.1056/NEJMoa2208686
12	9. Crescioli E, Lass Klitgaard T, Perner A, Lilleholt Schjorring O, Steen Rasmussen B.
13	Lower versus higher oxygenation targets in hypoxaemic ICU patients after cardiac arrest.
14	Resuscitation. 2023;188:109838. doi: 10.1016/j.resuscitation.2023.109838
15	10. Jakkula P, Reinikainen M, Hastbacka J, Loisa P, Tiainen M, Pettila V, Toppila J, Lahde
16	M, Backlund M, Okkonen M, Bendel S, Birkelund T, Pulkkinen A, Heinonen J, Tikka T,
17	Skrifvars MB, group Cs. Targeting two different levels of both arterial carbon dioxide and
18	arterial oxygen after cardiac arrest and resuscitation: a randomised pilot trial. Intensive Care
19	Med. 2018;44:2112-2121. doi: 10.1007/s00134-018-5453-9
20	11. Thomas M, Voss S, Benger J, Kirby K, Nolan JP. Cluster randomised comparison of the
21	effectiveness of 100% oxygen versus titrated oxygen in patients with a sustained return of
22	spontaneous circulation following out of hospital cardiac arrest: a feasibility study. PROXY: post
23	ROSC OXYgenation study. BMC Emerg Med. 2019;19:16. doi: 10.1186/s12873-018-0214-1

1	12. Eastwood GM, Tanaka A, Espinoza ED, Peck L, Young H, Martensson J, Zhang L,
2	Glassford NJ, Hsiao YF, Suzuki S, Bellomo R. Conservative oxygen therapy in mechanically
3	ventilated patients following cardiac arrest: A retrospective nested cohort study. Resuscitation.
4	2016;101:108-114. doi: 10.1016/j.resuscitation.2015.11.026
5	13. Young P, Mackle D, Bellomo R, Bailey M, Beasley R, Deane A, Eastwood G, Finfer S,
6	Freebairn R, King V, Linke N, Litton E, McArthur C, McGuinness S, Panwar R, Investigators I-
7	R, the A, New Zealand Intensive Care Society Clinical Trials G. Conservative oxygen therapy
8	for mechanically ventilated adults with suspected hypoxic ischaemic encephalopathy. Intensive
9	Care Med. 2020;46:2411-2422. doi: 10.1007/s00134-020-06196-y
10	14. Bray JE, Hein C, Smith K, Stephenson M, Grantham H, Finn J, Stub D, Cameron P,
11	Bernard S, Investigators E. Oxygen titration after resuscitation from out-of-hospital cardiac
12	arrest: A multi-centre, randomised controlled pilot study (the EXACT pilot trial). Resuscitation.
13	2018;128:211-215. doi: 10.1016/j.resuscitation.2018.04.019
14	15. Kuisma M, Boyd J, Voipio V, Alaspaa A, Roine RO, Rosenberg P. Comparison of 30
15	and the 100% inspired oxygen concentrations during early post-resuscitation period: a
16	randomised controlled pilot study. Resuscitation. 2006;69:199-206. doi:
17	10.1016/j.resuscitation.2005.08.010
18	16. Investigators I-R, the A, New Zealand Intensive Care Society Clinical Trials G, Mackle
19	D, Bellomo R, Bailey M, Beasley R, Deane A, Eastwood G, Finfer S, Freebairn R, King V,
20	Linke N, Litton E, McArthur C, McGuinness S, Panwar R, Young P, Australian I-RIt, New
21	Zealand Intensive Care Society Clinical Trials G. Conservative Oxygen Therapy during
22	Mechanical Ventilation in the ICU. N Engl J Med. 2020;382:989-998. doi:
23	10.1056/NEJMoa1903297

1	17. Sjoding MW, Dickson RP, Iwashyna TJ, Gay SE, Valley TS. Racial Bias in Pulse
2	Oximetry Measurement. N Engl J Med. 2020;383:2477-2478. doi: 10.1056/NEJMc2029240
3	18. Wong AI, Charpignon M, Kim H, Josef C, de Hond AAH, Fojas JJ, Tabaie A, Liu X,
4	Mireles-Cabodevila E, Carvalho L, Kamaleswaran R, Madushani R, Adhikari L, Holder AL,
5	Steyerberg EW, Buchman TG, Lough ME, Celi LA. Analysis of Discrepancies Between Pulse
6	Oximetry and Arterial Oxygen Saturation Measurements by Race and Ethnicity and Association
7	With Organ Dysfunction and Mortality. JAMA Netw Open. 2021;4:e2131674. doi:
8	10.1001/jamanetworkopen.2021.31674
9	19. Jamali H, Castillo LT, Morgan CC, Coult J, Muhammad JL, Osobamiro OO, Parsons EC,
10	Adamson R. Racial Disparity in Oxygen Saturation Measurements by Pulse Oximetry: Evidence
11	and Implications. Ann Am Thorac Soc. 2022;19:1951-1964. doi: 10.1513/AnnalsATS.202203-
12	270CME
13	20. Moon SW, Lee SW, Choi SH, Hong YS, Kim SJ, Kim NH. Arterial minus end-tidal CO2
14	as a prognostic factor of hospital survival in patients resuscitated from cardiac arrest.
15	Resuscitation. 2007;72:219-225. doi: 10.1016/j.resuscitation.2006.06.034
16	21. Mueller M, Jankow E, Grafeneder J, Schoergenhofer C, Poppe M, Schriefl C, Clodi C,
17	Koch M, Ettl F, Holzer M, Losert H. The difference between arterial pCO(2) and etCO(2) after
18	cardiac arrest - Outcome predictor or marker of unfavorable resuscitation circumstances? $Am J$
19	Emerg Med. 2022;61:120-126. doi: 10.1016/j.ajem.2022.08.058
20	22. Kim YW, Hwang SO, Kang HS, Cha KC. The gradient between arterial and end-tidal
21	carbon dioxide predicts in-hospital mortality in post-cardiac arrest patient. Am J Emerg Med.
22	2019;37:1-4. doi: 10.1016/j.ajem.2018.04.025

1 251 Horananie (102 Hill, Counte ord, Danielson Hill, Daiger 1(2), Harjiara C, Carloom D	ahamowicz AA, (nowicz AA, Counts CR, Danielso	on KR, Bulger NE, Ma	ynard C, Carlbom E
---	-----------------	--------------------------------	----------------------	--------------------

- 2 Swenson ER, Latimer AJ, Yang B, Sayre MR, Johnson NJ. The association between arterial-end-
- 3 tidal carbon dioxide difference and outcomes after out-of-hospital cardiac arrest. *Resuscitation*.
- 4 2022;181:3-9. doi: 10.1016/j.resuscitation.2022.09.019
- 5 24. Callaway CW, Soar J, Aibiki M, Bottiger BW, Brooks SC, Deakin CD, Donnino MW,
- 6 Drajer S, Kloeck W, Morley PT, Morrison LJ, Neumar RW, Nicholson TC, Nolan JP, Okada K,
- 7 O'Neil BJ, Paiva EF, Parr MJ, Wang TL, Witt J, Advanced Life Support Chapter C. Part 4:
- 8 Advanced Life Support: 2015 International Consensus on Cardiopulmonary Resuscitation and
- 9 Emergency Cardiovascular Care Science With Treatment Recommendations. *Circulation*.
- 10 2015;132:S84-145. doi: 10.1161/CIR.000000000000273
- 11 25. Soar J, Callaway CW, Aibiki M, Bottiger BW, Brooks SC, Deakin CD, Donnino MW,
- 12 Drajer S, Kloeck W, Morley PT, Morrison LJ, Neumar RW, Nicholson TC, Nolan JP, Okada K,
- 13 O'Neil BJ, Paiva EF, Parr MJ, Wang TL, Witt J, Advanced Life Support Chapter C. Part 4:
- 14 Advanced life support: 2015 International Consensus on Cardiopulmonary Resuscitation and
- 15 Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation*.
- 16 2015;95:e71-120. doi: 10.1016/j.resuscitation.2015.07.042
- 17 26. Niemela V, Siddiqui F, Ameloot K, Reinikainen M, Grand J, Hastbacka J, Hassager C,
- 18 Kjaergaard J, Aneman A, Tiainen M, Nielsen N, Harboe Olsen M, Jorgensen CK, Juul Petersen
- 19 J, Dankiewicz J, Saxena M, Jakobsen JC, Skrifvars MB. Higher versus lower blood pressure
- 20 targets after cardiac arrest: Systematic review with individual patient data meta-analysis.
- 21 Resuscitation. 2023;189:109862. doi: 10.1016/j.resuscitation.2023.109862
- 22 27. Skrifvars MB HM, Ohshimo S, Berg KM, Drennan I. Mean arterial blood pressure target
- 23 after cardiac arrest: Consensus on Science With Treatment Recommendations. Accessed

1	February 8, 2024. https://costr.ilcor.org/document/mean-arterial-blood-pressure-target-in-post-
2	cardiac-arrest-care-patients-als-new-tfsr
3	28. Ameloot K, De Deyne C, Eertmans W, Ferdinande B, Dupont M, Palmers PJ, Petit T,
4	Nuyens P, Maeremans J, Vundelinckx J, Vanhaverbeke M, Belmans A, Peeters R, Demaerel P,
5	Lemmens R, Dens J, Janssens S. Early goal-directed haemodynamic optimization of cerebral
6	oxygenation in comatose survivors after cardiac arrest: the Neuroprotect post-cardiac arrest trial.
7	Eur Heart J. 2019;40:1804-1814. doi: 10.1093/eurheartj/ehz120
8	29. Grand J, Meyer AS, Kjaergaard J, Wiberg S, Thomsen JH, Frydland M, Ostrowski SR,
9	Johansson PI, Hassager C. A randomised double-blind pilot trial comparing a mean arterial
10	pressure target of 65 mm Hg versus 72 mm Hg after out-of-hospital cardiac arrest. Eur Heart J
11	Acute Cardiovasc Care. 2020;9:S100-S109. doi: 10.1177/2048872619900095
12	30. Jakkula P, Pettila V, Skrifvars MB, Hastbacka J, Loisa P, Tiainen M, Wilkman E,
13	Toppila J, Koskue T, Bendel S, Birkelund T, Laru-Sompa R, Valkonen M, Reinikainen M, group
14	Cs. Targeting low-normal or high-normal mean arterial pressure after cardiac arrest and
15	resuscitation: a randomised pilot trial. Intensive Care Med. 2018;44:2091-2101. doi:
16	10.1007/s00134-018-5446-8
17	31. Kjaergaard J, Moller JE, Schmidt H, Grand J, Molstrom S, Borregaard B, Veno S,
18	Sarkisian L, Mamaev D, Jensen LO, Nyholm B, Hofsten DE, Josiassen J, Thomsen JH, Thune
19	JJ, Obling LER, Lindholm MG, Frydland M, Meyer MAS, Winther-Jensen M, Beske RP,
20	Frikke-Schmidt R, Wiberg S, Boesgaard S, Madsen SA, Jorgensen VL, Hassager C. Blood-

21 Pressure Targets in Comatose Survivors of Cardiac Arrest. *N Engl J Med.* 2022;387:1456-1466.

22 doi: 10.1056/NEJMoa2208687

Greif - 121

1 32. Bro-Jeppesen J, Annborn M, Hassager C, Wise MP, Pelosi P, Nielsen N, Erlinge D, 2 Wanscher M, Friberg H, Kjaergaard J, Investigators TTM. Hemodynamics and vasopressor 3 support during targeted temperature management at 33 degrees C Versus 36 degrees C after out-4 of-hospital cardiac arrest: a post hoc study of the target temperature management trial*. Crit 5 Care Med. 2015;43:318-327. doi: 10.1097/CCM.000000000000691 6 33. Laurikkala J, Wilkman E, Pettila V, Kurola J, Reinikainen M, Hoppu S, Ala-Kokko T, 7 Tallgren M, Tiainen M, Vaahersalo J, Varpula T, Skrifvars MB, Group FS. Mean arterial 8 pressure and vasopressor load after out-of-hospital cardiac arrest: Associations with one-year 9 neurologic outcome. Resuscitation. 2016;105:116-122. doi: 10.1016/j.resuscitation.2016.05.026 10 34. McGuigan PJ, Giallongo E, Blackwood B, Doidge J, Harrison DA, Nichol AD, Rowan 11 KM, Shankar-Hari M, Skrifvars MB, Thomas K, McAuley DF. The effect of blood pressure on 12 mortality following out-of-hospital cardiac arrest: a retrospective cohort study of the United 13 Kingdom Intensive Care National Audit and Research Centre database. Crit Care. 2023;27:4. 14 doi: 10.1186/s13054-022-04289-2 15 35. Rhodes A, Evans LE, Alhazzani W, Levy MM, Antonelli M, Ferrer R, Kumar A, 16 Sevransky JE, Sprung CL, Nunnally ME, Rochwerg B, Rubenfeld GD, Angus DC, Annane D, 17 Beale RJ, Bellinghan GJ, Bernard GR, Chiche JD, Coopersmith C, De Backer DP, French CJ, 18 Fujishima S, Gerlach H, Hidalgo JL, Hollenberg SM, Jones AE, Karnad DR, Kleinpell RM, Koh 19 Y, Lisboa TC, Machado FR, Marini JJ, Marshall JC, Mazuski JE, McIntyre LA, McLean AS, Mehta S, Moreno RP, Myburgh J, Navalesi P, Nishida O, Osborn TM, Perner A, Plunkett CM, 20 21 Ranieri M, Schorr CA, Seckel MA, Seymour CW, Shieh L, Shukri KA, Simpson SQ, Singer M, 22 Thompson BT, Townsend SR, Van der Poll T, Vincent JL, Wiersinga WJ, Zimmerman JL,

1	Dellinger RP. Surviving Sepsis Campaign: International Guidelines for Management of Sepsis
2	and Septic Shock: 2016. Intensive Care Med. 2017;43:304-377. doi: 10.1007/s00134-017-4683-6
3	36. Granfeldt A, Holmberg MJ, Nolan JP, Soar J, Andersen LW, International Liaison
4	Committee on Resuscitation IALSTF. Temperature control after adult cardiac arrest: An updated
5	systematic review and meta-analysis. Resuscitation. 2023;191:109928. doi:
6	10.1016/j.resuscitation.2023.109928
7	37. Granfeldt A, Holmberg MJ, Soar J, Nolan JP, Skrifvars M, Berg KM, Drennan I; on
8	behalf of the ILCOR ALS Task Force. Temperature control in adult cardiac arrest: Consensus on
9	Science With Treatment Recommendations. Accessed February 8, 2024.
10	https://costr.ilcor.org/document/temperature-control-in-adult-cardiac-arrest-als-tf-sr
11	38. Bernard SA, Gray TW, Buist MD, Jones BM, Silvester W, Gutteridge G, Smith K.
12	Treatment of comatose survivors of out-of-hospital cardiac arrest with induced hypothermia. N
13	Engl J Med. 2002;346:557-563. doi: 10.1056/NEJMoa003289
14	39. Hypothermia after Cardiac Arrest Study G. Mild therapeutic hypothermia to improve the
15	neurologic outcome after cardiac arrest. N Engl J Med. 2002;346:549-556. doi:
16	10.1056/NEJMoa012689
17	40. Laurent I, Adrie C, Vinsonneau C, Cariou A, Chiche JD, Ohanessian A, Spaulding C,
18	Carli P, Dhainaut JF, Monchi M. High-volume hemofiltration after out-of-hospital cardiac arrest:
19	a randomized study. J Am Coll Cardiol. 2005;46:432-437. doi: 10.1016/j.jacc.2005.04.039
20	41. Lascarrou JB, Merdji H, Le Gouge A, Colin G, Grillet G, Girardie P, Coupez E, Dequin
21	PF, Cariou A, Boulain T, Brule N, Frat JP, Asfar P, Pichon N, Landais M, Plantefeve G, Quenot
22	JP, Chakarian JC, Sirodot M, Legriel S, Letheulle J, Thevenin D, Desachy A, Delahaye A, Botoc

23 V, Vimeux S, Martino F, Giraudeau B, Reignier J, Group C-T. Targeted Temperature

2 2337. doi: 10.1056/NEJMoa1906661

3 42. Dankiewicz J, Cronberg T, Lilja G, Jakobsen JC, Levin H, Ullen S, Rylander C, Wise 4 MP, Oddo M, Cariou A, Belohlavek J, Hovdenes J, Saxena M, Kirkegaard H, Young PJ, Pelosi 5 P, Storm C, Taccone FS, Joannidis M, Callaway C, Eastwood GM, Morgan MPG, Nordberg P, 6 Erlinge D, Nichol AD, Chew MS, Hollenberg J, Thomas M, Bewley J, Sweet K, Grejs AM, 7 Christensen S, Haenggi M, Levis A, Lundin A, During J, Schmidbauer S, Keeble TR, Karamasis 8 GV, Schrag C, Faessler E, Smid O, Otahal M, Maggiorini M, Wendel Garcia PD, Jaubert P, Cole 9 JM, Solar M, Borgquist O, Leithner C, Abed-Maillard S, Navarra L, Annborn M, Unden J, 10 Brunetti I, Awad A, McGuigan P, Bjorkholt Olsen R, Cassina T, Vignon P, Langeland H, Lange 11 T, Friberg H, Nielsen N, Investigators TTMT. Hypothermia versus Normothermia after Out-of-12 Hospital Cardiac Arrest. N Engl J Med. 2021;384:2283-2294. doi: 10.1056/NEJMoa2100591 13 43. Wolfrum S, Roedl K, Hanebutte A, Pfeifer R, Kurowski V, Riessen R, Daubmann A, 14 Braune S, Soffker G, Bibiza-Freiwald E, Wegscheider K, Schunkert H, Thiele H, Kluge S, 15 Hypothermia After In-Hospital Cardiac Arrest Study G. Temperature Control After In-Hospital 16 Cardiac Arrest: A Randomized Clinical Trial. Circulation. 2022;146:1357-1366. doi: 17 10.1161/CIRCULATIONAHA.122.060106 18 44. Hachimi-Idrissi S, Zizi M, Nguyen DN, Schiettecate J, Ebinger G, Michotte Y, Huyghens 19 L. The evolution of serum astroglial S-100 beta protein in patients with cardiac arrest treated

- 20 with mild hypothermia. *Resuscitation*. 2005;64:187-192. doi:
- 21 10.1016/j.resuscitation.2004.08.008
- 22 45. Nielsen N, Wetterslev J, Cronberg T, Erlinge D, Gasche Y, Hassager C, Horn J,
- 23 Hovdenes J, Kjaergaard J, Kuiper M, Pellis T, Stammet P, Wanscher M, Wise MP, Aneman A,

1	Al-Subaie N, Boesgaard S, Bro-Jeppesen J, Brunetti I, Bugge JF, Hingston CD, Juffermans NP,
2	Koopmans M, Kober L, Langorgen J, Lilja G, Moller JE, Rundgren M, Rylander C, Smid O,
3	Werer C, Winkel P, Friberg H, Investigators TTMT. Targeted temperature management at 33
4	degrees C versus 36 degrees C after cardiac arrest. N Engl J Med. 2013;369:2197-2206. doi:
5	10.1056/NEJMoa1310519
6	46. Kwon WY, Jung YS, Suh GJ, Kim T, Kwak H, Kim T, Kim JY, Lee MS, Kim KS, Shin
7	J, Lee HJ, You KM. Regional cerebral oxygen saturation in cardiac arrest survivors undergoing
8	targeted temperature management 36 degrees C versus 33 degrees C: A randomized clinical trial.
9	Resuscitation. 2021;167:362-371. doi: 10.1016/j.resuscitation.2021.07.026
10	47. Tahara Y, Noguchi T, Yonemoto N, Nakashima T, Yasuda S, Kikuchi M, Hashiba K,
11	Arimoto H, Nishioka K, Kokubu N, Atsumi T, Kashiwase K, Kasaoka S, Kuroda Y, Kada A,
12	Yokoyama H, Nonogi H, Group JP-H-DTS. Cluster Randomized Trial of Duration of Cooling in
13	Targeted Temperature Management After Resuscitation for Cardiac Arrest. Circ Rep.
14	2021;3:368-374. doi: 10.1253/circrep.CR-21-0062
15	48. Kirkegaard H, Soreide E, de Haas I, Pettila V, Taccone FS, Arus U, Storm C, Hassager
16	C, Nielsen JF, Sorensen CA, Ilkjaer S, Jeppesen AN, Grejs AM, Duez CHV, Hjort J, Larsen AI,
17	Toome V, Tiainen M, Hastbacka J, Laitio T, Skrifvars MB. Targeted Temperature Management
18	for 48 vs 24 Hours and Neurologic Outcome After Out-of-Hospital Cardiac Arrest: A
19	Randomized Clinical Trial. JAMA. 2017;318:341-350. doi: 10.1001/jama.2017.8978
20	49. Pittl U, Schratter A, Desch S, Diosteanu R, Lehmann D, Demmin K, Horig J, Schuler G,
21	Klemm T, Mende M, Thiele H. Invasive versus non-invasive cooling after in- and out-of-hospital
22	cardiac arrest: a randomized trial. Clin Res Cardiol. 2013;102:607-614. doi: 10.1007/s00392-
23	013-0572-3

1	50. Deye N, Cariou A, Girardie P, Pichon N, Megarbane B, Midez P, Tonnelier JM, Boulain
2	T, Outin H, Delahaye A, Cravoisy A, Mercat A, Blanc P, Santre C, Quintard H, Brivet F,
3	Charpentier J, Garrigue D, Francois B, Quenot JP, Vincent F, Gueugniaud PY, Mira JP, Carli P,
4	Vicaut E, Baud FJ, Clinical, Economical Impact of Endovascular Cooling in the Management of
5	Cardiac Arrest Study G. Endovascular Versus External Targeted Temperature Management for
6	Patients With Out-of-Hospital Cardiac Arrest: A Randomized, Controlled Study. Circulation.
7	2015;132:182-193. doi: 10.1161/CIRCULATIONAHA.114.012805
8	51. Look X, Li H, Ng M, Lim ETS, Pothiawala S, Tan KBK, Sewa DW, Shahidah N, Pek
9	PP, Ong MEH. Randomized controlled trial of internal and external targeted temperature
10	management methods in post- cardiac arrest patients. Am J Emerg Med. 2018;36:66-72. doi:
11	10.1016/j.ajem.2017.07.017
12	52. Lascarrou JB, Guichard E, Reignier J, Le Gouge A, Pouplet C, Martin S, Lacherade JC,
13	Colin G, After Rn. Impact of rewarming rate on interleukin-6 levels in patients with shockable
14	cardiac arrest receiving targeted temperature management at 33 degrees C: the ISOCRATE pilot
15	randomized controlled trial. Crit Care. 2021;25:434. doi: 10.1186/s13054-021-03842-9
16	53. Hassager C, Schmidt H, Moller JE, Grand J, Molstrom S, Beske RP, Boesgaard S,
17	Borregaard B, Bekker-Jensen D, Dahl JS, Frydland MS, Hofsten DE, Isse YA, Josiassen J, Lind
18	Jorgensen VR, Kondziella D, Lindholm MG, Moser E, Nyholm BC, Obling LER, Sarkisian L,
19	Sondergaard FT, Thomsen JH, Thune JJ, Veno S, Wiberg SC, Winther-Jensen M, Meyer MAS,
20	Kjaergaard J. Duration of Device-Based Fever Prevention after Cardiac Arrest. N Engl J Med.
21	2023;388:888-897. doi: 10.1056/NEJMoa2212528
22	54. Wyckoff MH, Greif R, Morley PT, Ng KC, Olasveengen TM, Singletary EM, Soar J,
23	Cheng A, Drennan IR, Liley HG, Scholefield BR, Smyth MA, Welsford M, Zideman DA,

1	Acworth J, Aickin R, Andersen LW, Atkins D, Berry DC, Bhanji F, Bierens J, Borra V, Bottiger
2	BW, Bradley RN, Bray JE, Breckwoldt J, Callaway CW, Carlson JN, Cassan P, Castren M,
3	Chang WT, Charlton NP, Chung SP, Considine J, Costa-Nobre DT, Couper K, Couto TB, Dainty
4	KN, Davis PG, de Almeida MF, de Caen AR, Deakin CD, Djarv T, Donnino MW, Douma MJ,
5	Duff JP, Dunne CL, Eastwood K, El-Naggar W, Fabres JG, Fawke J, Finn J, Foglia EE, Folke F,
6	Gilfoyle E, Goolsby CA, Granfeldt A, Guerguerian AM, Guinsburg R, Hirsch KG, Holmberg
7	MJ, Hosono S, Hsieh MJ, Hsu CH, Ikeyama T, Isayama T, Johnson NJ, Kapadia VS, Kawakami
8	MD, Kim HS, Kleinman M, Kloeck DA, Kudenchuk PJ, Lagina AT, Lauridsen KG, Lavonas EJ,
9	Lee HC, Lin YJ, Lockey AS, Maconochie IK, Madar RJ, Malta Hansen C, Masterson S,
10	Matsuyama T, McKinlay CJD, Meyran D, Morgan P, Morrison LJ, Nadkarni V, Nakwa FL,
11	Nation KJ, Nehme Z, Nemeth M, Neumar RW, Nicholson T, Nikolaou N, Nishiyama C, Norii T,
12	Nuthall GA, O'Neill BJ, Ong YG, Orkin AM, Paiva EF, Parr MJ, Patocka C, Pellegrino JL,
13	Perkins GD, Perlman JM, Rabi Y, Reis AG, Reynolds JC, Ristagno G, Rodriguez-Nunez A,
14	Roehr CC, Rudiger M, Sakamoto T, Sandroni C, Sawyer TL, Schexnayder SM, Schmolzer GM,
15	Schnaubelt S, Semeraro F, Skrifvars MB, Smith CM, Sugiura T, Tijssen JA, Trevisanuto D, Van
16	de Voorde P, Wang TL, Weiner GM, Wyllie JP, Yang CW, Yeung J, Nolan JP, Berg KM,
17	Collaborators. 2022 International Consensus on Cardiopulmonary Resuscitation and Emergency
18	Cardiovascular Care Science With Treatment Recommendations: Summary From the Basic Life
19	Support; Advanced Life Support; Pediatric Life Support; Neonatal Life Support; Education,
20	Implementation, and Teams; and First Aid Task Forces. Circulation. 2022;146:e483-e557. doi:
21	10.1161/CIR.000000000001095
22	55. Wyckoff MH, Greif R, Morley PT, Ng KC, Olasveengen TM, Singletary EM, Soar J,
23	Cheng A, Drennan IR, Liley HG, Scholefield BR, Smyth MA, Welsford M, Zideman DA,

1	Acworth J, Aickin R, Andersen LW, Atkins D, Berry DC, Bhanji F, Bierens J, Borra V, Bottiger
2	BW, Bradley RN, Bray JE, Breckwoldt J, Callaway CW, Carlson JN, Cassan P, Castren M,
3	Chang WT, Charlton NP, Phil Chung S, Considine J, Costa-Nobre DT, Couper K, Couto TB,
4	Dainty KN, Davis PG, de Almeida MF, de Caen AR, Deakin CD, Djarv T, Donnino MW,
5	Douma MJ, Duff JP, Dunne CL, Eastwood K, El-Naggar W, Fabres JG, Fawke J, Finn J, Foglia
6	EE, Folke F, Gilfoyle E, Goolsby CA, Granfeldt A, Guerguerian AM, Guinsburg R, Hirsch KG,
7	Holmberg MJ, Hosono S, Hsieh MJ, Hsu CH, Ikeyama T, Isayama T, Johnson NJ, Kapadia VS,
8	Kawakami MD, Kim HS, Kleinman M, Kloeck DA, Kudenchuk PJ, Lagina AT, Lauridsen KG,
9	Lavonas EJ, Lee HC, Lin YJ, Lockey AS, Maconochie IK, Madar RJ, Malta Hansen C,
10	Masterson S, Matsuyama T, McKinlay CJD, Meyran D, Morgan P, Morrison LJ, Nadkarni V,
11	Nakwa FL, Nation KJ, Nehme Z, Nemeth M, Neumar RW, Nicholson T, Nikolaou N, Nishiyama
12	C, Norii T, Nuthall GA, O'Neill BJ, Gene Ong YK, Orkin AM, Paiva EF, Parr MJ, Patocka C,
13	Pellegrino JL, Perkins GD, Perlman JM, Rabi Y, Reis AG, Reynolds JC, Ristagno G, Rodriguez-
14	Nunez A, Roehr CC, Rudiger M, Sakamoto T, Sandroni C, Sawyer TL, Schexnayder SM,
15	Schmolzer GM, Schnaubelt S, Semeraro F, Skrifvars MB, Smith CM, Sugiura T, Tijssen JA,
16	Trevisanuto D, Van de Voorde P, Wang TL, Weiner GM, Wyllie JP, Yang CW, Yeung J, Nolan
17	JP, Berg KM, Collaborators. 2022 International Consensus on Cardiopulmonary Resuscitation
18	and Emergency Cardiovascular Care Science With Treatment Recommendations: Summary
19	From the Basic Life Support; Advanced Life Support; Pediatric Life Support; Neonatal Life
20	Support; Education, Implementation, and Teams; and First Aid Task Forces. Resuscitation.
21	2022;181:208-288. doi: 10.1016/j.resuscitation.2022.10.005
22	56. Bartlett ES, Valenzuela T, Idris A, Deye N, Glover G, Gillies MA, Taccone FS, Sunde K,
23	Flint AC, Thiele H, Arrich J, Hemphill C, Holzer M, Skrifvars MB, Pittl U, Polderman KH, Ong

1	MEH, Kim KH	I, Oh SH, Do	Shin S, Kirkega	ard H, Nichol G	G. Systematic	review and meta-
	,	, ,	, , , , , , , , , , , , , , , , , , , ,	,	2	

2 analysis of intravascular temperature management vs. surface cooling in comatose patients

3 resuscitated from cardiac arrest. *Resuscitation*. 2020;146:82-95. doi:

- 4 10.1016/j.resuscitation.2019.10.035
- 5 57. Kim JG, Ahn C, Shin H, Kim W, Lim TH, Jang BH, Cho Y, Choi KS, Lee J, Na MK.
- 6 Efficacy of the cooling method for targeted temperature management in post-cardiac arrest

7 patients: A systematic review and meta-analysis. *Resuscitation*. 2020;148:14-24. doi:

- 8 10.1016/j.resuscitation.2019.12.025
- 9 58. Nicholson TC, Hirsch K, Berg KM, Drennan I, Lavonas E; on behalf of the Advanced

10 Life Support Task Force. Effect of seizure treatment for adults and children following cardiac

11 arrest on patient outcomes: a systematic review. Accessed February 8, 2024.

12 https://costr.ilcor.org/document/effect-of-prophylaxis-and-treatment-of-seizures-on-outcome-of-

13 adults-following-cardiac-arrest-als-tfsr

14 59. Brain Resuscitation Clinical Trial ISG. Randomized clinical study of thiopental loading

15 in comatose survivors of cardiac arrest. *N Engl J Med.* 1986;314:397-403. doi:

16 10.1056/NEJM198602133140701

17 60. Longstreth WT, Jr., Fahrenbruch CE, Olsufka M, Walsh TR, Copass MK, Cobb LA.

18 Randomized clinical trial of magnesium, diazepam, or both after out-of-hospital cardiac arrest.

- 19 Neurology. 2002;59:506-514. doi: 10.1212/wnl.59.4.506
- 20 61. Monsalve F, Rucabado L, Ruano M, Cunat J, Lacueva V, Vinuales A. The neurologic
- 21 effects of thiopental therapy after cardiac arrest. *Intensive Care Med.* 1987;13:244-248. doi:

22 10.1007/BF00265112

1	62. Ruijter BJ, Keijzer HM, Tjepkema-Cloostermans MC, Blans MJ, Beishuizen A, Tromp					
2	SC, Scholten E, Horn J, van Rootselaar AF, Admiraal MM, van den Bergh WM, Elting JJ,					
3	Foudraine NA, Kornips FHM, van Kranen-Mastenbroek V, Rouhl RPW, Thomeer EC,					
4	Moudrous W, Nijhuis FAP, Booij SJ, Hoedemaekers CWE, Doorduin J, Taccone FS, van der					
5	Palen J, van Putten M, Hofmeijer J, Investigators T. Treating Rhythmic and Periodic EEG					
6	Patterns in Comatose Survivors of Cardiac Arrest. N Engl J Med. 2022;386:724-734. doi:					
7	10.1056/NEJMoa2115998					
8	63. Hirsch LJ, Fong MWK, Leitinger M, LaRoche SM, Beniczky S, Abend NS, Lee JW,					
9	Wusthoff CJ, Hahn CD, Westover MB, Gerard EE, Herman ST, Haider HA, Osman G,					
10	Rodriguez-Ruiz A, Maciel CB, Gilmore EJ, Fernandez A, Rosenthal ES, Claassen J, Husain AM,					
11	Yoo JY, So EL, Kaplan PW, Nuwer MR, van Putten M, Sutter R, Drislane FW, Trinka E,					
12	Gaspard N. American Clinical Neurophysiology Society's Standardized Critical Care EEG					
13	Terminology: 2021 Version. J Clin Neurophysiol. 2021;38:1-29. doi:					
14	10.1097/WNP.0000000000000806					
15	64. Solanki P, Coppler PJ, Kvaloy JT, Baldwin MA, Callaway CW, Elmer J, Pittsburgh Post-					
16	Cardiac Arrest S. Association of antiepileptic drugs with resolution of epileptiform activity after					
17	cardiac arrest. Resuscitation. 2019;142:82-90. doi: 10.1016/j.resuscitation.2019.07.007					
18	65. Rossetti AO, Schindler K, Sutter R, Ruegg S, Zubler F, Novy J, Oddo M, Warpelin-					
19	Decrausaz L, Alvarez V. Continuous vs Routine Electroencephalogram in Critically Ill Adults					
20	With Altered Consciousness and No Recent Seizure: A Multicenter Randomized Clinical Trial.					
21	JAMA Neurol. 2020;77:1225-1232. doi: 10.1001/jamaneurol.2020.2264					
22	66. Holmberg MJ, Geri G, Wiberg S, Guerguerian AM, Donnino MW, Nolan JP, Deakin CD,					
23	Andersen LW, International Liaison Committee on Resuscitation's Advanced Life S, Pediatric					

1		1 1 1	•• .	1	· · ·
	Lock H Hytrocorpored	l cordioniilmonor	V requirentation to	r cordine orrect. A	suctamotic routou
1	TASK F. EXHAUDIDOICA	i caluiopunnonai	v resuscitation for	i Calulac allest. A	systematic review.
-					

2 Resuscitation. 2018;131:91-100. doi: 10.1016/j.resuscitation.2018.07.029

3 67. Holmberg MJ, Granfeldt A, Guerguerian AM, Sandroni C, Hsu CH, Gardner RM, Lind

4 PC, Eggertsen MA, Johannsen CM, Andersen LW. Extracorporeal cardiopulmonary

5 resuscitation for cardiac arrest: An updated systematic review. *Resuscitation*. 2023;182:109665.

6 doi: 10.1016/j.resuscitation.2022.12.003

7 68. International Liaison Committee on Resuscitation. Extracorporeal cardiopulmonary

8 resuscitation (ECPR) for cardiac arrest. Accessed February 8, 2024.

9 https://costr.ilcor.org/document/extracorporeal-cardiopulmonary-resuscitation-ecpr-for-cardiac-

10 arrest-als-sr

11 69. Suverein MM, Delnoij TSR, Lorusso R, Brandon Bravo Bruinsma GJ, Otterspoor L, Elzo

12 Kraemer CV, Vlaar APJ, van der Heijden JJ, Scholten E, den Uil C, Jansen T, van den Bogaard

13 B, Kuijpers M, Lam KY, Montero Cabezas JM, Driessen AHG, Rittersma SZH, Heijnen BG,

14 Dos Reis Miranda D, Bleeker G, de Metz J, Hermanides RS, Lopez Matta J, Eberl S, Donker

15 DW, van Thiel RJ, Akin S, van Meer O, Henriques J, Bokhoven KC, Mandigers L, Bunge JJH,

16 Bol ME, Winkens B, Essers B, Weerwind PW, Maessen JG, van de Poll MCG. Early

17 Extracorporeal CPR for Refractory Out-of-Hospital Cardiac Arrest. N Engl J Med.

18 2023;388:299-309. doi: 10.1056/NEJMoa2204511

19 70. Yannopoulos D, Bartos J, Raveendran G, Walser E, Connett J, Murray TA, Collins G,

20 Zhang L, Kalra R, Kosmopoulos M, John R, Shaffer A, Frascone RJ, Wesley K, Conterato M,

21 Biros M, Tolar J, Aufderheide TP. Advanced reperfusion strategies for patients with out-of-

22 hospital cardiac arrest and refractory ventricular fibrillation (ARREST): a phase 2, single centre,

1 open-label, randomised controlled trial. Lancet. 2020;396:1807-1816. doi: 10.1016/S0140-

2 6736(20)32338-2

3 71. Hsu CH, Meurer WJ, Domeier R, Fowler J, Whitmore SP, Bassin BS, Gunnerson KJ,

4 Haft JW, Lynch WR, Nallamothu BK, Havey RA, Kidwell KM, Stacey WC, Silbergleit R,

5 Bartlett RH, Neumar RW. Extracorporeal Cardiopulmonary Resuscitation for Refractory Out-of-

6 Hospital Cardiac Arrest (EROCA): Results of a Randomized Feasibility Trial of Expedited Out-

7 of-Hospital Transport. Ann Emerg Med. 2021;78:92-101. doi:

8 10.1016/j.annemergmed.2020.11.011

9 72. Belohlavek J, Smalcova J, Rob D, Franek O, Smid O, Pokorna M, Horak J, Mrazek V,

10 Kovarnik T, Zemanek D, Kral A, Havranek S, Kavalkova P, Kompelentova L, Tomkova H,

11 Mejstrik A, Valasek J, Peran D, Pekara J, Rulisek J, Balik M, Huptych M, Jarkovsky J, Malik J,

12 Valerianova A, Mlejnsky F, Kolouch P, Havrankova P, Romportl D, Komarek A, Linhart A,

13 Prague OSG. Effect of Intra-arrest Transport, Extracorporeal Cardiopulmonary Resuscitation,

14 and Immediate Invasive Assessment and Treatment on Functional Neurologic Outcome in

15 Refractory Out-of-Hospital Cardiac Arrest: A Randomized Clinical Trial. JAMA. 2022;327:737-

16 747. doi: 10.1001/jama.2022.1025

17 73. Zelop CM, Shamshirsaz A, Drennan I, Berg K; on behalf of the Advanced Life Support

18 Task Force. Resuscitation interventions for cardiac arrest during pregnancy: Consensus on

19 Science With Treatment Recommendations. Accessed February 8, 2024.

20 https://costr.ilcor.org/document/resuscitation-interventions-for-cardiac-arrest-during-pregnancy21 als-scr

22 74. van den Bosch OFC, Chaudhry R, Wicker J, Mubashir T, Limb D, Jogendran R, Munshi

23 L, Balki M. Predictors and Hospital Outcomes in Pregnant Patients Undergoing Extracorporeal

1 Membrane Oxygenation: A Nationwide Study. *Anesth Analg.* 2022;135:1172-1179. doi:

2 10.1213/ANE.000000000006210

3 75. Naoum EE, Chalupka A, Haft J, MacEachern M, Vandeven CJM, Easter SR, Maile M,

4 Bateman BT, Bauer ME. Extracorporeal Life Support in Pregnancy: A Systematic Review. J Am

5 Heart Assoc. 2020;9:e016072. doi: 10.1161/JAHA.119.016072

6 76. Dohi S, Ichizuka K, Matsuoka R, Seo K, Nagatsuka M, Sekizawa A. Coronary perfusion

7 pressure and compression quality in maternal cardiopulmonary resuscitation in supine and left-

8 lateral tilt positions: A prospective, crossover study using mannequins and swine models. *Eur J*

9 Obstet Gynecol Reprod Biol. 2017;216:98-103. doi: 10.1016/j.ejogrb.2017.07.019

10 77. Kobori S, Toshimitsu M, Nagaoka S, Yaegashi N, Murotsuki J. Utility and limitations of

11 perimortem cesarean section: A nationwide survey in Japan. J Obstet Gynaecol Res.

12 2019;45:325-330. doi: 10.1111/jog.13819

13 78. Beckett VA, Knight M, Sharpe P. The CAPS Study: incidence, management and

14 outcomes of cardiac arrest in pregnancy in the UK: a prospective, descriptive study. *BJOG*.

15 2017;124:1374-1381. doi: 10.1111/1471-0528.14521

16 79. Maurin O, Lemoine S, Jost D, Lanoe V, Renard A, Travers S, The Paris Fire Brigade

17 Cardiac Arrest Work G, Lapostolle F, Tourtier JP. Maternal out-of-hospital cardiac arrest: A

18 retrospective observational study. *Resuscitation*. 2019;135:205-211. doi:

19 10.1016/j.resuscitation.2018.11.001

20 80. Schaap TP, Overtoom E, van den Akker T, Zwart JJ, van Roosmalen J, Bloemenkamp

21 KWM. Maternal cardiac arrest in the Netherlands: A nationwide surveillance study. Eur J Obstet

22 Gynecol Reprod Biol. 2019;237:145-150. doi: 10.1016/j.ejogrb.2019.04.028
1	81.	Benson MD, Padovano A, Bourjeily G, Zhou Y. Maternal collapse: Challenging the four-
2	minut	e rule. EBioMedicine. 2016;6:253-257. doi: 10.1016/j.ebiom.2016.02.042
3	82.	Zarocostas J. Global maternal mortality rates stagnating. Lancet. 2023;401:632. doi:
4	10.10	16/S0140-6736(23)00385-9
5	83.	Thoma ME, Declercq ER. Changes in Pregnancy-Related Mortality Associated With the
6	Coror	navirus Disease 2019 (COVID-19) Pandemic in the United States. Obstet Gynecol.
7	2023;	141:911-917. doi: 10.1097/AOG.000000000005182
8	84.	Ford ND, DeSisto CL, Galang RR, Kuklina EV, Sperling LS, Ko JY. Cardiac Arrest
9	Durin	g Delivery Hospitalization : A Cohort Study. Ann Intern Med. 2023;176:472-479. doi:
10	10.732	26/M22-2750
11	85.	Aljanoubi M, Almazrua M, Drennan I, Reynolds, J, Soar J, Couper K; on behalf of the
12	Intern	ational Liaison Committee on Resuscitation Advanced Life Support Task Force.
13	Emerg	gency front of neck airway access in adult cardiac arrest: Consensus on Science With
14	Treatr	ment Recommendations. Accessed February 8, 2024.
15	https:/	//costr.ilcor.org/document/emergency-front-of-neck-airway-access-in-adult-cardiac-arrest-
16	als-tf-	scr
17	86.	Beshey BN, Helmy TA, Asaad HS. Emergency percutaneous tracheotomy in failed
18	intuba	ation. Egyptian Journal of Chest Diseases and Tuberculosis. 2014;63:939-945.
19	87.	Adams BD, Cuniowski PA, Muck A, De Lorenzo RA. Registry of emergency airways
20	arrivii	ng at combat hospitals. J Trauma. 2008;64:1548-1554. doi:
21	10.10	97/TA.0b013e3181728c41
22	88.	Alkhouri H, Richards C, Miers J, Fogg T, McCarthy S. Case series and review of
23	emerg	gency front-of-neck surgical airways from The Australian and New Zealand Emergency

- 1 Department Airway Registry. Emerg Med Australas. 2021;33:499-507. doi: 10.1111/1742-
- 2 6723.13678
- 3 89. Arora RD, Rao KN, Satpute S, Mehta R, Dange P, Nagarkar NM, Abishek AP.
- 4 Emergency Tracheostomy in Locally Advanced Anaplastic Thyroid Cancer. Indian J Surg
- 5 Oncol. 2023;14:714-722. doi: 10.1007/s13193-023-01753-5
- 6 90. Aziz S, Foster E, Lockey DJ, Christian MD. Emergency scalpel cricothyroidotomy use in
- 7 a prehospital trauma service: a 20-year review. *Emerg Med J.* 2021;38:349-354. doi:
- 8 10.1136/emermed-2020-210305
- 9 91. Bair AE, Filbin MR, Kulkarni RG, Walls RM. The failed intubation attempt in the
- 10 emergency department: analysis of prevalence, rescue techniques, and personnel. *J Emerg Med.*
- 11 2002;23:131-140. doi: 10.1016/s0736-4679(02)00501-2
- 12 92. Bair AE, Panacek EA, Wisner DH, Bales R, Sakles JC. Cricothyrotomy: a 5-year
- 13 experience at one institution. J Emerg Med. 2003;24:151-156. doi: 10.1016/s0736-
- 14 4679(02)00715-1
- 15 93. Barnard EBG, Ervin AT, Mabry RL, Bebarta VS. Prehospital and en route
- 16 cricothyrotomy performed in the combat setting: a prospective, multicenter, observational study.
- 17 J Spec Oper Med. 2014;14:35-39. doi: 10.55460/62V1-UIZC
- 18 94. Beit Ner E, Tsur AM, Nadler R, Glassberg E, Benov A, Chen J. High Success Rate of
- 19 Prehospital and En Route Cricothyroidotomy Performed in the Israel Defense Forces: 20 Years
- 20 of Experience. *Prehosp Disaster Med.* 2021;36:713-718. doi: 10.1017/S1049023X21001199
- 21 95. Benov A, Shkolnik I, Glassberg E, Nadler R, Gendler S, Antebi B, Chen J, Fink N, Bader
- 22 T. Prehospital trauma experience of the Israel defense forces on the Syrian border 2013-2017. J
- 23 Trauma Acute Care Surg. 2019;87:S165-S171. doi: 10.1097/TA.00000000002217

1	96.	Boyle MF, Hatton D, Sheets C. Surgical cricothyrotomy performed by air ambulance
2	flight	nurses: a 5-year experience. J Emerg Med. 1993;11:41-45. doi: 10.1016/0736-
3	4679(9	93)90008-u
4	97.	Brown CA, 3rd, Cox K, Hurwitz S, Walls RM. 4,871 Emergency airway encounters by
5	air me	dical providers: a report of the air transport emergency airway management (NEAR VI:
6	"A-TE	EAM") project. West J Emerg Med. 2014;15:188-193. doi: 10.5811/westjem.2013.11.18549
7	98.	Bulger EM, Copass MK, Maier RV, Larsen J, Knowles J, Jurkovich GJ. An analysis of
8	advan	ced prehospital airway management. J Emerg Med. 2002;23:183-189. doi: 10.1016/s0736-
9	4679((02)00490-0
10	99.	Cook TM, Woodall N, Frerk C, Fourth National Audit P. Major complications of airway
11	manag	gement in the UK: results of the Fourth National Audit Project of the Royal College of
12	Anaes	thetists and the Difficult Airway Society. Part 1: anaesthesia. Br J Anaesth. 2011;106:617-
13	631. d	oi: 10.1093/bja/aer058
14	100.	Cook TM, Woodall N, Harper J, Benger J, Fourth National Audit P. Major complications
15	of airv	vay management in the UK: results of the Fourth National Audit Project of the Royal
16	Colleg	ge of Anaesthetists and the Difficult Airway Society. Part 2: intensive care and emergency
17	depart	ments. Br J Anaesth. 2011;106:632-642. doi: 10.1093/bja/aer059
18	101.	Darby JM, Halenda G, Chou C, Quinlan JJ, Alarcon LH, Simmons RL. Emergency
19	Surgic	al Airways Following Activation of a Difficult Airway Management Team in Hospitalized
20	Critica	ally Ill Patients: A Case Series. J Intensive Care Med. 2018;33:517-526. doi:
21	10.117	77/0885066616680594
22	102.	DeLaurier GA, Hawkins ML, Treat RC, Mansberger AR, Jr. Acute airway management.
23	Role o	of cricothyroidotomy. Am Surg. 1990;56:12-15.

1	103. Diggs LA, Yusuf JE, De Leo G. An update on out-of-hospital airway management
2	practices in the United States. Resuscitation. 2014;85:885-892. doi:
3	10.1016/j.resuscitation.2014.02.032
4	104. Duggan LV, Lockhart SL, Cook TM, O'Sullivan EP, Dare T, Baker PA. The Airway
5	App: exploring the role of smartphone technology to capture emergency front-of-neck airway
6	experiences internationally. Anaesthesia. 2018;73:703-710. doi: 10.1111/anae.14247
7	105. Erlandson MJ, Clinton JE, Ruiz E, Cohen J. Cricothyrotomy in the emergency
8	department revisited. J Emerg Med. 1989;7:115-118. doi: 10.1016/0736-4679(89)90254-0
9	106. Gellerfors M, Fevang E, Backman A, Kruger A, Mikkelsen S, Nurmi J, Rognas L,
10	Sandstrom E, Skallsjo G, Svensen C, Gryth D, Lossius HM. Pre-hospital advanced airway
11	management by anaesthetist and nurse anaesthetist critical care teams: a prospective
12	observational study of 2028 pre-hospital tracheal intubations. Br J Anaesth. 2018;120:1103-
13	1109. doi: 10.1016/j.bja.2017.12.036
14	107. George N, Consunji G, Storkersen J, Dong F, Archambeau B, Vara R, Serrano J, Hajjafar
15	R, Tran L, Neeki MM. Comparison of emergency airway management techniques in the
16	performance of emergent Cricothyrotomy. Int J Emerg Med. 2022;15:24. doi: 10.1186/s12245-
17	022-00427-3
18	108. Gerich TG, Schmidt U, Hubrich V, Lobenhoffer HP, Tscherne H. Prehospital airway
19	management in the acutely injured patient: the role of surgical cricothyrotomy revisited. J
20	Trauma. 1998;45:312-314. doi: 10.1097/00005373-199808000-00017
A 1	

- 21 109. Germann CA, Baumann MR, Kendall KM, Strout TD, McGraw K. Performance of
- 22 endotracheal intubation and rescue techniques by emergency services personnel in an air medical
- 23 service. Prehosp Emerg Care. 2009;13:44-49. doi: 10.1080/10903120802474505

1	110. Gillespie MB, Eisele DW. Outcomes of emergency surgical airway procedures in a
2	hospital-wide setting. Laryngoscope. 1999;109:1766-1769. doi: 10.1097/00005537-199911000-
3	00008
4	111. Graham DB, Eastman AL, Aldy KN, Carroll EA, Minei JP, Brakenridge SC, Phelan HA.
5	Outcomes and long term follow-up after emergent cricothyroidotomy: is routine conversion to
6	tracheostomy necessary? Am Surg. 2011;77:1707-1711. doi: 10.1177/000313481107701248
7	112. Hawkins ML, Shapiro MB, Cue JI, Wiggins SS. Emergency cricothyrotomy: a
8	reassessment. Am Surg. 1995;61:52-55.
9	113. High K, Brywczynski J, Han JH. Cricothyrotomy in Helicopter Emergency Medical
10	Service Transport. Air Med J. 2018;37:51-53. doi: 10.1016/j.amj.2017.10.004
11	114. Himmler A, McDermott C, Martucci J, Rhoades E, Trankiem CT, Johnson LS. Code
12	Critical Airway: A Collaborative Solution to a Catastrophic Problem. Am Surg. 2023;89:2460-
13	2467. doi: 10.1177/00031348221101485
14	115. Hudson IL, Blackburn MB, Staudt AM, Ryan KL, Mann-Salinas EA. Analysis of
15	Casualties That Underwent Airway Management Before Reaching Role 2 Facilities in the
16	Afghanistan Conflict 2008-2014. Mil Med. 2020;185:10-18. doi: 10.1093/milmed/usz383
17	116. Isaacs JH, Jr. Emergency cricothyrotomy: long-term results. Am Surg. 2001;67:346-349;
18	discussion 349-350.
19	117. Jacobson LE, Gomez GA, Sobieray RJ, Rodman GH, Solotkin KC, Misinski ME.
20	Surgical cricothyroidotomy in trauma patients: analysis of its use by paramedics in the field. J
21	Trauma. 1996;41:15-20. doi: 10.1097/00005373-199607000-00004

- 22 118. Jansen G, Scholz SS, Rehberg SW, Wnent J, Grasner JT, Seewald S. Indications and
- 23 measures of medical emergency teams: a retrospective evaluation of in-hospital emergency

1 operations of the German Resuscitation Register. *Minerva Anestesiol*. 2023;89:56-65. doi:

2 10.23736/S0375-9393.22.16665-4

3 119. Kamiutsuri K, Okutani R, Kozawa S. Analysis of prehospital endotracheal intubation

4 performed by emergency physicians: retrospective survey of a single emergency medical center

5 in Japan. J Anesth. 2013;27:374-379. doi: 10.1007/s00540-012-1528-x

- 6 120. Katzenell U, Lipsky AM, Abramovich A, Huberman D, Sergeev I, Deckel A, Kreiss Y,
- 7 Glassberg E. Prehospital intubation success rates among Israel Defense Forces providers:
- 8 epidemiologic analysis and effect on doctrine. *J Trauma Acute Care Surg.* 2013;75:S178-183.
- 9 doi: 10.1097/TA.0b013e318299d650
- 10 121. King D, Ogilvie M, Michailidou M, Velmahos G, Alam H, deMoya M, Fikry K. Fifty-
- 11 four emergent cricothyroidotomies: are surgeons reluctant teachers? Scand J Surg. 2012;101:13-
- 12 15. doi: 10.1177/145749691210100103
- 13 122. Kwon YS, Lee CA, Park S, Ha SO, Sim YS, Baek MS. Incidence and outcomes of
- 14 cricothyrotomy in the "cannot intubate, cannot oxygenate" situation. *Medicine (Baltimore)*.

15 2019;98:e17713. doi: 10.1097/MD.000000000017713

- 16 123. Kyle T, le Clerc S, Thomas A, Greaves I, Whittaker V, Smith JE. The success of
- 17 battlefield surgical airway insertion in severely injured military patients: a UK perspective. J R
- 18 Army Med Corps. 2016;162:460-464. doi: 10.1136/jramc-2016-000637
- 19 124. Lairet JR, Bebarta VS, Burns CJ, Lairet KF, Rasmussen TE, Renz EM, King BT,
- 20 Fernandez W, Gerhardt R, Butler F, DuBose J, Cestero R, Salinas J, Torres P, Minnick J,
- 21 Blackbourne LH. Prehospital interventions performed in a combat zone: a prospective
- 22 multicenter study of 1,003 combat wounded. J Trauma Acute Care Surg. 2012;73:S38-42. doi:
- 23 10.1097/TA.0b013e3182606022

1	125.	Leibovici D, Fredman B, Gofrit ON, Shemer J, Blumenfeld A, Shapira SC. Prehospital
2	cricot	hyroidotomy by physicians. Am J Emerg Med. 1997;15:91-93. doi: 10.1016/s0735-
3	6757(97)90059-0
4	126.	Mabry RL, Frankfurt A. An analysis of battlefield cricothyrotomy in Iraq and
5	Afgha	anistan. J Spec Oper Med. 2012;12:17-23. doi: 10.55460/FYQG-8E49
6	127.	Malkan RM, Borelli CM, Fairley RR, De Lorenzo RA, April MD, Schauer SG.
7	Outco	omes after Prehospital Cricothyrotomy. Med J (Ft Sam Houst Tex). 2023:70-73.
8	128.	McGill J, Clinton JE, Ruiz E. Cricothyrotomy in the emergency department. Ann Emerg
9	Med.	1982;11:361-364. doi: 10.1016/s0196-0644(82)80362-4
10	129.	McIntosh SE, Swanson ER, Barton ED. Cricothyrotomy in air medical transport. J
11	Traun	na. 2008;64:1543-1547. doi: 10.1097/TA.0b013e3181271b60
12	130.	Moroco AE, Armen SB, Goldenberg D. Emergency Cricothyrotomy: A 10-Year Single
13	Institu	ation Experience. Am Surg. 2023;89:1243-1246. doi: 10.1177/0003134821995075
14	131.	Nugent WL, Rhee KJ, Wisner DH. Can nurses perform surgical cricothyrotomy with
15	accep	table success and complication rates? Ann Emerg Med. 1991;20:367-370. doi:
16	10.10	16/s0196-0644(05)81656-7
17	132.	Offenbacher J, Nikolla DA, Carlson JN, Smith SW, Genes N, Boatright DH, Brown CA,
18	3rd. In	ncidence of rescue surgical airways after attempted orotracheal intubation in the emergency
19	depar	tment: A National Emergency Airway Registry (NEAR) Study. Am J Emerg Med.
20	2023;	68:22-27. doi: 10.1016/j.ajem.2023.02.020
21	133.	Okada A, Okada Y, Kandori K, Ishii W, Narumiya H, Iizuka R. Adverse events of
22	emerg	gency surgical front of neck airway access: an observational descriptive study. Acute Med

23 Surg. 2022;9:e750. doi: 10.1002/ams2.750

1	134. Paix BR, Griggs WM. Emergency surgical cricothyroidotomy: 24 successful cases
2	leading to a simple 'scalpel-finger-tube' method. Emerg Med Australas. 2012;24:23-30. doi:
3	10.1111/j.1742-6723.2011.01510.x
4	135. Peters J, Bruijstens L, van der Ploeg J, Tan E, Hoogerwerf N, Edwards M. Indications
5	and results of emergency surgical airways performed by a physician-staffed helicopter
6	emergency service. Injury. 2015;46:787-790. doi: 10.1016/j.injury.2014.11.024
7	136. Peters J, van Wageningen B, Hendriks I, Eijk R, Edwards M, Hoogerwerf N, Biert J.
8	First-pass intubation success rate during rapid sequence induction of prehospital anaesthesia by
9	physicians versus paramedics. Eur J Emerg Med. 2015;22:391-394. doi:
10	10.1097/MEJ.00000000000161
11	137. Prekker ME, Kwok H, Shin J, Carlbom D, Grabinsky A, Rea TD. The process of
12	prehospital airway management: challenges and solutions during paramedic endotracheal
13	intubation. Crit Care Med. 2014;42:1372-1378. doi: 10.1097/CCM.00000000000213
14	138. Pugh HE, LeClerc S, McLennan J. A review of pre-admission advanced airway
15	management in combat casualties, Helmand Province 2013. J R Army Med Corps.
16	2015;161:121-126. doi: 10.1136/jramc-2014-000271
17	139. Robinson KJ, Katz R, Jacobs LM. A 12-year experience with prehospital
18	cricothyrotomies. Air Med J. 2001;20:27-30.
19	140. Rosenstock CV, Norskov AK, Wetterslev J, Lundstrom LH, Danish Anaesthesia D.
20	Emergency surgical airway management in Denmark: a cohort study of 452 461 patients
21	registered in the Danish Anaesthesia Database. Br J Anaesth. 2016;117 Suppl 1:i75-i82. doi:
22	10.1093/bja/aew190

1	141. Salvino CK, Dries D, Gamelli R, Murphy-Macabobby M, Marshall W. Emergency
2	cricothyroidotomy in trauma victims. J Trauma. 1993;34:503-505. doi: 10.1097/00005373-
3	199304000-00006
4	142. Schauer SG, Bellamy MA, Mabry RL, Bebarta VS. A comparison of the incidence of
5	cricothyrotomy in the deployed setting to the emergency department at a level 1 military trauma
6	center: a descriptive analysis. Mil Med. 2015;180:60-63. doi: 10.7205/MILMED-D-14-00384
7	143. Schauer SG, Naylor JF, Maddry JK, Beaumont DM, Cunningham CW, Blackburn MB,
8	April MD. Prehospital Airway Management in Iraq and Afghanistan: A Descriptive Analysis.
9	South Med J. 2018;111:707-713. doi: 10.14423/SMJ.000000000000000906
10	144. Schober P, Biesheuvel T, de Leeuw MA, Loer SA, Schwarte LA. Prehospital
11	cricothyrotomies in a helicopter emergency medical service: analysis of 19,382 dispatches. BMC
12	Emerg Med. 2019;19:12. doi: 10.1186/s12873-019-0230-9
13	145. Shapey IM, Kumar DS, Roberts K. Invasive and surgical procedures in pre-hospital care:
14	what is the need? Eur J Trauma Emerg Surg. 2012;38:633-639. doi: 10.1007/s00068-012-0207-9
15	146. Spaite DW, Joseph M. Prehospital cricothyrotomy: an investigation of indications,
16	technique, complications, and patient outcome. Ann Emerg Med. 1990;19:279-285. doi:
17	10.1016/s0196-0644(05)82045-1
18	147. Sunde GA, Heltne JK, Lockey D, Burns B, Sandberg M, Fredriksen K, Hufthammer KO,
19	Soti A, Lyon R, Jantti H, Kamarainen A, Reid BO, Silfvast T, Harm F, Sollid SJ, Airport Study
20	G. Airway management by physician-staffed Helicopter Emergency Medical Services - a
21	prospective, multicentre, observational study of 2,327 patients. Scand J Trauma Resusc Emerg

22 Med. 2015;23:57. doi: 10.1186/s13049-015-0136-9

- 1 148. Thomas SH, Harrison T, Wedel SK. Flight crew airway management in four settings: a
- 2 six-year review. Prehosp Emerg Care. 1999;3:310-315. doi: 10.1080/10903129908958960
- 3 149. Tobin JM, Nordmann GR, Kuncir EJ. Resuscitation During Critical Care Transportation
- 4 in Afghanistan. J Spec Oper Med. 2015;15:72-75. doi: 10.55460/V3ZO-RG71
- 5 150. Wang HE, Mann NC, Mears G, Jacobson K, Yealy DM. Out-of-hospital airway
- 6 management in the United States. *Resuscitation*. 2011;82:378-385. doi:
- 7 10.1016/j.resuscitation.2010.12.014
- 8 151. Warner KJ, Sharar SR, Copass MK, Bulger EM. Prehospital management of the difficult
- 9 airway: a prospective cohort study. *J Emerg Med.* 2009;36:257-265. doi:
- 10 10.1016/j.jemermed.2007.10.058
- 11 152. Willinge GJA, Hietbrink F, Leenen LPH. Surgical airway procedures in emergency
- 12 surgical patients: Results of what has become a back-up procedure. World J Surg. 2021;45:2683-
- 13 2693. doi: 10.1007/s00268-021-06110-7
- 14 153. Wong E, Ng YY. The difficult airway in the emergency department. Int J Emerg Med.
- 15 2008;1:107-111. doi: 10.1007/s12245-008-0030-6
- 16 154. Xeropotamos NS, Coats TJ, Wilson AW. Prehospital surgical airway management: 1
- 17 year's experience from the Helicopter Emergency Medical Service. *Injury*. 1993;24:222-224. doi:
- 18 10.1016/0020-1383(93)90172-3

Greif 143

1 PEDIATRIC LIFE SUPPORT

2 Blood Pressure Targets Following Return of Circulation After Pediatric Cardiac Arrest

3 (PLS 4190-01: SysRev)

4 Rationale for Review

5 Determining the optimal BP targets in infants and children following cardiac arrest after 6 ROSC, or after return of circulation (ROC) on mechanical support, poses a significant challenge 7 due to lack of evidence. Clinical practice in this area is based on a few pediatric studies, 8 extrapolation from studies conducted in adults, or expert consensus recommendations. While 9 individual studies in infants and children suggest there is an association between hypotension 10 post-ROSC or post-ROC and poor outcomes, these studies are small and it is unclear if the association is causal or a surrogate marker of more severe postresuscitation syndrome. To answer 11 12 this knowledge gap, a systematic review aimed to evaluate the literature on the effects of BP 13 targets on outcomes post-ROSC/ROC in infants and children (PROSPERO registration CRD42023483865). The full CoSTR can be found online.¹ 14 15 Population, Intervention, Comparator, Outcome, Study Design, and Time Frame 16 Population: Infants and children in any setting (in-hospital or out-of-hospital cardiac arrest) after ROC 17 • Intervention: A specific BP target 18 19 • Comparator: No BP target or a different BP target 20 • Outcome 21 - Critical: Survival/survival with favorable neurological outcome as per Pediatric Core 22 Outcome Set for Cardiac Arrest²

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1	• Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series,
2	controlled before-and-after studies, cohort studies) were eligible for inclusion.
3	Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All
4	languages were included if there was an English abstract.
5	• Time frame: All years were included. The initial search was done on January 25, 2023,
6	and updated on November 3, 2023.
7	Consensus on Science
8	Six studies were identified. ³⁻⁸ All 6 were nonrandomized observational cohort studies,
9	with 5 being secondary analyses. We identified significant variation in BP target definitions (eg,
10	systolic, mean, and diastolic BP and >5th, >10th, and >50th percentile for age) and time frames
11	for measurement (<20 minutes, 0–6 hours, within 24 hours, and 0–72 hours). In our final
12	analysis, we included 4 studies ^{4,5,7,8} examining the BP targets of systolic BP >5th percentile for
13	age compared with systolic BP \leq 5th percentile within the first 6 hours after ROC. The pooled
14	sample included 463/930 (49.8%) patients following IHCA and 467/930 (50.2%) after OHCA.
15	We also included 1 study ³ that enrolled 693 infants and children after IHCA (excluding patients
16	who required extracorporeal life support [ECLS]). This study compared systolic BP >10th
17	percentile with systolic BP \leq 10th percentile within the first 6 hours after ROC. The systolic BP
18	cutoff at the 10th percentile was generated from receiver operator characteristic curves and
19	spline curves created from the study data.
20	Results from included pediatric studies are included in Table 14. A random effects model
21	was chosen for meta-analysis to better account for study heterogeneity.

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

1 Table 14. Studies Comparing BP Targets Post–Cardiac Arrest

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

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Prior Treatment Recommendation (2020)

2	We recommend that for infants and children after ROSC, parenteral fluids and/or
3	inotropes or vasopressors should be used to maintain a systolic blood pressure of at least greater
4	than the fifth percentile for age (strong recommendation, very low-certainty evidence).9
5	2024 Treatment Recommendations
6	We suggest in infants and children with return of circulation following an IHCA or
7	OHCA that a systolic BP >10th percentile for age should be targeted (weak recommendation,
8	very low-certainty evidence).
9	Justification and Evidence-to-Decision Framework Highlights
10	The complete evidence-to-decision table is provided in Appendix A3.
11	• The PLS Task Force considered that the measurement and treatment of BP is a standard
12	component of the postresuscitation bundle of care after cardiac arrest. However, current
13	post-cardiac arrest BP targets and thresholds for treatment have been suggested through
14	expert consensus and evidence extrapolated from individual studies.
15	• Measurement of BP is a low-cost intervention and available in nearly all resource
16	settings. However, the PLS Task Force did not compare the cost-effectiveness of
17	intermittent noninvasive BP measurement with invasive arterial or continuous BP
18	measurement.
19	• There were no randomized controlled studies comparing 2 treatment approaches or 2 BP
20	targets following cardiac arrest. The available evidence consisted of observational data
21	demonstrating the impact of exposure to 2 different BP thresholds on clinically important
22	outcomes. However, the BP thresholds were chosen either a priori by investigators as a
23	clinically important threshold (eg, <fifth cutoff="" derived<="" or="" percentile)="" td="" the="" value="" was=""></fifth>

1	statistically from the population data as the most significant inflection point (<10th
2	percentile). The PLS Task Force focused on the impact of hypotension on clinical
3	outcome and did not include studies assessing normotension or hypertension on
4	outcomes. This will form part of future assessments.
5	• The PLS Task Force considered the exposure overlap of the 2 thresholds, <5th percentile
6	and <10th percentile. It was not statistically possible to perform meta-regression to
7	compare the 2 treatment targets. The consensus of the task force was that the higher
8	threshold target (<10th percentile) included the population included in the <5th percentile
9	group. Acknowledging the low certainty of evidence, the target of >10th percentile
10	systolic BP was the more acceptable systolic BP goal and ensured avoidance of the 5th to
11	10th BP percentiles that were associated with worse outcome in the larger study. ³
12	• The PLS Task Force concluded that although the effect size from the pooled studies is
13	small, the value of the outcome is high and the potential impact on infant and child
14	survivors globally is, therefore, large.
15	Knowledge Gaps
16	• There are no interventional RCTs comparing benefit or harm of targeting specific BP
17	targets.
18	• The impact of prehospital BP measurement or treatment for OHCA
19	• Whether specific subgroups of pediatric patients after ROC require different BP targets.
20	Observational data demonstrate an association between exposure to lower BP targets and
21	worse outcome; however, more data are required to demonstrate a causal relationship
22	between treatment interventions to achieve higher BP targets and improved outcomes.

1	The task force was unable to assess the benefits or harm of exposure to hypertension in
2	the period after cardiac arrest.
3	• Whether patients receiving targeted temperature management (eg, 33°C) require different
4	BP targets
5	• We encourage consistent reporting of BP monitoring definitions (eg, site, repeated
6	measurement, component of BP [systolic, diastolic, mean BP]) and definitions of
7	exposure to hypotension (eg, single episode versus percentage of time).
8	• Most studies report exposure to BP thresholds within 6 hours; impact of BP interventions
9	outside this time frame is important.
10	• Which strategy is optimal to achieve a BP above the threshold level (eg, fluids,
11	vasopressor support, mechanical support)
12	• Whether a BP target or another marker of end organ perfusion is the most appropriate
13	target
14	• Optimal BP targets during ECLS post-cardiac arrest. Some patients on ECLS may lack
15	heart pulsatility, which also limits use of systolic BP targets in this patient group.
16	• The optimal strategy to use when cerebral autoregulation is impaired
17	Effect of Prophylactic Antiseizure Medication and/or Treatment of Seizures on Outcome of
18	Children Following Cardiac Arrest (PLS 4210-02: SysRevs)
19	Rationale for Review
20	Cardiac arrest in children is relatively uncommon and has a very high mortality rate, with
21	hypoxic-ischemic brain injury being a common cause of death. Seizures including suspected
22	clinical, electroclinical, and electrographic seizures with EEG correlation are common
23	manifestations of post-cardiac arrest brain injury in children, with an incidence of approximately

1	10% to 40%. ¹⁰⁻¹² Seizures and abnormalities on EEG post-cardiac arrest are associated with poor
2	neurologic outcome in children. ¹²⁻¹⁵ It is unclear if prophylactic antiseizure medication to prevent
3	seizures and/or treatment of seizures when they are identified improves outcome. There are no
4	existing ILCOR recommendations for children, and this SysRev was thus undertaken
5	(PROSPERO registrations CRD42023460746 and CRD42023463581). The full CoSTR can be
6	found online. ¹⁶
7	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
8	• Population: Adults or pediatric patients in any setting (IHCA or OHCA) with ROC
9	• Intervention: One strategy for prophylactic antiseizure medication <i>or</i> seizure treatment
10	• Comparator: Another strategy or no prophylactic antiseizure medication <i>or</i> seizure
11	treatment
12	• Outcome
13	- Critical: Survival or survival with favorable neurological outcome as per Pediatric Core
14	Outcome Set for Cardiac Arrest ²
15	• Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series,
16	controlled before-and-after studies, cohort studies) were eligible for inclusion.
17	Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All
18	relevant publications in any language were included if there was an English abstract.
19	• Time frame: Literature search includes all years up to September 11, 2023.
20	Consensus on Science
21	Prophylactic Antiseizure Medication
22	For the critical outcome of survival with favorable neurological outcome at discharge/30
23	days or longer, no pediatric RCTs nor nonrandomized comparative studies were identified.

- 1 Indirect evidence from adult studies was identified and included (Table 15). We
- 2 identified 2 randomized studies^{17,18} and a single nonrandomized study¹⁹ enrolling adult patients
- 3 only. No studies reported improvement in survival with favorable neurological outcome or
- 4 survival with prophylactic antiseizure medication.

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

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

Outcomes (importance)	Participants, n (studies, n/study type)	Investigation	Certainty of evidence (GRADE)	RR (95% CI)	ARD with intervention
Survival to	107 (1	Bolus and	Very low	1.40 (0.83–	119 more adult survivors per 1000 patients
hospital discharge	nonrandomized	continuous		2.36)	(95% CI, from 50 fewer to 403 more)
	study) ¹⁹	infusion of			
		thiopentone and			
		phenobarbital			
		compared with			
		historic controls			

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

1ARD indicates2RR, risk ratio.

1 Treatment of Seizures

2	For the critical outcome of survival with favorable neurological outcome at discharge/30
3	days or longer, no pediatric RCTs or nonrandomized comparative studies were identified.
4	Indirect evidence from adult studies was identified and included. We identified a single
5	randomized study ²⁰ of 172 patients, assessing the effect of treatment of rhythmic and periodic
6	discharges with antiseizure medication on the critical outcome of survival with favorable
7	neurologic outcome at 3 months and finding no benefit (RR, 1.23 [95% CI, 0.48–3.15], or 19
8	more per 1000 patients [95% CI, from 43 fewer to 179 more]). There was also no difference in
9	survival (RR, 1.14 [95% CI, 0.62–2.12], or 27 more survivors per 1000 patients [95% CI, from
10	68 fewer to 200 more]).
11	2024 Good Practice Statements—New
12	Prophylactic Antiseizure Medication
13	We suggest against the routine use of prophylactic antiseizure medication in children
14	post-cardiac arrest (good practice statement).
15	Seizure Treatment
16	We suggest the treatment of seizures in children post-cardiac arrest (good practice
17	statement).
18	Justification and Evidence-to-Decision Framework Highlights
19	The complete evidence-to-decision table is provided in Appendix A3.
20	Prophylactic Antiseizure Medication
21	• Due to the lack of direct evidence in children post-cardiac arrest and very low certainty
22	of indirect evidence from adults, the PLS Task Force was unable to make a treatment
23	recommendation. The task force's decision to provide a good practice statement

1	suggesting against post-cardiac arrest prophylactic antiseizure medication was based on
2	the absence of indirect evidence from adult comatose cardiac arrest survivors that
3	prophylactic therapy with antiseizure medication prevents seizures or improves important
4	outcomes. However, the PLS Task Force recognized the low certainty of the evidence
5	from RCTs. The PLS Task Force also considered that the administration of prophylactic
6	antiseizure medication in other forms of acute brain injury (eg, neonatal hypoxic-
7	ischemic encephalopathy) ²¹ is not associated with improved long-term outcomes.
8	Although prophylactic antiseizure medication is recommended following traumatic brain
9	injury in children, ²² the evidence of benefit for early seizure prevention is of very low
10	certainty and there is no evidence of improved long-term outcomes. ²³
11	• The medications used for antiseizure prophylaxis in the included adult trials (eg,
12	barbiturates) can have significant side effects, although the cardiac side effects seen in
13	adults may be less common in children. The PLS Task Force acknowledged that newer
14	antiseizure medications have not been evaluated and that their efficacy and side effect
15	profile may differ. Further evaluation is encouraged.
16	Seizure Treatment
17	• No direct pediatric evidence of the effects of treating seizures in children after cardiac
18	arrest was identified, and the PLS Task Force could not make a treatment
19	recommendation.
20	• The PLS Task Force chose to make the good practice statement based on the knowledge
21	that high seizure burden in children has been associated with poor neurological
22	outcome. ^{24,25} There are safe and effective antiseizure medications that can reduce seizure

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

3 The PLS Task Force acknowledges the challenge of seizure diagnosis and the important 4 role of confirmatory EEG in addition to clinical signs of seizure to increase certainty of 5 diagnosis. The potential risk of treating suspected seizures in settings without access to 6 EEG confirmation needs to be balanced with potential harm of antiseizure medications. 7 EEG confirmation remains the reference standard approach for seizure diagnosis; however, EEG may not be available in many clinical settings because it requires 8 significant resources, including neurophysiology equipment, training, and expertise. 9 Continuous EEG monitoring is labor intensive and likely to add significant cost to patient 10 care. The cost-effectiveness of this approach is controversial and may depend on the 11 12 setting. The relative benefit of continuous EEG compared with intermittent EEG 13 monitoring was not reviewed.

There is insufficient evidence to suggest for or against the treatment of rhythmic and
 periodic EEG patterns in children post-cardiac arrest. One RCT in adults²⁰ did not find a
 difference in the primary outcome with 1 therapeutic approach to treatment of rhythmic
 and periodic EEG patterns. However, no significant harm was noted in adults assigned to
 the treatment or control arm. Further research is required in children to evaluate the
 impact on treating specific EEG patterns and electrographic seizures.

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

1 Knowledge Gaps

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

Advanced Airway Interventions in Pediatric Cardiac Arrest (PLS 4060-01: SysRevs) *Rationale for Review*

- 13 Airway management is vital in pediatric resuscitation, especially since respiratory 14 conditions are frequently the primary cause of pediatric cardiac arrest. Maintaining an open 15 airway and delivering sustained effective ventilations using a bag-mask device can be difficult, even in skilled hands. Placement of an advanced airway device, such as a supraglottic airway 16 17 (SGA) or tracheal tube, may facilitate more effective resuscitation than bag-mask ventilation 18 (BMV). Both require skilled personnel, and the time taken to perform either procedure may 19 interfere with other vital components of resuscitation (eg, chest compressions). Since the last review of this topic,²⁹ the PLS Task Force was aware of new data, 20 21 prompting this updated SysRev (PROSPERO registration CRD42023482459). The full CoSTR
- 22 can be found online.³⁰

1	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
2	• Population: Infants and children who received CPR after OHCA or IHCA (excluding
3	newborn children)
4	• Intervention: Placement of an advanced airway device
5	• Comparator: BMV alone or non-advanced airway interventions (primary) or another
6	advanced airway device (secondary)
7	• Outcome
8	- Critical: Survival to hospital discharge with favorable neurological outcome and survival
9	to hospital discharge
10	- Important: ROSC ²
11	• Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series,
12	controlled before-and-after studies, cohort studies) were eligible for inclusion.
13	Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All
14	relevant publications in any language were included if there was an English abstract.
15	• Time frame: The previous SysRev included studies up to September 24, 2018. The
16	updated search included studies from June 2018 through August 15, 2023.
17	Consensus on Science
18	The PLS Task Force reviewed the evidence for the following comparisons: tracheal
19	intubation (TI) compared with BMV, SGA compared with BMV, and TI compared with SGA
20	during pediatric cardiac arrest.
21	Nineteen studies were included. Only 1 study provided clinical trial data. ³¹ Five studies
22	provided propensity-adjusted cohort data. ³²⁻³⁶ Nine other studies provided retrospective cohort
23	data amenable to meta-analysis. ³⁷⁻⁴⁵ Four studies provided retrospective cohort data in adjusted

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form only, not amenable to meta-analysis.⁴⁶⁻⁴⁹ One study⁵⁰ that was included in the original
 SysRev²⁹ was excluded from this updated SysRev because it overlapped with a newer study.³⁶
 Summative results from 15 of the studies are included in Table 16; the 4 cohort studies with
 results not amenable to meta-analysis were excluded.

5 A random effects model was chosen for meta-analysis to better account for study 6 heterogeneity. The results suggest that resuscitation with TI is not superior to BMV-based 7 resuscitation for cardiac arrest in children for the critically important outcomes of survival with 8 favorable neurological outcome and survival to hospital discharge (with low to very low 9 certainty). Some very low–certainty evidence suggests the use of TI may be associated with

10 harm.

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

1	Table 16. Summative Results of Studi	es Used in the Pedia	tric Airway SysRey for H	Each Comparison. Gro	ouned by Outcome
1	Tuble 10. Summarie Results of Studi	es esca in the i cula	the fill way syster for 1	Such Comparison, Or	supeu by Outcome

Outcomes (importance)	Participants, n (studies, n/study type)	Certainty of evidence, GRADE	RR (95% CI)	Absolute risk with comparator	ARD with intervention
		SGA (I) comp	ared with BMV	V (C)	
Survival with	3123 (4 propensity-	Very low	0.57 (0.26–	76/1000	33 fewer per 1000 (from 56
favorable	matched		1.23)		fewer to 18 more)
neurologic outcome	observational) ³³⁻³⁶				
(critical)					
Survival to hospital	3123 (4 propensity-	Very low	0.89 (0.54–	126/1000	14 fewer per 1000 (from 58
discharge (critical)	matched		1.46)		fewer to 58 more)
	observational				
	studies) ³³⁻³⁶				
	3085 (2 observational	Very low	0.53 (0.21–	90/1000	43 fewer per 1000 (from 71
	studies) ^{37,43}		1.34)		fewer to 31 more)
		TI (I) compa	red with SGA	(C)	
Survival with	1514 (3 propensity-	Very low	0.80 (0.44–	40/1000	8 fewer per 1000 (from 23
favorable	matched		1.43)		fewer to 17 more)
neurologic outcome	observational				
(critical)	studies) ^{33,34,51}				
	452 (1 observational	Very low	2.75 (0.67–	13/1000	24 more per 1000 (from 4 fewer
	studies) ³⁶		11.27)		to 138 more)
Survival to hospital	1514 (3 propensity-	Very low	0.80 (0.55–	126/1000	25 fewer per 1000 (from 57
discharge (critical)	matched		1.15)		fewer to 19 more)

Outcomes (importance)	Participants, n (studies, n/study type)	Certainty of evidence, GRADE	RR (95% CI)	Absolute risk with comparator	ARD with intervention
	observational studies) ^{33,34,51}				
	1007 (3 observational studies) ^{36,37,43}	Very low	1.35 (0.82– 2.22)	67/1000	24 more per 1000 (from 12 fewer to 82 more)

ARD indicates absolute risk difference; BMV, bag-mask ventilation; C, comparator; GRADE, Grading of Recommendations Assessment, Development, and 1 2

Evaluation; I, intervention; RCT, randomized controlled trial; RR, risk ratio; SGA, supraglottic airway; SysRev, systematic review; TI, tracheal intubation.

1 IHCA Versus OHCA

2	Separate analyses of studies of IHCA and OHCA produced similar results. However, the
3	body of evidence for IHCA is particularly small (consisting of 1 propensity-matched cohort
4	study and 3 other cohort studies) and provides very low-certainty evidence. ^{32,40-42} The studies are
5	very heterogenous and showed inconsistent results.
6	Prior Treatment Recommendations (2019)
7	We suggest the use of BMV rather than TI or SGA in the management of children during
8	cardiac arrest in the out-of-hospital setting (weak recommendation, very low-certainty evidence).
9	There is insufficient evidence to support any recommendation about the use of TI or SGA
10	in the management of children with cardiac arrest in the in-hospital setting.
11	2024 Treatment Recommendations
12	We suggest the use of bag-mask ventilation rather than tracheal intubation or supraglottic
13	airway in the management of children during cardiac arrest in the out-of-hospital setting (weak
14	recommendation, very low-certainty evidence).
15	There is insufficient quality evidence to support any recommendation for or against the
16	use of the bag-mask ventilation compared with tracheal intubation or supraglottic airway for in-
17	hospital cardiac arrest.
18	The main goal of cardiopulmonary resuscitation is effective ventilation and oxygenation,
19	by whatever means, without compromising the quality of chest compressions. We suggest that
20	clinicians consider transitioning to an advanced airway intervention (supraglottic airway or
21	tracheal intubation) when the team has sufficient expertise, resources, and equipment to enable
22	placement to occur with minimal interruptions to chest compressions or when bag-valve-mask is
23	not providing adequate oxygenation and ventilation (good practice statement).

1	Justification and Evidence-to-Decision Framework Highlights
2	The complete evidence-to-decision table is provided in Appendix A3.
3	• Advanced airway interventions, particularly TI, are long-established components of the
4	advanced life support bundle of care in children. As a result of inherent limitations in
5	their design and data sources, the available studies, though individually well conducted,
6	can provide only very low-certainty evidence about whether attempting advanced airway
7	placement before ROSC improves resuscitation outcomes.
8	• Most of the available data were obtained from registries, and an unknown proportion of
9	events labeled as BMV resuscitation may have had failed intubation and/or SGA attempts
10	(which would bias against BMV). Conversely, most of the included studies are
11	susceptible to resuscitation-time bias, ie, the longer the child is in cardiac arrest, the more
12	likely they will receive interventions but the less likely they will survive (which should
13	bias against TI/SGA).
14	• The best available data show no benefit from these advanced airway interventions, and
15	some suggest association with harm, for the critical outcomes of survival with favorable
16	neurological outcome and survival to hospital discharge.
17	• Effective BMV, TI, and SGA are difficult skills that require initial training, retraining,
18	and quality assurance to be done consistently, safely, and effectively. Pediatric advanced
19	airway programs require a moderate investment in equipment and a significant
20	investment in training, skills maintenance, and quality control programs to be successful.
21	• The decision on choice of airway management technique in the setting of pediatric
22	cardiac arrest is complex because the benefit or harm may differ depending on setting,
23	age of the child, cause of arrest, and experience of the resuscitation team. Importantly, the

1	available data do not inform the questions of whether better outcomes might be achieved
2	by different airway strategies in long transport times or in prolonged resuscitation
3	situations with highly experienced airway operators. The analyzed data are only relevant
4	to advanced airway interventions during CPR and do not pertain to airway management
5	in other critical situations or once ROSC is achieved.
6	Knowledge Gaps
7	• Prehospital, emergency department-based, and in-hospital studies comparing TI, SGA,
8	and BMV with planned subgroup analyses based on patient age and etiology of arrest
9	(trauma versus nontrauma)
10	• The benefit of advanced airway interventions in particular settings (including in patients
11	with poor pulmonary compliance and long transport times)
12	• The efficacy and speed of placement of advanced airways using newer technologies, such
13	as video-assisted laryngoscopy (compared with regular laryngoscopy)
14	• Studies including measures of quality of ventilation (and cardiac metrics), timing of
15	airway intervention, duration of CPR, and measures of the training and experience of the
16	clinicians performing the interventions
17	Ventilation Rates in Pediatric CPR With an Advanced Airway (PLS 4120-02: SysRevs)
18	Rationale for Review
19	Ventilation is a major component of CPR for children and infants in cardiac arrest.
20	During CPR, an adequate ventilation rate is an important element of ventilation. ^{52,53} However,
21	the appropriate ventilatory rate for children and infants during CPR remains a topic of ongoing
22	debate and investigation. ⁵⁴ In 2010, the PLS Task Force reviewed the evidence about optimal
23	minute ventilation (product of tidal volume and respiratory rate per minute) after the placement

1	of an advanced airway during CPR in infants or children. ⁵² The minute ventilation recommended
2	in the 2010 CoSTR was based on expert consensus. In 2020, an EvUp was completed to identify
3	any evidence published after 2010 that might indicate the need for a new SysRev. The EvUp
4	identified a single-center observational paper that reported an association between ventilatory
5	rate during IHCA >12 to 20 breaths per minute and improved outcomes. ⁵⁵ Since this EvUp, the
6	task force was aware of new evidence that led the task force to conduct a SysRev (PROSPERO
7	registration CRD42023480925). The full CoSTR can be found online. ⁵⁶
8	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
9	• Population: Infants and children (excluding newborn infants) with OHCA or IHCA and
10	an advanced airway
11	• Intervention: Use of any specific ventilatory rate
12	• Comparator: Use of a ventilatory rate of 8 to 10 breaths per minute
13	• Outcome:
14	- Critical: Survival with favorable neurological outcome as per Pediatric Core Outcome Set
15	for Cardiac Arrest ²
16	• Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series,
17	controlled before-and-after studies, cohort studies) were eligible for inclusion.
18	Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All
19	relevant publications in any language were included if there was an English abstract.
20	• Time frame: Literature search includes all years up to June 1, 2023.
21	Consensus on Science
22	No studies were identified that compared the ventilatory rate of 8 to 10 breaths per
23	minute with any other specific ventilatory rate.

1 Prior Treatment Recommendations (2020)

2	After placement of a secure airway, avoid hyperventilation of infants and children during
3	resuscitation from cardiac arrest, whether asphyxial or arrhythmic in origin. A reduction in
4	minute ventilation to less than baseline for age is reasonable to provide sufficient ventilation to
5	maintain adequate ventilation-to-perfusion ratio during CPR while avoiding the harmful effects
6	of hyperventilation. There are insufficient data to identify the optimal tidal volume or respiratory
7	rate. ⁵⁵
8	2024 Treatment Recommendations
9	There is currently no supporting evidence to make a treatment recommendation on a
10	specific ventilatory rate in pediatric cardiopulmonary resuscitation with an advanced airway.
11	For cardiac arrest that occurs with an advanced airway in place, the use of ventilatory
12	rates >10 breaths per minute may be reasonable. The PLS Task Force suggests using ventilatory
13	rates close to age-appropriate respiratory rates with avoidance of hypoventilation and
14	hyperventilation (good practice statement).
15	Justification and Evidence-to-Decision Framework Highlights
16	• The PLS Task Force discussed that no study met inclusion in this SysRev because none
17	specifically addressed the ventilation rate comparison of 8 to 10 breaths per minute that
18	had been defined in the PICOST.
19	• The PLS Task Force discussed that the previous treatment recommendations of
20	ventilation rates of 10 breaths per minute during cardiac arrest were derived from adult
21	data. More recent adult studies suggest that ventilation rates of 10 breaths per minute
22	during cardiac arrest were not associated with improved outcomes in adults. A ventilation

1	rate of 10 breaths per minute could cause hypoventilation in infants and children, and no
2	pediatric data to support this ventilation rate were identified.
3	Knowledge Gaps
4	• The optimal ventilation rate during continuous chest compressions in children with an
5	advanced airway
6	• The optimal minute ventilation and other ventilation measurements, including peak
7	pressure, positive end-expiratory pressure, capnography, and blood gas analysis and their
8	impact on oxygenation and ventilation during CPR
9	• The influence of hypocarbia and hypercarbia on outcomes
10	• The optimal ventilation rate according to cardiac arrest etiology
11	Management of Pulmonary Hypertension With Cardiac Arrest in Infants and Children in
12	the Hospital Setting (PLS 4160-11: ScopRev)
13	
	Rationale for Review
14	Rationale for Review This topic, with a new PICOST, was chosen by the PLS Task Force with input from the
14 15	Rationale for Review This topic, with a new PICOST, was chosen by the PLS Task Force with input from the Neonatal Life Support Task Force because of the concern that children with pulmonary
14 15 16	Rationale for Review This topic, with a new PICOST, was chosen by the PLS Task Force with input from the Neonatal Life Support Task Force because of the concern that children with pulmonary hypertension who are hospitalized are reported to be at higher risk of death following a
14 15 16 17	Rationale for Review This topic, with a new PICOST, was chosen by the PLS Task Force with input from the Neonatal Life Support Task Force because of the concern that children with pulmonary hypertension who are hospitalized are reported to be at higher risk of death following a cardiopulmonary arrest. ⁵⁷
14 15 16 17 18	Rationale for Review This topic, with a new PICOST, was chosen by the PLS Task Force with input from the Neonatal Life Support Task Force because of the concern that children with pulmonary hypertension who are hospitalized are reported to be at higher risk of death following a cardiopulmonary arrest. ⁵⁷ In 2015, the American Heart Association and the American Thoracic Society published a
14 15 16 17 18 19	Rationale for Review This topic, with a new PICOST, was chosen by the PLS Task Force with input from the Neonatal Life Support Task Force because of the concern that children with pulmonary hypertension who are hospitalized are reported to be at higher risk of death following a cardiopulmonary arrest. ⁵⁷ In 2015, the American Heart Association and the American Thoracic Society published a guideline on the management of pediatric pulmonary hypertension. ⁵⁸ In 2018, the American
14 15 16 17 18 19 20	Rationale for ReviewThis topic, with a new PICOST, was chosen by the PLS Task Force with input from theNeonatal Life Support Task Force because of the concern that children with pulmonaryhypertension who are hospitalized are reported to be at higher risk of death following acardiopulmonary arrest. ⁵⁷ In 2015, the American Heart Association and the American Thoracic Society published aguideline on the management of pediatric pulmonary hypertension. ⁵⁸ In 2018, the AmericanHeart Association published a statement on the management of CPR in infants and children with
14 15 16 17 18 19 20 21	Rationale for Review This topic, with a new PICOST, was chosen by the PLS Task Force with input from the Neonatal Life Support Task Force because of the concern that children with pulmonary hypertension who are hospitalized are reported to be at higher risk of death following a cardiopulmonary arrest. ⁵⁷ In 2015, the American Heart Association and the American Thoracic Society published a guideline on the management of pediatric pulmonary hypertension. ⁵⁸ In 2018, the American Heart Association published a statement on the management of CPR in infants and children with cardiac disease that included a section on pulmonary hypertension. ⁵⁹ In 2018, the American Heart

22 Association published a statement on right-sided heart failure and its management, but this

2	provided guidance on the acute treatment of pulmonary hypertension.
3	Faced with these children at high risk of cardiopulmonary arrest, we formulated the new
4	PICOST and conducted a ScopRev to better understand if evidence for new specific therapies to
5	treat cardiopulmonary arrest had been published. The full report of this ScopRev can be found
6	online. ⁶¹
7	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
8	• Population: Infants and children with pulmonary hypertension at high risk of pulmonary
9	hypertensive crises with a cardiac arrest in the in-hospital setting, including
10	postoperatively
11	• Intervention: Specific management strategies included (1) respiratory management and
12	monitoring to avoid hypoxia and acidosis; (2) use of opioids, sedatives, and
13	neuromuscular blocking agents; and (3) pulmonary arterial hypertension-specific
14	targeted therapy, like (a) phosphodiesterase-5 inhibitors, endothelin receptor antagonists,
15	inhaled pulmonary vasodilators (eg, inhaled nitric oxide or prostaglandin) or (b) drugs
16	that enhance the nitric oxide-cyclic guanosine monophosphate biological pathway (eg,
17	sildenafil, tadalafil, or riociguat), prostacyclin pathway agonists (eg, epoprostenol or
18	treprostinil), or endothelin pathway antagonists (eg, bosentan or ambrisentan).
19	• Comparator: Standard care without specific management strategies for pulmonary
20	hypertensive crisis
21	• Outcome
22	- Critical: All, including survival to hospital discharge with favorable neurological
23	outcome and survival to hospital discharge

statement focused on adults and did not include content for children.⁶⁰ The 2019 ILCOR EvUps

1
1 Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series, 2 controlled before-and-after studies, cohort studies) and case series with >5 cases were 3 included. Gray literature, social media, and non-peer-reviewed studies, unpublished 4 studies, and conference abstracts were excluded. Trial protocols were eligible if they 5 informed the question. All languages were included if there was an English abstract. 6 Time frame: The literature search was completed, and the selection focused on the most 7 recent decade—from January 1, 2012, to December 22, 2023 8 Summary of Evidence 9 We included 19 studies in the ScopRev; 16 provided foundational background literature on the acute management of children with pulmonary hypertension, 57-59,62-74 and 3 presented data 10 11 on the management of cardiac arrest in children with pulmonary hypertension.⁷⁵⁻⁷⁷ Most did not 12 report patient-level data in children with pulmonary hypertension and cardiac arrest. These

articles collectively highlight the increased risk of death in children with pulmonary hypertension
and the results of recent international efforts in establishing a pediatric pulmonary hypertension
classification to support future international and multisite research and general therapeutic

16 management.

17 Definition and Classification of Pediatric Pulmonary Hypertension

During the 6th World Symposium on Pulmonary Hypertension, the hemodynamic definition for pulmonary hypertension in children was aligned with the adult definition as a mean pulmonary artery pressure of >20 mm Hg⁷⁸⁻⁸⁰ from being previously \geq 25 mm Hg.⁵⁸ Five large clinical groups were updated—(1) pulmonary arterial hypertension, which includes pulmonary hypertension associated with congenital heart disease and persistent pulmonary hypertension of the newborn syndrome (the most frequent cause of transient pulmonary

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1 hypertension)⁷⁹; (2) pulmonary hypertension due to left heart disease; (3) pulmonary

2 hypertension owing to lung diseases and or hypoxia; (4) pulmonary hypertension due to

3 pulmonary artery obstructions; and (5) pulmonary hypertension with unclear multifactorial

4 mechanism.

5 Risk of Death and Intensive Care Hospitalizations

6 To promote the study of children with pulmonary hypertension, the term clinical 7 worsening is emerging as a meaningful composite endpoint for interventional trials. In a recent 8 multicenter study from the Pediatric Cardiac Critical Care Consortium from 2014 to 2019, the risk of death for children with pulmonary hypertension was higher compared with all other 9 10 medical cardiac admissions (10% versus 3.9%). Importantly, 6.1% of these admissions with pulmonary hypertension experienced a CPR event. Among this cohort, the receipt of mechanical 11 12 ventilation and vasoactive therapies within the first 2 days of ICU admission were associated with increased mortality.⁶⁷ 13

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

More recently, an analysis of 1129 pediatric IHCA events from the prospective
 multicenter ICU-RESUS (Improving Outcomes from Pediatric Cardiac Arrest—the ICU Resuscitation Project) study, where 16% of children had preexisting pulmonary hypertension,

- 1 concluded that pre-arrest pulmonary hypertension was not associated with statistically significant
- 2 differences in survival or intra-arrest physiologic measures.⁸¹

3 ECLS Technologies, Extracorporeal Membrane Oxygenation, and Pediatric Pulmonary

4 Hypertension

5 Before a cardiac arrest, extracorporeal membrane oxygenation (ECMO) may be used to 6 stabilize infants with persistent pulmonary hypertension of the newborn or congenital 7 diaphragmatic hernia or in the postoperative period of congenital heart disease when inhaled nitric oxide and mechanical ventilation with general measures are insufficient.58 8 Pulmonary Hypertensive–Specific Therapies and Interventions for the Treatment of Cardiac 9 10 Arrest Only 3 articles presented data on the management of cardiac arrest in children with 11 pulmonary hypertension (Table 17).⁷⁵⁻⁷⁷ Two of these studies included ECMO cannulation as 12

13 intervention.^{75,77}

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

1	Table 17. Reports of Studies I	ncluding Patient-Level Data	With Pulmonary Hy	pertension and Cardiac Arrest
	Tuble 17. Reports of Studies I	nerualing i accent Bever Data	vy ich i unnonar y iry	per tempron and Car afac fir i est

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

1 Task Force Insights

2	General approaches to improving cardiopulmonary physiology in the context of a
3	pulmonary hypertension crisis or cardiac arrest are important. Children hospitalized with
4	pulmonary hypertension are at higher risk of cardiac arrest than other children. The next steps
5	should focus on generating original evidence in pulmonary hypertension disease groups
6	characterized using contemporary classification systems and definitions. This disease remains
7	relatively rare, which suggests that future research will require multicenter studies or large
8	registry-based comparative studies to better understand the value of one intervention over
9	another for treatment of cardiac arrest.
10	The PLS Task Force discussed the importance of using the classification of 5 groups and
11	diagnoses detailed in the most recent international guidelines on pediatric pulmonary
12	hypertension when studying the risk of cardiopulmonary arrest or interventions to treat
13	cardiopulmonary arrest. ^{58,80,82}
14	Good Practice Statements
15	In children, including neonates, with pulmonary hypertension hospitalized for a clinical
16	worsening event, we propose avoiding factors that may increase pulmonary vascular resistance
17	while treating the aggravating condition to decrease the risk of cardiac arrest. Management
18	strategies include avoiding hypoxia; hypercapnia; acidosis; stressors, such as pain, agitation,
19	dehydration, or fluid overload; anemia; infection; or arrhythmias. Pulmonary hypertension-
20	specific treatments-eg, inhaled nitric oxide, L-arginine, phosphodiesterase inhibitors (eg,
21	milrinone, sildenafil), or endothelin-1 inhibitors (eg, bosentan)-may be considered (good
22	practice statement).

1 In children who develop signs of pulmonary hypertensive crisis, low cardiac output, or 2 right ventricular failure despite optimal medical therapy, ECMO may be considered before cardiac arrest or for refractory cardiac arrest as a bridge to recovery or as a bridge to the 3 4 evaluation for organ replacement and transplantation in very select cases (good practice 5 statement). 6 Knowledge Gaps 7 Specific resuscitation management approaches for infants or children with pulmonary 8 hypertension at high risk of cardiopulmonary arrest during cardiac arrest and after 9 resuscitation Optimal approaches to mechanical ventilation during the resuscitation of children with 10 pulmonary hypertension (eg, timing of the advanced airway; the use of oxygen therapy in 11 12 cyanotic and noncyanotic heart disease or in the context of an atrial septostomy; the use 13 of positive end-expiratory pressure, of peak inspiratory pressure, of minute ventilation 14 [normal ventilation or hyperventilation], or of inhaled nitric oxide; or modes of 15 mechanical ventilation during the post-cardiac arrest care period to best support the right 16 and left ventricles and minimize harmful cardiopulmonary interactions) 17 The dose or type of inotrope or vasopressor that could be delivered during a 18 cardiopulmonary arrest event and the physiologic endpoints to target during the intra-19 arrest period, such as the optimal target in end-tidal capnography value 20 Whether children with pulmonary hypertension with known right heart catheterization data should receive personalized resuscitation measures instead of standard measures 21

1	•	The timing of transitioning from high-quality CPR to extracorporeal CPR in pediatric
2		patients with severe pulmonary hypertension (eg, pulmonary hypertension listed for lung
3		transplantation, pulmonary hypertension after atrial septostomy) ⁸³
4	٠	Optimal diagnostic and severity classification systems to improve knowledge of pediatric
5		pulmonary hypertension patients who suffer cardiopulmonary arrest ⁸²
6	•	Risk factors for cardiac arrest in children with pulmonary hypertension in the context of
7		(1) anesthesia (for diagnostic catheterization or for other procedures), (2) postoperative
8		period, ⁶⁷ (3) hospitalizations with deteriorations associated with clinical worsening
9		events. ⁸⁴ We propose adding "cardiopulmonary arrest events" as a study variable among
10		clinical worsening endpoints in longitudinal epidemiological registries; this would serve
11		as a first step to measure the burden of this problem.
12		Topics reviewed by EvUps are summarized in Table 18. Complete EvUps can be found
13	in Ap	pendix B3.

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

1 Table 18. Summary of Pediatric Life Support EvUps

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

aOR indicates adjusted odds ratio; ECG, electrocardiogram; ECLS, extracorporeal life support; ECPR, extracorporeal cardiopulmonary resuscitation; EvUps,

evidence updates; PICO, population, intervention, comparator, outcome; RCTs, randomized controlled trials; SysRev, systematic review; TR, treatment recommendation.

1 2 3

1 References

- 2 1. Nuthall G, Christoff A, Morrison LJ, Scholefield B; on behalf of the International Liaison
- 3 Committee on Resuscitation Pediatric Life Support Task Force. Blood pressure targets following
- 4 return of circulation after cardiac arrest: Consensus on Science With Treatment
- 5 Recommendations. 2024. Updated January 24, 2024. Accessed February 14, 2024.
- 6 https://costr.ilcor.org/document/blood-pressure-targets-following-return-of-circulation-after-
- 7 pediatric-cardiac-arrest-pls-4190-01-sr
- 8 2. Topjian AA, Scholefield BR, Pinto NP, Fink EL, Buysse CMP, Haywood K, Maconochie
- 9 I, Nadkarni VM, de Caen A, Escalante-Kanashiro R, Ng KC, Nuthall G, Reis AG, Van de
- 10 Voorde P, Suskauer SJ, Schexnayder SM, Hazinski MF, Slomine BS. P-COSCA (Pediatric Core
- 11 Outcome Set for Cardiac Arrest) in Children: An Advisory Statement From the International
- 12 Liaison Committee on Resuscitation. *Resuscitation*. 2021;162:351-364. doi:
- 13 10.1016/j.resuscitation.2021.01.023
- 14 3. Gardner MM, Hehir DA, Reeder RW, Ahmed T, Bell MJ, Berg RA, Bishop R, Bochkoris
- 15 M, Burns C, Carcillo JA, Carpenter TC, Dean JM, Diddle JW, Federman M, Fernandez R, Fink
- 16 EL, Franzon D, Frazier AH, Friess SH, Graham K, Hall M, Harding ML, Horvat CM, Huard LL,
- 17 Maa T, Manga A, McQuillen PS, Meert KL, Morgan RW, Mourani PM, Nadkarni VM, Naim
- 18 MY, Notterman D, Pollack MM, Sapru A, Schneiter C, Sharron MP, Srivastava N, Tilford B,
- 19 Viteri S, Wessel D, Wolfe HA, Yates AR, Zuppa AF, Sutton RM, Topjian AA. Identification of
- 20 post-cardiac arrest blood pressure thresholds associated with outcomes in children: an ICU-
- 21 Resuscitation study. Crit Care. 2023;27:388. doi: 10.1186/s13054-023-04662-9

1	4. Laverriere EK, Polansky M, French B, Nadkarni VM, Berg RA, Topjian AA. Association
2	of Duration of Hypotension With Survival After Pediatric Cardiac Arrest. Pediatr Crit Care
3	Med. 2020;21:143-149. doi: 10.1097/PCC.000000000002119
4	5. Topjian AA, French B, Sutton RM, Conlon T, Nadkarni VM, Moler FW, Dean JM, Berg
5	RA. Early postresuscitation hypotension is associated with increased mortality following
6	pediatric cardiac arrest. Crit Care Med. 2014;42:1518-1523. doi:
7	10.1097/CCM.00000000000216
8	6. Topjian AA, Sutton RM, Reeder RW, Telford R, Meert KL, Yates AR, Morgan RW,
9	Berger JT, Newth CJ, Carcillo JA, McQuillen PS, Harrison RE, Moler FW, Pollack MM,
10	Carpenter TC, Notterman DA, Holubkov R, Dean JM, Nadkarni VM, Berg RA, Eunice Kennedy
11	Shriver National Institute of Child H, Human Development Collaborative Pediatric Critical Care
12	Research Network I, Zuppa AF, Graham K, Twelves C, Diliberto MA, Landis WP, Tomanio E,
13	Kwok J, Bell MJ, Abraham A, Sapru A, Alkhouli MF, Heidemann S, Pawluszka A, Hall MW,
14	Steele L, Shanley TP, Weber M, Dalton HJ, Bell A, Mourani PM, Malone K, Locandro C,
15	Coleman W, Peterson A, Thelen J, Doctor A. The association of immediate post cardiac arrest
16	diastolic hypertension and survival following pediatric cardiac arrest. Resuscitation.
17	2019;141:88-95. doi: 10.1016/j.resuscitation.2019.05.033
18	7. Topjian AA, Telford R, Holubkov R, Nadkarni VM, Berg RA, Dean JM, Moler FW,
19	Therapeutic Hypothermia After Pediatric Cardiac Arrest Trial I. Association of Early
20	Postresuscitation Hypotension With Survival to Discharge After Targeted Temperature
21	Management for Pediatric Out-of-Hospital Cardiac Arrest: Secondary Analysis of a Randomized
22	Clinical Trial. JAMA Pediatr. 2018;172:143-153. doi: 10.1001/jamapediatrics.2017.4043

1	8. Topjian AA, Telford R, Holubkov R, Nadkarni VM, Berg RA, Dean JM, Moler FW,
2	Therapeutic Hypothermia after Pediatric Cardiac Arrest Trial I. The association of early post-
3	resuscitation hypotension with discharge survival following targeted temperature management
4	for pediatric in-hospital cardiac arrest. Resuscitation. 2019;141:24-34. doi:
5	10.1016/j.resuscitation.2019.05.032
6	9. Maconochie IK, Aickin R, Hazinski MF, Atkins DL, Bingham R, Couto TB, Guerguerian
7	AM, Nadkarni VM, Ng KC, Nuthall GA, Ong GYK, Reis AG, Schexnayder SM, Scholefield
8	BR, Tijssen JA, Nolan JP, Morley PT, Van de Voorde P, Zaritsky AL, de Caen AR.; on behalf of
9	the International Liaison Committee on Resuscitation Pediatric Life Support Collaborators.
10	Pediatric Life Support: 2020 International Consensus on Cardiopulmonary Resuscitation and
11	Emergency Cardiovascular Care Science With Treatment Recommendations. Circulation.
12	2020;142(16)(Suppl 1):S140-S184. doi: 10.1161/CIR.000000000000894
13	10. Abend NS, Mani R, Tschuda TN, Chang T, Topjian AA, Donnelly M, LaFalce D, Krauss
14	MC, Schmitt SE, Levine JM. EEG monitoring during therapeutic hypothermia in neonates,
15	children, and adults. Am J Electroneurodiagnostic Technol. 2011;51:141-164.
16	11. Brooks GA, Park JT. Clinical and Electroencephalographic Correlates in Pediatric
17	Cardiac Arrest: Experience at a Tertiary Care Center. Neuropediatrics. 2018;49:324-329.
18	12. Fung FW, Topjian AA, Xiao R, Abend NS. Early EEG Features for Outcome Prediction
19	After Cardiac Arrest in Children. Journal of clinical neurophysiology : official publication of the
20	American Electroencephalographic Society. 2019;36:349-357.
21	13. Lin JJ, Hsu MH, Hsia SH, Lin YJ, Wang HS, Kuo HC, Chiang MC, Chan OW, Lee EP,
22	Lin KL. Epileptiform discharge and electrographic seizures during the hypothermia phase as

predictors of rewarming seizures in children after resuscitation. *Journal of Clinical Medicine*.
 2020;9:1-11.

3 14. Ostendorf AP, Hartman ME, Friess SH. Early Electroencephalographic Findings

4 Correlate With Neurologic Outcome in Children Following Cardiac Arrest. Pediatr Crit Care

5 Med. 2016;17:667-676. doi: 10.1097/pcc.000000000000791

6 10.1097/PCC.000000000000791.

7 15. Topjian AA, Sanchez SM, Shults J, Berg RA, Dlugos DJ, Abend NS. Early

8 Electroencephalographic Background Features Predict Outcomes in Children Resuscitated From

9 Cardiac Arrest. Pediatr Crit Care Med. 2016;17:547-557. doi: 10.1097/pcc.000000000000740

10 10.1097/PCC.00000000000740.

11 16. Scholefield B, Nicholson TC, Topjian A, Rech L, Bach A, Hahn C, Morrison LJ; on

12 behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task

13 Force. Effect of prophylactic anti-seizure medication and treatment of seizures on outcome of

14 pediatric patients following cardiac arrest: Consensus on Science With Treatment

15 Recommendations. 2023. Updated January 19, 2024. Accessed February 14, 2024.

16 https://costr.ilcor.org/document/effect-of-prophylactic-anti-seizure-medication-and-treatment-of-

17 seizures-on-outcome-of-pediatric-patients-following-cardiac-arrest

18 17. Brain Resuscitation Clinical Trial ISG. Randomized clinical study of thiopental loading

19 in comatose survivors of cardiac arrest. *N Engl J Med.* 1986;314:397-403. doi:

- 20 10.1056/NEJM198602133140701
- 21 18. Longstreth WT, Jr., Fahrenbruch CE, Olsufka M, Walsh TR, Copass MK, Cobb LA.
- 22 Randomized clinical trial of magnesium, diazepam, or both after out-of-hospital cardiac arrest.

23 Neurology. 2002;59:506-514. doi: 10.1212/wnl.59.4.506

1	19. Monsalve F, Rucabado L, Ruano M, Cuñat J, Lacueva V, Viñuales A. The neurologic
2	effects of thiopental therapy after cardiac arrest. Intensive Care Med. 1987;13:244-248. doi:
3	10.1007/bf00265112
4	20. Ruijter BJ, Keijzer HM, Tjepkema-Cloostermans MC, Blans MJ, Beishuizen A, Tromp
5	SC, Scholten E, Horn J, van Rootselaar AF, Admiraal MM, et al. Treating Rhythmic and
6	Periodic EEG Patterns in Comatose Survivors of Cardiac Arrest. New England journal of
7	medicine. 2022;386:724-734. doi: 10.1056/NEJMoa2115998
8	21. Young L, Berg M, Soll R. Prophylactic barbiturate use for the prevention of morbidity
9	and mortality following perinatal asphyxia. Cochrane Database Syst Rev. 2016;2016:Cd001240.
10	doi: 10.1002/14651858.CD001240.pub3
11	22. Kochanek PM, Tasker RC, Carney N, Totten AM, Adelson PD, Selden NR, Davis-
12	O'Reilly C, Hart EL, Bell MJ, Bratton SL, Grant GA, Kissoon N, Reuter-Rice KE, Vavilala MS,
13	Wainwright MS. Guidelines for the Management of Pediatric Severe Traumatic Brain Injury,
14	Third Edition: Update of the Brain Trauma Foundation Guidelines, Executive Summary.
15	Neurosurgery. 2019; doi: 10.1093/neuros/nyz051
16	10.1093/neuros/nyz051.
17	23. Liesemer K, Bratton SL, Zebrack CM, Brockmeyer D, Statler KD. Early post-traumatic
18	seizures in moderate to severe pediatric traumatic brain injury: rates, risk factors, and clinical
19	features. J Neurotrauma. 2011;28:755-762. doi: 10.1089/neu.2010.1518
20	24. Payne ET, Zhao XY, Frndova H, McBain K, Sharma R, Hutchison JS, Hahn CD. Seizure
21	burden is independently associated with short term outcome in critically ill children. Brain.

22 2014;137:1429-1438. doi: 10.1093/brain/awu042

1	25. Srinivasakumar P, Zempel J, Trivedi S, Wallendorf M, Rao R, Smith B, Inder T, Mathur
2	AM. Treating EEG Seizures in Hypoxic Ischemic Encephalopathy: A Randomized Controlled
3	Trial. Pediatrics. 2015;136:e1302-1309. doi: 10.1542/peds.2014-3777
4	26. Kapur J, Elm J, Chamberlain JM, Barsan W, Cloyd J, Lowenstein D, Shinnar S, Conwit
5	R, Meinzer C, Cock H, Fountain N, Connor JT, Silbergleit R. Randomized Trial of Three
6	Anticonvulsant Medications for Status Epilepticus. N Engl J Med. 2019;381:2103-2113. doi:
7	10.1056/NEJMoa1905795
8	27. Dalziel SR, Borland ML, Furyk J, Bonisch M, Neutze J, Donath S, Francis KL, Sharpe C,
9	Harvey AS, Davidson A, Craig S, Phillips N, George S, Rao A, Cheng N, Zhang M, Kochar A,
10	Brabyn C, Oakley E, Babl FE. Levetiracetam versus phenytoin for second-line treatment of
11	convulsive status epilepticus in children (ConSEPT): an open-label, multicentre, randomised
12	controlled trial. Lancet. 2019;393:2135-2145. doi: 10.1016/s0140-6736(19)30722-6
13	28. Lyttle MD, Rainford NEA, Gamble C, Messahel S, Humphreys A, Hickey H, Woolfall
14	K, Roper L, Noblet J, Lee ED, Potter S, Tate P, Iyer A, Evans V, Appleton RE. Levetiracetam
15	versus phenytoin for second-line treatment of paediatric convulsive status epilepticus (EcLiPSE):
16	a multicentre, open-label, randomised trial. Lancet. 2019;393:2125-2134. doi: 10.1016/s0140-
17	6736(19)30724-x
18	29. Lavonas EJ, Ohshimo S, Nation K, Van de Voorde P, Nuthall G, Maconochie I, Torabi
19	N, Morrison LJ. Advanced airway interventions for paediatric cardiac arrest: A systematic
20	review and meta-analysis. Resuscitation. 2019;138:114-128. doi:

- 21 10.1016/j.resuscitation.2019.02.040
- 22 30. Acworth J, del Castillo J, Acworth E, Tiwari L, Lopez-Herce J, Lavonas E, Morrison L;
- 23 on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task

1	Force. Advanced airway interventions in pediatric cardiac arrest: Consensus on Science With
2	Treatment Recommendations 2023. Updated December 05, 2023. Accessed February 14, 2024.
3	https://costr.ilcor.org/document/advanced-airway-interventions-in-pediatric-cardiac-arrest-pls-
4	p1-tfsr
5	31. Gausche M, Lewis RJ, Stratton SJ, Haynes BE, Gunter CS, Goodrich SM, Poore PD,
6	McCollough MD, Henderson DP, Pratt FD, Seidel JS. Effect of out-of-hospital pediatric
7	endotracheal intubation on survival and neurological outcome: a controlled clinical trial. Jama.
8	2000;283:783-790. doi: 10.1001/jama.283.6.783
9	32. Andersen LW, Raymond TT, Berg RA, Nadkarni VM, Grossestreuer AV, Kurth T,
10	Donnino MW. Association Between Tracheal Intubation During Pediatric In-Hospital Cardiac
11	Arrest and Survival. Jama. 2016;316:1786-1797. doi: 10.1001/jama.2016.14486
12	33. Hansen ML, Lin A, Eriksson C, Daya M, McNally B, Fu R, Yanez D, Zive D, Newgard
13	C. A comparison of pediatric airway management techniques during out-of-hospital cardiac
14	arrest using the CARES database. Resuscitation. 2017;120:51-56. doi:
15	10.1016/j.resuscitation.2017.08.015
16	34. Ohashi-Fukuda N, Fukuda T, Doi K, Morimura N. Effect of prehospital advanced airway
17	management for pediatric out-of-hospital cardiac arrest. Resuscitation. 2017;114:66-72. doi:
18	10.1016/j.resuscitation.2017.03.002
19	35. Okubo M, Komukai S, Izawa J, Gibo K, Kiyohara K, Matsuyama T, Kiguchi T, Iwami T,
20	Callaway CW, Kitamura T. Prehospital advanced airway management for paediatric patients
21	with out-of-hospital cardiac arrest: A nationwide cohort study. Resuscitation. 2019;145:175-184.
22	doi: 10.1016/j.resuscitation.2019.09.007

1	36. Tham LP, Fook-Chong S, Binte Ahmad NS, Ho AF, Tanaka H, Shin SD, Ko PC, Wong
2	KD, Jirapong S, Rao GVR, Cai W, Al Qahtani S, Ong MEH. Pre-hospital airway management
3	and survival outcomes after paediatric out-of-hospital cardiac arrests. Resuscitation. 2022;176:9-
4	18. doi: 10.1016/j.resuscitation.2022.04.018
5	37. Abe T, Nagata T, Hasegawa M, Hagihara A. Life support techniques related to survival
6	after out-of-hospital cardiac arrest in infants. Resuscitation. 2012;83:612-618. doi:
7	10.1016/j.resuscitation.2012.01.024
8	38. Aijian P, Tsai A, Knopp R, Kallsen GW. Endotracheal intubation of pediatric patients by
9	paramedics. Ann Emerg Med. 1989;18:489-494. doi: 10.1016/s0196-0644(89)80830-3
10	39. Deasy C, Bernard SA, Cameron P, Jaison A, Smith K, Harriss L, Walker T, Masci K,
11	Tibballs J. Epidemiology of paediatric out-of-hospital cardiac arrest in Melbourne, Australia.
12	Resuscitation. 2010;81:1095-1100. doi: 10.1016/j.resuscitation.2010.04.029
13	40. Del Castillo J, López-Herce J, Matamoros M, Cañadas S, Rodríguez-Calvo A, Cecchetti
14	C, Rodriguez-Núñez A, Álvarez AC. Long-term evolution after in-hospital cardiac arrest in
15	children: Prospective multicenter multinational study. Resuscitation. 2015;96:126-134. doi:
16	10.1016/j.resuscitation.2015.07.037
17	41. Guay J, Lortie L. An evaluation of pediatric in-hospital advanced life support
18	interventions using the pediatric Utstein guidelines: a review of 203 cardiorespiratory arrests.
19	Can J Anaesth. 2004;51:373-378. doi: 10.1007/bf03018242
20	42. Handley SC, Passarella M, Raymond TT, Lorch SA, Ades A, Foglia EE. Epidemiology
21	and outcomes of infants after cardiopulmonary resuscitation in the neonatal or pediatric intensive
22	care unit from a national registry. Resuscitation. 2021;165:14-22. doi:
23	10.1016/j.resuscitation.2021.05.029

1	43. Hansen M, Wang H, Le N, Lin A, Idris A, Kornegay J, Schmicker R, Daya M.					
2	Prospective evaluation of airway management in pediatric out-of-hospital cardiac arrest.					
3	Resuscitation. 2020;156:53-60. doi: 10.1016/j.resuscitation.2020.08.003					
4	44. Pitetti R, Glustein JZ, Bhende MS. Prehospital care and outcome of pediatric out-of-					
5	hospital cardiac arrest. Prehosp Emerg Care. 2002;6:283-290. doi: 10.1080/10903120290938300					
6	45. Sirbaugh PE, Pepe PE, Shook JE, Kimball KT, Goldman MJ, Ward MA, Mann DM. A					
7	prospective, population-based study of the demographics, epidemiology, management, and					
8	outcome of out-of-hospital pediatric cardiopulmonary arrest. Ann Emerg Med. 1999;33:174-184.					
9	doi: 10.1016/s0196-0644(99)70391-4					
10	46. Cheng FJ, Wu WT, Hung SC, Ho YN, Tsai MT, Chiu IM, Wu KH. Pre-hospital					
11	Prognostic Factors of Out-of-Hospital Cardiac Arrest: The Difference Between Pediatric and					
12	Adult. Front Pediatr. 2021;9:723327. doi: 10.3389/fped.2021.723327					
13	47. Fink EL, Prince DK, Kaltman JR, Atkins DL, Austin M, Warden C, Hutchison J, Daya					
14	M, Goldberg S, Herren H, Tijssen JA, Christenson J, Vaillancourt C, Miller R, Schmicker RH,					
15	Callaway CW. Unchanged pediatric out-of-hospital cardiac arrest incidence and survival rates					
16	with regional variation in North America. Resuscitation. 2016;107:121-128. doi:					
17	10.1016/j.resuscitation.2016.07.244					
18	48. Le Bastard Q, Rouzioux J, Montassier E, Baert V, Recher M, Hubert H, Leteurtre S,					
19	Javaudin F. Endotracheal intubation versus supraglottic procedure in paediatric out-of-hospital					
20	cardiac arrest: a registry-based study. Resuscitation. 2021;168:191-198. doi:					
21	10.1016/j.resuscitation.2021.08.015					
22	49. Tijssen JA, Prince DK, Morrison LJ, Atkins DL, Austin MA, Berg R, Brown SP,					

23 Christenson J, Egan D, Fedor PJ, Fink EL, Meckler GD, Osmond MH, Sims KA, Hutchison JS.

1	Time on the scene and interventions are associated with improved survival in pediatric out-of-
2	hospital cardiac arrest. Resuscitation. 2015;94:1-7. doi: 10.1016/j.resuscitation.2015.06.012
3	50. Tham LP, Wah W, Phillips R, Shahidah N, Ng YY, Shin SD, Nishiuchi T, Wong KD, Ko
4	PC, Khunklai N, Naroo GY, Ong MEH. Epidemiology and outcome of paediatric out-of-hospital
5	cardiac arrests: A paediatric sub-study of the Pan-Asian resuscitation outcomes study (PAROS).
6	Resuscitation. 2018;125:111-117. doi: 10.1016/j.resuscitation.2018.01.040
7	51. Fukuda T, Sekiguchi H, Taira T, Hashizume N, Kitamura Y, Terada T, Ohashi-Fukuda
8	N, Kukita I. Type of advanced airway and survival after pediatric out-of-hospital cardiac arrest.
9	Resuscitation. 2020;150:145-153. doi: 10.1016/j.resuscitation.2020.02.005
10	52. de Caen AR, Kleinman ME, Chameides L, Atkins DL, Berg RA, Berg MD, Bhanji F,
11	Biarent D, Bingham R, Coovadia AH, Hazinski MF, Hickey RW, Nadkarni VM, Reis AG,
12	Rodriguez-Nunez A, Tibballs J, Zaritsky AL, Zideman D. Part 10: Paediatric basic and advanced
13	life support: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency
14	Cardiovascular Care Science with Treatment Recommendations. Resuscitation. 2010;81 Suppl
15	1:e213-259. doi: 10.1016/j.resuscitation.2010.08.028
16	53. Niles DE, Duval-Arnould J, Skellett S, Knight L, Su F, Raymond TT, Sweberg T, Sen
17	AI, Atkins DL, Friess SH, de Caen AR, Kurosawa H, Sutton RM, Wolfe H, Berg RA, Silver A,
18	Hunt EA, Nadkarni VM. Characterization of Pediatric In-Hospital Cardiopulmonary
19	Resuscitation Quality Metrics Across an International Resuscitation Collaborative. Pediatr Crit
20	Care Med. 2018;19:421-432. doi: 10.1097/pcc.000000000001520
21	54. Sutton RM, Reeder RW, Landis WP, Meert KL, Yates AR, Morgan RW, Berger JT,
22	Newth CJ, Carcillo JA, McQuillen PS, Harrison RE, Moler FW, Pollack MM, Carpenter TC,
23	Notterman DA, Holubkov R, Dean JM, Nadkarni VM, Berg RA, Eunice Kennedy Shriver

1	National Institute of Child H, Human Development Collaborative Pediatric Critical Care
2	Research N. Ventilation Rates and Pediatric In-Hospital Cardiac Arrest Survival Outcomes. Crit
3	Care Med. 2019;47:1627-1636. doi: 10.1097/CCM.000000000003898
4	55. Maconochie IK, Aickin R, Hazinski MF, Atkins DL, Bingham R, Couto TB, Guerguerian
5	AM, Nadkarni VM, Ng KC, Nuthall GA, Ong GYK, Reis AG, Schexnayder SM, Scholefield
6	BR, Tijssen JA, Nolan JP, Morley PT, Van de Voorde P, Zaritsky AL, de Caen AR, Pediatric
7	Life Support C. Pediatric Life Support: 2020 International Consensus on Cardiopulmonary
8	Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations.
9	Resuscitation. 2020;156:A120-A155. doi: 10.1016/j.resuscitation.2020.09.013
10	56. Del Castillo J, Acworth J, López-Herce J, Kleinman M, Atkins D; on behalf of the
11	International Liaison Committee on Resuscitation Pediatric Life Support Task Force. Ventilation
12	rates in pediatric CPR with an advanced airway: Consensus on Science With Treatment
13	Recommendations. 2024. Updated January 05, 2024. Accessed Februrary 14, 2024.
14	https://costr.ilcor.org/document/ventilation-rates-in-pediatric-cpr-with-an-advanced-airway-pls-
15	1587-tf-sr
16	57. Morgan RW, Himebauch AS, Griffis H, Quarshie WO, Yeung T, Kilbaugh TJ, Topjian
17	AA, Traynor D, Nadkarni VM, Berg RA, Nishisaki A, Sutton RM. Pulmonary hypertension
18	among children with in-hospital cardiac arrest: A multicenter study. Resuscitation. 2021;168:52-
19	57. doi: 10.1016/j.resuscitation.2021.09.009
20	58. Abman SH, Hansmann G, Archer SL, Ivy DD, Adatia I, Chung WK, Hanna BD,
21	Rosenzweig EB, Raj JU, Cornfield D, Stenmark KR, Steinhorn R, Thebaud B, Fineman JR,

22 Kuehne T, Feinstein JA, Friedberg MK, Earing M, Barst RJ, Keller RL, Kinsella JP, Mullen M,

1	Deterding R, Kulik T, Mallory G, Humpl T, Wessel DL. Pediatric pulmonary hypertension.
2	Circulation. 2015;132:2037-2099. doi: 10.1161/CIR.000000000000329
3	59. Marino BS, Tabbutt S, MacLaren G, Hazinski MF, Adatia I, Atkins DL, Checchia PA,
4	DeCaen A, Fink EL, Hoffman GM, Jefferies JL, Kleinman M, Krawczeski CD, Licht DJ,
5	Macrae D, Ravishankar C, Samson RA, Thiagarajan RR, Toms R, Tweddell J, Laussen PC,
6	American Heart Association Congenital Cardiac Defects Committee of the Council on
7	Cardiovascular Disease in the Y, Council on Clinical C, Council on C, Stroke N, Council on
8	Cardiovascular S, Anesthesia, Emergency Cardiovascular Care C. Cardiopulmonary
9	Resuscitation in Infants and Children With Cardiac Disease: A Scientific Statement From the
10	American Heart Association. Circulation. 2018;137:e691 - e782. doi:
11	10.1161/CIR.00000000000524
12	60. Konstam MA, Kiernan MS, Bernstein D, Bozkurt B, Jacob M, Kapur NK, Kociol RD,
13	Lewis EF, Mehra MR, Pagani FD, Raval AN, Ward C. Evaluation and Management of Right-
14	Sided Heart Failure: A Scientific Statement From the American Heart Association. Circulation.
15	2018;137:e578-e622. doi: 10.1161/cir.000000000000560
16	61. Ng K-C, Kurosawa H, Guerguerian A-M, Schmoelzer G, Zhang D, Rech L, Lim J,
17	Cunningham J; on behalf of the Pediatric Life Support Task Force. Management of pulmonary
18	hypertension with cardiac arrest in infants and children in the hospital setting. 2023. Updated
19	January 19, 2024. Accessed February 14, 2024. https://costr.ilcor.org/document/management-of-
20	pulmonary-hypertension-with-cardiac-arrest-in-infants-and-children-in-the-hospital-setting-pls-
21	scr
22	62. Abman SH, Ivy DD, Archer SL, Wilson K. Executive summary of the American Heart
23	Association and American thoracic society joint guidelines for pediatric pulmonary

- 1 hypertension. *American Journal of Respiratory and Critical Care Medicine*. 2016;194:898-906.
- 2 doi: 10.1164/rccm.201606-1183ST

3 63. Ball MK, Seabrook RB, Bonachea EM, Chen B, Fathi O, Nankervis CA, Osman A,

4 Schlegel AB, Magers J, Kulpa T, Sharpin P, Snyder ML, Gajarski RJ, i D, Backes CH.

5 Evidence-Based Guidelines for Acute Stabilization and Management of Neonates with Persistent

6 Pulmonary Hypertension of the Newborn. American Journal of Perinatology. 2022; doi:

7 10.1055/a-1711-0778

8 64. Dabbagh MA, Banjar H, Galal N, Kouatli A, il H, Chehab M. Saudi guidelines on the

9 diagnosis and treatment of pulmonary hypertension: Pulmonary hypertension in children. Annals

10 of Thoracic Medicine. 2014;9:S113-S120. doi: 10.4103/1817-1737.134053

11 65. Durongpisitkul K, Sompradeekul S, Nanagara R, Jakrapanichakul D, Wanitkun S,

12 Limsuwan A, Jaimchariyatam N, Sawasdiwipachi P, Boonyaratavej S, Lertsapcharoen P,

13 Pussadhamma B, Pornsuriyasak P, Louthrenoo W, Arromdee E, Chungsomprasong P, Vijarnsorn

14 C, Chirakarnjanakorn S, Phrommintikul A, Kanitsap A, Sricharoenchai T, Disayabutr S,

15 Tangcharoen T, Wongsa A, Sangsayune P, Rittayamai N, Samankatiwat P. Executive summary

16 thai pulmonary hypertension guidelines 2020. Journal of the Medical Association of Thailand.

17 2021;104:679-694. doi: 10.35755/jmedassocthai.2021.04.11939

18 66. Kuang H, Li Q, Yi Q, Lu T. The Efficacy and Safety of Aerosolized Iloprost in

19 Pulmonary Arterial Hypertension: A Systematic Review and Meta-Analysis. American Journal

20 of Cardiovascular Drugs. 2019;19:393-401. doi: 10.1007/s40256-018-00324-2

- 21 67. Morell E, Gaies M, Fineman JR, Charpie J, Rao R, Sasaki J, Zhang W, Reichle G,
- 22 Banerjee M, Tabbutt S. Mortality from pulmonary hypertension in the pediatric cardiac ICU.

- 1 American Journal of Respiratory and Critical Care Medicine. 2021;204:454-461. doi:
- 2 10.1164/rccm.202011-4183OC
- 3 68. Morgan RW, Topjian AA, Wang Y, Atkin NJ, Kilbaugh TJ, McGowan FX, Berg RA,
- 4 Mercer-Rosa L, Sutton RM, Himebauch AS. Prevalence and outcomes of pediatric in-hospital
- 5 cardiac arrest associated with pulmonary hypertension. *Pediatric Critical Care Medicine*.
- 6 2020:305-313. doi: 10.1097/PCC.00000000002187
- 7 69. Mulligan C, Beghetti M. Inhaled iloprost for the control of acute pulmonary hypertension
- 8 in children: A systematic review. *Pediatric Critical Care Medicine*. 2012;13:472-480. doi:
- 9 10.1097/PCC.0b013e31822f192b
- 10 70. Nasr VG, Faraoni D, DiNardo JA, Thiagarajan RR. Adverse Outcomes in Neonates and
- 11 Children with Pulmonary Artery Hypertension Supported with ECMO. Asaio j. 2016;62:728-
- 12 731. doi: 10.1097/mat.000000000000419
- 13 71. Olsson KM, Halank M, Egenlauf B, Fistera D, Gall H, Kaehler C, Kortmann K, Kramm
- 14 T, Lichtblau M, Marra AM, Nagel C, Sablotzki A, Seyfarth H-J, Schranz D, Ulrich S, Hoeper
- 15 MM, Lange TJ. Decompensated right heart failure, intensive care and perioperative management
- 16 in patients with pulmonary hypertension: Updated recommendations from the Cologne
- 17 Consensus Conference 2018. International journal of cardiology. 2018;272:46-52. doi:
- 18 10.1016/j.ijcard.2018.08.081
- 19 72. Opitz C, Rosenkranz S, Ghofrani HA, Grünig E, Klose H, Olschewski H, Hoeper M.
- 20 [ESC guidelines 2015 pulmonary hypertension: diagnosis and treatment]. Dtsch Med
- 21 Wochenschr. 2016;141:1764-1769. doi: doi:10.1055/s-0042-117784 %(ESC-Leitlinie 2015:
- 22 Diagnostik und Therapie der pulmonalen Hypertonie.

1	73. Hansmann G, Koestenberger M, Alastalo TP, Apitz C, Austin ED, Bonnet D, Budts W,
2	D'Alto M, Gatzoulis MA, Hasan BS, Kozlik-Feldmann R, Kumar RK, Lammers AE, Latus H,
3	Michel-Behnke I, Miera O, Morrell NW, Pieles G, Quandt D, Sallmon H, Schranz D, Tran-
4	Lundmark K, Tulloh RMR, Warnecke G, Wåhlander H, Weber SC, Zartner P. 2019 updated
5	consensus statement on the diagnosis and treatment of pediatric pulmonary hypertension: The
6	European Pediatric Pulmonary Vascular Disease Network (EPPVDN), endorsed by AEPC,
7	ESPR and ISHLT. J Heart Lung Transplant. 2019;38:879-901. doi:
8	10.1016/j.healun.2019.06.022
9	74. Kozlik-Feldmann R, Hansmann G, Bonnet D, Schranz D, Apitz C, Michel-Behnke I.
10	Pulmonary hypertension in children with congenital heart disease (PAH-CHD, PPHVD-CHD).
11	Expert consensus statement on the diagnosis and treatment of paediatric pulmonary
12	hypertension. The European Paediatric Pulmonary Vascular Disease Network, endorsed by
13	ISHLT and DGPK. Heart. 2016;102 Suppl 2:ii42-48. doi: 10.1136/heartjnl-2015-308378
14	75. Boudjemline Y, Sizarov A, Malekzadeh-Milani S, Mirabile C, Lenoir M, Khraiche D,
15	Levy M, Bonnet D. Safety and Feasibility of the Transcatheter Approach to Create a Reverse
16	Potts Shunt in Children With Idiopathic Pulmonary Arterial Hypertension. Canadian Journal of
17	Cardiology. 2017;33:1188-1196. doi: 10.1016/j.cjca.2017.06.004
18	76. Li Q, Zhang C, Wang R, Keller BB, Gu H. Pulmonary hypertensive crisis in children
19	with pulmonary arterial hypertension undergoing cardiac catheterization. Pulmonary Circulation.
20	2022;12:e12067. doi: 10.1002/pul2.12067
21	77. Morell E, Rajagopal SK, Oishi P, Thiagarajan RR, Fineman JR, Steurer MA.
22	Extracorporeal membrane oxygenation in pediatric pulmonary hypertension. Pediatric Critical
23	Care Medicine. 2020:256-266. doi: 10.1097/PCC.000000000002127

1	78. Galiè N, McLaughlin VV, Rubin LJ, Simonneau G. An overview of the 6th World
2	Symposium on Pulmonary Hypertension. Eur Respir J. 2019;53 doi: 10.1183/13993003.02148-
3	2018
4	79. Rosenzweig EB, Abman SH, Adatia I, Beghetti M, Bonnet D, Haworth S, Ivy DD,
5	Berger RMF. Paediatric pulmonary arterial hypertension: Updates on definition, classification,
6	diagnostics and management. European Respiratory Journal. 2019;53:1-18. doi:
7	10.1183/13993003.01916-2018
8	80. Simonneau G, Montani D, Celermajer DS, Denton CP, Gatzoulis MA, Krowka M,
9	Williams PG, Souza R. Haemodynamic definitions and updated clinical classification of
10	pulmonary hypertension. Eur Respir J. 2019;53:1. doi: 10.1183/13993003.01913-2018
11	81. Morgan RW, Reeder RW, Ahmed T, Bell MJ, Berger JT, Bishop R, Bochkoris M, Burns
12	C, Carcillo JA, Carpenter TC, Dean JM, Diddle JW, Federman M, Fernandez R, Fink EL,
13	Franzon D, Frazier AH, Friess SH, Graham K, Hall M, Hehir DA, Himebauch AS, Horvat CM,
14	Huard LL, Maa T, Manga A, McQuillen PS, Meert KL, Mourani PM, Nadkarni VM, Naim MY,
15	Notterman D, Page K, Pollack MM, Sapru A, Schneiter C, Sharron MP, Srivastava N, Tabbutt S,
16	Tilford B, Viteri S, Wessel D, Wolfe HA, Yates AR, Zuppa AF, Berg RA, Sutton RM. Outcomes
17	and characteristics of cardiac arrest in children with pulmonary hypertension: A secondary
18	analysis of the ICU-RESUS clinical trial. Resuscitation. 2023;190:1. doi:
19	10.1016/j.resuscitation.2023.109897
20	82. Abman SH, Mullen MP, Sleeper LA, Austin ED, Rosenzweig EB, Kinsella JP, Ivy D,
21	Hopper RK, Usha Raj J, Fineman J, Keller RL, Bates A, Krishnan US, Avitabile CM, Davidson
22	A, Natter MD, 1 KD. Characterisation of Pediatric Pulmonary Hypertensive Vascular Disease

1 from the PPHNet Registry. *The European respiratory journal*. 2021:1-14. doi:

2 10.1183/13993003.03337-2020

3 83. Taylor K, Holtby H. Emergency Interventional Lung Assist for Pulmonary Hypertension.
4 Anesthesia & Analgesia. 2009;109:382.

5 84. Ploegstra MJ, Arjaans S, Zijlstra WMH, Douwes JM, Vissia-Kazemier TR, Roofthooft

6 MTR, Hillege HL, Berger RMF. Clinical Worsening as Composite Study End Point in Pediatric

7 Pulmonary Arterial Hypertension. Chest. 2015;148:655-666. doi: 10.1378/chest.14-3066

8 85. Conway JA, Kharayat P, Sanders RC, Jr., Nett S, Weiss SL, Edwards LR, Breuer R,

9 Kirby A, Krawiec C, Page-Goertz C, Polikoff L, Turner DA, Shults J, Giuliano JS, Jr., Orioles

10 A, Balkandier S, Emeriaud G, Rehder KJ, Kian Boon JL, Shenoi A, Vanderford P, Nuthall G,

11 Lee A, Zeqo J, Parsons SJ, Furlong-Dillard J, Meyer K, Harwayne-Gidansky I, Jung P, Adu-

12 Darko M, Bysani GK, McCarthy MA, Shlomovich M, Toedt-Pingel I, Branca A, Esperanza MC,

13 Al-Subu AM, Pinto M, Tallent S, Shetty R, Thyagarajan S, Ikeyama T, Tarquinio KM, Skippen

14 P, Kasagi M, Howell JD, Nadkarni VM, Nishisaki A, National Emergency Airway Registry for

15 C, for the Pediatric Acute Lung I, Sepsis I. Ketamine Use for Tracheal Intubation in Critically III

16 Children Is Associated With a Lower Occurrence of Adverse Hemodynamic Events. Crit Care

17 *Med.* 2020;48:e489-e497. doi: 10.1097/CCM.00000000004314

18 86. Holmberg MJ, Wiberg S, Ross CE, Kleinman M, Hoeyer-Nielsen AK, Donnino MW,

19 Andersen LW. Trends in Survival After Pediatric In-Hospital Cardiac Arrest in the United

20 States. Circulation. 2019;140:1398-1408. doi: 10.1161/CIRCULATIONAHA.119.041667

21 87. Menendez JJ, Sanchez-Galindo AC, Balcells J, Tejero-Hernandez MA, Ferrer-Barba A,

22 Ibiza-Palacios E, Medrano-Lopez C, Gran F, Frias-Perez MA, Garcia-Vieites M, Cano-Sanchez

23 A, Polo L, Gil-Jaurena JM, Abella RF, Merino-Cejas C, Martinez-Bendayan I, Serrano F,

Garcia-Guereta L. Short- and long-term survival of children treated with ventricular assist
 devices in Spain, based on 15 years' experience. *Eur J Cardiothorac Surg.* 2023;63 doi:
 10.1093/ejcts/ezad050
 88. Holmberg MJ, Nicholson T, Nolan JP, Schexnayder S, Reynolds J, Nation K, Welsford
 M, Morley P, Soar J, Berg KM, Adult Pediatric Advanced Life Support Task Forces at the
 International Liaison Committee on R. Oxygenation and ventilation targets after cardiac arrest: A

7 systematic review and meta-analysis. *Resuscitation*. 2020;152:107-115. doi:

8 10.1016/j.resuscitation.2020.04.031

1 NEONATAL LIFE SUPPORT

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

3 Rationale for Review

4 Adaptation to air breathing immediately after birth requires that several critical 5 interdependent physiologic events occur rapidly.¹ Air breathing reduces pulmonary vascular 6 resistance, which increases pulmonary blood flow. If the umbilical cord is clamped immediately, 7 the increased pulmonary flow is initially from the aorta via the ductus arteriosus. If cord 8 clamping occurs after the onset of breathing, the increased pulmonary blood flow can come from the placenta via the umbilical vein and ductus venosus, thereby maintaining left ventricular 9 filling and output (vital for coronary and cerebral perfusion).² Both milking the intact (not 10 11 clamped or cut) umbilical cord and milking a long segment of clamped and cut cord have been 12 proposed as alternatives to deferring clamping of the umbilical cord. Decisions about umbilical cord management can critically influence the cardiorespiratory adaptation after birth,^{3,4} how and 13 14 when other resuscitation interventions are provided, and mortality during subsequent hospitalization, particularly among preterm infants.⁵ 15

The topic was last reviewed in by ILCOR in 2021.^{6,7} Since then, additional RCTs have 16 been completed and compiled into a very large pairwise individual patient data (IPD) meta-17 18 analysis and network meta-analysis (NMA), the "individual participant data on cord management at preterm birth" (iCOMP) study,⁸ which provided higher-certainty evidence for various methods 19 20 of umbilical cord management than could have been achieved with study-level meta-analysis alone.^{5,9} The Neonatal Life Support Task Force used the process of adolopment to appraise this 21 evidence and develop updated treatment recommendations.¹⁰ Task force members and content 22 23 experts overlapped with the iCOMP study team, but assessment of suitability of the iCOMP

1	analyses for adolopment was assessed by task force members and content experts who had no
2	conflict of interest. The IPD meta-analysis is presented first and then the NMA, because the
3	PICOST structure differs. The pairwise IPD meta-analysis was used for subgroup analyses, and
4	the NMA was used for multiple between-intervention comparisons.
5	The iCOMP SysRev was registered before initiation (PROSPERO Registration
6	CRD42019136640). The full online CoSTR can be found on the ILCOR website. ¹⁰
7	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
8	Individual Patient Data Pairwise Meta-Analysis ^{5,8}
9	• Population: Preterm infants born at <37+0 weeks' gestation and their mothers
10	• Interventions:
11	 Deferred (delayed/later) cord clamping (>15 seconds)
12	- Umbilical cord milking (cord milking or stripping immediately after birth or after
13	deferred cord clamping)
14	Comparators:
15	- Immediate (early) cord clamping (≤ 15 seconds or as defined by the trialist) without cord
16	milking and without initiation of respiratory support for any reason
17	 Between-intervention comparisons
18	• Outcomes:
19	- Infant outcomes (importance assigned by task force consensus, in accordance with
20	available guidelines11,12):
21	 Mortality before hospital discharge (critical)

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

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

6 Consensus on Science

7 *Comparison 1: Deferred cord clamping compared with immediate cord clamping.* The pairwise IPD meta-analysis⁵ identified 21 eligible studies including 3292 infants.¹⁴⁻³² The median 8 9 study sample size was 65 (IOR, 40–101). The median (IOR) gestational age at birth was 29 (27– 10 33) weeks. Deferred cord clamping ranged from 30 to ≥ 180 seconds (some trials encouraging deferrals up to 5 minutes where feasible). For immediate cord clamping, most trials (14/21) 11 12 specified clamping within 10 seconds. Of all infants, 61% were born by cesarean delivery 25% 13 were multiples, and 56% were male. Trials were conducted in high-income (9/21), upper-middle-14 income (5/21), and lower-middle-income (7/21) countries as defined by World Bank country classification.³³ For this review, we present odds ratios, aligning with the iCOMP statistical 15 analysis plan.^{5,8,9} Key results are summarized in Table 19. 16

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

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

				Anticipated absolute effect	
Outcomes (importance)	Participants (studies)	Certainty of the evidence (GRADE)	OR (95% CI)	Risk or mean concentration (± SD) with ICC	RD (CI) or MD (CI) with DCC; NNTB or NNTH if applicable
					NNTB, 40 (26–
					143) infants
Hemoglobin	523	Moderate	NA	16 (± 2) g/dL	0.88 (0.52–
concentration	$(8 \text{ RCTs})^{15,18-21,28,31,32}$				1.24) g/dL
(g/dL) for infants					
<32 weeks'					
gestation					
(important)					
Red cell	1929	Moderate	0.59	57/1000	131 fewer
transfusion for	(13 RCTs) ^{15,17-}		(0.47–		infants received
infants <32 weeks'	19,21,22,24,26,28,29,31,32,34		0.73)		red cell
gestation					transfusion per
(important)					1000 (186
-					fewer-78
					fewer);
					NNTB, 7 (6–13)
					infants
Hypothermia on	1995	Moderate	1.28	449/1000	62 more infants
admission to NICU	(8 RCTs) ¹⁷⁻		(1.06–		were
for infants <32	19,26,28,31,32,34		1.56)		hypothermic per
weeks' gestation					1000 (14 more-
(adverse effect—					111 more);
important)					NNTH, 16 (9–
					71) infants

DCC indicates deferred cord clamping; GRADE, Grading of Recommendations, Assessment, Development, and

Evaluation; ICC, immediate cord clamping; MD, mean difference; NA, not applicable; NICU, neonatal intensive

care unit; NNTB, number needed to treat to benefit; NNTH, number needed to treat to harm; OR, odds ratio; RCT,

randomized controlled trial; RD, risk difference; SD, standard deviation.

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

7 *Comparison 2: Umbilical cord milking compared with immediate cord clamping.* The pairwise IPD meta-analysis⁵ identified 18 trials including 1565 infants.^{18,20,25,35-49} The median 8 study sample size was 60 (IQR, 45-122). The median gestational age at birth was 29 (IQR, 27-9 10 31) weeks. The cord was milked intact 2 to 4 times in 12 trials (866 infants), whereas in 4 trials 11 (340 infants) the cut cord was milked once, and in 2 trials (359 infants) there was a delay before 12 intact-cord milking. Of all infants, 64% were born by cesarean delivery, 13% were multiples, and 13 56% were male. Trials were conducted in high-income (10/18), upper-middle-income (4/18), and 14 lower-middle-income (4/18) countries. Key results are presented in Table 20.

15	Table 20. Comparison 2: Umbilical Cord Milking Compared With Immediate Con
16	Clamping
10	ommping

				Anticipated a	bsolute effect
Outcomes (importance)	Participants (studies)	Certainty of the evidence (GRADE)	OR (95% CI)	Risk or weighted mean concentration (± SD) with ICC	RD (CI) or MD (CI) with UCM; NNTB or NNTH if applicable
Mortality before	1565	Low	0.73	56/1000	14 fewer
hospital discharge	(18 RCTs) ^{18,20,25,35-}		(0.44–		infants died
(critical)	47,49,50		1.20)		per 1000 (30
					fewer-10
					more) infants

				Anticipated absolute effect	
Outcomes (importance)	Participants (studies)	Certainty of the evidence (GRADE)	OR (95% CI)	Risk or weighted mean concentration (± SD) with ICC	RD (CI) or MD (CI) with UCM; NNTB or NNTH if applicable
Hemoglobin	944	Low	NA	15 (± 2) g/dL	0.45 (0.17–
concentration (g/dL)	(12 RCTs) ^{35,37,39-}				0.73) g/dL
for infants	41,43,45-47,50				
<32 weeks' gestation					
(important)					
Red cell transfusion	1163	Moderate	0.69	443/1000	92 fewer
for infants <32	(15 RCTs) ^{18 35-37, 39-}		(0.51–		infants
weeks' gestation	47,49,50		0.93)		received red
(important)					cell
					transfusion per
					1000 (167
					fewer-18
					fewer);
					NNTB, 11 (6-
					56) infants

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

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

1 *Comparison 3: Umbilical cord milking compared with deferred cord clamping.* The pairwise IPD meta-analysis⁵ identified 15 trials including 1655 infants.^{18,20,25,51-62} The median 2 3 study sample size was 44 (IQR, 36–171). The median gestational age at birth was 30 (IQR, 28– 4 33) weeks. The intact cord was milked 2 to 4 times in 14 studies including 1649 infants and once in 1 study including 6 infants. Deferral times in the deferred cord clamping group ranged from 5 6 30 to 120 seconds. Of all infants, 64% were born by cesarean delivery, 15% were multiples, and 7 54% were male. Trials were conducted in high-income (8/15), upper-middle-income (3/15), and 8 lower-middle-income (4/15) countries. Results are summarized in Table 21.

9 Table 21. Comparison 3: Umbilical Cord Milking Compared With Deferred Cord 10 Clamping

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

				Anticipated absolute effect	
Outcomes (importance)	Participants (studies)	Certainty of the evidence (GRADE)	OR (95% CI)	Risk or mean concentration (± SD) with DCC	RD or change with UCM; NNTB or NNTH if applicable
Maternal	653	Low	2.72	25/1000	39 more
postpartum blood	(4 RCTs) ^{18,51,52,55}		(1.11–		mothers
transfusion			6.65)		received
(critical)					blood
					transfusion
					per 1000 (3
					more-118
					more);
					NNTH, 25
					(8–333)
					mothers

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

5 For all other critical and important infant and maternal outcomes, clinical benefit or harm

6 could not be determined.

7

Subgroup analyses: For all 3 comparisons, subgroup analyses by gestational age at birth,

8 multiple versus singleton birth, caesarean section versus vaginal birth, study start year, perinatal

9 mortality rate of country where study was conducted, and sex of infant did not influence the

10 effect on mortality (very low-certainty to low-certainty evidence).

11 Individual Patient Data Network Meta-Analysis

- Population: Preterm infants born at <37+0 weeks' gestation and their mothers.
- 13 Interventions:
| 1 | _ | Immediate (early) cord clamping at ≤ 15 seconds, without cord milking or initiation of |
|----|--------|---|
| 2 | | respiratory support or as defined by the trialist |
| 3 | _ | Short deferral of cord clamping for >15 seconds to <45 seconds without milking, with or |
| 4 | | without respiratory support |
| 5 | _ | Medium deferral of cord clamping for \geq 45 to <120 seconds without milking, with or |
| 6 | | without respiratory support |
| 7 | _ | Long deferral of cord clamping for ≥ 120 seconds without milking, with or without |
| 8 | | respiratory support |
| 9 | _ | Intact cord milking immediately after birth (with the umbilical cord attached to the |
| 10 | | placenta) |
| 11 | • | Comparisons: Between-intervention comparisons |
| 12 | • | Outcomes: |
| 13 | _ | Mortality before hospital discharge (critical) |
| 14 | _ | Intraventricular hemorrhage (critical) |
| 15 | _ | Blood transfusion (important) |
| 16 | • | Study design: As for the pairwise IPD meta-analysis, ⁵ RCTs comparing umbilical cord |
| 17 | | management strategies at preterm birth were included. Interventions were grouped into |
| 18 | | the following nodes: immediate clamping, short deferral, medium deferral, long deferral, |
| 19 | | and intact cord milking.9 |
| 20 | • | Time frame: As for the pairwise IPD meta-analysis ^{5,9} |
| 21 | | Certainty of evidence was assessed using the Confidence in Network Meta-Analysis |
| 22 | (CINe | MA) framework, which is based on the GRADE framework but is adapted for network |
| 23 | meta-a | analysis. ⁶⁵ |

2	The IPD NMA ⁹ identified 47 eligible studies including 6094 infants. ^{14-18,20-32,34,35,37-}
3	^{39,41,43,44,49,52-59,62,66-75} The median study sample size was 60 infants (IQR, 40–127). The median
4	gestational age at birth was 29.6 weeks (IQR, 27.6-33.3). Of all infants, 61% were born by
5	cesarean delivery, 17% were multiples, and 54% were male. The primary outcome was missing
6	for 4 (<0.1%) infants.
7	Sufficient data were found to include comparisons of the following 5 interventions in the
8	NMA:
9	1. Immediate (early) cord clamping (as soon as possible or within 15 seconds)
10	2. Short deferral of cord clamping (≥ 15 seconds–<45 seconds)
11	3. Medium deferral of cord clamping (\geq 45 seconds–<120 seconds)
12	4. Long deferral of cord clamping (≥120 seconds)
13	5. Intact cord milking immediately after birth (milking the umbilical cord before the cord
14	was clamped)
15	For the outcomes of death before discharge, any intraventricular hemorrhage, and blood
16	transfusion, the number of trials for each comparison ranged from 0 to 8 and the number of
17	infants varied from 29 to 1993.9 The largest number of trials providing data for each outcome
18	were for the cord milking compared with immediate cord clamping, for cord milking compared
19	with medium deferral of cord clamping, and for immediate cord clamping compared with
20	medium deferral of cord clamping. Note that in each case, the analysis was by intention to treat.
21	Only 70% of the 47 trials reported treatment adherence. ⁹ Key results are presented in Table 22.

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

1 Table	22. Network	x Meta-Analys	is of Methods of	f Umbilical Cord	Management
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GRADE indicates Grading of Recommendations, Assessment, Development, and Evaluation; NA, not applicable;
 NNTB, number needed to treat to benefit; RCT, randomized controlled trial.

4 For comparisons and outcomes not included in Table 22, clinical benefit or harm could

5 not be determined, and details are provided in the online CoSTR.¹⁰

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

1	Prior Treatment Recommendations (2021)
2	In infants born at <34 weeks' gestational age who do not require immediate resuscitation
3	after birth, we suggest deferring clamping the cord for at least 30 seconds (weak
4	recommendation, moderate-certainty evidence). ^{6,7}
5	In infants born at 28+0 to 33+6 weeks' gestational age who do not require immediate
6	resuscitation after birth, we suggest intact-cord milking as a reasonable alternative to deferring
7	cord clamping (weak recommendation, moderate-certainty evidence). ^{6,7}
8	We suggest against intact-cord milking for infants born at <28 weeks' gestational age
9	(weak recommendation, very low-certainty evidence). ^{6,7}
10	In infants born at <34 weeks' gestational age who require immediate resuscitation, there
11	is insufficient evidence to make a recommendation with respect to cord management. ^{6,7}
12	There is also insufficient evidence to make recommendations on cord management for
13	maternal, fetal, or placental conditions that were considered exclusion criteria in many studies (in
14	particular, multiple fetuses, congenital anomalies, placental abnormalities, alloimmunization,
15	fetal anemia, fetal compromise, and maternal illness). In these situations, we suggest
16	individualized decisions based on severity of the condition and assessment of maternal and
17	neonatal risk (weak recommendation, very low-certainty evidence).6,7
18	2024 Treatment Recommendations
19	In preterm infants born at less than 37 weeks' gestational age who are deemed not to
20	require immediate resuscitation at birth, we recommend deferring clamping of the umbilical cord
21	for at least 60 seconds (strong recommendation, moderate-certainty evidence).
22	In preterm infants born at 28+0 to 36+6 weeks' gestational age who do not receive
23	deferred cord clamping, we suggest umbilical cord milking as a reasonable alternative to
24	immediate cord clamping to improve infant hematologic outcomes. Individual maternal and

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infant circumstances should be taken into account (conditional recommendation, low-certainty
 evidence).

3	We suggest against intact cord milking for infants born at less than 28 weeks' gestation
4	(weak recommendation, low-certainty evidence). There is insufficient evidence to make a
5	recommendation regarding cut-cord milking in this gestational age group.
6	In preterm infants born at less than 37 weeks' gestational age who are deemed to require
7	immediate resuscitation at birth, there is insufficient evidence to make a recommendation with
8	respect to cord management (weak recommendation, low-certainty evidence).
9	There is insufficient evidence to make recommendations on cord management for
10	maternal, fetal, or placental conditions that were considered exclusion criteria in many studies
11	(monochorionic multiple fetuses, congenital anomalies, placental abnormalities,
12	alloimmunization and/or fetal anemia, fetal compromise, and maternal illness). In these
13	situations, we suggest individualized decisions based on severity of the condition and assessment
14	of maternal and neonatal risk (weak recommendation, very low-certainty evidence).
15	Whenever circumstances allow, the plan for umbilical cord management should be
16	discussed between maternity and neonatal providers and parents before delivery and should take
17	into account individual maternal and infant circumstances (good practice statement).
18	Justification and Evidence-to-Decision Framework Highlights
19	The complete evidence-to-decision table can be found in Appendix A4.
20	The strong recommendation for deferring cord clamping for at least 60 seconds in
21	preterm infants <37 weeks' gestation reflects the following considerations:
22	• Evidence for reduced mortality after deferred cord clamping compared with immediate
23	cord clamping was rated high-certainty. ^{5,10} The reduction in mortality was robust across
24	several participant-level and trial-level subgroups (including gestational age at birth,

mode of birth, multiple birth, sex, trial year, and perinatal mortality rate) and consistent in
 all prespecified sensitivity analyses.

We place high value on the outcome of mortality, and this has guided the strong
 treatment recommendation. The certainty of evidence for other outcomes varied from low
 to moderate, and, therefore, we concluded that the overall certainty of evidence is
 moderate.

- There was moderate-certainty evidence in infants <32 weeks' gestation for fewer red cell
 transfusions and in infants both < and ≥32 weeks' gestation for higher hemoglobin
 concentrations within the first 24 hours after birth after deferred cord clamping compared
 with immediate cord clamping.
- Sixty seconds or more was chosen as the recommended interval for deferred cord 11 12 clamping because that threshold defined 80% of infants who received deferred clamping in the combined studies. The evidence for medium (60–119 seconds) or long (>120 13 14 seconds) deferral of cord clamping is based on fewer infants and trials. Moreover, the 15 analysis was by intention to treat, many trials did not report actual interval from birth to 16 cord clamping, and most trials allowed clinicians to clamp the cord when considered 17 necessary to perform resuscitation. The reported adherence to long delay was lowest at 67% (compared with about 80% for medium deferral and 95% for immediate cord 18 19 clamping, umbilical cord milking, and short deferred cord clamping), so the proportion 20 and clinical characteristics of infants who benefited from medium or long delay are 21 unclear. Furthermore, there were fewer than 121 extremely preterm infants in the trials of long delay.^{26,27} 22

1	• Medium or long delay may be justified for infants who are coping well without
2	resuscitation or where appropriate newborn stabilization can be provided before umbilical
3	cord clamping (skilled team, proper training, appropriate equipment, enough space, and
4	ability to provide measures to maintain normal temperature).
5	• The task force noted that there was moderate-certainty evidence for the adverse effect of
6	an increase in the risk of hypothermia (body temperature <36.5°C) on admission after
7	deferred cord clamping compared with immediate cord clamping for infants <32 weeks'
8	gestation. Refer to ILCOR recommendations regarding maintaining normal temperature
9	immediately after birth in preterm infants. ⁸⁰
10	• Parents report that deferred cord clamping provides a positive experience, with the
11	mothers feeling closer and more attached to their infants. ⁸¹
12	In making the suggestion to consider umbilical cord milking as an alternative to
13	immediate cord clamping in infants born at 28+0 to 36+6 weeks' gestation, the task force
14	considered the following:
15	• Low-certainty evidence that umbilical cord milking may not reduce the critical outcome
16	of death before discharge compared with immediate cord clamping
17	• Moderate-certainty evidence for reduced red cell transfusion after umbilical cord milking
18	compared with immediate cord clamping in infants both <32 weeks' gestation and ≥32
19	weeks' gestation
20	• Low-certainty evidence for higher hemoglobin after umbilical cord milking compared
21	with immediate cord clamping in infants, both <32 weeks' gestation and ≥32 weeks'
22	gestation.
23	• No evidence for adverse effects in preterm infants <37 weeks' gestation or their mothers
24	after umbilical cord milking compared with immediate cord clamping

1	• No evidence for adverse effects after umbilical cord milking compared with deferred cord
2	clamping in preterm infants born at 28+0 to 36+6 weeks' gestation
3	• The IPD meta-analyses did not distinguish between the 2 methods of cord milking
4	(intact-cord and cut-cord). The intact cord was milked 2 to 4 times in most trials, while a
5	few trials milked the cut cord once; therefore, no specific recommendations are made for
6	either method.
7	In making the suggestion against intact umbilical cord milking in infants <28 weeks'
8	gestation, but not in infants of higher gestational age, the task force considered the following:
9	• Low-certainty evidence for increased severe intraventricular hemorrhage after intact-cord
10	milking compared with deferred cord clamping
11	• One trial was stopped early because of increased rates of severe intraventricular
12	hemorrhage in the prespecified subgroup of preterm infants born at <28 weeks'
13	gestation. ⁵⁴
14	• The same RCT has subsequently reported that for infants born at 28 to 32 weeks'
15	gestation there was no increase in severe intraventricular hemorrhage, mortality, or other
16	adverse clinical outcomes after umbilical cord milking compared with deferred cord
17	clamping. ⁸² This study was not included in the analysis because it was published after the
18	iCOMP meta-analysis was completed and the CoSTR development process was started.
19	There was insufficient evidence to make a recommendation regarding cord management
20	of preterm infants who are deemed to require resuscitation at birth. This conclusion reflected the
21	following:
22	• Adherence to deferred cord clamping was low (<75% in those trials reporting adherence),
23	in most cases because health care providers chose immediate cord clamping or cord

1	milking in preference to deferred cord clamping when they judged that the infant required
2	assisted ventilation. ⁵ Some studies did not report adherence. Taken together, these factors
3	led to a conclusion that the benefits and risks of deferred cord clamping remain unclear
4	for nonvigorous preterm infants and those who require resuscitation at birth. ⁵
5	• The evidence from animal studies and feasibility studies in human infants increasingly
6	supports provision of some resuscitation measures while deferring cord clamping
7	(variously described in studies as resuscitation with intact cord, physiologic cord
8	clamping, or baby-directed cord clamping). Results of studies currently underway that
9	evaluate these strategies may lead to changes in recommendations in the future, but there
10	was insufficient evidence to make a recommendation now.
11	The suggestion for individualized decision-making in the context of maternal, fetal, or
12	placental conditions that were exclusion criteria is unchanged from 2021 and took into account
13	that similar constraints applied to the results of the iCOMP systematic reviews.
14	In suggesting discussion before birth (whenever possible) about the plan for umbilical
15	cord management, the task force considered that this approach is most likely to lead to the best
16	decisions about what plan of cord management to use and how to coordinate the steps in care of
17	the infant among different care providers and the parents.
18	Knowledge Gaps
19	• Long-term neurodevelopment and health outcomes following different cord management
20	strategies
21	• Effectiveness of optimized cord management as a public health strategy to improve child
22	health and development

- Optimal cord management of preterm infants who are not breathing after initial steps of
 resuscitation
- Optimal cord management for preterm infants born with specific maternal, fetal, and
 placental conditions that led to exclusion from RCTs
- 5 Optimal measures to prevent hypothermia during deferred cord clamping
- Optimal duration of deferred cord clamping, and the criteria to determine that duration
- 7 Circumstances where cut-cord milking represents best-available management
- 8 Impact of cord management on vertical transmission of infectious diseases
- 9 Widely agreed-upon nomenclature and definition of different interventions, including
- 10 delayed, deferred, later, optimal, and physiologic cord clamping as well as milking,
- 11 stripping, intact-cord milking, and cut-cord milking

12 Effect of Rewarming Rate on Outcomes for Newborns Who are Unintentionally

13 Hypothermic After Delivery (NLS 5700: SysRev)

14 Rationale for Review

Both term and preterm newborn infants are at high risk of hypothermia during and 15 immediately after resuscitation in high-, middle-, and low-income countries.⁸³⁻⁸⁵ Previous large 16 observational studies have found an association between hypothermia and neonatal mortality and 17 18 morbidity.⁸⁶⁻⁹³ The optimal rate of rewarming for unintentionally hypothermic infants has not 19 been defined. Slow rewarming could prolong metabolic demands and increase adverse outcomes of hypothermia such as apnea, respiratory distress, and hypoglycemia,^{86,94,95} but there is a 20 21 suggestion from a few preclinical and clinical studies in other age groups and contexts (such as after therapeutic hypothermia) that rapid rewarming could be harmful.⁹⁶ In 2020, the Neonatal 22 23 Life Support Task Force undertook an evidence update which concluded that there were

sufficient new studies to consider updating the systematic review. ⁹⁷ The SysRev was registered
before initiation (PROSPERO Registration CRD42022359005). The full online CoSTR can be
found on the ILCOR website.98
Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
• Population: Newborn infants who are hypothermic (<36.0°C) on admission
● Intervention: Rapid rewarming (≥0.5°C/hour)
• Comparators: Slow rewarming (<0.5°C/hour)
• Outcomes (importance assigned by task force consensus, in accord with available
guidelines ^{11,12}):
 Mortality rate (critical)
 Neurodevelopmental impairment (critical)
 Need for respiratory support during the first 48 hours of life (important)
 Hypoglycemia during the first week of life (important)
 Convulsions/seizures during hospital stay (important)
 Length of hospital stay (important)
 In addition, for preterm infants born at <34 weeks:
 Intraventricular hemorrhage (all grades—important; severe [III or IV]—
critical)
Periventricular leukomalacia (critical)
 Necrotizing enterocolitis (important)
• Study designs: RCTs and nonrandomized studies (nonrandomized controlled trials,
interrupted time series, controlled before-and-after studies, cohort studies) were eligible

- for inclusion. Unpublished studies (eg, conference abstracts, trial protocols), case series,
 case reports, and animal studies were excluded.
- Time frame: All years and all languages were included if there was an English abstract.
 The search strategy designed for the 2020 evidence update was rerun in July 2022 and
 updated in July 2023.
- 6 Consensus on Science

7 The review identified 1 RCT of 42 infants comparing maximum temperature set points for the servo-controlled radiant warmers used for rewarming; rates of rewarming depended on 8 these set points.⁹⁹ The study enrolled only otherwise well, term newborn infants of normal birth 9 10 weight. The review also identified 2 observational studies including a total of 280 infants, one of which included only infants born at ≤ 28 weeks' gestation and/or birth weight ≤ 1000 g¹⁰⁰ while 11 the other enrolled only infants with birthweight <1500 grams.¹⁰¹ For the critical outcome of 12 13 mortality, these 2 studies could not exclude benefit or harm from rapid rewarming compared with slow rewarming (RR, 1.09 [95% CI, 0.7–1.71]; absolute risk difference, 17 fewer deaths per 14 1000 infants [95% CI, from 58 fewer-138 more]) (low-certainty evidence).^{100,101} 15

16 For other critical and important outcomes, either data were inconclusive or there were no17 data.

18 Prior Treatment Recommendations (2015)

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

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1 2024 Treatment Recommendations

2	In newborn infants who are unintentionally hypothermic after birth, rewarming should be
3	commenced, but there is insufficient evidence to recommend either rapid ($\geq 0.5^{\circ}$ C/hour) or slow
4	(<0.5°C/hour) rates of rewarming.
5	Regardless of the rewarming rate chosen, a protocol for rewarming should be used.
6	Frequent or continuous monitoring of temperature should be undertaken, particularly if using a
7	supraphysiological set temperature point to accelerate the rewarming rate, because of the risk of
8	causing hyperthermia. In any hypothermic infant, monitor blood glucose because there is a risk
9	of hypoglycemia (good practice statement).
10	Justification and Evidence-to-Decision Framework Highlights
11	The complete evidence-to-decision table can be found in Appendix A4.
12	• Although hypothermia after birth is associated with increased mortality and morbidity,
13	the included studies were too small to determine the effect of rate of rewarming on
14	mortality and other outcomes. One observational study showed an association of rapid
15	rewarming with a reduced rate of respiratory distress syndrome in preterm infants. ¹⁰⁰
16	However, numbers were small, the absolute risk difference was not shown, and the
17	authors did not report whether this resulted in a clinical difference in need for respiratory
18	support for respiratory distress syndrome.
19	• The task force considered that both the intervention and control treatment were
20	acceptable and feasible. Two of the 3 included studies used servo-controlled devices to
21	monitor and control the rate of rewarming. Regarding equity, servo-controlled devices
22	(eg, servo-controlled radiant warmers, incubators, or thermal mattresses) have not yet
23	been demonstrated to improve outcomes of rewarming. The cost of devices capable of

1

2

operating in servo mode and disposable temperature probes may be unaffordable in resource-limited settings.

3	•	The rate of rewarming varied widely in the rapid rewarming groups in the included
4		studies. The task force noted that a safe maximum rate of rewarming has not been
5		identified. Furthermore, none of the included studies reported hyperthermia as an
6		outcome. One observational study that did not meet inclusion criteria found that 43
7		(12.5%) of 344 included infants developed hyperthermia (>37.5°C). ¹⁰³ In this study, a
8		rapid rewarming rate, compared with a slow rewarming rate, was associated with
9		hyperthermia. It is unclear whether this related to specific settings of the devices used for
10		rewarming (which were radiant warmers and incubators in manual mode) in this study or
11		to other characteristics of the included infants. These findings may be clinically important
12		because recent observational studies have confirmed an association between
13		hyperthermia on neonatal ICU admission and adverse outcomes. ^{104,105} Future studies
14		should consider this important outcome.
15	Know	ledge Gaps
16	•	The optimal method and rate of rewarming, including equipment and settings
17	•	Effect of rewarming rate on short-term and long-term outcomes, for both preterm and
18		term infants
19	•	Effect of rewarming rate on metabolic markers such as acidosis and glycemic status
20	٠	Cost-effectiveness of rewarming strategies, including equipment and the need for and
21		duration of neonatal ICU admission
22	•	The effects of protocols for rewarming on parental separation and the establishment of
23		breastfeeding and on the safety and effectiveness of skin-to-skin care for rewarming

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

2 Rationale for Review

3 Therapeutic hypothermia is now standard care in high-income countries for the treatment of moderate or severe hypoxic ischemic encephalopathy in term and near-term infants.¹⁰⁶ 4 5 However, uncertainty persists about the efficacy of therapeutic hypothermia in low-resource 6 settings or in low- and middle-income countries. Because asphyxia is a leading cause of neonatal 7 mortality and morbidity in low- and middle-income countries, it is critical to determine whether 8 therapeutic hypothermia improves mortality and neurodevelopmental outcomes in this setting. The treatment shown to be effective in high-income countries generally consists of cooling to 9 10 33.5°C commencing within 6 hours of birth and for a duration of 72 hours. Servo-controlled 11 cooling devices are increasingly used in high-income countries because they achieve more consistent adherence to target temperatures,¹⁰⁷ although effective cooling can be accomplished 12 13 by removal of heat sources and clothing and by applying refrigerated gel packs, making the treatment feasible in low-resource settings.¹⁰⁸ The topic was last reviewed by the task force in 14 15 2015, with an emphasis on the use of passive hypothermia and/or cold packs.¹ An evidence update in 2020⁹⁷ identified new studies and an ongoing large multicenter RCT that has since 16 been published.¹⁰⁹ 17 18 The SysRev was registered before initiation (PROSPERO Registration CRD42022360554). The full online CoSTR can be found on the ILCOR website.¹¹⁰ 19 20 Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

Population: Late preterm and term infants (34+0 or more weeks' gestation) with
 moderate or severe hypoxic ischemic encephalopathy managed in low-resource settings

- Intervention: Therapeutic hypothermia to a specified target temperature for a defined
 duration
- 3 Comparators: Standard care
- Outcomes (importance assigned by task force consensus, in accord with available
- 5 guidelines^{11,12}):
- 6 Death or neurodevelopmental impairment at 18 months to 2 years—composite outcome
- 7 (critical)
- 8 Death at hospital discharge (critical)
- 9 Neurodevelopmental impairments at 18 months to 2 years (critical)
- 10 Cerebral palsy (critical)
- 11 Blindness (critical)
- 12 Deafness (critical)
- 13 Persistent pulmonary hypertension of the newborn or other adverse outcome (as defined
- 14 by the study authors)
- 15 Neurodevelopmental impairment was defined as abnormal motor, sensory, or cognitive
- 16 function using an appropriate standardized test.
- Study designs: RCTs and nonrandomized studies (nonrandomized controlled trials,
- 18 interrupted time series, controlled before-and-after studies, cohort studies) were eligible
- 19 for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) were
- 20 excluded. All languages were included if there was an English abstract.
- Time frame: Databases were searched from inception until September 2022, and the search was updated to July 2023.
 - CONFIDENTIAL

1 Consensus on Science

- 2 The systematic review identified 21 RCTs involving 2145 infants with hypoxic ischemic
- 3 encephalopathy.¹¹¹⁻¹³¹ Most studies were single site, but 3 were multicenter.^{121,128,130} Key results
- 4 are summarized in Table 23.
- Table 23. Use of Therapeutic Hypothermia for Infants With Moderate or Severe Hypoxic
 Ischemic Encephalopathy in Low- or Middle-Income Countries
 - Anticipated absolute effect Certainty RR Risk **RD** with Outcomes of the **Participants (studies)** (95%) with therapeutic (importance) evidence CI) standard hypothermia; (GRADE) **NNTB if** care applicable Death or NDI 813 Moderate 0.67 458/1000 151 fewer (5 RCTs)^{112,121,128,130,131} at 18–24 (0.45 infants died or months 0.99) had NDI per 1000 (5 (critical) fewer-252 fewer); NNTB, 7 (4-200) infants Death or NDI 1168 0.50 474/1000 237 fewer Low (9 at any time of (0.35 infants died or RCTs)^{112,114,117,118,121,126,128,130,131} follow-up 0.71) had NDI per (critical) 1000 (138 fewer-308 (post-hoc outcome) fewer); NNTB, 5 (4-8) infants 1488 0.70 215/1000 64 fewer Death at Moderate (15 RCTs)^{112-116,120,122-129,131} hospital (0.47 infants died 1.02) per 1000 (114

		Containty	RR (95% CI)	Anticipated absolute effect	
Outcomes (importance)	Participants (studies)	of the evidence (GRADE)		Risk with standard care	RD with therapeutic hypothermia; NNTB if applicable
discharge					fewer-4
(critical)					more)
Cerebral palsy	919	High	0.52	186/1000	89 fewer
(critical)	$(6 \text{ RCTs})^{112,119,121,126,128,130}$		(0.37–		infants had
			0.72)		cerebral palsy
					per 1000 (52
					fewer-117
					fewer);
					NNTB, 12 (9–
					20) infants
Blindness	718	Moderate	0.48	53/1000	28 fewer
(critical)	(4 RCTs) ^{117-119,128}		(0.22–		infants were
		· · · ·	1.03)		blind per 1000
					(41 fewer-2
					more)
Deafness	718	Moderate	0.42	72/1000	42 fewer
(critical)	(4 RCTs) ^{117-119,128}		(0.21–		infants were
			0.82)		deaf per 1000
					(57 fewer-13
					fewer);
					NNTB, 24
					(18–77)
					infants
PPHN	564	High	1.31	74/1000	23 more
(adverse	(3 RCTs) ^{111,127,128}		(0.76–		infants had
			2.25)		PPHN per

		Containty		Anticipated absolute effect	
Outcomes (importance)	Participants (studies)	of the evidence (GRADE)	RR (95% CI)	Risk with standard care	RD with therapeutic hypothermia; NNTB if applicable
effect—					1000 (18
critical)					fewer-92
					more)

1 2 3

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

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

8 servo-controlled methods.

9 Prior Treatment Recommendations (2015)

10 We suggest that newly born infants at term or near term with evolving moderate-to-

11 severe hypoxic-ischemic encephalopathy in low-income countries and/or other settings with

12 limited resources may be treated with therapeutic hypothermia (weak recommendation, low-

13 quality evidence).¹⁰²

14 Cooling should only be considered, initiated, and conducted under clearly defined

15 protocols with treatment in neonatal care facilities with the capabilities for multidisciplinary care

16 and availability of adequate resources to offer intravenous therapy, respiratory support, pulse

- 17 oximetry, antibiotics, antiseizure medications, and pathology testing. Treatment should be
- 18 consistent with the protocols used in the randomized clinical trials in developed countries, ie,

cooling to commence within 6 hours, strict temperature control at 33°C to 34°C for 72 hours, and
 rewarming over at least 4 hours.¹⁰²

3 2024 Treatment Recommendations

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

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

Therapeutic hypothermia should only be considered, initiated, and conducted under 11 12 clearly defined protocols with treatment in neonatal care facilities with the capabilities for 13 multidisciplinary care and availability of adequate resources to offer intravenous therapy, 14 respiratory support, pulse oximetry, antibiotics, antiseizure medication, transfusion services, 15 radiology (including ultrasound), and pathology testing, as required. Treatment should be 16 consistent with the protocols used in RCTs. Most protocols included commencement of cooling 17 within 6 hours after birth, strict temperature control to a specified range (typically $33^{\circ}C-34^{\circ}C$) 18 and most commonly for a duration of 72 hours with rewarming over at least 4 hours. Adoption of 19 hypothermia techniques without close monitoring, without protocols, or without availability of 20 comprehensive neonatal intensive care may lead to harm (good practice statement).

21 Justification and Evidence-to-Decision Framework Highlights

22

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

- The largest included (multicenter) RCT found that therapeutic hypothermia significantly
 increased mortality and did not reduce the combined outcome of death or disability at 18
 months.¹²⁸
- 4 Nevertheless, the combined (moderate certainty) evidence from all RCTs that assessed 5 death plus disability at 18 to 24 months or cerebral palsy found that therapeutic hypothermia reduced neurodevelopmental impairment without increasing mortality. For 6 7 several of the critical outcomes, there was high heterogeneity, which together with the preponderance of smaller, single-center trials mostly reporting benefit, raised the 8 possibility of publication bias. For some studies, concerns have been raised about study 9 10 methodology underlying participant heterogeneity, including methods of patient selection, as well as consistency of diagnosis and etiology.¹³² Therefore, the task force 11 12 concluded that the overall certainty of evidence was low. Furthermore, for adverse effects 13 of therapeutic hypothermia, there was heterogeneity and inconsistency of reporting 14 among the included studies, precluding meta-analysis. Although the PICOST intended to evaluate infants ε 34+0 weeks of gestational age, 15 of 15
- 16 the 21 included studies specified ε 37 weeks of gestational age as an inclusion criterion,

17 making the data for late preterm infants insufficient to support a treatment

18 recommendation.

Distinction between low- and middle-income countries versus high-income countries,
 based on World Bank determinations, is straightforward.¹³³ However, the hospitals in the
 included studies (all in low- and middle-income countries) could provide neonatal ICU
 care, including advanced respiratory support, indicating a high level of resources despite
 their location in low- and middle-income countries. Therefore, the recommendation is

1		made in relation to low- and middle-income countries rather than to the low-resource
2		settings intended by the PICOST.
3	•	In high-income countries, adequate follow-up assessment and care are also considered
4		necessary to optimize neurodevelopmental outcomes and to monitor the effectiveness of
5		treatment.
6	Knowl	ledge Gaps
7	•	The minimum intensive care resources required for safe and effective provision of
8		therapeutic hypothermia in low- and middle-income countries
9	•	Cost effectiveness of therapeutic hypothermia in low- and middle-income countries
10	•	Resource implications for safe and effective care of infants during provision of
11		therapeutic hypothermia in low- and middle-income countries
12	•	Strategies for optimal case selection of infants who may benefit from or may be harmed
13		by therapeutic hypothermia in countries at all income levels
14	Refere	ences
15	1.	Perlman JM, Wyllie J, Kattwinkel J, Wyckoff MH, Aziz K, Guinsburg R, Kim HS, Liley
16		HG, Mildenhall L, Simon WM, et al; on behalf of the Neonatal Resuscitation Chapter
17		Collaborators. Part 7: neonatal resuscitation: 2015 International Consensus on
18		Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With
19		Treatment Recommendations. Circulation. 2015;132(suppl 1):S204–S241. doi:
20		10.1161/CIR.00000000000276
21	2.	Polglase GR, Blank DA, Barton SK, Miller SL, Stojanovska V, Kluckow M, Gill AW,
22		LaRosa D, Te Pas AB, Hooper SB. Physiologically based cord clamping stabilises
23		cardiac output and reduces cerebrovascular injury in asphyxiated near-term lambs.

1		Archives of disease in childhood Fetal and neonatal edition. 2018;103:F530-F538. doi:
2		10.1136/archdischild-2017-313657
3	3.	Bhatt S, Alison BJ, Wallace EM, Crossley KJ, Gill AW, Kluckow M, te Pas AB, Morley
4		CJ, Polglase GR, Hooper SB. Delaying cord clamping until ventilation onset improves
5		cardiovascular function at birth in preterm lambs. J Physiol. 2013;591:2113-2126. doi:
6		10.1113/jphysiol.2012.250084
7	4.	Yao AC, Moinian M, Lind J. Distribution of blood between infant and placenta after
8		birth. Lancet. 1969;2:871-873. doi: 10.1016/s0140-6736(69)92328-9
9	5.	Seidler AL, Aberoumand M, Hunter KE, Barba A, Libesman S, Williams JG, Shrestha N,
10		Aagerup J, Sotiropoulos JX, Montgomery AA, et al. Deferred cord clamping, cord
11		milking, and immediate cord clamping at preterm birth: a systematic review and
12		individual participant data meta-analysis. Lancet. 2023;402:2209-2222. doi:
13		10.1016/s0140-6736(23)02468-6
14	6.	Seidler AL, Gyte GML, Rabe H, Díaz-Rossello JL, Duley L, Aziz K, Testoni Costa-
15		Nobre D, Davis PG, Schmölzer GM, Ovelman C, et al. Umbilical Cord Management for
16		Newborns <34 Weeks' Gestation: A Meta-analysis. <i>Pediatrics</i> . 2021;147:e20200576. doi:
17		10.1542/peds.2020-0576
18	7.	Wyckoff MH, Singletary EM, Soar J, Olasveengen TM, Greif R, Liley HG, Zideman D,
19		Bhanji F, Andersen LW, Avis SR, et al. 2021 International Consensus on
20		Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With
21		Treatment Recommendations: Summary From the Basic Life Support; Advanced Life
22		Support; Neonatal Life Support; Education, Implementation, and Teams; First Aid Task

1		Forces; and the COVID-19 Working Group. Resuscitation. 2021;169:229-311. doi:
2		10.1016/j.resuscitation.2021.10.040
3	8.	Seidler AL, Duley L, Katheria AC, De Paco Matallana C, Dempsey E, Rabe H,
4		Kattwinkel J, Mercer J, Josephsen J, Fairchild K, et al. Systematic review and network
5		meta-analysis with individual participant data on cord management at preterm birth
6		(iCOMP): study protocol. BMJ Open. 2020;10:e034595. doi: 10.1136/bmjopen-2019-
7		034595
8	9.	Seidler AL, Libesman S, Hunter KE, Barba A, Aberoumand M, Williams JG, Shrestha N,
9		Aagerup J, Sotiropoulos JX, Montgomery AA, et al. Short, medium, and long deferral of
10		umbilical cord clamping compared with umbilical cord milking and immediate clamping
11		at preterm birth: a systematic review and network meta-analysis with individual
12		participant data. Lancet. 2023;402:2223-2234. doi: 10.1016/s0140-6736(23)02469-8
13	10.	El-Naggar W, Davis PG, Josephsen J, Seidler AL, Soll R, Costa-Nobre D, Isayama T,
14		Couper K, Schmölzer G, Weiner G, et al. Cord Management at Birth for Preterm Infants
15		(NLS # 5051). International Liaison Committee on Resuscitation. https://costr.ilcor.org.
16		2023.
17	11.	Strand ML, Simon WM, Wyllie J, Wyckoff MH, Weiner G. Consensus outcome rating
18		for international neonatal resuscitation guidelines. Archives of disease in childhood Fetal
19		and neonatal edition. 2020;105::F328-F330. doi: 10.1136/archdischild-2019-316942
20	12.	Webbe JWH, Duffy JMN, Afonso E, Al-Muzaffar I, Brunton G, Greenough A, Hall NJ,
21		Knight M, Latour JM, Lee-Davey C, et al. Core outcomes in neonatology: development
22		of a core outcome set for neonatal research. Archives of disease in childhood Fetal and
23		neonatal edition. 2020;105:425-431. doi: 10.1136/archdischild-2019-317501

1	13.	Hunter KE, Webster AC, Page MJ, Willson M, McDonald S, Berber S, Skeers P, Tan-
2		Koay AG, Parkhill A, Seidler AL. Searching clinical trials registers: guide for systematic
3		reviewers. BMJ. 2022;377:e068791. doi: 10.1136/bmj-2021-068791
4	14.	Backes CH, Huang H, Iams JD, Bauer JA, Giannone PJ. Timing of umbilical cord
5		clamping among infants born at 22 through 27 weeks' gestation. Journal of Perinatology.
6		2016;36:35. doi: 10.1038/jp.2015.117
7	15.	Chu K, Whittle W, Windrim R, Shah PS, Murphy K. The DUC trial: a pilot randomized
8		controlled trial of immediate vs. delayed umbilical cord clamping in preterm infants born
9		between 24 and 32 weeks gestation. Am J Obstet Gynecol. 2011:S502.
10	16.	Datta BV, Kumar A, Yadav R. A Randomized Controlled Trial to Evaluate the Role of
11		Brief Delay in Cord Clamping in Preterm Neonates (34-36 weeks) on Short-term
12		Neurobehavioural Outcome. J Trop Pediatr. 2017;63:418-424. doi:
13		10.1093/tropej/fmx004
14	17.	Duley L, Dorling J, Pushpa-Rajah A, Oddie SJ, Yoxall CW, Schoonakker B, Bradshaw
15		L, Mitchell EJ, Fawke JA. Randomised trial of cord clamping and initial stabilisation at
16		very preterm birth. Archives of disease in childhood Fetal and neonatal edition.
17		2018;103:F6-14. doi: 10.1136/archdischild-2016-312567
18	18.	Finn D, Ryan DH, Pavel A, O'Toole JM, Livingstone V, Boylan GB, Kenny LC,
19		Dempsey EM. Clamping the Umbilical Cord in Premature Deliveries (CUPiD):
20		Neuromonitoring in the Immediate Newborn Period in a Randomized, Controlled Trial of
21		Preterm Infants Born at <32 Weeks of Gestation. J Pediatr. 2019;208:121-126.e122. doi:
22		10.1016/j.jpeds.2018.12.039

1	19.	García C, Prieto MT, Escudero F, Bosh-Giménez V, Quesada L, Lewanczyk M, Pertegal
2		M, Delgado JL, Blanco-Carnero JE, De Paco Matallana C. The impact of early versus
3		delayed cord clamping on hematological and cardiovascular changes in preterm
4		newborns between 24 and 34 weeks' gestation: a randomized clinical trial. Arch Gynecol
5		Obstet. 2023. doi: 10.1007/s00404-023-07119-0
6	20.	Gharehbaghi MM, Yasrebinia S, Mostafa Gharabaghi P. Umbilical Cord Clamping
7		Timing in Preterm Infants Delivered by Cesarean Section. International Journal of
8		Pediatrics. 2020;8:11095-11101. doi: 10.22038/ijp.2019.43193.3606
9	21.	Gregoraci A, Carbonell M, Linde A, Goya M, Maiz N, Gabriel P, Villena Y, Bérgamo S,
10		Beneitez D, Montserrat I, et al. Timing of umbilical cord occlusion, delayed vs early, in
11		preterm babies: A randomized controlled trial (CODE-P Trial). Eur J Obstet Gynecol
12		Reprod Biol. 2023;289:203-207. doi: 10.1016/j.ejogrb.2023.08.376
13	22.	Kamal D, Abel-Fattah A, Saleh D. Delayed cord clamping in premature fetuses:
14		randomised clinical trial. Reprod Health Popul Sci. 2019;44:66-87.
15	23.	Liu J. Delayed cord clamping prevents respiratory distress of infants delivered by
16		selective cesarean section, a randomized controlled trial
17		https://www.chictr.org.cn/showproj.html?proj=30199. 2018.
18	24.	Oh W, Fanaroff AA, Carlo WA, Donovan EF, Mcdonald SA, Poole WK. Effects of
19		delayed cord clamping in very-low-birth-weight infants. Journal of Perinatology.
20		2011;31:S68. doi: 10.1038/jp.2010.186
21	25.	Okulu E, Haskologlu S, Guloglu D, Kostekci E, Erdeve O, Atasay B, Koc A, Soylemez
22		F, Dogu F, Ikinciogullari A, et al. Effects of Umbilical Cord Management Strategies on
23		Stem Cell Transfusion, Delivery Room Adaptation, and Cerebral Oxygenation in Term

and Late Preterm Infants. <i>Front Pediatr</i> . 2022;10:838444. doi
--

- 2 10.3389/fped.2022.838444
- Rana A, Agarwal K, Ramji S, Gandhi G, Sahu L. Safety of delayed umbilical cord
 clamping in preterm neonates of less than 34 weeks of gestation: a randomized controlled
 trial. *Obstet Gynecol Sci.* 2018;61:655-661. doi: 10.5468/ogs.2018.61.6.655
- 6 27. Ranjit T, Nesargi S, Rao PNS, Sahoo JP, Ashok C, Chandrakala BS, Bhat S. Effect of
- Early versus Delayed Cord Clamping on Hematological Status of Preterm Infants at 6 wk
 of Age. *Indian J Pediatr.* 2015;82:29-34.
- 9 28. Ruangkit C, Bumrungphuet S, Panburana P, Khositseth A, Nuntnarumit P. A
- 10 Randomized Controlled Trial of Immediate versus Delayed Umbilical Cord Clamping in
- 11 Multiple-Birth Infants Born Preterm. *Neonatology*. 2019;115:156-163. doi:
- 12 10.1159/000494132
- Sahoo T, Thukral A, Sankar MJ, Gupta SK, Agarwal R, Deorari AK, Paul VK. Delayed
 cord clamping in Rh-alloimmunised infants: a randomised controlled trial. *Eur J Pediatr*.
- 15 2020;179:881-889. doi: 10.1007/s00431-020-03578-8
- 30. Salae R, Tanprasertkul C, Somprasit C, Bhamarapravatana K, Suwannarurk K. Efficacy
 of Delayed versus Immediate Cord Clamping in Late Preterm Newborns following
- 18 Normal Labor: A Randomized Control Trial. J Med Assoc Thai. 2016;99 Suppl 4:S159-
- 19 165.
- 20 31. Tarnow-Mordi W, Morris J, Kirby A, Robledo K, Askie L, Brown R, Evans N, Finlayson
- 21 S, Fogarty M, Gebski V, et al. Delayed versus Immediate Cord Clamping in Preterm
- 22 Infants. N Engl J Med. 2017;377:2445-2455. doi: 10.1056/NEJMoa1711281

1	32.	Yunis M, Nour I, Gibreel A, Darwish M, Sarhan M, Shouman B, Nasef N. Effect of
2		delayed cord clamping on stem cell transfusion and hematological parameters in preterm
3		infants with placental insufficiency: a pilot randomized trial. Eur J Pediatr.
4		2021;180:157-166. doi: 10.1007/s00431-020-03730-4
5	33.	The World Bank Group. World Bank Open Data. https://data.worldbank.org/ (accessed
6		28 June 2023).
7	34.	Kugelman A, Borenstein-Levin L, Riskin A, Chistyakov I, Ohel G, Gonen R, Bader D.
8		Immediate versus Delayed Umbilical Cord Clamping in Premature Neonates Born < 35
9		Weeks: A Prospective, Randomized, Controlled Study. American Journal Of
10		Perinatology. 2007;24:307-315. doi: 10.1055/s-2007-981434
11	35.	Alan S, Arsan S, Okulu E, Akin IM, Kilic A, Taskin S, Cetinkaya E,
12		Erdeve O, Atasay B. Effects of umbilical cord milking on the
13		need for packed red blood cell transfusions and early neonatal
14		hemodynamic adaptation in preterm infants born ≤1500 g: a
15		prospective, randomized, controlled trial. J Pediatr Hematol Oncol.
16		2014;36:e493-498. doi: 10.1097/mph.000000000000143
17	36.	Chellappan MV, Divakaran D, Neetha G, Varghese PR, Unnikrishnan UG, Vellore M,
18		Maya KN, Ditty M. 1061 Long term effects of milking of cut umbilical cord in very
19		preterm neonates: a randomised controlled trial in Southern India. Archives of Disease in
20		Childhood. 2022;107:A178-A179. doi: https://doi.org/10.1136/archdischild-2022-
21		rcpch.286
22	37.	El-Naggar W, Simpson D, Hussain A, Armson A, Dodds L, Warren A, Whyte R,
23		McMillan D. Cord milking versus immediate clamping in preterm infants: a randomised

1		controlled trial. Archives of disease in childhood Fetal and neonatal edition.
2		2019;104:F145-150. doi: 10.1136/archdischild-2018-314757
3	38.	George AA, Isac M. Effect of Umbilical Cord Milking on Maternal and Neonatal
4		Outcomes in a Tertiary Care Hospital in South India: A Randomized Control Trial. J
5		Obstet Gynaecol India. 2022;72:291-298. doi: 10.1007/s13224-021-01515-9
6	39.	Hosono S, Mugishima H, Fujita H, Hosono A, Minato M, Okada T, Takahashi S, Harada
7		K. Umbilical cord milking reduces the need for red cell transfusions and improves
8		neonatal adaptation in infants born at less than 29 weeks' gestation: a randomised
9		controlled trial. Archives of disease in childhood Fetal and neonatal edition.
10		2008;93:F14-19. doi: 10.1136/adc.2006.108902
11	40.	Hosono S, Tamura M, Kusuda S, Hirano S, Fujimura M, Takahashi S. One-time
12		umbilical cord milking after cord cutting reduces the need for red blood cell transfusion
13		and reduces the mortality rate in extremely preterm infants; a multicenter randomized
14		controlled trial. Paper/Poster presented at: Pediatric Academic Societies Annual Meeting;
15		2015;
16	41.	Josephsen JB, Potter S, Armbrecht ES, Al-Hosni M. Umbilical Cord Milking in
17		Extremely Preterm Infants: A Randomized Controlled Trial Comparing Cord Milking
18		with Immediate Cord Clamping. Am J Perinatol. 2022;39:436-443. doi: 10.1055/s-0040-
19		1716484
20	42.	Katheria A, Blank D, Rich W, Finer N. Umbilical cord milking improves transition in
21		premature infants at birth. PLoS One. 2014;9:e94085. doi: 10.1371/journal.pone.0094085
22	43.	Lago Leal V, Pamplona Bueno L, Cabanillas Vilaplana L, Nicolás Montero E,
23		Martín Blanco M, Fernández Romero C, El Bakkali S, Pradillo Aramendi T,

1		Sobrino Lorenzano L, Castellano Esparza P, et al. Effect of Milking Maneuver in Preterm
2		Infants: A Randomized Controlled Trial. Fetal Diagnosis and Therapy. 2019;45:57-61.
3		doi: 10.1159/000485654
4	44.	March MI, Hacker MR, Parson AW, Modest AM, de Veciana M. The effects of umbilical
5		cord milking in extremely preterm infants: a randomized controlled trial. J Perinatol.
6		2013;33:763-767. doi: 10.1038/jp.2013.70
7	45.	Mercer JS, Erickson-Owens DA, Vohr BR, Tucker RJ, Parker AB, Oh W, Padbury JF.
8		Effects of Placental Transfusion on Neonatal and 18 Month Outcomes in Preterm Infants:
9		A Randomized Controlled Trial. J Pediatr. 2016;168:50-55.e51. doi:
10		10.1016/j.jpeds.2015.09.068
11	46.	Ram Mohan G, Shashidhar A, Chandrakala BS, Nesargi S, Suman Rao PN. Umbilical
12		cord milking in preterm neonates requiring resuscitation: A randomized controlled trial.
13		Resuscitation. 2018;130:88-91. doi: 10.1016/j.resuscitation.2018.07.003
14	47.	Shen SP, Chen CH, Chang HY, Hsu CH, Lin CY, Jim WT, Chang JH. A 20-cm cut
15		umbilical cord milking may not benefit the preterm infants < 30 week's gestation: A
16		randomized clinical trial. J Formos Med Assoc. 2022;121:912-919. doi:
17		10.1016/j.jfma.2021.09.013
18	48.	Tanthawat S. The effect of one-time umbilical cord milking and early cord clamping in
19		preterm infants: a randomized controlled trial (one-time umbilical cord milking).
20		clinicaltrials.in.th/index.php?tp=regtrials&menu=trialsearch&smenu=fulltext&task=searc
21		h&task2=view1&id=2347 In: TCTR20170201003

1	49.	Xie YJ, Xiao JL, Zhu JJ, Wang YW, Wang B, Xie LJ. Effects of Umbilical Cord Milking
2		on Anemia in Preterm Infants: A Multicenter Randomized Controlled Trial. Am J
3		Perinatol. 2022;39:31-36. doi: 10.1055/s-0040-1713350
4	50.	Tanthawat S. The effect of one-time umbilical cord milking and early cord clamping in
5		preterm infants: a randomized controlled trial (one-time umbilical cord milking).
6		TCTR20170201003 clinicaltrials.in.th.
7	51.	Al-Wassia H, Shah PS. Efficacy and safety of umbilical cord milking at birth: a
8		systematic review and meta-analysis. JAMA Pediatr. 2015;169:18-25. doi:
9		10.1001/jamapediatrics.2014.1906
10	52.	Atia H, Badawie A, Elsaid O, Kashef M, Alhaddad N, Gomaa M. The hematological
11		impact of umbilical cord milking versus delayed cord clamping in premature neonates: a
12		randomized controlled trial. BMC Pregnancy Childbirth. 2022;22:714. doi:
13		10.1186/s12884-022-05046-7
14	53.	Garg A, Shekhar S. Delayed cord clamping versus milking of umbilical cord in term and
15		near term neonates-a randomized controlled trial. In: Clinical Trials Registry of India;
16		2020:CTRI/2020/2002/023364.
17	54.	Katheria A, Reister F, Essers J, Mendler M, Hummler H, Subramaniam A, Carlo W, Tita
18		A, Truong G, Davis-Nelson S, et al. Association of Umbilical Cord Milking vs Delayed
19		Umbilical Cord Clamping With Death or Severe Intraventricular Hemorrhage Among
20		Preterm Infants. Jama. 2019;322:1877-1886. doi: 10.1001/jama.2019.16004
21	55.	Katheria AC, Truong G, Cousins L, Oshiro B, Finer NN. Umbilical Cord Milking Versus
22		Delayed Cord Clamping in Preterm Infants. Pediatrics. 2015;136:61-69. doi:
23		10.1542/peds.2015-0368

1	56.	Ling L, Hao P. Effect of delayed cord clamping and umbilical cord milking on cerebral
2		hemodynamics in preterm infants: a randomized double-blind controlled trial. Chinese
3		Journal of Contemporary Pediatrics. 2021;23:332-337.
4	57.	Mangla MK, Thukral A, Sankar MJ, Agarwal R, Deorari AK, Paul VK. Effect of
5		Umbilical Cord Milking vs Delayed Cord Clamping on Venous Hematocrit at 48 Hours
6		in Late Preterm and Term Neonates: A Randomized Controlled Trial. Indian Pediatr.
7		2020;57:1119-1123.
8	58.	Pratesi S, Montano S, Ghirardello S, Mosca F, Boni L, Tofani L, Dani C. Placental
9		Circulation Intact Trial (PCI-T)-Resuscitation With the Placental Circulation Intact vs.
10		Cord Milking for Very Preterm Infants: A Feasibility Study. Front Pediatr. 2018;6:364.
11		doi: 10.3389/fped.2018.00364
12	59.	Rabe H, Jewison A, Fernandez Alvarez R, Crook D, Stilton D, Bradley R, Holden D.
13		Milking compared with delayed cord clamping to increase placental transfusion in
14		preterm neonates: a randomized controlled trial. Obstet Gynecol. 2011;117:205-211. doi:
15		10.1097/AOG.0b013e3181fe46ff
16	60.	Schober L, Schwaberger B, Urlesberger B. The influence of cut-umbilical cord milking
17		(C-UCM) on the cerebral oxygenation and perfusion of preterm and term infants.
18		https://clinicaltrials.gov/. 2018.
19	61.	Sura M, Osoti A, Gachuno O, Musoke R, Kagema F, Gwako G, Ondieki D, Ndavi PM,
20		Ogutu O. Effect of umbilical cord milking versus delayed cord clamping on preterm
21		neonates in Kenya: A randomized controlled trial. PLoS One. 2021;16:e0246109. doi:
22		10.1371/journal.pone.0246109

1	62.	Trongkamonthum T, Puangpaka B, Panichkul P, Chamnanvanakij S. Effect of delayed
2		cord clamping versus cord milking in preterm infants: a randomized controlled trial.
3		Journal of Southeast Asian Medical Research. 2018;2:22-27. doi:
4		10.55374/jseamed.v2i1.20
5	63.	Garg A, Shekhar S. Delayed cord clamping versus milking of umbilical cord in term and
6		near term neonates—a randomized controlled trial. CTRI/2020/02/023364. Clinical Trials
7		Registry of India.
8		http://ctri.nic.in/Clinicaltrials/pmaindet2.php?trialid=39871&EncHid=&userName=CTRI
9		/2020/02/023364. 2020.
10	64.	Trongkamonthum T, Puangpaka B, Panichkul P, Chamnanvanakij S. Effect of delayed
11		cord clamping versus cord milkin in preterm infants: a randomized controlled trial
12		Journal of Southeast Asian Medical Research. 2018;2:22-27. doi:
13		10.55374/jseamed.v2i1.20
14	65.	Nikolakopoulou A, Higgins JPT, Papakonstantinou T, Chaimani A, Del Giovane C,
15		Egger M, Salanti G. CINeMA: An approach for assessing confidence in the results of a
16		network meta-analysis. PLoS Med. 2020;17:e1003082. doi:
17		10.1371/journal.pmed.1003082
18	66.	Al-Wassia H. Deferred Cord Clamping Compared to Umbilical Cord Milking in Preterm
19		Infants. Clinicaltrialsgov.NCT02996799.
20	67.	Badurdeen S, Davis PG, Hooper SB, Donath S, Santomartino GA,
21		Heng A, Zannino D, Hoq M, Omar FKC, Kane SC, et al.
22		Physiologically based cord clamping for infants ≥32+0 weeks
23		gestation: A randomised clinical trial and reference percentiles

1		for heart rate and oxygen saturation for infants ≥35+0 weeks
2		gestation. PLoS Med. 2022;19:e1004029. doi: 10.1371/journal.pmed.1004029
3	68.	Ceriani Cernadas JM, Carroli G, Pellegrini L, Ferreira M, Ricci C, Casas O, Lardizabal J,
4		Morasso Mdel C. [The effect of early and delayed umbilical cord clamping on ferritin
5		levels in term infants at six months of life: a randomized, controlled trial]. Arch Argent
6		Pediatr. 2010;108:201-208. doi: 10.1590/s0325-00752010000300005
7	69.	Hua SP, Zhang HY, Zhou H, Zhang SH, Chen W, Xie CL. Effect of time of clamping
8		umbilical cord on outcome of mothers and newborns. J Hainan Med Coll. 2010;16:1572-
9		1575.
10	70.	Katheria AC, Leone TA, Woelkers D, Garey DM, Rich W, Finer NN. The effects of
11		umbilical cord milking on hemodynamics and neonatal outcomes in premature neonates.
12		J Pediatr. 2014;164:1045-1050.e1041. doi: 10.1016/j.jpeds.2014.01.024
13	71.	Kc A, Rana N, Målqvist M, Jarawka Ranneberg L, Subedi K, Andersson O. Effects of
14		delayed umbilical cord clamping vs early clamping on anemia in infants at 8 and 12
15		months: a randomized clinical trial. JAMA Pediatr. 2017;171:264-270. doi:
16		10.1001/jamapediatrics.2016.3971
17	72.	Kc A, Singhal N, Gautam J, Rana N, Andersson O. Effect of early versus delayed cord
18		clamping in neonate on heart rate, breathing and oxygen saturation during first 10
19		minutes of birth - randomized clinical trial. Matern Health Neonatol Perinatol. 2019;5:7.
20		doi: 10.1186/s40748-019-0103-y
21	73.	Martin J. Optimal timing of cord clamping in preterm pregnancy following vaginal
22	or cesa	arean delivery (CordClamp). Clinicaltrialsgov.NCT01766908.

1	74.	Raina JS, Chawla D, Jain S, Khurana S, Sehgal A, Rani S. Resuscitation with intact cord
2		versus clamped cord in late preterm and term neonates: A randomized controlled trial. J
3		Pediatr. 2023;254:54-60.e54. doi: 10.1016/j.jpeds.2022.08.061
4	75.	Sura M, Osoti A, Gachuno O, Musoke R. Umbilical cord milking versus delayed cord
5		clamping for preterm neonates in Kenya, a randomized trial American Journal of
6		Obstetrics & Gynecology. 2020;222:S612.
7	76.	Rana N, Kc A, Målqvist M, Subedi K, Andersson O. Effect of Delayed Cord Clamping of
8		Term Babies on Neurodevelopment at 12 Months: A Randomized Controlled Trial.
9		Neonatology. 2019;115:36-42. doi: 10.1159/000491994
10	77.	De Paco C, Florido J, Garrido MC, Prados S, Navarrete L. Umbilical cord blood acid-
11		base and gas analysis after early versus delayed cord clamping in neonates at term. Arch
12		Gynecol Obstet. 2011;283:1011-1014. doi: 10.1007/s00404-010-1516-z
13	78.	Li J, Yu B, Wang W, Luo D, Dai QL, Gan XQ. Does intact umbilical cord milking
14		increase infection rates in preterm infants with premature prolonged rupture of
15		membranes? J Matern Fetal Neonatal Med. 2020;33:184-190. doi:
16		10.1080/14767058.2018.1487947
17	79.	Song SY, Kim Y, Kang BH, Yoo HJ, Lee M. Safety of umbilical cord milking in very
18		preterm neonates: a randomized controlled study. Obstet Gynecol Sci. 2017;60:527-534.
19		doi: 10.5468/ogs.2017.60.6.527
20	80.	Berg KM, Bray JE, Ng KC, Liley HG, Greif R, Carlson JN, Morley PT, Drennan IR,
21		Smyth M, Scholefield BR, et al. 2023 International Consensus on Cardiopulmonary
22		Resuscitation and Emergency Cardiovascular Care Science With Treatment
23		Recommendations: Summary From the Basic Life Support; Advanced Life Support;

81.	 and First Aid Task Forces. <i>Circulation</i>. 2023;148:e187-e280. doi: 10.1161/cir.00000000001179 Bradshaw L, Sawyer A, Mitchell E, Armstrong-Buisseret L, Ayers S, Duley L. Women's experiences of participating in a randomised trial comparing alternative policies for 	
81.	10.1161/cir.00000000001179Bradshaw L, Sawyer A, Mitchell E, Armstrong-Buisseret L, Ayers S, Duley L. Women's experiences of participating in a randomised trial comparing alternative policies for	
81.	Bradshaw L, Sawyer A, Mitchell E, Armstrong-Buisseret L, Ayers S, Duley L. Women's experiences of participating in a randomised trial comparing alternative policies for	
	experiences of participating in a randomised trial comparing alternative policies for	
	timing of cord clamping at very preterm birth: a questionnaire study. Trials. 2019;20:225.	
	doi: 10.1186/s13063-019-3325-4	
82.	Katheria AC, Clark E, Yoder B, Schmölzer GM, Yan Law BH, El-Naggar W, Rittenberg	
	D, Sheth S, Mohamed MA, Martin C, et al. Umbilical cord milking in nonvigorous	
	infants: a cluster-randomized crossover trial. Am J Obstet Gynecol. 2023;228:217.e211-	
	217.e214. doi: 10.1016/j.ajog.2022.08.015	
83.	McCall EM, Alderdice F, Halliday HL, Vohra S, Johnston L. Interventions to prevent	
	hypothermia at birth in preterm and/or low birth weight infants. Cochrane Database Syst	
	Rev. 2018;2:Cd004210. doi: 10.1002/14651858.CD004210.pub5	
84.	Ramaswamy VV, Dawson JA, de Almeida MF, Trevisanuto D, Nakwa FL, Kamlin COF,	
	Trang J, Wyckoff MH, Weiner GM, Liley HG. Maintaining normothermia immediately	
	after birth in preterm infants <34 weeks' gestation: A systematic review and meta-	
	analysis. Resuscitation. 2023;191:c. doi: 10.1016/j.resuscitation.2023.109934	
85.	Ramaswamy VV, de Almeida MF, Dawson JA, Trevisanuto D, Nakwa FL, Kamlin CO,	
	Hosono S, Wyckoff MH, Liley HG. Maintaining normal temperature immediately after	
	birth in late preterm and term infants: A systematic review and meta-analysis.	
	Resuscitation. 2022;180:81-98. doi: 10.1016/j.resuscitation.2022.09.014	
	82. 83. 84.	
1	86.	Boo NY, Guat-Sim Cheah I. Admission hypothermia among VLBW infants in Malaysian
----	-----	--
2		NICUs. J Trop Pediatr. 2013;59:447-452. doi: 10.1093/tropej/fmt051
3	87.	Guinsburg R, de Almeida MF, de Castro JS, Silveira RC, Caldas JP, Fiori HH, do Vale
4		MS, Abdallah VO, Cardoso LE, Alves Filho N, et al. Death or survival with major
5		morbidity in VLBW infants born at Brazilian neonatal research network centers. J
6		Matern Fetal Neonatal Med. 2016;29:1005-1009. doi: 10.3109/14767058.2015.1031740
7	88.	Laptook AR, Salhab W, Bhaskar B. Admission temperature of low birth weight infants:
8		predictors and associated morbidities. Pediatrics. 2007;119:e643-649. doi:
9		10.1542/peds.2006-0943
10	89.	Meyer MP, Payton MJ, Salmon A, Hutchinson C, de Klerk A. A clinical comparison of
11		radiant warmer and incubator care for preterm infants from birth to 1800 grams.
12		Pediatrics. 2001;108:395-401. doi: 10.1542/peds.108.2.395
13	90.	Miller SS, Lee HC, Gould JB. Hypothermia in very low birth weight infants: distribution,
14		risk factors and outcomes. J Perinatol. 2011;31 Suppl 1:S49-56. doi:
15		10.1038/jp.2010.177
16	91.	Mullany LC, Katz J, Khatry SK, LeClerq SC, Darmstadt GL, Tielsch JM. Risk of
17		mortality associated with neonatal hypothermia in southern Nepal. Arch Pediatr Adolesc
18		Med. 2010;164:650-656. doi: 10.1001/archpediatrics.2010.103
19	92.	S AA-EH, Badr-El Din MM, Dabous NI, Saad KM. Effect of the use of a polyethylene
20		wrap on the morbidity and mortality of very low birth weight infants in Alexandria
21		University Children's Hospital. J Egypt Public Health Assoc. 2012;87:104-108. doi:
22		10.1097/01.EPX.0000421565.24496.d9

93.	Zayeri F, Kazemnejad A, Ganjali M, Babaei G, Khanafshar N, Nayeri F. Hypothermia in
	Iranian newborns. Incidence, risk factors and related complications. Saudi Med J.
	2005;26:1367-1371.
94.	Elliott RI, Mann TP. Neonatal cold injury due to accidental exposure to cold. Lancet.
	1957;272:229-234.
95.	Stephenson JM, Du JN, Oliver TK, Jr. The effect of cooling on blood gas tensions in
	newborn infants. J Pediatr. 1970;76:848-852. doi: 10.1016/s0022-3476(70)80364-x
96.	Wassink G, Davidson JO, Dhillon SK, Zhou K, Bennet L, Thoresen M, Gunn AJ.
	Therapeutic Hypothermia in Neonatal Hypoxic-Ischemic Encephalopathy. Curr Neurol
	Neurosci Rep. 2019;19:2. doi: 10.1007/s11910-019-0916-0
97.	Wyckoff MH, Wyllie J, Aziz K, de Almeida MF, Fabres J, Fawke J, Guinsburg R,
	Hosono S, Isayama T, Kapadia VS, et al. Neonatal Life Support: 2020 International
	Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care
	Science With Treatment Recommendations. Circulation. 2020;142:S185-s221. doi:
	10.1161/cir.00000000000895
98.	Rüdiger M, Kawakami MD, Madar J, Finan E, Hooper SB, Schmölzer G, Weiner G,
	Liley HG, on behalf of the Neonatal Life Support Task Force International Liaison
	Committee on Resuscitation. Effect of rewarming rate on outcomes for newborn infants
	who are unintentionally hypothermic after delivery International Liaison Committee on
	Resuscitation. https://costr.ilcor.org. 2023.
99.	Motil KJ, Blackburn MG, Pleasure JR. The effects of four different radiant warmer
	temperature set-points used for rewarming neonates. J Pediatr. 1974;85:546-550. doi:
	10.1016/s0022-3476(74)80467-1
	 93. 94. 95. 96. 97. 98. 99.

1	100.	Rech Morassutti F, Cavallin F, Zaramella P, Bortolus R, Parotto M, Trevisanuto D.
2		Association of Rewarming Rate on Neonatal Outcomes in Extremely Low Birth Weight
3		Infants with Hypothermia. J Pediatr. 2015;167:557-561.e551-552. doi:
4		10.1016/j.jpeds.2015.06.008
5	101.	Feldman A, De Benedictis B, Alpan G, La Gamma EF, Kase J. Morbidity and mortality
6		associated with rewarming hypothermic very low birth weight infants. J Neonatal
7		Perinatal Med. 2016;9:295-302. doi: 10.3233/npm-16915143
8	102.	Perlman JM, Wyllie J, Kattwinkel J, Wyckoff MH, Aziz K, Guinsburg R, Kim HS, Liley
9		HG, Mildenhall L, Simon WM, et al. Part 7: Neonatal Resuscitation: 2015 International
10		Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care
11		Science With Treatment Recommendations. Circulation. 2015;132:S204-241. doi:
12		10.1161/cir.00000000000276
13	103.	Rossi E, Maziku DM, Leluko DE, Guadagno C, Brasili L, Azzimonti G, Putoto G,
14		Pietravalle A, Cavallin F, Trevisanuto D. Rewarming rate of hypothermic neonates in a
15		low-resource setting: a retrospective single-center study. Front Pediatr.
16		2023;11:1113897. doi: 10.3389/fped.2023.1113897
17	104.	Brophy H, Tan GM, Yoxall CW. Very Low Birth Weight Outcomes and Admission
18		Temperature: Does Hyperthermia Matter? Children (Basel). 2022;9. doi:
19		10.3390/children9111706
20	105.	Wilson E, Maier RF, Norman M, Misselwitz B, Howell EA, Zeitlin J, Bonamy AK,
21		Effective Perinatal Intensive Care in Europe Research G. Admission Hypothermia in
22		Very Preterm Infants and Neonatal Mortality and Morbidity. J Pediatr. 2016;175:61-67
23		e64. doi: 10.1016/j.jpeds.2016.04.016

1	106.	Jacobs SE, Berg M, Hunt R, Tarnow-Mordi WO, Inder TE, Davis PG. Cooling for
2		newborns with hypoxic ischaemic encephalopathy. Cochrane Database Syst Rev.
3		2013;2013:Cd003311. doi: 10.1002/14651858.CD003311.pub3
4	107.	Bonifacio SL, Chalak LF, Van Meurs KP, Laptook AR, Shankaran S. Neuroprotection
5		for hypoxic-ischemic encephalopathy: Contributions from the neonatal research network.
6		Semin Perinatol. 2022;46:151639. doi: 10.1016/j.semperi.2022.151639
7	108.	Jacobs SE, Morley CJ, Inder TE, Stewart MJ, Smith KR, McNamara PJ, Wright IM,
8		Kirpalani HM, Darlow BA, Doyle LW. Whole-body hypothermia for term and near-term
9		newborns with hypoxic-ischemic encephalopathy: a randomized controlled trial. Arch
10		Pediatr Adolesc Med. 2011;165:692-700. doi: 10.1001/archpediatrics.2011.43
11	109.	Thayyil S, Oliveira V, Lally PJ, Swamy R, Bassett P, Chandrasekaran M, Mondkar J,
12		Mangalabharathi S, Benkappa N, Seeralar A, et al. Hypothermia for encephalopathy in
13		low and middle-income countries (HELIX): study protocol for a randomised controlled
14		trial. Trials. 2017;18:432. doi: 10.1186/s13063-017-2165-3
15	110.	Lee H, Costa-Nobre D, Katheria A, Mausling R, Nakwa F, Schmölzer G, Weiner G,
16		Liley HG, on behalf of the Neonatal Life Support Task Force* International Liaison
17		Committee on Resuscitation. Therapeutic hypothermia in limited resource settings (NLS
18		#5701). International Liaison Committee on Resuscitation (ILCOR) Neonatal Life
19		Support Task Force. https://costr.ilcor.org. 2023.
20	111.	Aker K, Støen R, Eikenes L, Martinez-Biarge M, Nakken I, Håberg AK, Gibikote S,
21		Thomas N. Therapeutic hypothermia for neonatal hypoxic-ischaemic encephalopathy in
22		India (THIN study): a randomised controlled trial. Archives of disease in childhood Fetal
23		and neonatal edition. 2020;105:405-411. doi: 10.1136/archdischild-2019-317311

1	112.	Aker K, Thomas N, Adde L, Koshy B, Martinez-Biarge M, Nakken I, Padankatti CS,
2		Støen R. Prediction of outcome from MRI and general movements assessment after
3		hypoxic-ischaemic encephalopathy in low-income and middle-income countries: data
4		from a randomised controlled trial. Archives of disease in childhood Fetal and neonatal
5		edition. 2022;107:32-38. doi: 10.1136/archdischild-2020-321309
6	113.	Akisu M, Huseyinov A, Yalaz M, Cetin H, Kultursay N. Selective head cooling with
7		hypothermia suppresses the generation of platelet-activating factor in cerebrospinal fluid
8		of newborn infants with perinatal asphyxia. Prostaglandins Leukot Essent Fatty Acids.
9		2003;69:45-50. doi: 10.1016/s0952-3278(03)00055-3
10	114.	Bharadwaj SK, Bhat BV. Therapeutic hypothermia using gel packs for term neonates
11		with hypoxic ischaemic encephalopathy in resource-limited settings: a randomized
12		controlled trial. J Trop Pediatr. 2012;58:382-388. doi: 10.1093/tropej/fms005
13	115.	Catherine RC, Ballambattu VB, Adhisivam B, Bharadwaj SK, Palanivel C. Effect of
14		Therapeutic Hypothermia on the Outcome in Term Neonates with Hypoxic Ischemic
15		Encephalopathy-A Randomized Controlled Trial. J Trop Pediatr. 2021;67. doi:
16		10.1093/tropej/fmaa073
17	116.	Chen X, Peng W, Zhang Z, Zhao Q, Zhou Y, Chen L, Pan J. [Efficacy and safety of
18		selective brain hypothermia therapy on neonatal hypoxic-ischemic encephalopathy].
19		Zhonghua Wei Zhong Bing Ji Jiu Yi Xue. 2018;30:1046-1050. doi:
20		10.3760/cma.j.issn.2095-4352.2018.011.007
21	117.	Das S, Sarkar N, Bhattacharya M, Basu S, Sanyal D, Chatterjee A, Aich B, Chatterjee K.
22		Neurological Outcome at 30 Months of Age after Mild Hypothermia via Selective Head
23		Cooling in Term Neonates with Perinatal Asphyxia Using Low-Cost CoolCap: A Single-

1		Center Randomized Control Pilot Trial in India. Journal of Pediatric Neurology.
2		2017;15:157-165. doi: 10.1055/s-0037-1603681
3	118.	Gane BD, Bhat V, Rao R, Nandhakumar S, Harichandrakumar KT, Adhisivam B. Effect
4		of therapeutic hypothermia on DNA damage and neurodevelopmental outcome among
5		term neonates with perinatal asphyxia: a randomized controlled trial. J Trop Pediatr.
6		2014;60:134-140. doi: 10.1093/tropej/fmt098
7	119.	Jose S, Ismael KM. Effect of hypothermia for perinatal asphyxia on childhood outcomes.
8		International Journal of Contemporary Pediatrics. 2017;5:86-91. doi: 10.18203/2349-
9		3291.ijcp20175489
10	120.	Joy R, Pournami F, Bethou A, Bhat VB, Bobby Z. Effect of therapeutic hypothermia on
11		oxidative stress and outcome in term neonates with perinatal asphyxia: a randomized
12		controlled trial. J Trop Pediatr. 2013;59:17-22. doi: 10.1093/tropej/fms036
13	121.	Li T, Xu F, Cheng X, Guo X, Ji L, Zhang Z, Wang X, Blomgren K, Simbruner G, Zhu C.
14		Systemic hypothermia induced within 10 hours after birth improved neurological
15		outcome in newborns with hypoxic-ischemic encephalopathy. Hosp Pract (1995).
16		2009;37:147-152. doi: 10.3810/hp.2009.12.269
17	122.	Liao W, Xu H, Ding J, Huang H. Mild Hypothermia Therapy for Moderate or Severe
18		Hypoxicischemic Encephalopathy in Neonates. Iran J Public Health. 2018;47:64-69.
19	123.	Lin ZL, Yu HM, Lin J, Chen SQ, Liang ZQ, Zhang ZY. Mild hypothermia via selective
20		head cooling as neuroprotective therapy in term neonates with perinatal asphyxia: an
21		experience from a single neonatal intensive care unit. J Perinatol. 2006;26:180-184. doi:
22		10.1038/sj.jp.7211412

1	124.	Rakesh K, Vishnu Bhat B, Adhisivam B, Ajith P. Effect of therapeutic hypothermia on
2		myocardial dysfunction in term neonates with perinatal asphyxia - a randomized
3		controlled trial. J Matern Fetal Neonatal Med. 2018;31:2418-2423. doi:
4		10.1080/14767058.2017.1344633
5	125.	Robertson NJ, Nakakeeto M, Hagmann C, Cowan FM, Acolet D, Iwata O, Allen E,
6		Elbourne D, Costello A, Jacobs I. Therapeutic hypothermia for birth asphyxia in low-
7		resource settings: a pilot randomised controlled trial. Lancet. 2008;372:801-803. doi:
8		10.1016/s0140-6736(08)61329-x
9	126.	Sun J, Li J, Cheng G, Sha B, Zhou W. Effects of hypothermia on NSE and S-100 protein
10		levels in CSF in neonates following hypoxic/ischaemic brain damage. Acta Paediatr.
11		2012;101:e316-320. doi: 10.1111/j.1651-2227.2012.02679.x
12	127.	Tanigasalam V, Bhat V, Adhisivam B, Sridhar MG. Does therapeutic hypothermia
13		reduce acute kidney injury among term neonates with perinatal asphyxia?a randomized
14		controlled trial. J Matern Fetal Neonatal Med. 2016;29:2545-2548. doi:
15		10.3109/14767058.2015.1094785
16	128.	Thayyil S, Pant S, Montaldo P, Shukla D, Oliveira V, Ivain P, Bassett P, Swamy R,
17		Mendoza J, Moreno-Morales M, et al. Hypothermia for moderate or severe neonatal
18		encephalopathy in low-income and middle-income countries (HELIX): a randomised
19		controlled trial in India, Sri Lanka, and Bangladesh. Lancet Glob Health. 2021;9:e1273-
20		e1285. doi: 10.1016/s2214-109x(21)00264-3
21	129.	Yang T, Li S. Efficacy of different treatment times of mild cerebral hypothermia on
22		oxidative factors and neuroprotective effects in neonatal patients with moderate/severe

1		hypoxic-ischemic encephalopathy. J Int Med Res. 2020;48:300060520943770. doi:
2		10.1177/0300060520943770
3	130.	Zhou WH, Cheng GQ, Shao XM, Liu XZ, Shan RB, Zhuang DY, Zhou CL, Du LZ, Cao
4		Y, Yang Q, et al. Selective head cooling with mild systemic hypothermia after neonatal
5		hypoxic-ischemic encephalopathy: a multicenter randomized controlled trial in China. J
6		Pediatr. 2010;157:367-372, 372.e361-363. doi: 10.1016/j.jpeds.2010.03.030
7	131.	Zou L, Yuan H, Liu Q, Lu C, Wang L. Potential protective effects of bilirubin following
8		the treatment of neonatal hypoxic-ischemic encephalopathy with hypothermia therapy.
9		Biosci Rep. 2019;39. doi: 10.1042/bsr20182332
10	132.	Krishnan V, Kumar V, Shankaran S, Thayyil S. Rise and Fall of Therapeutic
11		Hypothermia in Low-Resource Settings: Lessons from the HELIX Trial. Indian J
12		Pediatr. 2021. doi: 10.1007/s12098-021-03861-y
13	133.	Griffiths UK, Legood R, Pitt C. Comparison of Economic Evaluation Methods Across
14		Low-income, Middle-income and High-income Countries: What are the Differences and
15		Why? Health Econ. 2016;25 Suppl 1:29-41. doi: 10.1002/hec.3312

1 EDUCATION, IMPLEMENTATION, AND TEAMS

2 Cardiac Arrest Centers (EIT 6301: SysRev)

3 Rationale for Review

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

8 In 2020, ILCOR reviewed the evidence on CACs despite a lack of high-quality data to 9 support their implementation.² Since then, new evidence on CACs has been published, triggering 10 this update of the SysRev (PROSPERO number CRD420180933690). CACs are defined as specialized institutions offering treatment or services for patients with OHCA, including a 11 12 coronary angiography laboratory with 24/7 percutaneous coronary intervention, post-cardiac 13 arrest temperature control, extracorporeal membrane oxygenation, mechanical ventilation, and neurologic prognostication.³ For this review, we defined CAC as having the capability for 2 or 14 15 more of the above interventions and explicitly referred to by study authors as CACs (or 16 synonymous terms such as critical care medical center, tertiary heart center, or regional *center*).⁴ We excluded studies that used high volume (number of cases/patients) or percutaneous 17 18 coronary intervention capability as the only distinguishing characteristics. The full CoSTR can be found online.⁵ 19

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

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

1	• Comparator: Care in an institute not designated as a specialized CAC
2	• Outcome:
3	- Critical: Survival at 30 days with favorable neurological outcome, survival at hospital
4	discharge with favorable neurological outcome, survival at 30 days, and survival at
5	hospital discharge
6	- Important: ROSC after hospital admission for patients with ongoing CPR
7	• Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series,
8	controlled before-and-after studies, cohort studies) were eligible for inclusion.
9	Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All
10	relevant publications in any language were included as long as there was an English
11	abstract available.
12	• Time frame: Literature search included all years to June 23, 2023.
13	Consensus on Science
14	Sixteen studies were included in our review. ⁶⁻²¹ All studies had moderate to serious risk
15	of bias from confounding, and the certainty of evidence was rated as low. Because of substantial
16	heterogeneity, no meta-analyses could be performed.
17	Individual study details are provided in the published SysRev and online. ⁵ Three
18	observational studies showed improved outcomes associated with treatment at a CAC for
19	survival to 30 days with favorable neurological outcomes (Figure 1), ⁶⁻⁸ 10 for hospital discharge
20	with favorable neurological outcomes (Figure 2), ^{6,7,9-16} and 3 for survival to 30 days (Figure
21	3). ^{6,8,12}

- The only RCT identified did not show any difference in outcomes, but its results were
- 2 limited to non-ST-segment elevation myocardial infarction (non-STEMI) patients with
- prehospital ROSC in an urban setting. Findings were not generalizable to other patient cohorts.⁶ 3



4 5 6 Figure 1. Survival to 30 days with favorable neurological outcomes.⁶⁻⁸

CAC indicates cardiac arrest center.

	СА	с	non-0	CAC	Risk ratio	Risk ratio
Study or Subgroup	Events	Total	Events	Total	M-H, Random, 95% Cl	M-H, Random, 95% Cl
1.2.1 Non-randomise	ed trials					
Jung 2022	2113	23292	3450	72639	1.91 [1.81 , 2.01]	1
Kim 2019	251	4036	87	5876	4.20 [3.30 , 5.34]	+
Kragholm 2017	400	1359	20	148	2.18 [1.44 , 3.30]	+
McKenzie 2018	206	404	46	105	1.16 [0.92 , 1.47]	+
Soholm 2015	218	586	96	492	1.91 [1.55 , 2.35]	+
Spaite 2014	153	1727	26	439	1.50 [1.00 , 2.24]	
Sunde 2007	34	61	15	58	2.16 [1.32 , 3.52]	
Tagami 2012	21	712	4	770	5.68 [1.96 , 16.46]	— — — — — — — — — — — — — — — — — — —
Yeh 2021	160	1222	18	366	2.66 [1.66 , 4.27]	+
1.2.2 Randomised tr	ial					
Patterson 2023	130	413	130	402	0.97 [0.80 , 1.19]	+
					+ 0.0 Favours Care	1 0.1 1 10 100 e at non-CAC Favours Care at CA



1

Figure 2. Hospital discharge with favorable neurological outcomes.^{6,7,9-16}

CAC indicates cardiac arrest center.

CA	с	non-C	CAC	Risk ratio	Risk ratio
Events	Total	Events	Total	M-H, Random, 95% Cl	M-H, Random, 95% Cl
ed trials					
1556	15118	1004	24847	2.55 [2.36 , 2.75]	+
222	404	47	105	1.23 [0.98 , 1.55]	+
ial					
153	411	149	412	1.03 [0.86 , 1.23]	+
				ہ 0.0 Favours Care	1 0.1 1 10 100 e at non-CAC Favours Care at CAC
	CA Events ed trials 1556 222 ial 153	CAC Events Total ed trials 1556 15118 222 404 ial 153 411	CAC non-C Events Total Events ed trials 1556 15118 1004 222 404 47 ial 153 411 149	CAC non-CAC Events Total Events Total ed trials 1556 15118 1004 24847 222 404 47 105 ial 153 411 149 412	CAC non-CAC Risk ratio Events Total Events Total M-H, Random, 95% CI ed trials 1556 15118 1004 24847 2.55 [2.36, 2.75] 222 404 47 105 1.23 [0.98, 1.55] ial 153 411 149 412 1.03 [0.86, 1.23] Favours Care Care Favours Care

Figure 3. Survival to 30 days.^{6,8,12} CAC indicates cardiac arrest center.

1 2 3

Eleven observational studies showed improved outcome of survival to hospital discharge

associated with care at a CAC (Figure 4).^{7,9-18} 5

	CA	с	non-0	CAC	Risk ratio	Risk ratio	
Study or Subgroup	Events	Total	Events	Total	M-H, Fixed, 95% Cl	M-H, Fixed, 95% Cl	
Cournoyer 2018	479	2389	282	2533	1.80 [1.57 , 2.06]	+	
Jung 2022	3120	23292	5345	72639	1.82 [1.75 , 1.90]	1	
Kim 2019	455	4036	196	5876	3.38 [2.87 , 3.98]	+	
Kragholm 2017	455	1359	21	148	2.36 [1.58 , 3.53]	+	
McKenzie 2018	227	404	47	105	1.26 [1.00 , 1.58]	+	
Soholm 2015	264	586	118	492	1.88 [1.57 , 2.25]	+	
Spaite 2014	250	1734	39	440	1.63 [1.18 , 2.24]	+	
Stub 2011	611	1816	235	890	1.27 [1.12 , 1.45]	+	
Sunde 2007	34	61	18	58	1.80 [1.15 , 2.80]	-+-	
Tagami 2012	30	712	18	770	1.80 [1.01 , 3.20]		
Yeh 2021	248	1222	39	366	1.90 [1.39 , 2.61]	+	
					ہ 0.0 Favours car	01 0.1 1 10 100 e at non-CAC Favours Care at CAC	

6 7 8 Figure 4. Survival to hospital discharge.

CAC indicates cardiac arrest center.

9

4

Three observational studies showed improved outcome for ROSC associated with care at

a CAC (Figure 5).^{8,10,17} 10

		CA	CAC non-CAC		Risk ratio	Risk ratio	
	Study or Subgroup	Events	Total	Events	Total	M-H, Random, 95% Cl	M-H, Random, 95% Cl
	Cournoyer 2018	1021	2389	666 656	2533	1.63 [1.50 , 1.76]	1
	Matsuyama 2017	1713	15118	1146	24847	2.46 [2.29 , 2.64]	5
						0.0	
1 2 3	Figure 5. Return CAC indicates cardi	n of spo ac arrest c	ntaneo center.	us circ	ulatio	Favours Care n.	e at non-CAC Favours Care at CAC
4	Prior Treatment	Recom	nendat	tion (20)19)		
5	We sugge	est adult	patient	s with	nontra	umatic OHCA be car	ed for in CACs rather than in
6	non-CACs (weak	x recom	nendat	ion, vei	ry low-	-certainty evidence). ²	2
7	2024 Treatment	Recomn	nendat	ion			
8	We sugge	est adult	s with (OHCA	should	l be cared for in cardi	ac arrest centers (weak
9	recommendation	, low-ce	rtainty	eviden	ce).		
10	Justification and	l Eviden	ce-to-l	Decisio	n Fran	nework Highlights	
11	The complete ev	idence-te	o-decis	ion tab	le is pr	ovided in Appendix A	A5.
12	• This topic	c was pr	ioritize	d by th	e EIT '	Task Force on the bas	sis of ongoing interest in
13	improvin	g patient	t outcoi	nes aft	er OH	CA.	
14	• A trial of	expedito	ed trans	sfer to a	a CAC	for non-ST-segment	elevation OHCA (ARREST
15	trial) was	publish	ed in 2	023. ⁶ T	he resu	ults did not show any	benefits among patients
16	transferre	ed to a C	AC. Ba	used on	these	results, we are unable	e to recommend for or against
17	transferri	ng OHC	A adul	ts with	presur	ned cardiac cause pre	senting with non-ST-segmen
18	elevation	with pre	ehospit	al ROS	C to a	CAC, because this R	CT was in a very large urban
19	city settir	ıg.					
20	• Given the	e lack of	genera	lizabili	ty of tl	he above trial, we inc	luded published data from
21	nonrando	mized st	tudies i	n our r	eview.		

1	• We considered the successful implementation of regionalized care for trauma, stroke, and
2	STEMI with improved outcomes.
3	• We reflected on the high level of resources required, particularly in regions with no
4	regionalized emergency transport in place for other conditions (eg, trauma, stroke,
5	STEMI) and concluded that the benefits potentially outweigh issues associated with
6	implementation of CACs.
7	• We recognized that implementing this recommendation may be resource and cost
8	intensive, and although it has been successfully implemented in some countries, it may
9	not be feasible in all regions.
10	• There were insufficient data for subgroup analyses to make any recommendations about
11	specific subgroups, including age group, presenting rhythm, and primary versus
12	secondary transfer, except from 1 RCT in a very specific setting.
13	• We did not identify any studies on children or in-hospital cardiac arrest in this review.
14	Knowledge Gaps
15	• The effect of CACs for cardiac arrest in children or in the in-hospital setting
16	• The effect of CACs on long-term neurological intact survival
17	• The long-term benefits of CACs and the impact on patient-reported outcomes ²³
18	• The effect of care at CACs in specific subgroups (eg, age, cardiac etiology, shockable or
19	nonshockable rhythm)
20	• The cost-effectiveness of transferring and/or caring for patients at CACs
21	• Whether there are any negative outcomes associated with bypassing the closest hospitals
22	(eg, deskilling in postarrest management) and transferring patients to CACs
23	• What defines a safe distance or time for transport to a CAC

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

5 Cognitive Aids During Resuscitation (EIT 6400: SysRev)

6 Rationale for Review

7 The management of cardiac arrest and other medical emergencies can be complex. 8 Cognitive aids have been widely adopted to enhance adherence to guidelines, improve 9 performance, and reduce errors. These aids may provide a structured framework and clinical 10 guidance through complex and dynamic processes. Resuscitation councils worldwide use cognitive aids during training and clinical practice in the form of algorithms, flow charts, 11 12 checklists, posters, digital applications, and other formats. Whether use of such cognitive aids 13 during resuscitation improves performance and patient outcomes is uncertain. 14 ILCOR reviewed the evidence in 2020 and did not recommend cognitive aids for 15 laypersons during training and real CPR; however, they were suggested for training of health care professionals.^{24,25} Since then, new evidence has been published, triggering this update of the 16 SysRev (PROSPERO registration CRD42020159162). The complete CoSTR can be found 17 18 online.²⁶ 19 Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

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

1	Comparator: No use of cognitive aids or checklists
2	• Outcome:
3	- Critical: Survival to hospital discharge with good neurological outcome, survival to
4	hospital discharge
5	- Important: Quality of performance in actual resuscitations, skill performance 1 year after
6	course conclusion, skill performance between course conclusion and 1 year, skill
7	performance at course conclusion, knowledge at course conclusion, adherence to
8	resuscitation guidelines, CPR quality and test scores
9	• Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series,
10	controlled before-and-after studies, cohort studies) were eligible for inclusion.
11	Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All years
12	and all languages were included as long as there was an English abstract available.
13	• Time frame: Literature search was updated from January 1990 to October 28, 2023.
14	Consensus on Science
15	All 29 studies included in this review were simulation studies that investigated the use of
16	cognitive aids to facilitate clinical performance. No study investigated cognitive aids as an
17	educational tool. No meta-analyses could be performed because of a high degree of
18	heterogeneity in the studies, and the overall certainty of evidence was very low for all outcomes.
19	Details of individual studies are included in the published review and online. ²⁶
20	Four simulation studies ²⁷⁻³⁰ investigated the effects of cognitive aids in neonatal
21	resuscitation by health care professionals. Findings included improvement in performance score
22	with a decision support toll using augmented reality (AR), ³⁰ fewer deviations from a
23	resuscitation algorithm with a decision support tool with auditory and visual prompts, ²⁸ and

1	improved adherence to a resuscitation algorithm and performance to a guideline with audio voice
2	guidance. ²⁹ A poster of an algorithm demonstrated no difference in performance. ²⁷
3	The use of cognitive aids during simulated pediatric resuscitation was assessed in 3
4	studies ³¹⁻³³ and showed no difference in CPR performance by using a noninteractive CPR
5	checklist, ³³ and no difference in CPR quality metrics with a decision support app. ³² However,
6	improved adherence to protocols or processes was found in 2 RCTs. ^{31,32} A computer-based
7	resuscitation tool improved task completion, ³¹ and a decision support app found significantly
8	fewer deviations from guideline recommendations. ³²
9	Eight studies ³⁴⁻⁴¹ used interactive cognitive aids during adult ALS simulated resuscitation
10	(smartphone apps, ^{34,38,40} tablet apps, ^{36,37,39} computer-based clinical decision display system ^{35,41})
11	with improved adherence to a protocol or process in all studies.
12	Five studies ⁴²⁻⁴⁶ investigated the effects of cognitive aids (noninteractive checklists) used
13	by health care professionals managing other emergencies in simulated events. In 4 RCTs:
14	average performance scores increased, ⁴⁴ failure to adhere to critical steps was reduced, ⁴² use of a
15	medical emergency checklist improved adherence to guideline-adherent critical process steps,45
16	and longer checklists seemed to be superior to shorter checklists or no checklist for overall CPR
17	performance on procedural variables but not for CPR quality. ⁴⁶ Access to crisis checklists
18	shortened time to adequate administration of glucose in a hypoglycemic coma scenario. ⁴³
19	Seven RCTs ⁴⁷⁻⁵³ and 2 observational studies ^{54,55} investigated the effects of cognitive aids
20	used by lay rescuers during simulated resuscitation. Three RCTs ^{48,49,51} of mobile phone
21	applications found improved adherence to clinical processes, while another mobile phone
22	application RCT ⁵³ found no improvement. Other RCTs found that using instruction cards
23	improved adherence to AED sequences and time to shock, ⁴⁷ a voice-activated visual and

1	auditory-assisted decision device improved adherence to a 30:2 CPR ratio, ⁵⁰ and use of a
2	flowchart demonstrated reduced hands-off time during CPR.52
3	An observational study ⁵⁴ investigated the use of speech recognition software and found
4	improved adherence to a clinical protocol assessed in an objective structured clinical
5	examination. Another observational study ⁵⁵ investigated the feasibility of Chatbot guidance,
6	which produced mixed results.
7	Three studies reported undesirable effects: increase in time to commencing chest
8	compressions ^{50,52} and delays in calling emergency services. ⁵¹
9	Prior Treatment Recommendations (2020)
10	• We recommend against the use of cognitive aids for the purposes of lay providers
11	initiating CPR (weak recommendation, low-certainty evidence).
12	• We suggest the use of cognitive aids for health care providers during trauma resuscitation
13	(weak recommendation, very low-certainty evidence). In the absence of studies on CPR,
14	no evidence-based recommendation can be made.
15	• There are insufficient data to suggest for or against the use of cognitive aids in lay
16	provider training.
17	• We suggest the use of cognitive aids for training of health care providers in resuscitation
18	(weak recommendation, very low-certainty evidence). ^{24,25}
19	2024 Treatment Recommendations
20	• We suggest the use of cognitive aids by health care professionals in resuscitation (weak
21	recommendation, very low-certainty evidence).
22	• We do not recommend the use of cognitive aids for lay providers initiating CPR (weak
23	recommendation, low-certainty evidence).

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

3 Justification and Evidence-to-Decision Framework Highlights

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

- The EIT Task Force continues to prioritize this topic because international resuscitation
 councils commonly provide cognitive aids to resuscitation course participants and health
 care organizations (algorithms, pocket cards, etc). However, it has not been determined if
 they are effective in improving patient outcomes or provider performance during actual
 resuscitation, because no evidence was found for the use of cognitive aids by trained
 health care professionals during actual resuscitation events.
- The 2021 EvUp focused on outcomes associated with CPR quality. In this review, the
 outcomes focused on improved team performance through adherence to clinical protocols
 and processes of care.

The task force's recommendations differentiate between health care professionals and laypersons, as well as between use during resuscitation and during training, because the evidence for use of cognitive aids in these different groups and conditions differs substantially.

For lay providers, there is consistent evidence that there are potentially clinically
 important delays in initiating CPR when using a cognitive aid; however, the evidence for
 impact on CPR-quality metrics (eg, rate, depth, chest compression fraction) is less
 consistent. We found insufficient evidence to issue a recommendation for the use of
 cognitive aids in layperson training.

For health care professionals, sufficient new studies provided the evidence to issue a
 recommendation for the use of cognitive aids during resuscitation. Because no study
 reported the use of cognitive aids during patient resuscitation, results from simulation
 studies might be used as a surrogate to justify the use of cognitive aids, as these have
 been used over decades by all resuscitation councils.

Because no studies on resuscitation were found in the review in 2019, the task force
previously considered the trauma resuscitation environment sufficiently similar to the
CPR environment to extrapolate evidence that shows that trauma resuscitation teams
generally adhere to resuscitation guidelines better, make fewer errors, and perform key
clinical tasks more frequently if they use cognitive aids. In this review, sufficient new
studies addressed the use of cognitive aids in resuscitation (however, only in a simulated
environment) that the task force decided to exclude trauma studies from this review.

- There were several studies that used composite scores as their primary outcome (eg, score
 calculated on the basis of completing several clinical tasks). We included these studies
 for this SysRev; however, given their heterogeneity, comparing and pooling the results
 were not possible.
- Even though all studies were simulation studies, none specifically investigated the use of
 cognitive aids as an educational tool. Therefore, we could not examine the use of
 cognitive aids for health care professionals or lay rescuer training in resuscitation. This
 needs to be examined in our next review.

21 Knowledge Gaps

22

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

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

6 Immersive Technologies for Resuscitation Teaching (EIT 6405: SysRev)

7 Rationale for Review

8 Current methods for training laypeople and health care professionals often fall short, 9 resulting in poor skill acquisition and long-term skill decay. Identification of alternative 10 educational strategies with improved learning outcomes will help to enhance process of care and patient outcomes from cardiac arrest. Immersive technologies, such as virtual reality (VR) 11 12 (defined as real-time simulation and interactions through sensorial channels created by a computer and displayed on a head-mounted or smartphone device)⁵⁶ and AR (defined as 13 14 computer-generated holographic images overlaid into the real environment enabling users to 15 interact with both the hologram and real objects),⁵⁷ provide an alternative learning modality to 16 traditional instructor-led training. These technologies can support training when combined with 17 other instructional methodologies such as video, manikin-based training, and/or online learning. 18 Implementation of immersive technology comes with a cost for both hardware and software 19 components. VR and AR technology have been used in educational settings for both laypersons 20 and health care professionals, but ILCOR has not previously reviewed the available evidence. A 21 SysRev was initiated because the overall impact of VR and AR on learning and performance 22 outcomes is unclear (PROSPERO registration CRD42023376751). The full CoSTR can be found online.58 23

1	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
2	• Population: Laypersons and health care professionals in any educational setting
3	• Intervention: Immersive technologies (VR, AR, mixed reality, extended reality) as part of
4	instructional design to train neonatal, pediatric, and adult BLS and ALS
5	• Comparator: Other methods of resuscitation training in BLS and ALS (eg, traditional
6	manikin-based simulation training)
7	• Outcome: Knowledge acquisition and retention, skills acquisition and retention, skill
8	performance in real CPR, willingness to help, bystander CPR rate, patients' survival
9	• Study design: RCTs, nonrandomized studies (non-RCTs, interrupted time series,
10	controlled before-and-after studies, cohort studies and case series where $n > 5$, conference
11	abstracts), and research letters were eligible for inclusion. All years and all languages
12	were included as long as there was an English abstract available.
13	• Time frame: Literature search from January 1, 1990, to April 3, 2023
14	Consensus on Science
15	No meta-analyses could be performed because of a high degree of heterogeneity in the
16	studies, and the overall certainty of evidence was very low for all outcomes. Details of individual
17	studies are included in tables in the published review and online. ⁵⁸
18	Out of 18 studies ^{56,57,59-74} included in this review, 3 studies used AR in BLS
19	training.56,57,60 Two of these used AR to provide real-time CPR feedback, with one study
20	favoring AR and the other favoring the non-AR feedback.56,60 The third study used AR to
21	provide clinical guidance during training, and results favored the AR intervention but were not
22	significant. ⁵⁷

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1	VR for BLS was explored in 9 studies assessing laypersons ^{59,61-67,74} and 3 studies of
2	health care professionals. ⁶⁸⁻⁷⁰ All featured VR as the primary instructional methodology. An
3	additional 3 studies described VR use for ALS training in health care professionals. ⁷¹⁻⁷³ Because
4	of significant heterogeneity in the design of the interventions, control groups, participant types,
5	and outcome measures, meta-analysis was not possible.
6	Of the 3 studies investigating AR, 2 demonstrated no difference in CPR depth
7	performance with and without use of AR during training.56,57 One study reported better CPR
8	depth compliance with the use of AR during training. ⁶⁰ Two studies showed no difference in
9	CPR-quality parameters (compression depth and rate), ^{56,57} while an additional study found no
10	difference in compression rate but a difference in depth with the use of AR during training. ⁶⁰
11	Overall CPR performance was assessed in 2 studies ^{56,60} and demonstrated mixed results.
12	Six studies looked at VR for acquisition of BLS knowledge. Knowledge acquisition was
13	significantly greater with VR in 3 studies compared with a serious game, ⁶⁸ e-learning with
14	video, ⁶³ and video-based training. ⁶⁴ Two studies showed no difference compared with traditional
15	training ⁶⁶ or video-based training. ⁶⁵ Knowledge retention with kindergarten teachers improved at
16	5 weeks after training with VR. ⁶⁴ Two other studies showed no difference at 6 months. ^{62,66}
17	Nine studies investigated the effects of VR on BLS skills outcomes. Adult laypeople
18	achieved significantly greater chest compression fraction with instructor-led training compared
19	with VR. ⁵⁹ Results for no-flow time were mixed. One study favored VR over web-based BLS
20	training, ⁷⁰ and the other favored conventional BLS training over VR. ⁶⁹
21	Three studies in adult laypersons showed significantly better CPR depth in the control
22	group compared with VR. ^{59,61,74} Two other studies showed no difference in CPR depth between
23	groups. ^{66,67} Participants in instructor-led CPR training had significantly better CPR depth

1	compliance compared with VR.59,74 One study demonstrated higher CPR rates with VR
2	(however, both groups were within the suggested guideline range for CPR rate). ⁵⁹ Two other
3	studies found no difference in CPR rate. ^{61,67} CPR rate compliance was not better with VR; CPR
4	rate compliance was either better for instructor-led training, ^{59,74} or no difference was found. ⁶⁶
5	One study reported better chest recoil compliance with VR, ⁵⁹ but 3 studies demonstrated no
6	difference. ^{66,67,74} For overall CPR performance after training, 3 studies found no difference when
7	comparing VR with instructor-led training ^{67,74} or video-based training. ⁶⁵ Two studies measured
8	retention of CPR skills at 6 months ⁶⁶ and 3 months ⁷⁴ after training and found no difference in
9	CPR depth, rate, or chest recoil when comparing traditional training and VR. ^{66,74}
10	A study in adult laypersons found more willingness to perform CPR with instructor-led
11	CPR training at 6 months after training than with VR-based CPR training [81% willing in the
12	instructor-led control group compared with 71% in the VR intervention group, $P=0.02$]. ⁶²
13	Three studies investigated VR for ALS training. A study in neonatal resuscitation
14	compared high-fidelity simulation with VR and showed no difference in knowledge immediately
15	after training. ⁷³ An advanced cardiovascular life support study found significantly improved
16	adherence to guidelines with traditional training compared with VR training with limited
17	feedback. No difference was found when comparing traditional training with VR training with
18	comprehensive feedback. ⁷¹ An additional study found no difference in objective structured
19	clinical examination scores for clinical performance between standard Helping Babies Breathe
20	training and VR-based Helping Babies Breathe immediately after training and 6 months later. ⁷²
21	2024 Treatment Recommendations (New)
22	We suggest the use of either augmented reality or traditional methods for BLS training of
23	laypeople and health care professionals (weak recommendation, very low-certainty evidence).

1	We suggest against the use of virtual reality only for BLS and ALS training of laypeople
2	and health care professionals (weak recommendation, very low-certainty evidence).
3	Justification and Evidence-to-Decision Framework Highlights
4	The complete evidence-to-decision table can be found in Appendix A5.
5	Augmented Reality
6	• The evidence was either equivocal or in support of AR.
7	• Only a few studies were identified, with few participants.
8	• Two studies used AR for feedback ^{56,60} and 1 for clinical guidance ⁵⁷ (ie, different
9	applications of the technology), and the control groups were different across these 3
10	studies (some included CPR feedback, others did not).
11	Virtual Reality
12	• The evidence was mixed but predominantly in favor of non–VR-based training or
13	equivocal in nature.
14	• Studies were very heterogeneous with respect to type of intervention, type of control, and
15	outcome measures.
16	• Although some studies reported improved knowledge acquisition with VR training, the
17	results for more important outcomes (ie, skills outcomes, adherence to guidelines, clinical
18	performance) were either in favor of non-VR-based training or equivocal in nature.
19	Knowledge Gaps
20	• The relative and synergistic effect of immersive technologies when combined with other
21	educational strategies (eg, video, gamification, feedback)
22	• The effects of different applications of AR and VR, which can be used in many ways (eg,
23	real-time feedback, gamification, knowledge delivery)

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

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

12 Rationale for Review

13 Increased familiarity and ease with technology and digital media are features of younger 14 generations. More effective teaching strategies for these learners may include a greater degree of 15 stimulation and engagement with the use of active participation with and alongside peers. 16 Gamification refers to the use of game-like elements (competition, point systems, scaffolded 17 levels of difficulty, leaderboards), usually in a digital format, to encourage interactive and 18 intuitive participation by learners. Some preliminary studies have found that gamified learning 19 improves knowledge and skill during CPR training, either alone or used as pretraining to a 20 standard life support course; other studies have found no significant difference. The task force 21 undertook a SysRev because the impact of gamified learning on learning and performance 22 outcomes is unclear (PROSPERO registration CRD42023483540). The full CoSTR can be found online.⁷⁵ 23

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

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

2 Consensus on Science

1

3	Six randomized trials and 7 observational studies were identified. ⁷⁶⁻⁸⁸ Details of study
4	design and key findings are presented in table form in the published review and online. ⁷⁵ No
5	meta-analyses could be performed because of a high degree of heterogeneity in the studies, and
6	the overall certainty of evidence was low to very low for all outcomes.
7	Eleven studies used digital platforms, including online or screen-based
8	platforms, ^{76,77,82,85,86,88} a digital leaderboard, ^{78,81,82} and smartphone applications. ^{84,87} One study
9	used a board game, and another a card game. ^{79,80} Eleven studies involved health care
10	professionals, ^{76-84,87,88} and 2 involved laypersons (high school students). ^{85,86} Three studies
11	examined performance of teams ^{80,86,87} ; the remaining 10 examined individual performance. No
12	study reported on outcomes of process, costs, and resources utilization, or on critical clinical and
13	patient outcomes.
14	Overall CPR performance was addressed in 4 RCTs ^{77,78,82,83} and 1 observational study. ⁸⁶
15	Three RCTs ^{77,82,83} found better performance with gaming for health care professionals and
16	laypersons. A multicenter RCT found no effect. ⁷⁸ The observational study in laypersons found
17	improved performance 6 months after training with gaming. ⁸⁶ In an observational study of BLS
18	training amongst high school students using a screen-based gamified learning interface, chest
19	compression depth and rate was improved immediately after training and remained improved 3
20	months later. ⁸⁵

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

1	Program knowledge reported high levels of perceived usefulness. ⁸⁰ Another observational study
2	found improved skills scores and faster time to positive pressure ventilation in a neonatal
3	scenario that followed gamified learning. ⁷⁶
4	For ALS knowledge, 2 RCTs in health care professionals showed improvements with
5	smartphone-based games. ^{84,87} The latter study showed no difference for skills during ALS
6	scenarios used in a smartphone-based game involving ALS scenarios but led to better self-
7	reported confidence among users.
8	An observational study ⁸¹ of nurses using a leaderboard showed decreased time to
9	epinephrine dosing in children as well as increased proportion of learners knowing the correct
10	concentration of epinephrine.
11	2024 Treatment Recommendation (New)
12	We suggest the use of gamified learning be considered as a component of resuscitation
13	training for all types of BLS and ALS courses (weak recommendation, very low-certainty
14	evidence).
15	Justification and Evidence-to-Decision Framework Highlights
16	The complete evidence-to-decision table is provided in Appendix A5.
17	• All studies were very heterogeneous with respect to subjects, type of intervention, type of
18	control, and outcome measure, and GRADE assessment showed that evidence was of
19	very low certainty.
20	• All studies reported at least 1 domain of learner outcome (skill, knowledge, attitude) with
21	a positive result when gamified learning elements were included; no studies found a
22	negative impact of gamified learning elements on any domain of learner outcomes.

1	• Most studies involved an intervention requiring a digital platform (eg, video-based,
2	smartphone-based); no studies reported any information about cost, implementation
3	outside their study group, or wider dissemination to other settings or learners.
4	Knowledge Gaps
5	• A more consistent definition of <i>gamification</i> across research studies (eg, use of video-
6	based content delivery alone does not necessarily constitute a "game," although this term
7	is frequently used to describe such training elements)
8	• No studies found on dissemination of gamified learning elements as well as platforms to
9	varied learner groups and settings
10	• Costs, resources, and time requirements for implementation of gamified learning
11	• The association between gamified learning elements and differences in stress and/or
12	cognitive load
13	• The impact of gamified learning on care delivery and/or patient outcomes
14	Rapid Cycle Deliberate Practice in Resuscitation Training (EIT 6414: SysRev)
15	Rationale for Review
16	Rapid cycle deliberate practice (RCDP) is a type of training in which feedback occurs
17	within the training. It should not be confused with repetitive practice. RCDP is characterized by
18	a goal to be achieved, a stop-and-go practice with immediate feedback on the performance,
19	ample time for repetition to improve performance aiming to improve clinical outcomes, and a
20	safe environment that fosters an atmosphere where students have no fear of making mistakes and
21	receive feedback from a constructive perspective. ⁸⁹ ILCOR has not previously reviewed
22	available evidence about RCDP in resuscitation training. Therefore, a SysRev was initiated
23	(PROSPERO registration CRD42023468862). The full CoSTR can be found online. ⁹⁰

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
• Population: Learners training in BLS or ALS
• Intervention: Instruction that uses RCDP
• Comparator: Traditional instruction or other forms of learning without RCDP
• Outcome: Knowledge acquisition and retention, skills acquisition and retention, skill
performance in real CPR, attitudes, willingness to help, and patients' survival
• Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series,
controlled before-and-after studies, cohort studies) were eligible for inclusion.
Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All years
and all languages were included as long as there was an English abstract available.
• Time frame: All years up to November 1, 2023
Consensus on Science
Seven RCTs ⁹¹⁻⁹⁷ and 1 observational before-after study ⁸⁹ were identified. ^{89,91-97} The
studies included medical students, ⁹⁶ interns, ^{93,94} residents, ^{89,92,97} physicians, ⁹⁵ and a mix of
fellows, nurses, and respiratory therapists ⁹¹ —all involved in adult, ^{95,96} pediatric, ^{89,91,92,94,97} and
neonatal ⁹³ simulated scenarios. Seven of them referred directly to RCDP ^{89,91-95,97} ; 1 used "in-
simulation debriefing" during the clinical scenario, which contained the key components of
RCDP. ⁹⁶
Details of individual studies are presented in the published review and online. ⁹⁰ No
studies reported clinical or patient outcomes, and meta-analysis was only possible for time to
chest compressions.
For time to chest compressions, 2 pediatric ^{92,97} studies and 1 neonatal ⁹³ study provided
very low-certainty evidence of no benefit from RCDP when compared with after-event

1 debriefing (Figure 6). In an observational study, RCDP resulted in a significantly shorter time



2 from cardiac arrest to initiation of chest compressions.⁸⁹

3 4



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

A single RCT found no benefit in time to recognition of cardiac arrest with RCDP.95 An 8 observational study found no benefit in time to bag-mask ventilation.⁸⁹ In an RCT, time to 9 positive-pressure ventilation within 1 minute was more frequent with RCDP than in the control.⁹³ 10 Three RCTs^{92,95,97} and 1 observational study⁸⁹ assessed time to defibrillation, with shorter time 11 from rhythm recognition to defibrillation in 2 RCTs^{92,95} and in the observational study.⁸⁹ Two 12 RCTs assessed time to administration of epinephrine,^{92,93} with 1 study describing a benefit with 13 RCDP.⁹³ RCDP also resulted in shorter pre-defibrillation pause durations in 2 studies.^{89,95} RCDP 14 improved compression fraction/no-flow fraction in an RCT⁹⁵ and in an observational study.⁸⁹ 15 Retention of skills at 4 months was analyzed in an RCT, and there was no difference with 16 RCDP.⁹³ 17

1	For adherence to protocol, 1 RCT reported higher scores, ⁹³ but 2 others found no
2	difference. ^{91,94} Team leader performance was better with RCDP in 1 study. ⁹⁷ In contrast,
3	participants' subjective perception of the teaching effectiveness scored lower for RCDP.96
4	2024 Treatment Recommendation (New)
5	We suggest that it may be reasonable to include Rapid Cycle Deliberate Practice as an
6	instructional design feature of BLS and ALS training (weak recommendation, very low-certainty
7	evidence).
8	Justification and Evidence-to-Decision Framework Highlights
9	The complete evidence-to-decision table is provided in Appendix A5.
10	• We favored RCDP as a teaching modality because no side effects or harmful outcomes
11	were reported and most outcomes showed a benefit from RCDP. Notably, shorter time to
12	critical task performance (ventilation, defibrillation, administration of epinephrine) and
13	shorter preshock pause durations were described in several studies.
14	• The only meta-analysis performed (for time to chest compressions) did not show a
15	difference. This contributed to the weakness of the recommendation, despite other
16	evidence being found in favor of RCDP.
17	• Only 1 study (addressing teaching effectiveness) out of the 8 included in the review
18	favored the control group.
19	• As most of the RCDP studies included trainees, generalizability of the findings to other
20	groups needs to be further explored.
21	Knowledge Gaps
22	• The effect of RCDP in other populations (laypeople, first responders, and experienced
23	health care professionals)

1	• The medium or long-term follow-up effect of RCDP
2	• Resources required and costs of implementation of RCDP in resuscitation training
3	curriculum of health care professionals and other populations
4	• The effect of RCDP on resuscitation training and clinical outcomes and patient survival
5	• There is heterogeneity in the use of terms, and standardized definitions of <i>deliberate</i>
6	practice and RCDP were not used across studies, making identification of relevant
7	comparative studies difficult.
8	Team Competencies Training for Resuscitation (EIT 6415: SysRev)
9	Rationale for Review
10	Team competencies are defined as nontechnical skills, including team-related
11	communication, task allocation, and leadership, that are known to be associated with patient
12	outcomes in resuscitation. Investigating whether specific training of team competencies
13	improves resuscitation performance could impact the organization of resuscitation services
14	worldwide and potentially improve patient care. In 2020 we recommended the use of specific
15	leadership training for resuscitation courses on the basis of very low-certainty evidence. ²⁴ This
16	SysRev aimed to assess the effect of specific training on a broader range of team competencies
17	as part of resuscitation training (PROSPERO registration CRD42023473154). The full CoSTR
18	can be found online. ⁹⁸
19	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
20	• Population: Learners undertaking life support training in any setting
21	• Intervention: Life support training with a specific emphasis on team competencies
22	• Comparator: Life support training without specific emphasis on team competencies

1	• Outcome: Patient survival, CPR skill performance at course completion, CPR skill
2	performance in actual resuscitation and simulation, CPR quality, confidence, and team
3	competencies—all at course completion, <1 year and ≥ 1 year after course completion;
4	resources (time, equipment, cost)
5	• Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series,
6	controlled before-and-after studies, cohort studies) were eligible for inclusion. Studies
7	evaluating scoring systems (no relevant outcome), studies with self-assessment as the
8	only outcome, reviews, and abstracts were excluded. All languages were included as long
9	as there was an English abstract available.
10	• Time frame: Literature search January 1, 1999, to August 30, 2023
11	Consensus on Science
12	Seventeen studies were included in this review, and individual study details are provided
13	in the published review and online.98-115 No evidence was identified for CPR-skill quality and
14	performance, confidence, and team competencies beyond 1 year. One RCT ¹⁰⁴ reported
15	descriptive data on patient survival outcomes favoring team competencies, but this was not
16	powered to make inferences.
17	For CPR skills and quality at course completion, 2 RCTs ^{99,109} reported shorter time to at
18	least 1 CPR-skills performance. One nonrandomized study for pediatric ALS ¹⁰⁵ reported higher
19	checklist scores for CPR skills with team training, and 1 RCT ¹⁰³ found greater adherence to ALS
20	guidelines. Nine studies (1 observational, ¹⁰⁵ 8 RCTs ^{101,104,108-110,112,114,115}) reporting CPR
21	performance found no effect from team competence training. One RCT ¹⁰⁰ reported shorter no-
22	flow time, whereas another found no difference. ¹⁰³ Two studies found no difference in hands-on
23	time or compression rate ¹⁰⁸ or chest compression quality. ¹⁰⁷

1	Two RCTs found no difference in CPR performance at 4 months ¹¹⁵ and 6 months. ¹¹⁰
2	Another RCT ¹⁰⁸ reported increased hands-on time and higher compression rates 4 months after
3	course completion. Confidence at course completion and at a nonspecified follow-up interval
4	showed was not different in 1 RCT. ¹⁰¹
5	Team competencies were evaluated at course completion by 14 studies (12 RCTs, 99-102, 106-
6	^{109,112-115} 2 nonrandomized studies ^{105,111}). Three RCTs ^{107,108,113} reported more leadership
7	statements, 3 RCTs ^{102,112,113} identified increased directed team communication, 1 RCT ¹¹² found
8	increased closed-loop communication, and another RCT ¹⁰⁰ reported higher "teamwork
9	verbalizations" (eg, directed orders, task assignments, planning).
10	Decision-making improved in 1 RCT. ¹⁰⁷ Leadership behavior was better in 2 RCTs, ^{104,106}
11	with 1 also reporting increased correction of improper chest compressions. A nonrandomized
12	study ¹¹¹ reported no difference in leadership behavior.
13	Teamwork improved in 1 RCT ¹⁰¹ with higher team-level efficacy, and 1 nonrandomized
14	study ¹⁰⁵ reported more teamwork intervention events. Two RCTs ^{114,115} and a nonrandomized
15	study ¹¹¹ found no differences in teamwork measures. Nontechnical skills performance was found
16	to be higher in 2 RCTs, ^{99,109} and 2 RCTs ^{113,114} reported improved workload management.
17	Beyond course completion, 1 RCT reported more leadership statements, task
18	assignments, commands, and decisions at 4 months. ¹⁰⁸ Another RCT found higher ratings on a
19	self-reported teamwork scale, ¹⁰¹ but no difference was found in teamwork scores (TEAM) at 3
20	months in another RCT. ¹¹⁵
21	Prior Treatment Recommendation (2020)
22	We suggest that specific team and leadership training be included as part of ALS training

23 for health care providers (weak recommendation, very low-certainty evidence).²⁴
1 2024 Treatment Recommendation

2	We suggest that teaching team competencies be included in BLS and ALS training (weak
3	recommendation, very low-certainty evidence).
4	Justification and Evidence-to-Decision Framework Highlights
5	The complete evidence-to-decision table is provided in Appendix A5.
6	• We identified no harmful effects of team competencies training in any course format.
7	• Several studies reported that team competencies training improved CPR skill
8	performance, which persisted beyond course completion.
9	• The evidence relating to team competency outcomes varies but was mostly positive.
10	• Previous clinical studies suggest that a lack of team competencies is a barrier to
11	successful resuscitation, and team competencies have been associated with improved
12	technical skill performance during clinical resuscitation attempts.
13	• We valued the fact that team competencies training appears widely accepted.
14	Knowledge Gaps
15	• Benefits of training team competencies on clinical resuscitation performance outcomes
16	and patient outcomes
17	• The optimal instructional design, duration, and mode of delivery for training of team
18	competencies
19	• Whether training in particular competencies is more important than others and whether
20	this depends on the group of learners
21	• Cost-effectiveness of team competencies training and effectiveness in low-resource
22	settings

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

2 Rationale for Review

3	The task force undertook this ScopRev because the individual backgrounds of specific
4	populations (eg, working in a special environment, someone with special needs, impairments, or
5	disabilities) who are not health care professionals may warrant specific BLS training that differs
6	from standard courses. ¹¹⁶⁻¹¹⁸ However, it is unclear which specific populations exactly could
7	benefit from adapted tailored teaching. The complete report of this ScopRev can be found
8	online. ¹¹⁹
9	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
10	• Population: Specific adult layperson populations and/or groups participating in BLS
11	training
12	Intervention: Tailored BLS training
13	Comparator: Nontailored BLS training
14	• Outcomes:
15	- Patient outcomes:
16	Critical: Survival to hospital discharge, 30-day survival, 12-month
17	survival, neurological outcome
18	Important: ROSC
19	- BLS quality outcomes: Starting CPR in case of real cardiac arrest, performance during
20	real CPR
21	- Educational outcomes: Knowledge and skills acquisition, willingness to perform CPR,
22	barriers toward performing CPR, participant satisfaction and/or knowledge and skills

1	retention at the end of the respective course and later (eg, 3 months, 1 year),
2	implementation success, resource implications, and cost-effectiveness
3	• Study design: RCTs and nonrandomized studies (non-RCTs, controlled before-and-after
4	studies, cohort studies, and case series $n \ge 5$), reviews, and surveys in respective
5	population groups with at least an abstract in English were eligible for inclusion.
6	Research aimed at teaching BLS to children and research on CPR training for health care
7	professionals (both sufficiently covered elsewhere) were excluded.
8	• Time frame: All years to July 10, 2023
9	Definitions
10	A) Specific population/subgroup: A group with a specific feature (eg, job, age group)
11	B) Layperson: An adult who is not a qualified, retired, or in-training health care professional.
12	We defined 2 groups of laypersons:
13	1) Duty to respond: Laypersons who have a duty to attend victims of an emergency because
14	of their profession (eg, law enforcement, firefighters, lifeguards, flight crews)
15	2) No duty to respond: Community laypersons who have no duty (occupational expectation)
16	to respond to a cardiac arrest
17	C) Standard BLS training (nontailored BLS courses): BLS courses that follow current
18	recommendations from the large course developers and organizers like the American Heart
19	Association or the European Resuscitation Council.
20	D) Tailored training (tailored courses): Courses altered to serve the special needs of a population
21	(eg, duration, frequency, content, assessment, feedback, materials and devices used, specific
22	aids, contextualization of the environment, specially trained instructors)

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1 Summary of Evidence

2 Details of the included studies and findings are presented in the published review and online.¹¹⁹ Most studies addressed training in those with disabilities, including Down 3 syndrome,^{120,121} blindness,^{122,123} and deafness or hearing impairment.¹²⁴⁻¹²⁶ No studies comparing 4 5 an approach tailored to specific populations with a standard course were identified. Only a small 6 percentage of persons with Down syndrome were able to perform high-quality chest 7 compression-only CPR after a tailored course (shorter sessions and videos with comic elements).^{120,121} Two studies assessed CPR education for blind learners, which resulted in chest 8 compression-only CPR similar to other BLS providers¹²²; supervisors with special pedagogic 9 training were able to teach rescue breaths.¹²³ Tailored courses for trainees with hearing 10 impairment¹²⁴⁻¹²⁶ incorporated sign language interpreters without altering the 30:2 approach. 11 12 Activating emergency medical services and following automated external defibrillator voice 13 prompts were the most challenging points. One tailored chest compression-only CPR course for 14 refugees was deemed feasible but needed translators and a special focus on general health 15 literacy.¹²⁷

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17 No studies were found comparing tailored courses with standard BLS courses, which was 18 the intended aim of this review. Thus, whether tailoring BLS courses to specific populations 19 yields better results than standard courses remains unknown. An overview of studies reporting 20 tailored courses for specific populations was provided instead. Unfortunately, studies reported 21 few details on the tailoring done or the development process. We acknowledge that educators 22 will often make minor adaptations in courses to meet individual needs of students, but real

tailoring has to address the needs of the special learners, include the specific populations in such
developments, and undergo proper validation to ensure benefits to the learners.
The task force thought that tailored BLS education for specific populations is probably
feasible and could expand the pool of potential bystander CPR providers to include groups that
may otherwise have been left out (eg, individuals with disabilities). The importance of defining a
structured way to tailor courses to those with specific needs and ways that members of specific
groups might be involved in developing such courses were also discussed.
Knowledge Gaps
• Which specific population groups may benefit from tailored BLS education
• Whether tailored BLS education is cost-effective across different populations
• What kind and amount of tailoring are optimal
• Whether tailored courses would be effective for first responders with and without a duty
to respond, including but not limited to police, firefighters, or lifeguards
• How standard courses compare with tailored courses in specific populations
International Facets of the Chain of Survival (EIT 6311: ScopRev)
Rationale for Review
The term Chain of Survival is widely used in literature, scientific presentations,
education, and awareness campaigns, with significant heterogeneity. This leads to confusion on
which version should be used for which purpose, and the educational and clinical impacts of this
heterogeneity are unclear. The American Heart Association issued various iterations of the Chain
of Survival in their latest guidelines. ¹¹⁷ The European Resuscitation Council switched to the
concept of Systems Saving Lives, and, while still mentioning the Chain of Survival, no longer

1	uses a depiction of the Chain of Survival. ¹¹⁸ No review of this topic has been done by ILCOR
2	previously. The full report of the ScopRev can be found online. ¹²⁸
3	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
4	• Population: Literature using the term <i>Chain of Survival</i> or similar terms (eg, <i>survival</i>
5	chain, chain of [other pathology])
6	• Intervention and exposure: Adaptations of the original Chain of Survival
7	Comparator: The original Chain of Survival
8	• Outcome:
9	 Composition of the specific variations in adapted versions
10	- Attitudes, rationale, and views concerning the adaptation
11	 Incentives to develop novel versions
12	- Way of implementation of adapted versions
13	- Way of utilization of adapted versions in education
14	- Variations in visualization
15	- Effect of the use of the Chain of Survival or variants on teaching, implementation, and
16	patient outcomes
17	• Study design: All types of studies, including randomized trials or non-RCTs, narrative
18	literature, letters, commentaries, or editorials in all languages
19	• Time frame: All years to August 14, 2023
20	Summary of Evidence
21	The heterogeneity of works identified made a SysRev or meta-analysis impossible.
22	Details of individual studies are summarized in the published review and online. ¹²⁸ We grouped
23	the publications into novel concepts related to resuscitation ($n=8$), ^{117,129-135} novel concepts not

directly related to resuscitation (n=23),¹³⁶⁻¹⁵⁸ simple adaptations of the original Chain of Survival
 (n=9),¹⁵⁹⁻¹⁶⁷ and impact on outcomes (n=3).¹⁶⁸⁻¹⁷⁰

Novel Chains of Survival have been suggested for resuscitation for IHCA, 117,130,133 3 pediatric resuscitation,^{117,134} and mass gatherings (including early planning).¹³¹ A chain mail of 4 survival¹³² and a specific Chinese version have also been proposed.¹³⁵ Adaptations of the existing 5 chains (mostly expansions) included survival after ventricular fibrillation,¹⁶⁷ rehabilitation,¹⁶³ 6 general prevention,¹⁶⁴ family support,¹⁶⁵ making the chain into a circle,¹⁵⁹ STEMI,¹⁶² the chain 7 mail of survival for low-resource settings,¹⁶⁶ survival odds along the chain in contrast to research 8 funding.¹⁶⁰ and a visual adaptation of the rings according to their impact on outcome in ratios.¹⁶¹ 9 10 Increased survival rates and better neurologic outcome after the introduction of the fifth link of the chain by the American Heart Association in 2010 was observed.^{168,169} After a public 11 campaign about the Chain of Survival in France, bystander CPR rates increased.¹⁷⁰ No 12 13 educational or other outcomes were reported. Several versions or adaptations not directly related to CPR were found ¹³⁶⁻¹⁵⁸, covering 14 specific pathologies (trauma, ^{136,150,157} severe hemorrhage, ¹⁴⁶ land mine incidents, ¹⁴¹ stroke, ^{142,149} 15 STEMI,^{138,148} drowning,^{151,152} septic shock,¹⁴³ complicated deliveries¹⁴⁰) or occasions and 16 situations (pandemics, ^{153,158} events, ¹⁴⁷ terror attacks, ¹⁵⁶ chemical/biological/radiological/nuclear 17 incidents,¹³⁹ industrial incidents¹⁴⁴). Others rethought the concept and proposed the survival 18 ladder,¹⁵⁵ or a Chain of Survival behaviors in first aid.¹⁵⁴ Peculiarities were the animal Chain of 19 Survival for veterinary patients,¹³⁷ and 1 for anesthesia equipment.¹⁴⁵ 20

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Chains of Survival range from classic versions used by resuscitation councils with minor
 adaptations to completely novel versions covering a variety of pathologies or situations. Most

1 health care workers know one or another version of the Chain of Survival because the concept 2 has penetrated scientific literature and guiding documents, including gray literature. Also, the 3 term is clinically and scientifically used as a synonym for whole systems of cardiac arrest care. 4 An educational aspect of the Chain of Survival does not really play a role in publications 5 included in this review. Several adaptations of the classic chain lack essential links of the chain. 6 Rehabilitation and prevention seem to be accepted as cornerstones of patient care. Special 7 circumstances of cardiac arrest (eg, pediatric, out-of-hospital, in-hospital, drowning) may require 8 consensus on more substantial modifications. Interestingly, only 3 publications assessed the impact of the Chain of Survival on outcomes,¹⁶⁸⁻¹⁷⁰ but the exact role the chain played in altering 9 10 outcomes, if any, is unclear. The EIT Task Force concluded that a version of the classic Chain of Survival with 6 links 11 (as currently proposed by the American Heart Association)¹¹⁷ (Figure 7) is a sensible choice as a 12 13 cognitive aid for laypersons in education, awareness campaigns, etc to convey the message of needed actions to save lives. If needed, modified versions of the chain for specific situations like 14 15 drowning or trauma might also be acceptable. The task force also thought that ILCOR, as the 16 international body on resuscitation, should provide the basic structure of this framework. Regional resuscitation councils can provide regional applications for their implementation 17 18 strategies.



Figure 7. The basic Chain of Survival with 6 links.

- 3 CA indicates cardiac arrest; CPR, cardiopulmonary resuscitation.
- 4 Knowledge Gaps

5	•	Whether there is a need for revising the classic Chain of Survival	

- Who the Chain of Survival is targeted toward (clinicians, scientists, laypeople,
- 7 stakeholders, or all of them), if laypersons need a simpler Chain of Survival than health
- 8 care professionals do, and how it should be used optimally (a depiction of local systems
- 9 to save lives, an educational framework, a cognitive aid, etc)
- Which of the various published Chains of Survival should be used by default; a
- 11 comprehensive system could be evaluated for applicability in the future
- The impact of various kinds of Chains of Survival on educational outcomes, clinical
- 13 outcomes, and patient survival
- 14 Provider Workload and Stress During Resuscitation (EIT 6401: ScopRev)
- 15 Rationale for Review
- 16 The workload and stress health care professionals might experience during resuscitation
- 17 have the potential to affect the performance of individual rescuers or the resuscitation team.^{171,172}
- 18 This ScopRev investigated what variables influence (ie, increase or decrease) health care
- 19 professional workload and stress during cardiac arrest, in both real-world and simulated
- 20 scenarios. The full report of the ScopRev can be found online.¹⁷³

1	Population, Exposure, Comparator, Outcome, Study Design, and Time Frame
2	• Population: Health care professionals performing resuscitation on patients in cardiac
3	arrest in clinical settings or on manikins in a simulated setting
4	• Exposure: Presence of any factors that would possibly impact the health care
5	professional's perceived workload or stress
6	• Comparator: Absence of the specific factor
7	• Outcome: Objective or subjective measures of workload and/or stress experienced by
8	health care professionals during resuscitations
9	• Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series,
10	controlled before-and-after studies, cohort studies), unpublished studies (eg, conference
11	abstracts, trial protocols), letters, editorials, comments, case reports, gray literature, and
12	social media were eligible for inclusion. All relevant publications in any language were
13	included as long as there was an English abstract available.
14	• Timeframe: From inception to April 21, 2023
15	Summary of Evidence
16	We included 21 studies, ^{37,45,174-193} including 17 RCTs, ^{37,45,175,177-183,185-188,191-193} 2
17	nonrandomized trials, ¹⁹⁰ and 2 observational studies. ^{174,189} Because of heterogeneity in study
18	design, SysRev with meta-analysis could not be performed. Study characteristics and key
19	findings are provided in table form in the published review and online. ¹⁷³ All but 2 studies ^{174,189}
20	were simulation studies.
21	The NASA Task Load Index ^{37,175,177-180,183,185-194} was used to measure subjective
22	workload, and the State-Trait Anxiety Inventory, ¹⁸² visual analog scale, ¹⁹⁵ and structured survey
23	questions ⁴⁵ were used to measure stress. Physiologic stress markers included salivary cortisol, α -

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1	amylase levels, heart rate, and BP. ^{176,188} Variables influencing perceived stress or workload were
2	categorized into (1) team composition and roles, (2) telemedicine, (3) workflows, (4) tools like
3	CPR-feedback devices, (5) cognitive aids, (6) presence of friends and families, and (7) provider
4	experience and exposure. Findings by category include the following:
5	• Team composition and roles: A dedicated nursing team leader alleviated the medical
6	team leader's workload during resuscitation. ¹⁹³ CPR coaches decreased mental workload
7	and increased physical workload among CPR providers ¹⁸⁷ but did not impact the team
8	leader's workload. ^{180,187} In real pediatric resuscitations, the team leader reported higher
9	mental load, whereas chest compressors had higher physical workload. ¹⁷⁴
10	• Telemedicine: Remotely led resuscitation teams experienced higher-overall workload and
11	mental demand compared with on-site leading. ¹⁷⁸ Active remote team leaders versus a
12	remote consultant on request increased workload for team members with teleconsulting
13	only. ¹⁹¹
14	• Workflows: Adjustment of workflows (prioritizing chest compression automation with
15	mechanical CPR device ¹⁹²), or deliberate reorientation with task-focusing questions, ¹⁸¹
16	reduced perceived workload and stress in simulation.
17	• Tools: The use of ventilation feedback devices or chest compression feedback devices
18	increased workload for CPR providers. ¹⁷⁵ Real-time feedback devices had no effect on
19	team leaders, while chest-compressing CPR providers reported higher workloads. ¹⁸³
20	Interestingly, equipment failure (defective defibrillator) in simulation did not increase
21	stress for the team. ¹⁸⁸
22	• Cognitive aids and smart apps: A smart app designed to help drug preparation reduced
23	acute stress in paramedics in simulated pediatric cardiac arrest. ¹⁸² A smart app with a

1	resuscitation algorithm did not increase workload for team leaders. ¹⁹⁰ A tablet-based
2	decision support tool's effect on workload was inconclusive because the increase in
3	workload disappeared later during simulation. ¹⁸⁵
4	• Family presence and socioemotional stress: Presence of next of kin increased mental
5	demands but did not change physical demands in simulation. ¹⁷⁹ An observational study of
6	real pediatric resuscitations showed lower workload when at least 1 parent was present. ¹⁸⁹
7	This is in accordance with an ILCOR CoSTR on family presence during resuscitation in
8	pediatric and neonatal cardiac arrest. ^{196,197}
9	• Provider experience: A quasi-experimental study found no association between level of
10	clinical experience and subjective stress and physiologic parameters among nursing
11	students during resuscitation simulation. ¹⁷⁶
12	Task Force Insights
13	In these studies, designated medical team leaders tended to experience increased
13 14	In these studies, designated medical team leaders tended to experience increased workload, which was attenuated by assistance from senior nurse leaders. However, additional
13 14 15	In these studies, designated medical team leaders tended to experience increased workload, which was attenuated by assistance from senior nurse leaders. However, additional CPR coaches did not affect the team leader's overall workload, and remote team leaders
13 14 15 16	In these studies, designated medical team leaders tended to experience increased workload, which was attenuated by assistance from senior nurse leaders. However, additional CPR coaches did not affect the team leader's overall workload, and remote team leaders increased team workload. A goal-directed approach or use of task-focusing questions during
13 14 15 16 17	In these studies, designated medical team leaders tended to experience increased workload, which was attenuated by assistance from senior nurse leaders. However, additional CPR coaches did not affect the team leader's overall workload, and remote team leaders increased team workload. A goal-directed approach or use of task-focusing questions during resuscitations can reduce perceived workload or stress for the team. External support from
 13 14 15 16 17 18 	In these studies, designated medical team leaders tended to experience increased workload, which was attenuated by assistance from senior nurse leaders. However, additional CPR coaches did not affect the team leader's overall workload, and remote team leaders increased team workload. A goal-directed approach or use of task-focusing questions during resuscitations can reduce perceived workload or stress for the team. External support from cognitive aids reduced stress and workload, but workload was sometimes higher with first use.
 13 14 15 16 17 18 19 	In these studies, designated medical team leaders tended to experience increased workload, which was attenuated by assistance from senior nurse leaders. However, additional CPR coaches did not affect the team leader's overall workload, and remote team leaders increased team workload. A goal-directed approach or use of task-focusing questions during resuscitations can reduce perceived workload or stress for the team. External support from cognitive aids reduced stress and workload, but workload was sometimes higher with first use. Therefore, introducing new equipment could potentially impose an additional cognitive burden if
 13 14 15 16 17 18 19 20 	In these studies, designated medical team leaders tended to experience increased workload, which was attenuated by assistance from senior nurse leaders. However, additional CPR coaches did not affect the team leader's overall workload, and remote team leaders increased team workload. A goal-directed approach or use of task-focusing questions during resuscitations can reduce perceived workload or stress for the team. External support from cognitive aids reduced stress and workload, but workload was sometimes higher with first use. Therefore, introducing new equipment could potentially impose an additional cognitive burden if the users are not adequately familiarized with it.
 13 14 15 16 17 18 19 20 21 	In these studies, designated medical team leaders tended to experience increased workload, which was attenuated by assistance from senior nurse leaders. However, additional CPR coaches did not affect the team leader's overall workload, and remote team leaders increased team workload. A goal-directed approach or use of task-focusing questions during resuscitations can reduce perceived workload or stress for the team. External support from cognitive aids reduced stress and workload, but workload was sometimes higher with first use. Therefore, introducing new equipment could potentially impose an additional cognitive burden if the users are not adequately familiarized with it. The factors identified in this review (team composition and roles, workflows, tools,
 13 14 15 16 17 18 19 20 21 22 	In these studies, designated medical team leaders tended to experience increased workload, which was attenuated by assistance from senior nurse leaders. However, additional CPR coaches did not affect the team leader's overall workload, and remote team leaders increased team workload. A goal-directed approach or use of task-focusing questions during resuscitations can reduce perceived workload or stress for the team. External support from cognitive aids reduced stress and workload, but workload was sometimes higher with first use. Therefore, introducing new equipment could potentially impose an additional cognitive burden if the users are not adequately familiarized with it. The factors identified in this review (team composition and roles, workflows, tools, telemedicine, cognitive aids, smart apps, and socioemotional stress) represent potential

1	workloads or stress and, consequently, on resuscitation performance as well. However, there may
2	be additional factors influencing the workload of resuscitation team members that were not
3	covered in our review. ¹⁹⁸
4	Given the few studies specifically designed to manipulate workload and its impact on
5	resuscitation performance, and that stress and workload may affect individuals' performance
6	differently, the task force did not include resuscitation performance in this review to avoid
7	incorrect conjecture and to maintain the integrity of the results.
8	Knowledge Gaps
9	• The association between workload/stress and resuscitation performance; more well-
10	crafted experimental studies exploring the relationship between workload and
11	performance of resuscitation teams are needed to gain more insight into this complex
12	interaction
13	• Health care professionals' workload or stress during resuscitation on actual patients and
14	how such workload and stress are associated with patient outcome
15	• The influence of personal factors, contextual factors, and clinical experience in mitigating
16	the impact of external stressors and perceived workload
17	Scripted Debriefing Compared With Nonscripted Debriefing in Resuscitation Training
18	(EIT 6413: ScopRev)
19	Rationale for Review
20	Debriefing conducted during simulation-based training improves provider knowledge,
21	clinical performance, and nontechnical skills performance. ¹⁹⁹⁻²⁰⁴ Studies assessing the impact of
22	debriefing after cardiac arrest events demonstrate improved provider performance, 205,206 while
23	debriefings informed by clinical data have been associated with enhanced survival outcomes

2	implemented, leading to variability in how debriefing is conducted across programs and
3	institutions. ²⁰⁹
4	Debriefing scripts and tools have been developed to help standardize the approach to
5	debriefing during resuscitation training. While their use has gained traction in both
6	educational ^{210,211} and clinical settings, ²¹²⁻²¹⁴ the benefits of debriefing scripts in resuscitation
7	education have not been clearly delineated, prompting this ScopRev. ²¹⁵ The full report of the
8	ScopRev can be found online. ²¹⁶
9	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame
10	• Population: Health care professionals or laypeople receiving resuscitation training
11	(primary) and instructors teaching resuscitation courses (secondary)
12	• Intervention: Debriefing with a cognitive aid, checklist, script, or tool
13	• Comparator: Debriefing without the use of a cognitive aid, checklist, script, or tool
14	• Outcome: Patient outcome, improved resuscitation performance in clinical environments,
15	improved learning outcomes (knowledge and skill acquisition and retention), satisfaction
16	of learning, quality of teaching/debriefing, workload/cognitive load of debriefer
17	• Study design: RCTs and nonrandomized studies (non-RCTs, interrupted time series,
18	controlled before-and-after studies, cohort studies) were eligible for inclusion.
19	Unpublished studies (eg, conference abstracts, trial protocols) and gray literature were
20	excluded. All relevant publications in any language were included as long as there was an
21	English abstract available.
22	• Time frame: All years to April 18, 2023

from cardiac arrest.^{207,208} Many different debriefing frameworks have been developed and

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1 Summary of Evidence

2	Six studies (5 RCTs ^{210,217-220} and 1 quasi-experimental study ²²¹) were included in this
3	review. Details of the included studies are summarized in the published review and online. ^{215,216}
4	No studies evaluated patient outcomes or provider performance on real patients.
5	Three studies used pediatric resuscitation scenarios ^{210,218,219} and 3 others adult
6	scenarios ^{217,220,221} as the trigger for the debriefing. Five studies ^{210,217-219,221} used a debriefing
7	script, including debriefing framework, topics for discussion, and suggested phrasing; the other
8	RCT ²²⁰ did not use suggested phrases. Only 1 study incorporated CPR-quality parameters as
9	objective data. ²¹⁹ Only 4 studies trained the debriefer in the use of the script. ^{217-219,221} The
10	PEARLS tool (Promoting Excellence and Reflective Learning in Simulation) ^{217,219,221} was used
11	most often, followed by advocacy-inquiry, ^{210,218} and then the gather-analyze-summarize
12	model. ²²⁰ A multicenter trial reported that scripting led to debriefings of higher quality, with
13	significant effects in novices, ²¹⁸ whereas another RCT found no difference when using a
14	PEARLS script. ²¹⁷ The latter study found reduced cognitive load with script debriefing for
15	novice debriefers (ie, simulation fellows).
16	Data-informed, PEARLS-scripted debriefing after a simulated pediatric cardiac arrest
17	scenario improved leaning outcomes (excellent CPR, guideline-compliant depth, chest
18	compression fraction, perishock pause) in 1 RCT. ²¹⁹ A study including medical and nursing
19	students showed no difference in teamwork performance comparing scripted with nonscripted
20	debriefings. ²²⁰ A multicenter RCT of health care professionals reported improved team
21	leadership skills and improved knowledge acquisition but no difference in clinical performance
22	scores with scripted debriefing by novice instructors. ²¹⁰

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2 All studies had significant heterogeneity in design and implementation of scripted debriefing interventions (eg, blended method and framework of debriefing,^{217,219,221} single 3 debriefing method like advocacy inquiry^{210,218}). There were differences in the methods of 4 5 familiarization of facilitators with scripts (from handing the debriefing script to facilitators 6 before debriefing to comprehensive debriefing training). These variables may have contributed to 7 the variability in results. 8 Our ScopRev did not identify any studies reporting patient or process outcomes in real 9 resuscitations. Only 1 study integrated CPR performance metrics directly into the debriefing script,²¹⁹ enabling a direct link between debriefing to clinically relevant performance metrics, 10 which might enhance the overall impact of debriefing during resuscitation education.²¹⁹ 11 12 2024 Good Practice Statement 13 Consider using debriefing scripts to support instructors during debriefing in resuscitation

14 programs because they may improve learning and performance. Instructors need to ensure they 15 have a complete understanding of how the debriefing script should be used (good practice 16 statement).

17 Knowledge Gaps

18	•	The relative and synergistic effect of scripted wording versus data-informed debriefing
19		during resuscitation training
20	•	The impact of scripted debriefing on knowledge and skill retention

The impact of scripted debriefing during training on patient or process outcomes in real
 resuscitations

1	•	The importance of debriefer adherence to debriefing scripts and its influence on learning
2		and performance outcomes

- The influence of debriefer experience and learner characteristics on the impact of
- 4 debriefing scripts
- 5 The impact of linking the content of debriefing scripts to clinically important metrics and
- 6 clinically relevant outcomes on learning outcome
- 7 EIT Topics Reviewed by EvUps
- 8 Topics reviewed by EvUps are summarized in Table 24. Complete EvUps are provided in

9 Appendix B4.

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1 Table 24. Topics Reviewed by EvUps

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

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		very low-certainty		and one on	were observed in	
		evidence).		training of health	neonatal deaths after 24	
		We recommend the		care	hours.	
		provision of accredited		professionals on	Items required for	
		courses in NRT (NRT,		neonatal	neonatal resuscitation	
		NRP) and HBB for health		outcomes in the	increased	
		care providers who provide		delivery room in	postintervention	
		ALS care for newborns and		Brazil.	substantially. Delivery	
		babies (strong			room mortality	
		recommendation, very low-			decreased by 73%.	
		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				

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

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

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

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

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

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

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

1 **References**

2	1. Yeung J, Matsuyama T, Bray J, Reynolds J, Skrifvars MB. Does care at a cardiac arrest
3	centre improve outcome after out-of-hospital cardiac arrest? - A systematic review.
4	Resuscitation. 2019;137:102-115. doi: https://dx.doi.org/10.1016/j.resuscitation.2019.02.006
5	2. Soar J, Berg KM, Andersen LW, Bottiger BW, Cacciola S, Callaway CW, Couper K,
6	Cronberg T, D'Arrigo S, Deakin CD, Donnino MW, Drennan IR, Granfeldt A, Hoedemaekers
7	CWE, Holmberg MJ, Hsu CH, Kamps M, Musiol S, Nation KJ, Neumar RW, Nicholson T,
8	O'Neil BJ, Otto Q, de Paiva EF, Parr MJA, Reynolds JC, Sandroni C, Scholefield BR, Skrifvars
9	MB, Wang T-L, Wetsch WA, Yeung J, Morley PT, Morrison LJ, Welsford M, Hazinski MF,
10	Nolan JP, Adult Advanced Life Support C. Adult Advanced Life Support: 2020 International
11	Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with
12	Treatment Recommendations. Resuscitation. 2020;156:A80-A119. doi:
13	https://dx.doi.org/10.1016/j.resuscitation.2020.09.012
14	3. Sinning C, Ahrens I, Cariou A, Beygui F, Lamhaut L, Halvorsen S, Nikolaou N, Nolan
15	JP, Price S, Monsieurs K, Behringer W, Cecconi M, Van Belle E, Jouven X, Hassager C, Sionis
16	A, Qvigstad E, Huber K, De Backer D, Kunadian V, Kutyifa V, Bossaert L. The cardiac arrest
17	centre for the treatment of sudden cardiac arrest due to presumed cardiac cause: aims, function,
18	and structure: position paper of the ACVC association of the ESC, EAPCI, EHRA, ERC,
19	EUSEM, and ESICM. European heart journal Acute cardiovascular care. 2020; doi:
20	https://dx.doi.org/10.1093/ehjacc/zuaa024
21	4. Yeo JW, Ng ZHC, Goh AXC, Gao JF, Liu N, Lam SWS, Chia YW, Perkins GD, Ong

22 MEH, Ho AFW. Impact of Cardiac Arrest Centers on the Survival of Patients With

1 Nontraumatic Out-of-Hospital Cardiac Arrest: A Systematic Review and Meta-Analysis. J Am

2 Heart Assoc. 2022;11:e023806. doi: 10.1161/jaha.121.023806

- 3 5. Yeung J, Abelairas-Gomez C, Boulton A, Olaussen A, Skrifvars M, Greif R, on behalf of
- 4 the International Liaison Committee on Resuscitation (ILCOR) Education Implementation and
- 5 Team (EIT) Task Force. Cardiac Arrest Centers: EIT 6301 TF SR. 2023. Updated.
- 6 <u>https://costr.ilcor.org/document/cardiac-arrest-centers-eit-6301-tf-sr</u>
- 7 6. Patterson T, Perkins GD, Perkins A, Clayton T, Evans R, Dodd M, Robertson S, Wilson
- 8 K, Mellett-Smith A, Fothergill RT, McCrone P, Dalby M, MacCarthy P, Firoozi S, Malik I,
- 9 Rakhit R, Jain A, Nolan JP, Redwood SR, collaborators At. Expedited transfer to a cardiac arrest
- 10 centre for non-ST-elevation out-of-hospital cardiac arrest (ARREST): a UK prospective,
- 11 multicentre, parallel, randomised clinical trial. *Lancet*. 2023;402:1329-1337. doi:
- 12 10.1016/S0140-6736(23)01351-X
- 13 7. Tagami T, Hirata K, Takeshige T, Matsui J, Takinami M, Satake M, Satake S, Yui T,
- 14 Itabashi K, Sakata T, Tosa R, Kushimoto S, Yokota H, Hirama H. Implementation of the fifth
- 15 link of the chain of survival concept for out-of-hospital cardiac arrest. *Circulation*.

16 2012;126:589-597. doi: 10.1161/CIRCULATIONAHA.111.086173

- 17 8. Matsuyama T, Kiyohara K, Kitamura T, Nishiyama C, Nishiuchi T, Hayashi Y,
- 18 Kawamura T, Ohta B, Iwami T. Hospital characteristics and favourable neurological outcome
- among patients with out-of-hospital cardiac arrest in Osaka, Japan. Resuscitation. 2017;110:146-
- 20 153. doi: 10.1016/j.resuscitation.2016.11.009
- 21 9. Jung E, Ro YS, Park JH, Ryu HH, Shin SD. Direct Transport to Cardiac Arrest Center
- 22 and Survival Outcomes after Out-of-Hospital Cardiac Arrest by Urbanization Level. Journal of
- 23 *clinical medicine*. 2022;11 doi: <u>https://dx.doi.org/10.3390/jcm11041033</u>

- 1 10. Kim JY, Moon S, Park JH, Cho HJ, Song JH, Jeon W, Chang H, Ro YS, Shin SD. Effect
- 2 of transported hospital resources on neurologic outcome after out-of-hospital cardiac arrest.

3 Signa Vitae. 2019;15:51-58. doi: https://dx.doi.org/10.22514/SV151.042019.7

- 4 11. Kragholm K, Malta Hansen C, Dupre ME, Xian Y, Strauss B, Tyson C, Monk L, Corbett
- 5 C, Fordyce CB, Pearson DA, Fosbol EL, Jollis JG, Abella BS, McNally B, Granger CB. Direct
- 6 Transport to a Percutaneous Cardiac Intervention Center and Outcomes in Patients With Out-of-

7 Hospital Cardiac Arrest. Circ Cardiovasc Qual Outcomes. 2017;10 doi:

8 10.1161/CIRCOUTCOMES.116.003414

9 12. McKenzie N, Williams TA, Ho KM, Inoue M, Bailey P, Celenza A, Fatovich D, Jenkins

10 I, Finn J. Direct transport to a PCI-capable hospital is associated with improved survival after

adult out-of-hospital cardiac arrest of medical aetiology. *Resuscitation*. 2018;128:76-82. doi:

12 <u>https://dx.doi.org/10.1016/j.resuscitation.2018.04.039</u>

- 13 13. Soholm H, Kjaergaard J, Bro-Jeppesen J, Hartvig-Thomsen J, Lippert F, Kober L,
- 14 Nielsen N, Engsig M, Steensen M, Wanscher M, Karlsen FM, Hassager C. Prognostic
- 15 Implications of Level-of-Care at Tertiary Heart Centers Compared With Other Hospitals After
- 16 Resuscitation From Out-of-Hospital Cardiac Arrest. Circ Cardiovasc Qual Outcomes.

17 2015;8:268-276. doi: 10.1161/CIRCOUTCOMES.115.001767

- 18 14. Spaite DW, Bobrow BJ, Stolz U, Berg RA, Sanders AB, Kern KB, Chikani V, Humble
- 19 W, Mullins T, Stapczynski JS, Ewy GA, Arizona Cardiac Receiving Center C. Statewide
- 20 regionalization of postarrest care for out-of-hospital cardiac arrest: association with survival and
- 21 neurologic outcome. Ann Emerg Med. 2014;64:496-506 e491. doi:
- 22 10.1016/j.annemergmed.2014.05.028

1 15. Sunde K, Pytte M, Jacobsen D, Mangschau A, Jensen LP, Smedsrud C, Draegni T, Steen 2 PA. Implementation of a standardised treatment protocol for post resuscitation care after out-of-3 hospital cardiac arrest. Resuscitation. 2007;73:29-39. doi: 10.1016/j.resuscitation.2006.08.016 4 16. Yeh CC, Chang CH, Seak CJ, Chen CB, Weng YM, Lin CC, Huang CH, Tseng HJ, Ng 5 CJ, LH. T. Survival analysis in out-of-hospital cardiac arrest patients with shockable rhythm 6 directly transport to Heart Centers. Signa Vitae. 2021;17:95-102. doi: 10.22514/sv.2021.084 7 17. Cournoyer A, Notebaert É, de Montigny L, Ross D, Cossette S, Londei-Leduc L, Iseppon 8 M, Lamarche Y, Sokoloff C, Potter BJ, Vadeboncoeur A, Larose D, Morris J, Daoust R, Chauny JM, Piette É, Paquet J, Cavayas YA, de Champlain F, Segal E, Albert M, Guertin MC, Denault 9 10 A. Impact of the direct transfer to percutaneous coronary intervention-capable hospitals on survival to hospital discharge for patients with out-of-hospital cardiac arrest. Resuscitation. 11 12 2018;125:28-33. doi: 10.1016/j.resuscitation.2018.01.048 13 18. Stub D, Smith K, Bray JE, Bernard S, Duffy SJ, Kaye DM. Hospital characteristics are 14 associated with patient outcomes following out-of-hospital cardiac arrest. Heart. 2011;97:1489-15 1494. doi: 10.1136/hrt.2011.226431 19. 16 Mumma BE, Diercks DB, Wilson MD, Holmes JF. Association between treatment at an 17 ST-segment elevation myocardial infarction center and neurologic recovery after out-of-hospital 18 cardiac arrest. American Heart Journal. 2015;170:516-523. doi: 19 https://doi.org/10.1016/j.ahj.2015.05.020

20 20. Chien C, Tsai S, Tsai L, Chen C, Seak C, Weng Y, Lin C, Ng C, Chien W, Huang C, Lin

- 21 C, Chaou C, Liu P, Tseng H, Fang C. Impact of Transport Time and Cardiac Arrest Centers on
- 22 the Neurological Outcome After Out-of-Hospital Cardiac Arrest: A Retrospective Cohort Study.

- 1 Journal of the American Heart Association. 2020;9:e015544. doi:
- 2 <u>https://dx.doi.org/10.1161/JAHA.119.015544</u>

3 21. Chocron R, Bougouin W, Beganton F, Juvin P, Loeb T, Adnet F, Lecarpentier E,

4 Lamhaut L, Jost D, Marijon E, Cariou A, Jouven X, Dumas F. Are characteristics of hospitals

5 associated with outcome after cardiac arrest? Insights from the Great Paris registry.

6 Resuscitation. 2017;118:63-69. doi: 10.1016/j.resuscitation.2017.06.019

7 22. Soar J, Maconochie I, Wyckoff MH, Olasveengen TM, Singletary EM, Greif R, Aickin

8 R, Bhanji F, Donnino MW, Mancini ME, Wyllie JP, Zideman D, Andersen LW, Atkins DL,

9 Aziz K, Bendall J, Berg KM, Berry DC, Bigham BL, Bingham R, Couto TB, Böttiger BW, Borra

10 V, Bray JE, Breckwoldt J, Brooks SC, Buick J, Callaway CW, Carlson JN, Cassan P, Castrén M,

11 Chang WT, Charlton NP, Cheng A, Chung SP, Considine J, Couper K, Dainty KN, Dawson JA,

12 de Almeida MF, de Caen AR, Deakin CD, Drennan IR, Duff JP, Epstein JL, Escalante R,

13 Gazmuri RJ, Gilfoyle E, Granfeldt A, Guerguerian AM, Guinsburg R, Hatanaka T, Holmberg

14 MJ, Hood N, Hosono S, Hsieh MJ, Isayama T, Iwami T, Jensen JL, Kapadia V, Kim HS,

15 Kleinman ME, Kudenchuk PJ, Lang E, Lavonas E, Liley H, Lim SH, Lockey A, Lofgren B, Ma

16 MH, Markenson D, Meaney PA, Meyran D, Mildenhall L, Monsieurs KG, Montgomery W,

17 Morley PT, Morrison LJ, Nadkarni VM, Nation K, Neumar RW, Ng KC, Nicholson T, Nikolaou

18 N, Nishiyama C, Nuthall G, Ohshimo S, Okamoto D, O'Neil B, Ong GY, Paiva EF, Parr M,

19 Pellegrino JL, Perkins GD, Perlman J, Rabi Y, Reis A, Reynolds JC, Ristagno G, Roehr CC,

20 Sakamoto T, Sandroni C, Schexnayder SM, Scholefield BR, Shimizu N, Skrifvars MB, Smyth

- 21 MA, Stanton D, Swain J, Szyld E, Tijssen J, Travers A, Trevisanuto D, Vaillancourt C, Van de
- 22 Voorde P, Velaphi S, Wang TL, Weiner G, Welsford M, Woodin JA, Yeung J, Nolan JP,
- 23 Hazinski MF. 2019 International Consensus on Cardiopulmonary Resuscitation and Emergency

1 Cardiovascular Care Science With Treatment Recommendations. Resuscitation. 2019;145:95-

2 150. doi: 10.1016/j.resuscitation.2019.10.016

Haywood K, Whitehead L, Nadkarni VM, Achana F, Beesems S, Böttiger BW, Brooks 3 23. 4 A, Castrén M, Ong ME, Hazinski MF, Koster RW, Lilja G, Long J, Monsieurs KG, Morley PT, 5 Morrison L, Nichol G, Oriolo V, Saposnik G, Smyth M, Spearpoint K, Williams B, Perkins GD. 6 COSCA (Core Outcome Set for Cardiac Arrest) in Adults: An Advisory Statement From the 7 International Liaison Committee on Resuscitation. Circulation. 2018;137:e783-e801. doi: 8 10.1161/cir.0000000000000562 9 Greif R, Bhanji F, Bigham BL, Bray J, Breckwoldt J, Cheng A, Duff JP, Gilfoyle E, 24. 10 Hsieh MJ, Iwami T, Lauridsen KG, Lockey AS, Ma MH, Monsieurs KG, Okamoto D, Pellegrino 11 JL, Yeung J, Finn JC. Education, Implementation, and Teams: 2020 International Consensus on 12 Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment 13 Recommendations. Circulation. 2020;142:S222-s283. doi: 10.1161/cir.00000000000896 25. 14 Greif R, Bhanji F, Bigham BL, Bray J, Breckwoldt J, Cheng A, Duff JP, Gilfoyle E, 15 Hsieh MJ, Iwami T, Lauridsen KG, Lockey AS, Ma MH, Monsieurs KG, Okamoto D, Pellegrino 16 JL, Yeung J, Finn JC, Baldi E, Beck S, Beckers SK, Blewer AL, Boulton A, Cheng-Heng L, 17 Yang CW, Coppola A, Dainty KN, Damjanovic D, Djärv T, Donoghue A, Georgiou M, Gunson I, Krob JL, Kuzovlev A, Ko YC, Leary M, Lin Y, Mancini ME, Matsuyama T, Navarro K, 18 19 Nehme Z, Orkin AM, Pellis T, Pflanzl-Knizacek L, Pisapia L, Saviani M, Sawyer T, Scapigliati 20 A, Schnaubelt S, Scholefield B, Semeraro F, Shammet S, Smyth MA, Ward A, Zace D. 21 Education, Implementation, and Teams: 2020 International Consensus on Cardiopulmonary 22 Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. 23 Resuscitation. 2020;156:A188-a239. doi: 10.1016/j.resuscitation.2020.09.014

1	26. Nabecker S, Nation K, Gilfoyle E, Abelairas-Gomez C, Koota E, Greif R, on behalf of
2	the International Liaison Committee on Resuscitation (ILCOR) Education Implementation and
3	Team (EIT) Task Force. Cognitive Aids used in Resuscitation (EIT 6400) TF SR. 2023.
4	Updated. https://costr.ilcor.org/document/cognitive-aids-used-in-resuscitation-eit-6400-tf-sr
5	27. Bould MD, Hayter MA, Campbell DM, Chandra DB, Joo HS, Naik VN. Cognitive aid
6	for neonatal resuscitation: a prospective single-blinded randomized controlled trial. British
7	Journal of Anaesthesia. 2009;103:570-575. doi: 10.1093/bja/aep221
8	28. Fuerch JH, Yamada NK, Coelho PR, Lee HC, Halamek LP. Impact of a novel decision
9	support tool on adherence to Neonatal Resuscitation Program algorithm. Resuscitation.
10	2015;88:52-56. doi: 10.1016/j.resuscitation.2014.12.016
11	29. Dinur G, Borenstein-Levin L, Vider S, Hochwald O, Jubran H, Littner Y, Fleischer-
12	Sheffer V, Kugelman A. Evaluation of audio-voice guided application for neonatal resuscitation:
13	a prospective, randomized, pilot study. Journal of Perinatal Medicine. 2021;49:520-525. doi:
14	doi:10.1515/jpm-2020-0173
15	30. Tsang KD, Ottow MK, van Heijst AFJ, Antonius TAJ. Electronic Decision Support in the
16	Delivery Room Using Augmented Reality to Improve Newborn Life Support Guideline
17	Adherence: A Randomized Controlled Pilot Study. Simulation in Healthcare. 2022;17
18	31. Lerner C, Gaca AM, Frush DP, Hohenhaus S, Ancarana A, Seelinger TA, Frush K.
19	Enhancing pediatric safety: assessing and improving resident competency in life-threatening
20	events with a computer-based interactive resuscitation tool. Pediatric Radiology. 2009;39:703-
21	709. doi: 10.1007/s00247-009-1265-y
22	32. Corazza F, Arpone M, Tardini G, Stritoni V, Mormando G, Graziano A, Navalesi P,
23	Fiorese E, Portalone S, De Luca M, Binotti M, Tortorolo L, Salvadei S, Nucci A, Monzani A,

- 1 Genoni G, Bazo M, Cheng A, Frigo AC, Da Dalt L, Bressan S. Effectiveness of a Novel Tablet
- 2 Application in Reducing Guideline Deviations During Pediatric Cardiac Arrest: A Randomized

3 Clinical Trial. JAMA Network Open. 2023;6:e2327272-e2327272. doi:

- 4 10.1001/jamanetworkopen.2023.27272
- 5 33. Ghazali DA, Rousseau R, Breque C, Oriot D. Effect of real-time feedback device
- 6 compared to use or non-use of a checklist performance aid on post-training performance and
- 7 retention of infant cardiopulmonary resuscitation: A randomized simulation-based trial.
- 8 Australasian Emergency Care. 2023;26:36-44. doi: <u>https://doi.org/10.1016/j.auec.2022.07.005</u>
- 9 34. Brophy SL, McCue MR, Reel RM, Jones TD, Dias RD. The impact of a smartphone-
- 10 based cognitive aid on clinical performance during cardiac arrest simulations: A randomized
- 11 controlled trial. *AEM Education and Training*. 2023;7:e10880. doi:
- 12 <u>https://doi.org/10.1002/aet2.10880</u>
- 13 35. Crabb DB, Hurwitz JE, Reed AC, Smith ZJ, Martin ET, Tyndall JA, Taasan MV, Plourde
- 14 MA, Beattie LK. Innovation in resuscitation: A novel clinical decision display system for
- advanced cardiac life support. *The American Journal of Emergency Medicine*. 2021;43:217-223.
- 16 doi: <u>https://doi.org/10.1016/j.ajem.2020.03.007</u>
- 17 36. Field LC, McEvoy MD, Smalley JC, Clark CA, McEvoy MB, Rieke H, Nietert PJ, Furse
- 18 CM. Use of an electronic decision support tool improves management of simulated in-hospital
- 19 cardiac arrest. *Resuscitation*. 2014;85:138-142. doi: 10.1016/j.resuscitation.2013.09.013
- 20 37. Grundgeiger T, Hahn F, Wurmb T, Meybohm P, Happel O. The use of a cognitive aid
- 21 app supports guideline-conforming cardiopulmonary resuscitations: A randomized study in a
- high-fidelity simulation. *Resuscitation Plus*. 2021;7:100152. doi:
- 23 <u>https://doi.org/10.1016/j.resplu.2021.100152</u>

1	38. Hejjaji V, Malik AO, Peri-Okonny PA, Thomas M, Tang Y, Wooldridge D, Spertus JA,
2	Chan PS. Mobile App to Improve House Officers' Adherence to Advanced Cardiac Life Support
3	Guidelines: Quality Improvement Study. JMIR Mhealth Uhealth. 2020;8:e15762. doi:
4	10.2196/15762
5	39. Jones I, Ann Hayes J, Williams J, Lonsdale H. Does electronic decision support influence
6	advanced life support in simulated cardiac arrest? British Journal of Cardiac Nursing.
7	2019;14:72-79. doi: 10.12968/bjca.2019.14.2.72
8	40. Low D, Clark N, Soar J, Padkin A, Stoneham A, Perkins GD, Nolan J. A randomised
9	control trial to determine if use of the iResus©application on a smart phone improves the
10	performance of an advanced life support provider in a simulated medical emergency*.
11	Anaesthesia. 2011;66:255-262. doi: https://doi.org/10.1111/j.1365-2044.2011.06649.x
12	41. Schneider AJL, Murray WB, Mentzer SC, Miranda F, Vaduva S. "Helper:" A critical
13	events prompter for unexpected emergencies. Journal of Clinical Monitoring. 1995;11:358-364.
14	doi: 10.1007/BF01616741
15	42. Arriaga AF, Bader AM, Wong JM, Lipsitz SR, Berry WR, Ziewacz JE, Hepner DL,
16	Boorman DJ, Pozner CN, Smink DS, Gawande AA. Simulation-Based Trial of Surgical-Crisis
17	Checklists. New England Journal of Medicine. 2013;368:246-253. doi:
18	10.1056/NEJMsa1204720
19	43. Dryver E, Knutsson J, Ekelund U, Bergenfelz A. Impediments to and impact of checklists
20	on performance of emergency interventions in primary care: an in situ simulation-based
21	randomized controlled trial. Scandinavian Journal of Primary Health Care. 2021;39:438-447.
22	doi: 10.1080/02813432.2021.1973250

1 11. Informe DD, Dubene C, Groud M, Duben II J, Element DD, A Simulation buber p.	Knoche BB, Busche C, Grodd M, Busch H-J, Lienkamp SS. A sin	mulation-based	pilot
--	---	----------------	-------

2 study of crisis checklists in the emergency department. Internal and Emergency Medicine.

3 2021;16:2269-2276. doi: 10.1007/s11739-021-02670-7

- 4 45. Sellmann T, Alchab S, Wetzchewald D, Meyer J, Rassaf T, Thal SC, Burisch C, Marsch
- 5 S, Breuckmann F. Simulation-based randomized trial of medical emergency cognitive aids.
- 6 Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. 2022;30:45. doi:
- 7 10.1186/s13049-022-01028-y
- 8 46. Ward P, Johnson LA, Mulligan NW, Ward MC, Jones DL. Improving cardiopulmonary
- 9 resuscitation skills retention: effect of two checklists designed to prompt correct performance.
- 10 Resuscitation. 1997;34:221-225. doi: 10.1016/S0300-9572(96)01069-6
- 11 47. Zhou Q, Dong X, Zhang W, Wu R, Chen K, Zhang H, Zheng Z, Zhang L. Effect of a
- 12 low-cost instruction card for automated external defibrillator operation in lay rescuers: a
- 13 randomized simulation study. World J Emerg Med. 2023;14:265-272. doi: 10.5847/wjem.j.1920-
- 14 8642.2023.070
- 15 48. Choa M, Cho J, Choi YH, Kim S, Sung JM, Chung HS. Animation-assisted CPRII
- 16 program as a reminder tool in achieving effective one-person-CPR performance. *Resuscitation*.
- 17 2009;80:680-684. doi: 10.1016/j.resuscitation.2009.03.019
- 18 49. Hawkes GA, Murphy G, Dempsey EM, Ryan AC. Randomised controlled trial of a
- 19 mobile phone infant resuscitation guide. Journal of Paediatrics and Child Health. 2015;51:1084-
- 20 1088. doi: <u>https://doi.org/10.1111/jpc.12968</u>
- 21 50. Hunt EA, Heine M, Shilkofski NS, Haggerty-Bradshaw J, Nelson-McMillan K, Duval-
- 22 Arnould J, R. E. Exploration of the impact of a voice activated decision support system
- 23 (VADSS) with video on resuscitation performance by lay rescuers during simulated

1	cardiopulmonary arrest. Emergency Medicine Journal. 2015;32:189. doi: 10.1136/emermed-
2	2013-202867

3	51.	Paal P, Pircher I, Baur T, Gruber E, Strasak AM, Herff H, Brugger H, Wenzel V,
4	Mitter	lechner T. Mobile Phone-assisted Basic Life Support Augmented with a metronome
5	Journ	al of Emergency Medicine. 2012;43:472-477. doi: 10.1016/j.jemermed.2011.09.011
6	52.	Rössler B, Ziegler M, Hüpfl M, Fleischhackl R, Krychtiuk KA, Schebesta K. Can a
7	flowcl	hart improve the quality of bystander cardiopulmonary resuscitation? Resuscitation.
8	2013;8	84:982-986. doi: 10.1016/j.resuscitation.2013.01.001
9	53.	Zanner R, Wilhelm D, Feussner H, Schneider G. Evaluation of M-AID, a first aid
10	applic	ation for mobile phones. Resuscitation. 2007;74:487-494. doi:
11	10.10	16/j.resuscitation.2007.02.004
12	54.	Ertl L, Christ F. Significant improvement of the quality of bystander first aid using an
13	expert	t system with a mobile multimedia device. Resuscitation. 2007;74:286-295. doi:
14	10.10	16/j.resuscitation.2007.01.006
15	55.	Otero-Agra M, Jorge-Soto C, Cosido-Cobos ÓJ, Blanco-Prieto J, Alfaya-Fernández C,
16	García	a-Ordóñez E, Barcala-Furelos R. Can a voice assistant help bystanders save lives? A
17	feasib	ility pilot study chatbot in beta version to assist OHCA bystanders. The American Journal
18	of Em	ergency Medicine. 2022;61:169-174. doi: https://doi.org/10.1016/j.ajem.2022.09.013
19	56.	Leary M, McGovern SK, Balian S, Abella BS, Blewer AL. A Pilot Study of CPR Quality
20	Comp	aring an Augmented Reality Application vs. a Standard Audio-Visual Feedback Manikin.
21	Fronti	iers in Digital Health. 2020;2 doi: 10.3389/fdgth.2020.00001
22	57.	Hou L, Dong X, Li K, Yang C, Yu Y, Jin X, Shang S. Comparison of Augmented

23 Reality-assisted and Instructor-assisted Cardiopulmonary Resuscitation: A Simulated
1 Randomized Controlled Pilot Trial. *Clinical Simulation In Nursing*. 2022;68:9-18. doi:

2 10.1016/j.ecns.2022.04.004

3 58. Lin Y, Lockey A, Greif R, Abelairas-Gomez C GL, Fijacko N, Cheng A, on behalf of the

4 International Liaison Committee on Resuscitation (ILCOR) Education Implementation and Team

- 5 (EIT) Task Force. Immersive technologies for resuscitation education: EIT 6405 TF SR. 2024.
- 6 Updated. https://costr.ilcor.org/document/immersive-technologies-for-resuscitation-education-

7 <u>eit-6405-tf-sr</u>

- 8 59. Nas J, Thannhauser J, Vart P, van Geuns RJ, Muijsers HEC, Mol JQ, Aarts GWA,
- 9 Konijnenberg LSF, Gommans DHF, Ahoud-Schoenmakers S, Vos JL, van Royen N, Bonnes JL,
- 10 Brouwer MA. Effect of Face-to-Face vs Virtual Reality Training on Cardiopulmonary
- 11 Resuscitation Quality: A Randomized Clinical Trial. JAMA Cardiol. 2020;5:328-335. doi:
- 12 10.1001/jamacardio.2019.4992
- 13 60. Jeffers JM, Schreurs BA, Dean JL, Scott B, Canares T, Tackett S, Smith B, Billings E,
- 14 Billioux V, Sampathkumar HD, Kleinman K. Paediatric chest compression performance
- 15 improves via novel augmented-reality cardiopulmonary resuscitation feedback system: A mixed-
- 16 methods pilot study in a simulation-based setting. *Resuscitation Plus*. 2022;11:100273. doi:

17 https://doi.org/10.1016/j.resplu.2022.100273

- 18 61. Leary M, McGovern SK, Chaudhary Z, Patel J, Abella BS, Blewer AL. Comparing
- 19 bystander response to a sudden cardiac arrest using a virtual reality CPR training mobile app
- 20 versus a standard CPR training mobile app. *Resuscitation*. 2019;139:167-173. doi:
- 21 10.1016/j.resuscitation.2019.04.017
- 22 62. Nas J, Thannhauser J, Konijnenberg LSF, van Geuns R-JM, van Royen N, Bonnes JL,
- 23 Brouwer MA. Long-term Effect of Face-to-Face vs Virtual Reality Cardiopulmonary

1	Resuscitation ((CPR)	Training on	Willingness to	Perform CPR.	Retention of	Knowledge, and
	(()					

2 Dissemination of CPR Awareness: A Secondary Analysis of a Randomized Clinical Trial. JAMA

3 Network Open. 2022;5:e2212964-e2212964. doi: 10.1001/jamanetworkopen.2022.12964

- 4 63. Barsom EZ, Duijm RD, Dusseljee-Peute LWP, Landman-van der Boom EB, van
- 5 Lieshout EJ, Jaspers MW, Schijven MP. Cardiopulmonary resuscitation training for high school
- 6 students using an immersive 360-degree virtual reality environment. British Journal of
- 7 Educational Technology. 2020;51:2050-2062. doi: https://doi.org/10.1111/bjet.13025
- 8 64. Liu ZM, Fan X, Liu Y, Ye XD. Effects of immersive virtual reality cardiopulmonary
- 9 resuscitation training on prospective kindergarten teachers' learning achievements, attitudes and
- 10 self-efficacy. British Journal of Educational Technology. 2022;53:2050-2070. doi:
- 11 <u>https://doi.org/10.1111/bjet.13237</u>
- 12 65. Liu Q, Tang Q, Wang Y. The effects of pretraining intervention in immersive embodied
- 13 virtual reality cardiopulmonary resuscitation training. *Behaviour & Information Technology*.
- 14 2021;40:1265-1277. doi: 10.1080/0144929X.2021.1960606
- 15 66. Castillo J, Rodríguez-Higueras E, Belmonte R, Rodríguez C, López A, Gallart A.
- 16 Efficacy of Virtual Reality Simulation in Teaching Basic Life Support and Its Retention at 6
- 17 Months. International Journal of Environmental Research and Public Health. 2023.
- 18 67. Hubail D, Mondal A, Al Jabir A, Patel B. Comparison of a virtual reality compression-
- 19 only Cardiopulmonary Resuscitation (CPR) course to the traditional course with content
- 20 validation of the VR course A randomized control pilot study. Annals of Medicine and
- 21 Surgery. 2022;73

1 68. Aksoy E. Comparing the Effects on Learning Outcomes of Tablet-Based and Virtual

2 Reality–Based Serious Gaming Modules for Basic Life Support Training: Randomized Trial.

3 JMIR Serious Games. 2019;7:e13442. doi: 10.2196/13442

4 69. Issleib M, Kromer A, Pinnschmidt HO, Süss-Havemann C, Kubitz JC. Virtual reality as a

5 teaching method for resuscitation training in undergraduate first year medical students: a

6 randomized controlled trial. Scandinavian Journal of Trauma, Resuscitation and Emergency

7 *Medicine*. 2021;29:27. doi: 10.1186/s13049-021-00836-y

8 70. Moll-Khosrawi P, Falb A, Pinnschmidt H, Zöllner C, Issleib M. Virtual reality as a

9 teaching method for resuscitation training in undergraduate first year medical students during

10 COVID-19 pandemic: a randomised controlled trial. *BMC Medical Education*. 2022;22:483. doi:

11 10.1186/s12909-022-03533-1

12 71. Khanal P, Vankipuram A, Ashby A, Vankipuram M, Gupta A, Drumm-Gurnee D, Josey

13 K, Tinker L, Smith M. Collaborative virtual reality based advanced cardiac life support training

simulator using virtual reality principles. *Journal of Biomedical Informatics*. 2014;51:49-59. doi:

15 https://doi.org/10.1016/j.jbi.2014.04.005

16 72. Umoren R, Bucher S, Hippe DS, Ezenwa BN, Fajolu IB, Okwako FM, Feltner J, Nafula

17 M, Musale A, Olawuyi OA, Adeboboye CO, Asangansi I, Paton C, Purkayastha S, Ezeaka CV,

18 F. E. eHBB: a randomised controlled trial of virtual reality or video for neonatal resuscitation

19 refresher training in healthcare workers in resource-scarce settings. *BMJ Open*.

20 2021;11:e048506. doi: 10.1136/bmjopen-2020-048506

21 73. Yang S-Y, Oh Y-H. The effects of neonatal resuscitation gamification program using

22 immersive virtual reality: A quasi-experimental study. *Nurse Education Today*.

23 2022;117:105464. doi: <u>https://doi.org/10.1016/j.nedt.2022.105464</u>

1	74. Chang Y-T, Wu K-C, Yang H-W, Lin C-Y, Huang T-F, Yu Y-C, Hu Y-J. Effects of
2	different cardiopulmonary resuscitation education interventions among university students: A
3	randomized controlled trial. PLOS ONE. 2023;18:e0283099. doi: 10.1371/journal.pone.0283099
4	75. Donoghue A, Sawyer T, Toft L, Olaussen A, Greif R, on behalf of the International
5	Liaison Committee on Resuscitation (ILCOR) Education Implementation and Team (EIT) Task
6	Force. Gamified learning for resuscitation education: EIT 6412 TFSR. 2023. Updated.
7	https://costr.ilcor.org/document/gamified-learning-for-resuscitation-education-eit-6412-tfsr
8	76. Billner-Garcia RM, Spilker A. Development and Implementation of a Game-Based
9	Neonatal Resuscitation Refresher Training: Effect on Registered Nurse Knowledge, Skills,
10	Motivation, Engagement. Journal for Nurses in Professional Development. 2024;40
11	77. Boada I, Rodriguez-Benitez A, Garcia-Gonzalez JM, Olivet J, Carreras V, Sbert M.
12	Using a serious game to complement CPR instruction in a nurse faculty. Computer Methods and
13	Programs in Biomedicine. 2015;122:282-291. doi: https://doi.org/10.1016/j.cmpb.2015.08.006
14	78. Chang TP, Raymond T, Dewan M, MacKinnon R, Whitfill T, Harwayne-Gidansky I,
15	Doughty C, Frisell K, Kessler D, Wolfe H, Auerbach M, Rutledge C, Mitchell D, Jani P, Walsh
16	CM. The effect of an International competitive leaderboard on self-motivated simulation-based
17	CPR practice among healthcare professionals: A randomized control trial. Resuscitation.
18	2019;138:273-281. doi: 10.1016/j.resuscitation.2019.02.050
19	79. Cutumisu M, Patel SD, Brown MRG, Fray C, von Hauff P, Jeffery T, Schmölzer GM.
20	RETAIN: A Board Game That Improves Neonatal Resuscitation Knowledge Retention.
21	Frontiers in Pediatrics. 2019;7 doi: 10.3389/fped.2019.00013
22	80. Gordon DW, Brown HN. Fun and games in reviewing neonatal emergency care.
23	Neonatal Netw. 1995;14:45-49.

- 1 81. King CE, Kells A, Trout L, Yirinec A, Zhou S, Zurca AD. Gamification educational
- 2 intervention improves pediatric nurses' comfort and speed drawing up code-dose epinephrine. J

3 Pediatr Nurs. 2023;71:55-59. doi: 10.1016/j.pedn.2023.03.013

- 4 82. MacKinnon RJ, Stoeter R, Doherty C, Fullwood C, Cheng A, Nadkarni V, Stenfors-
- 5 Hayes T, Chang TP. Self-motivated learning with gamification improves infant CPR
- 6 performance, a randomised controlled trial. BMJ Simul Technol Enhanc Learn. 2015;1:71-76.
- 7 doi: 10.1136/bmjstel-2015-000061
- 8 83. Otero-Agra M, Barcala-Furelos R, Besada-Saavedra I, Peixoto-Pino L, Martínez-Isasi S,
- 9 Rodríguez-Núñez A. Let the kids play: gamification as a CPR training methodology in secondary
- 10 school students. A quasi-experimental manikin simulation study. *Emergency Medicine Journal*.
- 11 2019;36:653. doi: 10.1136/emermed-2018-208108
- 12 84. Phungoen P, Promto S, Chanthawatthanarak S, Maneepong S, Apiratwarakul K,
- 13 Kotruchin P, Mitsungnern T. Precourse Preparation Using a Serious Smartphone Game on
- 14 Advanced Life Support Knowledge and Skills: Randomized Controlled Trial. J Med Internet
- 15 Res. 2020;22:e16987. doi: 10.2196/16987
- 16 85. Semeraro F, Frisoli A, Loconsole C, Mastronicola N, Stroppa F, Ristagno G, Scapigliati
- 17 A, Marchetti L, Cerchiari E. Kids (learn how to) save lives in the school with the serious game
- 18 Relive. Resuscitation. 2017;116:27-32. doi: 10.1016/j.resuscitation.2017.04.038
- 19 86. Toft LEB, Richie J, Wright JM, Amraotkar A, Katrapati P, Fulmer S, Dainty KN, Chugh
- 20 SS, Halperin H. A New Era of Lay Rescuer CPR Training: An Interactive Approach for
- 21 Engaging High Schoolers. Journal of the American College of Cardiology. 2022;80:2251-2253.
- 22 doi: <u>https://doi.org/10.1016/j.jacc.2022.09.040</u>

1	87. Gutiérrez-Puertas L, García-Viola A, Márquez-Hernández VV, Garrido-Molina JM,
2	Granados-Gámez G, Aguilera-Manrique G. Guess it (SVUAL): An app designed to help nursing
3	students acquire and retain knowledge about basic and advanced life support techniques. Nurse
4	Education in Practice. 2021;50:102961. doi: https://doi.org/10.1016/j.nepr.2020.102961
5	88. Hu L, Zhang L, Yin R, Li Z, Shen J, Tan H, Wu J, W. Z. NEOGAMES: A Serious
6	Computer Game That Improves Long-Term Knowledge Retention of Neonatal Resuscitation in
7	Undergraduate Medical Students. Frontiers in Pediatrics. 2021;9 doi: 10.3389/fped.2021.645776
8	89. Hunt EA, Duval-Arnould JM, Nelson-McMillan KL, Bradshaw JH, Diener-West M,
9	Perretta JS, Shilkofski NA. Pediatric resident resuscitation skills improve after "Rapid Cycle
10	Deliberate Practice" training. Resuscitation. 2014;85:945-951. doi:
11	10.1016/j.resuscitation.2014.02.025
12	90. Abelairas-Gómez C, Sawyer T, Donoghue A, Cortegiani A, Greif R, on behalf of the
13	International Liaison Committee on Resuscitation (ILCOR) Education Implementation and Team
14	(EIT) Task Force. Rapid cycle deliberate practice in resuscitation training (EIT6414) TF SR.
15	2024. Updated. https://costr.ilcor.org/document/rapid-cycle-deliberate-practice-in-resuscitation-
16	training-eit6414-tf-sr
17	91. Lemke DS, Fielder EK, Hsu DC, Doughty CB. Improved Team Performance During
18	Pediatric Resuscitations After Rapid Cycle Deliberate Practice Compared With Traditional
19	Debriefing: A Pilot Study. Pediatric Emergency Care. 2019;35
20	92. Lemke DS, Young AL, Won SK, Rus MC, Villareal NN, Camp EA, Doughty C. Rapid-
21	cycle deliberate practice improves time to defibrillation and reduces workload: A randomized
22	controlled trial of simulation-based education. AEM Education and Training. 2021;5:e10702.
23	doi: <u>https://doi.org/10.1002/aet2.10702</u>

1 93. Magee MJ, Farkouh-Karoleski C, Rosen TS. Improvement of Immediate Performance in

2 Neonatal Resuscitation Through Rapid Cycle Deliberate Practice Training. Journal of Graduate

3 Medical Education. 2018;10:192-197. doi: 10.4300/JGME-D-17-00467.1

4 94. Raju S, Tofil N, Gaither S, Norwood C, Zinkan J, Godsey V, Aban I, Xue Y, Rutledge C.

5 The Impact of a 9-Month Booster Training Using Rapid Cycle Deliberate Practice on Pediatric

6 Resident PALS Skills. Simulation in Healthcare. 2021;16

7 95. Teixeira de Castro L, Coriolano A, Burckart K, Soares M, Accorsi T, Rosa V, de Santis

8 Andrade Lopes A, Couto T. Rapid-cycle deliberate practice versus after-event debriefing clinical

9 simulation in cardiopulmonary resuscitation: a cluster randomized trial. *Advances in Simulation*.

- 10 2022;7:43. doi: 10.1186/s41077-022-00239-8
- 11 96. Van Heukelom JN, Begaz T, Treat R. Comparison of Postsimulation Debriefing Versus

12 In-Simulation Debriefing in Medical Simulation. *Simulation in Healthcare*. 2010;5

13 97. Won SK, Doughty CB, Young AL, Welch-Horan TB, Rus MC, Camp EA, Lemke DS.

14 Rapid Cycle Deliberate Practice Improves Retention of Pediatric Resuscitation Skills Compared

15 With Postsimulation Debriefing. Simulation in Healthcare. 2022;17

16 98. Farquharson B, Cortegiani A, Lauridsen KG, Yeung J, Greif R, on behalf of the

17 International Liaison Committee on Resuscitation (ILCOR) Education Implementation and Team

- 18 (EIT) Task Force. Teaching teamwork competencies for resuscitation: EIT 6415 TFSR. 2023.
- 19 Updated. https://costr.ilcor.org/document/teaching-teamwork-competencies-for-resuscitation-eit-

20 <u>6415-tfsr</u>

21 99. Blackwood J, Duff JP, Nettel-Aguirre A, Djogovic D, Joynt C. Does teaching crisis

22 resource management skills improve resuscitation performance in pediatric residents? *Pediatric*

23 *Critical Care Medicine*. 2014;15:e168-e174.

1	100. Castelao EF, Russo SG, Cremer S, Strack M, Kaminski L, Eich C, Timmermann A, Boos
2	M. Positive impact of crisis resource management training on no-flow time and team member
3	verbalisations during simulated cardiopulmonary resuscitation: a randomised controlled trial.
4	Resuscitation. 2011;82:1338-1343.
5	101. Coppens I, Verhaeghe S, Van Hecke A, Beeckman D. The effectiveness of crisis resource
6	management and team debriefing in resuscitation education of nursing students: A randomised
7	controlled trial. Journal of clinical nursing. 2018;27:77-85.
8	102. Fagan MJ, Connelly CD, Williams BS, Fisher ES. Integrating team training in the
9	pediatric life support program: an effective and efficient approach? JONA: The Journal of
10	Nursing Administration. 2018;48:279-284.
11	103. Fernandez Castelao E, Boos M, Ringer C, Eich C, Russo SG. Effect of CRM team leader
12	training on team performance and leadership behavior in simulated cardiac arrest scenarios: a
13	prospective, randomized, controlled study. BMC medical education. 2015;15:1-8.
14	104. Fernandez R, Rosenman ED, Olenick J, Misisco A, Brolliar SM, Chipman AK, Vrablik
15	MC, Kalynych C, Arbabi S, Nichol G. Simulation-based team leadership training improves team
16	leadership during actual trauma resuscitations: a randomized controlled trial. Critical Care
17	Medicine. 2020;48:73-82.
18	105. Gonçalves BAR, de Melo MDCB, Ferri Liu PM, Valente BCHG, Ribeiro VP, Vilaça e
19	Silva PH. Teamwork in Pediatric Resuscitation: Training Medical Students on High-Fidelity
20	Simulation. Advances in Medical Education and Practice. 2022:697-708. doi:
21	10.2147/AMEP.S365976

- 22 106. Haffner L, Mahling M, Muench A, Castan C, Schubert P, Naumann A, Reddersen S,
- 23 Herrmann-Werner A, Reutershan J, Riessen R. Improved recognition of ineffective chest

- 1 compressions after a brief Crew Resource Management (CRM) training: a prospective,
- 2 randomised simulation study. *BMC Emergency Medicine*. 2016;17:1-8.
- 3 107. Hochstrasser SR, Amacher SA, Tschan F, Semmer NK, Becker C, Metzger K, Hunziker
- 4 S, Marsch S. Gender-focused training improves leadership of female medical students: A
- 5 randomised trial. *Medical Education*. 2022;56:321-330.
- 6 108. Hunziker S, Bühlmann C, Tschan F, Balestra G, Legeret C, Schumacher C, Semmer NK,
- 7 Hunziker P, Marsch S. Brief leadership instructions improve cardiopulmonary resuscitation in a
- 8 high-fidelity simulation: a randomized controlled trial. Critical care medicine. 2010;38:1086-
- 9 1091.
- 10 109. Litke-Wager C, Delaney H, Mu T, Sawyer T. Impact of task-oriented role assignment on
- 11 neonatal resuscitation performance: a simulation-based randomized controlled trial. American
- 12 Journal of Perinatology. 2020;38:914-921.
- 13 110. Peltonen V, Peltonen LM, Rantanen M, Säämänen J, Vänttinen O, Koskela J, Perkonoja
- 14 K, Salanterä S, Tommila M. Randomized controlled trial comparing pit crew resuscitation model
- 15 against standard advanced life support training. Journal of the American College of Emergency
- 16 Physicians Open. 2022;3:e12721.
- 17 111. Rovamo L, Nurmi E, Mattila M-M, Suominen P, Silvennoinen M. Effect of a simulation-
- 18 based workshop on multidisplinary teamwork of newborn emergencies: an intervention study.
- 19 *BMC research notes*. 2015;8:1-8.
- 20 112. Scicchitano E, Stark P, Koetter P, Michalak N, Zurca AD. Blindfolding improves
- 21 communication in inexperienced residents undergoing ACLS training. Journal of graduate
- 22 *medical education*. 2021;13:123-127.

1 113.	Thomas E, Taggart B,	Crandell S, Lasky R,	Williams A, Love	L, Sexton J, T	yson J,
--------	----------------------	----------------------	------------------	----------------	---------

2 Helmreich R. Teaching teamwork during the Neonatal Resuscitation Program: a randomized

3 trial. Journal of Perinatology. 2007;27:409-414.

- 4 114. Thomas EJ, Williams AL, Reichman EF, Lasky RE, Crandell S, Taggart WR. Team
 5 training in the neonatal resuscitation program for interns: teamwork and quality of resuscitations.
- 6 *Pediatrics*. 2010;125:539-546.
- 7 115. Truchot J, Michelet D, Philippon AL, Drummond D, Freund Y, Plaisance P. Effect of a
- 8 specific training intervention with task interruptions on the quality of simulated advance life
- 9 support: A randomized multi centered controlled simulation study. Australasian Emergency
- 10 *Care*. 2023;26:153-157.
- 11 116. Berlanga-Macías C, Barcala-Furelos R, Méndez-Seijo N, Peixoto-Pino L, Martínez-Isasi
- 12 S. Basic life support training for people with disabilities. A scoping review. *Resuscitation Plus*.

13 2023;16:100467. doi: https://doi.org/10.1016/j.resplu.2023.100467

- 14 117. Berg KM, Cheng A, Panchal AR, Topjian AA, Aziz K, Bhanji F, Bigham BL, Hirsch
- 15 KG, Hoover AV, Kurz MC, Levy A, Lin Y, Magid DJ, Mahgoub M, Peberdy MA, Rodriguez
- 16 AJ, Sasson C, Lavonas EJ, null n. Part 7: Systems of Care: 2020 American Heart Association
- 17 Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*.
- 18 2020;142:S580-S604. doi: 10.1161/CIR.000000000000899
- 19 118. Semeraro F, Greif R, Böttiger BW, Burkart R, Cimpoesu D, Georgiou M, Yeung J,
- 20 Lippert F, S Lockey A, Olasveengen TM, Ristagno G, Schlieber J, Schnaubelt S, Scapigliati A,
- 21 G Monsieurs K. European Resuscitation Council Guidelines 2021: Systems saving lives.
- 22 Resuscitation. 2021;161:80-97. doi: 10.1016/j.resuscitation.2021.02.008

- 1 119. Schnaubelt S, Abelairas-Gomez C AN, Nabecker S, Neymayer M, Snijders E VC, Greif
- 2 R, on behalf of the International Liaison Committee on Resuscitation (ILCOR) Education
- 3 Implementation and Team (EIT) Task Force. Basic Life Support training for specific layperson
- 4 populations: EIT6108 TF ScR. 2023. Updated. <u>https://costr.ilcor.org/document/basic-life-</u>
- 5 support-training-for-specific-layperson-populations-eit6108-tf-scr
- 6 120. Jorge-Soto C, Barcala-Furelos R, Gómez-González C, Leborans-Iglesias P, Campos-
- 7 Varela I, Rodríguez-Núñez A. Brief training in automated external defibrillation use for persons
- 8 with down syndrome. *Resuscitation*. 2017;113:e5-e6. doi: 10.1016/j.resuscitation.2017.01.012
- 9 121. Rodríguez-Núñez A, Regueiro-García A, Jorge-Soto C, Cañas-González J, Leboráns-
- 10 Iglesias P, García-Crespo O, Barcala-Furelos R. Quality of chest compressions by Down
- 11 syndrome people: A pilot trial. *Resuscitation*. 2015;89:119-122. doi:
- 12 10.1016/j.resuscitation.2015.01.022
- 13 122. Martínez-Isasi S, Abelairas-Gómez C, Fernández-Méndez F, Barcala-Furelos R, Jorge-
- 14 Soto C, Gómez-Gónzalez C, Rodríguez-Nuñez A. Is it necessary to see to save a life? Pilot study
- 15 of basic CPR training for blind people. *Resuscitation*. 2019;134:165-166. doi:
- 16 10.1016/j.resuscitation.2018.11.020
- 17 123. Martínez-Isasi S, Jorge-Soto C, Barcala-Furelos R, Abelairas-Gómez C, Carballo-
- 18 Fazanes A, Fernández-Méndez F, Gómez-González C, Nadkarni VM, Rodríguez-Núñez A.
- 19 Performing Simulated Basic Life Support without Seeing: Blind vs. Blindfolded People.
- 20 International Journal of Environmental Research and Public Health. 2021.
- 21 124. Sandroni C, Fenici P, Franchi ML, Cavallaro F, Menchinelli C, Antonelli M. Automated
- 22 external defibrillation by untrained deaf lay rescuers. *Resuscitation*. 2004;63:43-48. doi:
- 23 10.1016/j.resuscitation.2004.03.010

- 1 125. Strnad M, Šalda Z, Jerko B, Vrečar V, Lesjak V, Petrovčič R. Challenges in basic life
- 2 support and automated external defibrillator training of deaf individuals. *Signa Vitae*.
- 3 2021;17:98-103. doi: 10.22514/sv.2021.019
- 4 126. Unnikrishnan R, Babu AS, Rao PT, Aithal V, Krishna HM. Training individuals with
- 5 speech and hearing impairment in basic life support: A pilot study. Resuscitation. 2017;117:e23-
- 6 e24. doi: 10.1016/j.resuscitation.2017.06.016
- 7 127. Schnaubelt S, Schnaubelt B, Pilz A, Oppenauer J, Yildiz E, Schriefl C, Ettl F, Krammel
- 8 M, Garg R, Niessner A, Greif R, Domanovits H, Sulzgruber P. BLS courses for refugees are
- 9 feasible and induce commitment towards lay rescuer resuscitation. European Journal of Clinical
- 10 Investigation. 2022;52:e13644. doi: https://doi.org/10.1111/eci.13644
- 11 128. Schnaubelt S, Fijacko N, Al-Hilali Z, Atiq H, Bigham B, Eastwood K, Odakha J,
- 12 Olaussen A, Ko YC, Matsuyama T, Veigl C, Monsieurs KG, Greif R, on behalf of the
- 13 International Liaison Committee on Resuscitation (ILCOR) Education Implementation and Team
- 14 (EIT) Task Force. EIT 6311 International facets of the 'Chain of Survival': EIT 6311; TF ScR.
- 15 2023. Updated. https://costr.ilcor.org/document/eit-6311-international-facets-of-the-chain-of-
- 16 <u>survival-eit-6311-tf-scr</u>
- 17 129. Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving survival from sudden cardiac
- 18 arrest: the "chain of survival" concept. A statement for health professionals from the Advanced
- 19 Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American
- 20 Heart Association. Circulation. 1991;83:1832-1847. doi: 10.1161/01.CIR.83.5.1832
- 21 130. Hwang SO, Cha K-C, Jung WJ, Roh Y-I, Kim TY, Chung SP, Kim Y-M, Park JD, Kim
- 22 H-S, Lee MJ, Na S-H, Cho GC, Kim A-RE, Resuscitation obotSCotKGfC, Emergency
- 23 Cardiovascular C. 2020 Korean Guidelines for Cardiopulmonary Resuscitation. Part 2.

- 1 Environment for cardiac arrest survival and the chain of survival. *Clin Exp Emerg Med.*
- 2 2021;8:S8-S14. doi: 10.15441/ceem.21.022
- 3 131. Ranse J, Zeitz K. Chain of Survival at Mass Gatherings: A Case Series of Resuscitation
- 4 Events. *Prehospital and Disaster Medicine*. 2010;25:457-463. doi:
- 5 10.1017/S1049023X00008566
- 6 132. Schnaubelt S, Greif R, Monsieurs K. The chainmail of survival: A modern concept of an

7 adaptive approach towards cardiopulmonary resuscitation. *Resuscitation*. 2023;184 doi:

- 8 10.1016/j.resuscitation.2023.109707
- 9 133. Smith GB. In-hospital cardiac arrest: Is it time for an in-hospital 'chain of prevention'?
- 10 Resuscitation. 2010;81:1209-1211. doi: 10.1016/j.resuscitation.2010.04.017
- 11 134. Rochester S, Walmsley AJ. Paediatric chain of survival. *Resuscitation*. 1997;35:88-89.
- 12 135. Wang L. [Survival cycle of Chinese cardiopulmonary resuscitation]. Zhonghua Wei
- 13 Zhong Bing Ji Jiu Yi Xue. 2019;31:536-538. doi: 10.3760/cma.j.issn.2095-4352.2019.05.003
- 14 136. Bakke HK, Wisborg T. The trauma chain of survival Each link is equally important (but
- some links are more equal than others). *Injury*. 2017;48:975-977. doi:
- 16 10.1016/j.injury.2017.04.001
- 17 137. Boller M, Boller EM, Oodegard S, Otto CM. Small animal cardiopulmonary resuscitation
- 18 requires a continuum of care: proposal for a chain of survival for veterinary patients. *Journal of*
- 19 the American Veterinary Medical Association. 2012;240:540-554. doi: 10.2460/javma.240.5.540
- 20 138. Bossaert L. The chain of survival of ST elevation myocardial infarction: From evidence
- 21 to practice. *Resuscitation*. 2009;80:391-392. doi: 10.1016/j.resuscitation.2009.02.001
- 22 139. Calamai F, Derkenne C, Jost D, Travers S, Klein I, Bertho K, Dorandeu F, Bignand M,
- 23 Prunet B. The chemical, biological, radiological and nuclear (CBRN) chain of survival: a new

1 pragmatic and didactic tool used by Paris Fire Brigade. Critical Care. 2019;23:66. doi:

2 10.1186/s13054-019-2364-2

- 3 140. Chandy H, Steinholt M, Husum H. Delivery life support: A preliminary report on the
- 4 chain of survival for complicated deliveries in rural Cambodia. *Nursing & Health Sciences*.
- 5 2007;9:263-269. doi: https://doi.org/10.1111/j.1442-2018.2007.00321.x
- 6 141. Husum H, Gilbert M, Wisborg T, Van Heng Y, Murad M. Rural Prehospital Trauma
- 7 Systems Improve Trauma Outcome in Low-Income Countries: A Prospective Study from North
- 8 Iraq and Cambodia. Journal of Trauma and Acute Care Surgery. 2003;54
- 9 142. Jauch EC, Saver JL, Adams HP, Bruno A, Connors JJ, Demaerschalk BM, Khatri P,
- 10 McMullan PW, Qureshi AI, Rosenfield K, Scott PA, Summers DR, Wang DZ, Wintermark M,
- 11 Yonas H. Guidelines for the Early Management of Patients With Acute Ischemic Stroke. *Stroke*.
- 12 2013;44:870-947. doi: 10.1161/STR.0b013e318284056a
- 13 143. Jouffroy R, Gueye P. Intensive care unit versus high-dependency care unit admission on
- 14 mortality in patients with septic shock: let's think to the survival chain concept for septic shock.
- 15 Journal of Intensive Care. 2022;10:52. doi: 10.1186/s40560-022-00643-2
- 16 144. Kaliaperumal P, Kole T. Chain of Survival in Industrial Emergencies and Industrial
- 17 Disasters. Disaster Medicine and Public Health Preparedness. 2022;16:279-284. doi:
- 18 10.1017/dmp.2020.165
- 19 145. Kalu Q, Edentekhe TA, Eguma S. Anesthesia equipment and their chain of survival.
- 20 Calabar Journal of Health Sciences. 2020;4 doi: 10.25259/CJHS_16_2020
- 21 146. Latif RK, Clifford SP, Baker JA, Lenhardt R, Haq MZ, Huang J, Farah I, Businger JR.
- 22 Traumatic hemorrhage and chain of survival. Scandinavian Journal of Trauma, Resuscitation
- 23 and Emergency Medicine. 2023;31:25. doi: 10.1186/s13049-023-01088-8

- 1 147. Lund A, Turris S. The Event Chain of Survival in the Context of Music Festivals: A
- 2 Framework for Improving Outcomes at Major Planned Events. *Prehospital and Disaster*
- 3 *Medicine*. 2017;32:437-443. doi: 10.1017/S1049023X1700022X
- 4 148. Ornato JP. The ST-Segment–Elevation Myocardial Infarction Chain of Survival.
- 5 Circulation. 2007;116:6-9. doi: 10.1161/CIRCULATIONAHA.107.710970
- 6 149. Rudd AG, Bladin C, Carli P, De Silva DA, Field TS, Jauch EC, Kudenchuk P, Kurz MW,
- 7 Lærdal T, Ong MEH, Panagos P, Ranta A, Rutan C, Sayre MR, Schonau L, Shin SD, Waters D,
- 8 Lippert F. Utstein recommendation for emergency stroke care. *International Journal of Stroke*.
- 9 2020;15:555-564. doi: 10.1177/1747493020915135
- 10 150. Søreide K. Strengthening the trauma chain of survival. British Journal of Surgery.
- 11 2012;99:1-3. doi: 10.1002/bjs.7795
- 12 151. Szpilman D, Webber J, Quan L, Bierens J, Morizot-Leite L, Langendorfer SJ, Beerman
- 13 S, Løfgren B. Creating a drowning chain of survival. *Resuscitation*. 2014;85:1149-1152. doi:
- 14 10.1016/j.resuscitation.2014.05.034
- 15 152. Webber JB. Drowning, the New Zealand way: Prevention, rescue, resuscitation.
- 16 Resuscitation. 2010;81:S27. doi: 10.1016/j.resuscitation.2010.09.120
- 17 153. Buléon C, Minehart RD, Bergot E, Chan A, Fischer MO. Pandemic chain of survival:
- 18 Gathering strength to revive our societies. *Anaesth Crit Care Pain Med.* 2020;39:547-548. doi:
- 19 10.1016/j.accpm.2020.07.011
- 20 154. International Federation of Red Cross and Red Crescent Societies (IFRC). International
- 21 first aid, resuscitation, and education guidelines 2020. 2020. Updated. Accessed 9 December.
- 22 https://www.ifrc.org/sites/default/files/2022-02/EN_GFARC_GUIDELINES_2020.pdf

- 1 155. Ludwig G. It's Time to Create The 'Survival Ladder'. 2008. Updated. Accessed 21
- 2 November. https://www.hmpgloballearningnetwork.com/site/emsworld/article/10321382/its-
- 3 <u>time-create-survival-ladder</u>
- 4 156. Martín-Ibáñez L, Pérez-Martínez J, Zamora-Mínguez D, Alcón-Rubio F, González-
- 5 Alonso V, Aroca García-Rubio S, Hernández-Hernández JM, Díaz F, Román-López P. A
- 6 civilian tactical survival chain for incidents involving multiple intentionalinjury victims: the
- 7 Victory I Consensus Report. *Emergencias*. 2019;31:195-201.
- 8 157. Mould-Millman NK, J. S. The African trauma chain of survival: Proposing a model of
- 9 integrated care. *Annals of Global Health*. 2014;80:219-220. doi:
- 10 https://doi.org/10.1016/j.aogh.2014.08.156
- 11 158. Timerman S, Guimarães HP, Rochitte CE, Polastri TF, Lopes M. COVID-19 Chain of
- 12 Survival 2020. Arg Bras Cardiol. 2021;116:351-354. doi: 10.36660/abc.20201171
- 13 159. Cánovas Martínez C, Salas Rodríguez JM, Sánchez-Arévalo Morato S, Pardo Ríos M.
- 14 Should the CRA Chain of Survival Be the Survival Cycle? *Revista Española de Cardiología*
- 15 (English Edition). 2018;71:412-413. doi: https://doi.org/10.1016/j.rec.2017.11.030
- 16 160. Coute RA, Mader TJ, Kurz MC. Evaluation of National Institutes of Health cardiac arrest
- 17 research based on "chain of survival" links. *Academic Emergency Medicine*. 2022;29:1381-1382.
- 18 doi: <u>https://doi.org/10.1111/acem.14569</u>
- 19 161. Deakin CD. The chain of survival: Not all links are equal. *Resuscitation*. 2018;126:80-82.
- 20 doi: 10.1016/j.resuscitation.2018.02.012
- 21 162. El-Deeb MH. The Chain of Survival for ST-Segment Elevation Myocardial Infarction:
- 22 Insights Into the Middle East. Critical Pathways in Cardiology. 2013;12

1	163. González-Salvado V, Barcala-Furelos R, Neiro-Rey C, Varela-Casal C, Peña-Gil C,
2	Ruano-Raviña A, González-Juanatey JR, Rodríguez-Núñez A. Cardiac rehabilitation: The
3	missing link to close the chain of survival? Resuscitation. 2017;113:e7-e8. doi:
4	10.1016/j.resuscitation.2017.01.013
5	164. Jacobs I, Callanan V, Nichol G, Valenzuela T, Mason P, Jaffe AS, Landau W, Vetter N.
6	The chain of survival. Annals of Emergency Medicine. 2001;37:S5-S16. doi:
7	10.1067/mem.2001.114176
8	165. Quinlan B, Cooper C, Murfitt K, Charlebois A. A Multi-disciplinary approach to the
9	development and implementation of best practices for the management of cardiac arrest patients:
10	increasing the 'chain of survival' Canadian Journal of Cardiology. 2015;31:S323-S324. doi:
11	10.1016/j.cjca.2015.07.677
12	166. Schnaubelt S, Garg R, Atiq H, Baig N, Bernardino M, Bigham B, Dickson S, Geduld H,
13	Al-Hilali Z, Karki S, Lahri Sa, Maconochie I, Montealegre F, Tageldin Mustafa M, Niermeyer S,
14	Athieno Odakha J, Perlman JM, Monsieurs KG, Greif R, Aldakak F, Bhanji F, Breckwoldt J,
15	Cheng A, Cortegiani A, Eastwood K, Farquharson B, Finn J, Gómez CA, Hsieh M-J, Lauridsen
16	KG, Lockey A, Nabecker S, Nation K, Olaussen A, Sawyer T, Yang C-W, Yeung J.
17	Cardiopulmonary resuscitation in low-resource settings: a statement by the International Liaison
18	Committee on Resuscitation, supported by the AFEM, EUSEM, IFEM, and IFRC. The Lancet
19	Global Health. 2023;11:e1444-e1453. doi: 10.1016/S2214-109X(23)00302-9
20	167. Bunch TJ, Hammill SC, White RD. Outcomes after ventricular fibrillation out-of-hospital
21	cardiac arrest: expanding the chain of survival. Mayo Clin Proc. 2005;80:774-782. doi:
22	10.1016/s0025-6196(11)61532-2

1	168. Liu C-T, Lai C-Y, Wang J-C, Chung C-H, Chien W-C, Tsai C-S. A Population-Based
2	Retrospective Analysis of Post-In-Hospital Cardiac Arrest Survival after Modification of the
3	Chain of Survival. Journal of Emergency Medicine. 2020;59:246-253. doi:
4	10.1016/j.jemermed.2020.04.045
5	169. Tagami T, Hirata K, Takeshige T, Matsui J, Takinami M, Satake M, Satake S, Yui T,
6	Itabashi K, Sakata T, Tosa R, Kushimoto S, Yokota H, Hirama H. Implementation of the Fifth
7	Link of the Chain of Survival Concept for Out-of-Hospital Cardiac Arrest. Circulation.
8	2012;126:589-597. doi: 10.1161/CIRCULATIONAHA.111.086173
9	170. Dahan B, Jabre P, Marijon E, Jost D, Tafflet M, Misslin R, Bougouin W, Dumas F,
10	Renaud B, Jouven X. Impact of a public information campaign about the chain of survival on out
11	of hospital cardiac arrest bystander cardiopulmonary resuscitation initiation. European Heart
12	Journal. 2014;35:14-15.
13	171. Xia J, Nooraei N, Kalluri S, Edwards B. Spatial release of cognitive load measured in a
14	dual-task paradigm in normal-hearing and hearing-impaired listeners. The Journal of the
15	Acoustical Society of America. 2015;137:1888-1898. doi: 10.1121/1.4916599
16	172. Sweller J. Cognitive Load During Problem Solving: Effects on Learning. Cognitive
17	Science. 1988;12:257-285. doi: https://doi.org/10.1207/s15516709cog1202_4
18	173. Yang CW, Liu CH, Lockey A, Cheng A, Greif R, on behalf of the International Liaison
19	Committee on Resuscitation (ILCOR) Education Implementation and Team (EIT) Task Force.
20	Work Load and Stress during Resuscitation: EIT 6401 TF ScR. 2023. Updated.
21	https://costr.ilcor.org/document/work-load-and-stress-during-resuscitation-eit-6401-eit-tf-scr-1

1	174. Roman A, Petersen T, McDermott K, Rajzer-Wakeham K, Rajapreyar P, Szadkowski A,
2	Scanlon M. 599A: Measuring workload during actual pediatric resuscitation events: A pilot
3	study. Critical Care Medicine. 2023;51
4	175. Wagner M, Gröpel P, Eibensteiner F, Kessler L, Bibl K, Gross IT, Berger A, Cardona FS.
5	Visual attention during pediatric resuscitation with feedback devices: a randomized simulation
6	study. Pediatric Research. 2022;91:1762-1768. doi: 10.1038/s41390-021-01653-w
7	176. Fernández-Ayuso D, Fernández-Ayuso R, Del-Campo-Cazallas C, Pérez-Olmo JL,
8	Matías-Pompa B, Fernández-Carnero J, Calvo-Lobo C. The Modification of Vital Signs
9	According to Nursing Students' Experiences Undergoing Cardiopulmonary Resuscitation
10	Training via High-Fidelity Simulation: Quasi-Experimental Study. JMIR Serious Games.
11	2018;6:e11061. doi: 10.2196/11061
12	177. Sellmann T, Oendorf A, Wetzchewald D, Schwager H, Thal SC, Marsch S. The Impact
13	of Withdrawn vs. Agitated Relatives during Resuscitation on Team Workload: A Single-Center
14	Randomised Simulation-Based Study. Journal of Clinical Medicine. 2022.
15	178. Butler L, Whitfill T, Wong AH, Gawel M, Crispino L, Auerbach M. The Impact of
16	Telemedicine on Teamwork and Workload in Pediatric Resuscitation: A Simulation-Based,
17	Randomized Controlled Study. Telemedicine and e-Health. 2018;25:205-212. doi:
18	10.1089/tmj.2018.0017
19	179. Willmes M, Sellmann T, Semmer N, Tschan F, Wetzchewald D, Schwager H, Russo SG,
20	S M. Impact of family presence during cardiopulmonary resuscitation on team performance and
21	perceived task load: a prospective randomised simulator-based trial. BMJ Open.
22	2022;12:e056798. doi: 10.1136/bmjopen-2021-056798

1	180.	Badke CM, Friedman ML, Harris ZL, McCarthy	-Kowols M, Tran S. Impact of an

2 untrained CPR Coach in simulated pediatric cardiopulmonary arrest: A pilot study. *Resuscitation*

3 Plus. 2020;4:100035. doi: https://doi.org/10.1016/j.resplu.2020.100035

- 4 181. Hunziker S, Pagani S, Fasler K, Tschan F, Semmer NK, Marsch S. Impact of a stress
- 5 coping strategy on perceived stress levels and performance during a simulated cardiopulmonary
- 6 resuscitation: a randomized controlled trial. *BMC Emergency Medicine*. 2013;13:8. doi:
- 7 10.1186/1471-227X-13-8
- 8 182. Lacour M, Bloudeau L, Combescure C, Haddad K, Hugon F, Suppan L, Rodieux F,
- 9 Lovis C, Gervaix A, Ehrler F, Manzano S, Siebert JN. Impact of a Mobile App on Paramedics'
- 10 Perceived and Physiologic Stress Response During Simulated Prehospital Pediatric
- 11 Cardiopulmonary Resuscitation: Study Nested Within a Multicenter Randomized Controlled

12 Trial. JMIR Mhealth Uhealth. 2021;9:e31748. doi: 10.2196/31748

- 13 183. Brown LL, Lin Y, Tofil NM, Overly F, Duff JP, Bhanji F, Nadkarni VM, Hunt EA,
- 14 Bragg A, Kessler D, Bank I, Cheng A. Impact of a CPR feedback device on healthcare provider
- 15 workload during simulated cardiac arrest. *Resuscitation*. 2018;130:111-117. doi:
- 16 10.1016/j.resuscitation.2018.06.035
- 17 184. Müller MP, Hänsel M, Fichtner A, Hardt F, Weber S, Kirschbaum C, Rüder S, Walcher
- 18 F, Koch T, Eich C. Excellence in performance and stress reduction during two different full scale
- 19 simulator training courses: A pilot study. *Resuscitation*. 2009;80:919-924. doi:
- 20 10.1016/j.resuscitation.2009.04.027
- 21 185. Roitsch CM, Hagan JL, Patricia KE, Jain S, Chen X, Arnold JL, Devaraj S, Sundgren
- 22 NC. Effects of Team Size and a Decision Support Tool on Healthcare Providers' Workloads in
- 23 Simulated Neonatal Resuscitation: A Randomized Trial. Simulation in Healthcare. 2021;16

- 1 186. Bjørshol CA, Myklebust H, Nilsen KL, Hoff T, Bjørkli C, Illguth E, Søreide E, Sunde K.
- 2 Effect of socioemotional stress on the quality of cardiopulmonary resuscitation during advanced
- 3 life support in a randomized manikin study*. Critical Care Medicine. 2011;39
- 4 187. Tofil NM, Cheng A, Lin Y, Davidson J, Hunt EA, Chatfield J, MacKinnon L, Kessler D.
- 5 Effect of a Cardiopulmonary Resuscitation Coach on Workload During Pediatric
- 6 Cardiopulmonary Arrest: A Multicenter, Simulation-Based Study. Pediatric Critical Care
- 7 *Medicine*. 2020;21
- 8 188. Ontrup G, Vogel M, Wolf OT, Zahn PK, Kluge A, Hagemann V. Does simulation-based
- 9 training in medical education need additional stressors? An experimental study. *Ergonomics*.
- 10 2020;63:80-90. doi: 10.1080/00140139.2019.1677948
- 11 189. Zehnder E, Law BHY, GM. S. Does parental presence affect workload during neonatal
- 12 resuscitation? Archives of Disease in Childhood Fetal and Neonatal Edition. 2020;105:559.
- 13 doi: 10.1136/archdischild-2020-318840
- 14 190. Corazza F, Snijders D, Arpone M, Stritoni V, Martinolli F, Daverio M, Losi MG, Soldi
- 15 L, Tesauri F, Da Dalt L, Bressan S. Development and Usability of a Novel Interactive Tablet
- 16 App (PediAppRREST) to Support the Management of Pediatric Cardiac Arrest: Pilot High-
- 17 Fidelity Simulation-Based Study. JMIR Mhealth Uhealth. 2020;8:e19070. doi: 10.2196/19070
- 18 191. Gross Isabel T, Whitfill T, Redmond B, Couturier K, Bhatnagar A, Joseph M, Joseph D,
- 19 Ray J, Wagner M, Auerbach M. Comparison of Two Telemedicine Delivery Modes for Neonatal
- 20 Resuscitation Support: A Simulation-Based Randomized Trial. *Neonatology*. 2020;117:159-166.
- 21 doi: 10.1159/000504853
- 22 192. Asselin N, Choi B, Pettit CC, Dannecker M, Machan JT, Merck DL, Merck LH, Suner S,
- 23 Williams KA, Baird J, Jay GD, Kobayashi L. Comparative Analysis of Emergency Medical

1	Service Provider Workload During Simulated Out-of-Hospital Cardiac Arrest Resuscitation
2	Using Standard Versus Experimental Protocols and Equipment. Simulation in Healthcare.
3	2018;13
4	193. Pallas JD, Smiles JP, M. Z. Cardiac Arrest Nurse Leadership (CANLEAD) trial: a
5	simulation-based randomised controlled trial implementation of a new cardiac arrest role to
6	facilitate cognitive offload for medical team leaders. <i>Emergency Medicine Journal</i> . 2021;38:572.
7	doi: 10.1136/emermed-2019-209298
8	194. Parsons SE, Carter EA, Waterhouse LJ, Sarcevic A, O'Connell KJ, Burd RS. Assessment
9	of workload during pediatric trauma resuscitation. Journal of Trauma and Acute Care Surgery.
10	2012;73
11	195. Lee K, Kim MJ, Park J, Park JM, Kim KH, Shin DW, Kim H, Jeon W, Kim H. The effect
12	of distraction by dual work on a CPR practitioner's efficiency in chest compression: A
13	randomized controlled simulation study. Medicine. 2017;96
14	196. Dainty KN, Atkins DL, Breckwoldt J, Maconochie I, Schexnayder SM, Skrifvars MB,
15	Tijssen J, Wyllie J, Furuta M, Aickin R, Acworth J, Atkins D, Couto TB, Guerguerian A-M,
16	Kleinman M, Kloeck D, Nadkarni V, Ng K-C, Nuthall G, Ong Y-KG, Reis A, Rodriguez-Nunez
17	A, Schexnayder S, Scholefield B, Tijssen J, Voorde Pvd, Wyckoff M, Liley H, El-Naggar W,
18	Fabres J, Fawke J, Foglia E, Guinsburg R, Hosono S, Isayama T, Kawakami M, Kapadia V, Kim
19	H-S, McKinlay C, Roehr C, Schmolzer G, Sugiura T, Trevisanuto D, Weiner G, Greif R, Bhanji
20	F, Bray J, Breckwoldt J, Cheng A, Duff J, Eastwood K, Gilfoyle E, Hsieh M-J, Lauridsen K,
21	Lockey A, Matsuyama T, Patocka C, Pellegrino J, Sawyer T, Schnaubel S, Yeung J, Aickin R,
22	Acworth J, Atkins D, Couto TB, Guerguerian A-M, Kleinman M, Kloeck D, Nadkarni V, Ng K-
23	C, Nuthall G, Ong Y-KG, Reis A, Rodriguez-Nunez A, Schexnayder S, Scholefield B, Tijssen J,

1	Voorde Pvd, Wyckoff M, Liley H, El-Naggar W, Fabres J, Fawke J, Foglia E, Guinsburg R,
2	Hosono S, Isayama T, Kawakami M, Kapadia V, Kim H-S, McKinlay C, Roehr C, Schmolzer G,
3	Sugiura T, Trevisanuto D, Weiner G, Greif R, Bhanji F, Bray J, Breckwoldt J, Cheng A, Duff J,
4	Eastwood K, Gilfoyle E, Hsieh M-J, Lauridsen K, Lockey A, Matsuyama T, Patocka C,
5	Pellegrino J, Sawyer T, Schnaubel S, Yeung J. Family presence during resuscitation in paediatric
6	and neonatal cardiac arrest: A systematic review. Resuscitation. 2021;162:20-34. doi:
7	10.1016/j.resuscitation.2021.01.017
8	197. Dainty KN, Atkins DL, Breckwoldt J MI, Schexnayder SM, Skrifvars MB, , Tijssen J,
9	Wyllie J, Furuta M, on behalf of the International Liaison Committee on Resuscitation's
10	(ILCOR) Pediatric Neonatal Life Support and Education Implementation and Teams Task
11	Forces. Family Presence During Resuscitation CoSTR (NLS 1590; PLS 384) ESR. 2021.
12	Updated. https://costr.ilcor.org/document/systematic-review-nls-family-presence-during-resus-
13	<u>neonatal-costr</u>
14	198. Lauridsen KG, Krogh K, Müller SD, Schmidt AS, Nadkarni VM, Berg RA, Bach L, Dodt
15	KK, Maack TC, Møller DS, Qvortrup M, Nielsen RP, Højbjerg R, Kirkegaard H, Løfgren B.
16	Barriers and facilitators for in-hospital resuscitation: A prospective clinical study. Resuscitation.
17	2021;164:70-78. doi: 10.1016/j.resuscitation.2021.05.007

- 18 199. Cheng A, Eppich W, Grant V, Sherbino J, Zendejas B, Cook DA. Debriefing for
- 19 technology-enhanced simulation: a systematic review and meta-analysis. *Medical Education*.
- 20 2014;48:657-666. doi: <u>https://doi.org/10.1111/medu.12432</u>
- 21 200. Fanning RM, Gaba DM. The Role of Debriefing in Simulation-Based Learning.
- 22 Simulation in Healthcare. 2007;2

- 1 201. Garden AL, Le Fevre DM, Waddington HL, Weller JM. Debriefing after Simulation-
- 2 Based Non-Technical Skill Training in Healthcare: A Systematic Review of Effective Practice.
- 3 Anaesthesia and Intensive Care. 2015;43:300-308. doi: 10.1177/0310057X1504300303
- 4 202. Levett-Jones T, Lapkin S. A systematic review of the effectiveness of simulation
- 5 debriefing in health professional education. *Nurse Education Today*. 2014;34:e58-e63. doi:
- 6 <u>https://doi.org/10.1016/j.nedt.2013.09.020</u>
- 7 203. Motola I, Devine LA, Chung HS, Sullivan JE, Issenberg SB. Simulation in healthcare
- 8 education: A best evidence practical guide. AMEE Guide No. 82. *Medical Teacher*.
- 9 2013;35:e1511-e1530. doi: 10.3109/0142159X.2013.818632
- 10 204. Raemer D, Anderson M, Cheng A, Fanning R, Nadkarni V, Savoldelli G. Research
- 11 Regarding Debriefing as Part of the Learning Process. Simulation in Healthcare. 2011;6
- 12 205. Couper K, Salman B, Soar J, Finn J, Perkins GD. Debriefing to improve outcomes from
- 13 critical illness: a systematic review and meta-analysis. Intensive Care Medicine. 2013;39:1513-
- 14 1523. doi: 10.1007/s00134-013-2951-7
- 15 206. Edelson DP, Litzinger B, Arora V, Walsh D, Kim S, Lauderdale DS, Vanden Hoek TL,
- 16 Becker LB, Abella BS. Improving In-Hospital Cardiac Arrest Process and Outcomes With
- 17 Performance Debriefing. Archives of Internal Medicine. 2008;168:1063-1069. doi:
- 18 10.1001/archinte.168.10.1063
- 19 207. Wolfe H, Zebuhr C, Topjian AA, Nishisaki A, Niles DE, Meaney PA, Boyle L, Giordano
- 20 RT, Davis D, Priestley M, Apkon M, Berg RA, Nadkarni VM, Sutton RM. Interdisciplinary ICU
- 21 Cardiac Arrest Debriefing Improves Survival Outcomes*. Critical Care Medicine. 2014;42
- 22 208. Hunt EA, Jeffers J, McNamara L, Newton H, Ford K, Bernier M, Tucker EW, Jones K,
- 23 O'Brien C, Dodge P, Vanderwagen S, Salamone C, Pegram T, Rosen M, Griffis HM, Duval-

1	Arnould J. Improved Cardiopulmonary Resuscitation Performance With CODE ACES2: A
2	Resuscitation Quality Bundle. Journal of the American Heart Association. 2018;7:e009860. doi:
3	10.1161/JAHA.118.009860
4	209. Sawyer T, Eppich W, Brett-Fleegler M, Grant V, Cheng A. More Than One Way to
5	Debrief: A Critical Review of Healthcare Simulation Debriefing Methods. Simulation in
6	Healthcare. 2016;11
7	210. Cheng A, Hunt EA, Donoghue A, Nelson-McMillan K, Nishisaki A, LeFlore J, Eppich
8	W, Moyer M, Brett-Fleegler M, Kleinman M, Anderson J, Adler M, Braga M, Kost S,
9	Stryjewski G, Min S, Podraza J, Lopreiato J, Hamilton MF, Stone K, Reid J, Hopkins J, Manos J,
10	Duff J, Richard M, Nadkarni VM, Express Investigators ft. Examining Pediatric Resuscitation
11	Education Using Simulation and Scripted Debriefing: A Multicenter Randomized Trial. JAMA
12	Pediatrics. 2013;167:528-536. doi: 10.1001/jamapediatrics.2013.1389
13	211. Eppich W, Cheng A. Promoting Excellence and Reflective Learning in Simulation
14	(PEARLS): Development and Rationale for a Blended Approach to Health Care Simulation
15	Debriefing. Simulation in Healthcare. 2015;10
16	212. Mullan PC, Wuestner E, Kerr TD, Christopher DP, Patel B. Implementation of an In Situ
17	Qualitative Debriefing Tool for Resuscitations. Resuscitation. 2013;84:946-951. doi:
18	10.1016/j.resuscitation.2012.12.005
19	213. Zinns LE, Mullan PC, O'Connell KJ, Ryan LM, Wratney AT. An Evaluation of a New
20	Debriefing Framework: REFLECT. Pediatric Emergency Care. 2020;36
21	214. Welch-Horan TB, Lemke DS, Bastero P, Leong-Kee S, Khattab M, Eggers J, Penn C,
22	Dangre A, Doughty CB. Feedback, reflection and team learning for COVID-19: development of

- 1 a novel clinical event debriefing tool. *BMJ Simul Technol Enhanc Learn*. 2021;7:54-57. doi:
- 2 10.1136/bmjstel-2020-000638
- 3 215. Lin Y, Lockey A, Greif R, Cheng A; on behalf of the Education Implementation Team
- 4 Task Force of the International Liaison Committee on Resuscitation. The effect of scripted
- 5 debriefing in resuscitation training: a scoping review. *Resusc Plus.* 2024;18:100581. doi:
- 6 10.1016/j.resplu.2024.100581
- 7 216. Lin Y, Greif R, Lockey A, Cheng A, on behalf of the International Liaison Committee on
- 8 Resuscitation (ILCOR) Education Implementation and Team (EIT) Task Force. Scripted
- 9 Debriefing for Resuscitation Training: A scoping review: EIT 6413 TF ScR. 2023. Updated.
- 10 https://costr.ilcor.org/document/scripted-debriefing-for-resuscitation-training-a-scoping-review-

11 <u>eit-6413-tf-scr</u>

- 12 217. Meguerdichian M, Bajaj K, Ivanhoe R, Lin Y, Sloma A, de Roche A, Altonen B, Bentley
- 13 S, Cheng A, Walker K. Impact of the PEARLS Healthcare Debriefing cognitive aid on facilitator
- 14 cognitive load, workload, and debriefing quality: a pilot study. *Advances in Simulation*.
- 15 2022;7:40. doi: 10.1186/s41077-022-00236-x
- 16 218. Snelling PJ, Dodson L, Monteagle E, Ware RS, Acworth J, Symon B, Lawton B. PRE-
- 17 scripted debriefing for Paediatric simulation Associated with Resuscitation EDucation
- 18 (PREPARED): A multicentre, cluster randomised controlled trial. *Resuscitation Plus*.
- 19 2022;11:100291. doi: https://doi.org/10.1016/j.resplu.2022.100291
- 20 219. Cheng A, Davidson J, Wan B, St-Onge-St-Hilaire A, Lin Y. Data-informed debriefing for
- 21 cardiopulmonary arrest: A randomized controlled trial. *Resuscitation Plus.* 2023;14:100401. doi:
- 22 https://doi.org/10.1016/j.resplu.2023.100401

Freytag J, Stroben F, Hautz WE, Penders D, Kämmer JE. Effects of using a cognitive aid 1 220. 2 on content and feasibility of debriefings of simulated emergencies. GMS J Med Educ. 2021;38:Doc95. doi: 10.3205/zma001491 3 Høegh-Larsen AM, Ravik M, Reierson IÅ, Husebø SIE, Gonzalez MT. PEARLS 4 221. 5 Debriefing Compared to Standard Debriefing Effects on Nursing Students' Professional 6 Competence and Clinical Judgment: A Quasi-Experimental Study. Clinical Simulation In 7 Nursing. 2023;74:38-48. doi: 10.1016/j.ecns.2022.09.003

8

1 FIRST AID

2 Use of Supplemental Oxygen in First Aid (ScopRev FA1649)

3 Rationale for Review

4 Training in oxygen administration is typically not included in standard first aid courses 5 but is sometimes offered in a separate first aid oxygen course. In the first aid setting, oxygen use 6 has been described for loss of consciousness, diving emergencies, carbon monoxide poisoning, and during cardiac arrest. A 2015 CoSTR^{1,2} followed by a 2022 ScopRev³ identified evidence of 7 potential harm with oxygen use in acute exacerbations of chronic obstructive pulmonary disease 8 9 (COPD) but used limited search dates and broad exclusion criteria. The current ScopRev expands the search dates and inclusion criteria. Topics recently reviewed were once again 10 excluded, such as the use of supplemental oxygen in acute coronary syndrome,⁴ suspected 11 stroke,⁵ drowning,⁶ and after the return of spontaneous circulation following cardiac arrest.⁷ The 12 full online ScopRev can be found online.⁸ 13 Population, Intervention, Comparator, Outcome, Study Design, and Time Frame 14 15 • Population: Adults and children who exhibit symptoms or signs of shortness of breath, difficulty breathing, or hypoxia outside of a hospital 16 Intervention: Administration of oxygen by a first aid provider 17 • Comparator: No administration of oxygen 18 • Outcomes: Functional outcome at discharge, 30 days, 60 days, 180 days, or 1 year; 19 20 survival only at discharge, 30 days, 60 days, 180 days, or 1 year; length of hospital stay; 21 resolution of symptoms or signs; patient comfort; therapeutic endpoints (eg, oxygenation, 22 ventilation)

1	• Study designs: RCTs and non-randomized studies (non-RCTs, interrupted time series,
2	controlled before-and-after studies, cohort studies), case series, and reports in English
3	were eligible for inclusion. Non-peer-reviewed studies, unpublished studies, conference
4	abstracts, evidence-based guidelines, trial registries, and protocols were eligible for
5	inclusion.
6	• Time frame: All dates to July 2023. The literature search was updated on December 1,
7	2023.
8	Summary of Evidence
9	The search identified 3305 records, of which 31 underwent full-text review. No articles
10	that directly addressed the PICOST were identified. The articles identified related to 3 main
11	areas: supplemental oxygen for the treatment of carbon monoxide poisoning in the out-of-
12	hospital setting (n=6), supplemental oxygen in the treatment of decompression injuries/illness in
13	divers using compressed gas (n=11), and titrated oxygen in the treatment of persons with an
14	acute exacerbation of COPD (n=13). One paper was identified that reviewed the supplemental
15	use of oxygen in the out-of-hospital management of spinal cord injury.9
16	For the use of supplemental oxygen in acute exacerbations of COPD, we identified 2
17	SysRevs, ^{10,11} 1 cluster RCT, ¹² 1 commentary on the same RCT, ¹³ 5 observational studies, ¹⁴⁻¹⁸ 1
18	literature review, ¹⁹ 3 evidence-based guidelines, ²⁰⁻²² and 1 registered with associated published
19	study protocol for an ongoing trial. ^{23,24} In the cluster RCT, ¹² 405 patients with acute
20	exacerbations of COPD in the out-of-hospital setting were treated either with high-flow oxygen
21	(defined as 8–10 L/min by nonrebreathing face mask and nebulized bronchodilators administered
22	with oxygen at 6-8 L/min) or with titrated oxygen delivered by nasal cannula to achieve oxygen
23	saturations between 88% and 92% and nebulized bronchodilators administered with compressed

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1 air and delivered with a face mask placed over the nasal cannula. In the intention-to-treat 2 analysis for the subgroup of patients with confirmed COPD, mortality was 9% (11 deaths) in the high-flow arm compared with 2% (2 deaths) in the titrated oxygen group (RR, 0.22; 95% CI, 3 4 0.05–0.91; *P*=0.04). 5 The remaining observational studies of oxygen administration for acute exacerbations of 6 COPD in the out-of-hospital setting reported mixed results and were noted to have significant within-study confounders and heterogeneity between the studies.¹⁴⁻¹⁸ 7 8 For the use of supplemental oxygen for carbon monoxide poisoning in the out-of-hospital setting, no clinical studies were identified. One older case series²⁵ reported the prehospital and 9 10 in-hospital management and clinical course of 206 patients with carbon monoxide poisoning, whereas 4 literature reviews²⁶⁻²⁹ and 1 guideline³⁰ focused on in-hospital management. All 11 articles commented on the need for immediate treatment with supplemental high-concentration 12 13 oxygen. For the use of supplemental oxygen for diving emergencies, 3 case series³¹⁻³³ described 14 use of oxygen in decompression sickness, with 1 case series³³ specifically describing the use of 15 16 first aid oxygen in 1045 cases in a sequential series of 2231 diving injury reports. The median 17 time for oxygen administration was 2.2 hours after symptom onset and 4 hours after surfacing. 18 First aid oxygen was reported to be associated with persistent complete relief in 14% and 19 improvement of symptoms in 51%. The odds of multiple recompression treatments were reduced 20 when oxygen was given at any time after surfacing (OR, 0.83; 95% CI, 0.70-0.98). The remaining articles identified in the search were literature reviews,³⁴⁻³⁹ a medical journal 21 22 summarizing other articles⁴⁰, and 1 experimental study⁴¹ in healthy divers to compare tissue

oxygenation levels while breathing oxygen by using different noninvasive delivery devices and
 oxygen flow rates.

A summary of all articles identified can be found in Tables 1 through 3 in Appendix C. *Task Force Insights*This ScopRev did not identify evidence to suggest for or against the first aid

administration of oxygen for adults or children with signs or symptoms of difficulty breathing.
However, we specifically excluded the use of supplemental oxygen in several settings because
these indications have been covered in recent reviews. The studies included are from the out-ofhospital setting, and the evidence is considered indirect to the population of first aid providers
trained in oxygen use.

The 1 RCT¹² that identified evaluating the use of out-of-hospital titrated versus high-flow 11 12 oxygen in acute exacerbations of COPD reported a 78% reduction in mortality with the use of 13 titrated oxygen in the out-of-hospital setting. In task force discussions, there was concern about 14 the potential for harm if high-flow oxygen was withheld from patients with acute exacerbations 15 of COPD and life-threatening hypoxemia. Task force members emphasized the need for first aid 16 providers trained in oxygen delivery to use pulse oximetry and to recognize that high-flow oxygen may be necessary if oxygen saturations are less than 88%. An update to the good practice 17 18 statement on this topic reflects this concern.

19 There was insufficient evidence identified to pursue SysRevs related to oxygen use in the 20 first aid setting for carbon monoxide poisoning, diving emergencies, general signs and symptoms 21 of shortness of breath or difficulty breathing, or any other specific condition.

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1 Prior Good Practice Statement (2023)

2	If first aid providers, trained to use oxygen, are administering supplemental oxygen to a					
3	person with known COPD, they should titrate the supplemental oxygen to maintain the oxygen					
4	saturation by pulse oximetry between 88% and 92% (good practice statement). ³					
5	2024 Good Practice Statement					
6	When a first aid provider trained in oxygen use administers oxygen to a person with acut					
7	difficulty breathing who confirms that they have chronic obstructive pulmonary disease, it is					
8	suggested that pulse oximetry be used and that oxygen be titrated to maintain an oxygen					
9	saturation between 88% and 92% (good practice statement).					
10	Although high-flow oxygen should in general be avoided in patients with chronic					
11	obstructive pulmonary disease with difficulty breathing in the out-of-hospital setting, high-flow					
12	oxygen should not be withheld in the presence of life-threatening hypoxemia (oxygen saturation					
13	<88%) (good practice statement).					
14	Recognition of Sepsis (ScopRev FA 7180)					
15	Rationale for Review					
16	A significant proportion of preventable deaths worldwide are caused by sepsis, and early					
17	detection and treatment is beneficial. No prior review has been undertaken, and in 2022, the task					
18	force elected by consensus to undertake a ScopRev on the recognition and awareness of sepsis					
19	by first aid providers evaluating adults with an acute illness. The full text of this ScopRev can be					
20	found online. ⁴²					
21	Population, Intervention, Comparator, Outcome, Study Design, and Time Frame					
22	• Population: Adults who are being evaluated by a first aid provider for an acute illness					

1	• Intervention: The presence of any specific signs or symptoms (ie, pale, blue, or mottled
2	skin, lips, tongue, gums, or nails; nonblanching rash; difficulty breathing or rapid
3	respiratory rates; rigors/shivering; lack of urination in a day; muscle pain; confusion; or
4	slurred speech)
5	• Comparator: Fever (≥38° C, 100.4° F) with signs of infection
6	• Outcomes: Recognition of a seriously ill person requiring hospitalization or evaluation by
7	a physician for sepsis and increased awareness of sepsis
8	• Study designs: RCTs and non-randomized studies (non-RCTs, interrupted time series,
9	controlled before-and-after studies, cohort studies) were eligible for inclusion. Gray
10	literature, social media posts, non-peer-reviewed studies, unpublished studies, conference
11	abstracts, and trial protocols were eligible for inclusion. All relevant publications in any
12	language are included as long as there was an English abstract.
13	• Time frame: Inception through December 2, 2023
14	Summary of Evidence
15	There were insufficient studies to support a SysRev. Studies that were selected for
16	inclusion evaluated physiologic variables that a lay provider could obtain in a first aid setting,
17	such as temperature, heart rate, and respiratory rate, either in isolation or when assessing by
18	using clinical scoring tools. It was noted that online resources that focused on educating the
19	public on sepsis recognition listed presenting signs and symptoms of sepsis under 9 general
20	categories: temperature (fever or hypothermia), neurologic (change in mental state, dizziness,
21	slurred speech), musculoskeletal (severe muscle pain, extreme shivering), urologic (poor urine
22	output), respiratory (rapid breathing or breathlessness), skin (clammy/sweaty, new rash, mottled
23	or discolored), cardiac (elevated heart rate), gastrointestinal (nausea, vomiting, diarrhea), and

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subjective (feeling very unwell or impending sense of doom). However, there was variability as
 to which signs or symptoms were highlighted by each campaign or organization.

3 Task Force Insights

4 Given the lack of any direct studies, the task force agreed to include studies that were 5 performed in either the prehospital setting by emergency medical service providers or the in-6 hospital setting, using extrapolated data to suggest relevance to the first aid setting. Despite the 7 use of early warning scoring tools to assist in the detection of sepsis, sepsis recognition by 8 trained clinicians in the health care setting remains challenging. Additionally, the definition of 9 sepsis and the criteria defining sepsis continues to change. Therefore, it was felt by the task force 10 that it was beyond the scope of a first aid provider to recognize and subsequently diagnose an 11 acute illness as sepsis. Because sepsis cannot occur without an infection, a more reasonable 12 expectation of a lay provider is to suspect an infection in a person presenting with an acute 13 illness. Therefore, those providing first aid should consider an infection in any person who 14 presents with an acute illness, and if the illness is associated with any abnormal signs or 15 symptoms, they should urgently seek further medical evaluation.

- 16 2024 Good Practice Statement
- 17 Those providing first aid should consider an infection in any person who presents with an 18 acute illness, and if the illness is associated with any abnormal signs or symptoms, they should 19 urgently seek further medical evaluation (good practice statement).

1 Topics Reviewed by Evidence Updates

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

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
Stroke	2020	We recommend that first aid	0	4	None of the new studies	No
recognition		providers use stroke assessment			of established stroke	
(FA 7170)		scales/tools for adults with suspected			scoring systems, or of	
		acute stroke (strong recommendation,			new stroke scoring	
		low-certainty evidence).			systems, offer any	
		For first aid, we suggest the use of			improvement in the	
		FAST, MASS, CPSS or LAPSS			public recognition of	
		scales/tools for stroke assessment			stroke by lay public or	
		(weak recommendation, low-			first aid provider.	
		certainty evidence).				
		For first aid, we suggest the use of				
		stroke assessment scales/tools that				
		include blood glucose measurement				
		when available, such as MASS or				
		LAPSS, to increase specificity of				
		stroke recognition (weak				
		1	1		1	1

3 Table 25. First Aid Topics Reviewed

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		recommendation, low-certainty				
		evidence).				
		For first aid, we suggest the use of				
		FAST or CPSS stroke assessment				
		scales/tools when blood glucose				
		measurement is unavailable (weak				
		recommendation, low-certainty				
		evidence).				
Oxygen in	2021	For adults with suspected acute	2	1	One RCT on high-flow	Yes
stroke		stroke, we suggest against the routine			oxygen compared with	
(FA7031)		use of supplementary oxygen in the			no oxygen found no	
		first aid setting compared with no use			significant difference in	
		of supplementary oxygen (weak			global disability scores.	
		recommendation, low- to moderate-			Another RCT found	
		certainty evidence).			better outcomes with	
					normobaric hyperoxia	
					compared with room air.	
Dental	2020	We suggest the use of HBSS,	1	2	One RCT found that, in	No
avulsion		propolis (from 0.04 mg to 2.5 mg per			general, PDL viability	
Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
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(FA 7361)		mL 0.4% ethanol), oral rehydration			was better at the cooler	
		salt solutions including Ricetral (oral			temperature for all	
		rehydration salt solutions containing			storage media, except	
		sodium chloride, glucose, potassium			HBSS. Milk was the	
		chloride, citrate [or extruded rice]),			most effective, followed	
		or cling film compared with any form			by propolis and HBSS at	
		of cow's milk for temporary storage			5° C, but at 20° C,	
		of an avulsed tooth that cannot be			HBSS was the most	
		immediately replanted (weak			effective, followed by	
		recommendation, very low-certainty			milk. Results from each	
		evidence). If none of the above			of the observational	
		choices are available, we suggest the			studies suggested that	
		use of cow's milk, any percent fat or			propolis, as well as cow	
		form, compared with tap water,			and almond milk, can be	
		buttermilk, castor oil, turmeric			alternative storage	
		extract, or saline (sodium chloride)			mediums.	
		for temporary storage of an avulsed				
		tooth (weak recommendation, very				
		low-certainty evidence).				

u	updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	data to warrant SysRev?
		There is insufficient evidence to recommend for or against temporary storage of an avulsed tooth in saliva compared with alternative solutions. There is insufficient evidence to recommend for or against temporary storage of an avulsed tooth in probiotic media, epigallocatechin-3- gallate, Dentosafe box, or egg white compared with cow's milk.				
Second dose 20 of epinephrine for anaphylaxis (FA 7111)	2021	We suggest a second dose of epinephrine be administered by autoinjector to adults and children with severe anaphylaxis whose symptoms are not relieved by an initial dose (weak recommendation, very low–quality evidence).	0	1	Observational study identifying that 29% (n=11) needed 2 doses and 5% (n=2) needed 3 doses of epinephrine	No

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
Naloxone for	2020	We suggest that CPR be started	0	0	N/A	No
opioid		without delay in any unconscious				
emergencies		person not breathing normally and				
(FA7442)		that naloxone be used by lay rescuers				
		in suspected opioid-related				
		respiratory or circulatory arrest				
		(weak recommendation based on				
		expert consensus).				
Exertion-	2022	We recommend the use of any	2	0	One RCT found that the	No
related		readily available rehydration drink or			percentage of fluid	
dehydration		water for treating exertion-related			retained at 3.5 hours	
and		dehydration in the first aid setting			after ingestion of a	
rehydration		(good practice statement).			sports drink was	
(FA7241)		We suggest rehydration for exertion-			statistically significantly	
		related dehydration with a 4% to 9%			higher than after	
		CED. Alternative rehydration options			ingestion of water.	
		include 0% to 3.9% CEDs, water,			In a second RCT that	
		coconut water, or skim or low-fat			compared green tea with	
					water, no differences in	

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

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		maneuvers (weak recommendation,				
		very low-certainty evidence).				
Recovery	2021	When providing first aid to a person	0	0		No
position		with a decreased level of				
(FA7040)		responsiveness of nontraumatic				
		etiology and who does not require				
		immediate resuscitative				
		interventions, we suggest the use of				
		the recovery position (weak				
		recommendation, very low-certainty				
		evidence).				
		When the recovery position is used,				
		monitoring should continue for signs				
		of airway occlusion, inadequate or				
		agonal breathing, and				
		unresponsiveness (good practice				
		statement).				
		If body position, including the				
		recovery position, is a factor				

Topic/PICO	Year last updated	Existing treatment recommendation	RCTs since last review	Observational studies since last review	Key findings	Sufficient data to warrant SysRev?
		impairing the first aid provider's				
		ability to determine the presence or				
		absence of signs of life, the person				
		should be immediately positioned				
		supine and reassessed (good practice				
		statement).				
		Persons found in positions associated				
		with aspiration and positional				
		asphyxia, such as face down, prone,				
		or in neck and torso flexion positions,				
		should be repositioned supine for				
		reassessment (good practice				
		statement).				

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

2 3 4

1

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1 Collaborators

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7	

1	1. Zideman DA, Singletary EM, De Buck ED, Chang WT, Jensen JL, Swain JM, Woodin
2	JA, Blanchard IE, Herrington RA, Pellegrino JL, Hood NA, Lojero-Wheatley LF, Markenson
3	DS, Yang HJ. Part 9: First aid: 2015 International Consensus on First Aid Science with
4	Treatment Recommendations. Resuscitation. 2015;95:e225-261. doi:
5	10.1016/j.resuscitation.2015.07.047
6	2. Singletary EM, Zideman DA, De Buck ED, Chang WT, Jensen JL, Swain JM, Woodin
7	JA, Blanchard IE, Herrington RA, Pellegrino JL, Hood NA, Lojero-Wheatley LF, Markenson
8	DS, Yang HJ. Part 9: First Aid: 2015 International Consensus on First Aid Science With
9	Treatment Recommendations. Circulation. 2015;132:S269-311. doi:
10	10.1161/cir.0000000000278
11	3. Berg KM, Bray JE, Ng KC, Liley HG, Greif R, Carlson JN, Morley PT, Drennan IR,
12	Smyth M, Scholefield BR, Weiner GM, Cheng A, Djärv T, Abelairas-Gómez C, Acworth J,
13	Andersen LW, Atkins DL, Berry DC, Bhanji F, Bierens J, Bittencourt Couto T, Borra V,
14	Böttiger BW, Bradley RN, Breckwoldt J, Cassan P, Chang WT, Charlton NP, Chung SP,
15	Considine J, Costa-Nobre DT, Couper K, Dainty KN, Dassanayake V, Davis PG, Dawson JA, de
16	Almeida MF, De Caen AR, Deakin CD, Dicker B, Douma MJ, Eastwood K, El-Naggar W,
17	Fabres JG, Fawke J, Fijacko N, Finn JC, Flores GE, Foglia EE, Folke F, Gilfoyle E, Goolsby
18	CA, Granfeldt A, Guerguerian AM, Guinsburg R, Hatanaka T, Hirsch KG, Holmberg MJ,
19	Hosono S, Hsieh MJ, Hsu CH, Ikeyama T, Isayama T, Johnson NJ, Kapadia VS, Kawakami MD,
20	Kim HS, Kleinman ME, Kloeck DA, Kudenchuk P, Kule A, Kurosawa H, Lagina AT, Lauridsen
21	KG, Lavonas EJ, Lee HC, Lin Y, Lockey AS, Macneil F, Maconochie IK, Madar RJ, Malta
22	Hansen C, Masterson S, Matsuyama T, McKinlay CJD, Meyran D, Monnelly V, Nadkarni V,
23	Nakwa FL, Nation KJ, Nehme Z, Nemeth M, Neumar RW, Nicholson T, Nikolaou N, Nishiyama

1	C, Norii T, Nuthall GA, Ohshimo S, Olasveengen TM, Ong YG, Orkin AM, Parr MJ, Patocka C,
2	Perkins GD, Perlman JM, Rabi Y, Raitt J, Ramachandran S, Ramaswamy VV, Raymond TT,
3	Reis AG, Reynolds JC, Ristagno G, Rodriguez-Nunez A, Roehr CC, Rüdiger M, Sakamoto T,
4	Sandroni C, Sawyer TL, Schexnayder SM, Schmölzer GM, Schnaubelt S, Semeraro F, Singletary
5	EM, Skrifvars MB, Smith CM, Soar J, Stassen W, Sugiura T, Tijssen JA, Topjian AA,
6	Trevisanuto D, Vaillancourt C, Wyckoff MH, Wyllie JP, Yang CW, Yeung J, Zelop CM,
7	Zideman DA, Nolan JP. 2023 International Consensus on Cardiopulmonary Resuscitation and
8	Emergency Cardiovascular Care Science With Treatment Recommendations: Summary From the
9	Basic Life Support; Advanced Life Support; Pediatric Life Support; Neonatal Life Support;
10	Education, Implementation, and Teams; and First Aid Task Forces. Circulation. 2023;148:e187-
11	e280. doi: 10.1161/cir.00000000001179
12	4. Nikolaou NI, Welsford M, Beygui F, Bossaert L, Ghaemmaghami C, Nonogi H,
13	O'Connor RE, Pichel DR, Scott T, Walters DL, Woolfrey KG, Acute Coronary Syndrome
14	Chapter C. Part 5: Acute coronary syndromes: 2015 International Consensus on
15	Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment
16	Recommendations. Resuscitation. 2015;95:e121-146. doi: 10.1016/j.resuscitation.2015.07.043
17	5. Singletary EM, Zideman DA, Bendall JC, Berry DC, Borra V, Carlson JN, Cassan P,
18	Chang WT, Charlton NP, Djarv T, Douma MJ, Epstein JL, Hood NA, Markenson DS, Meyran
19	D, Orkin AM, Sakamoto T, Swain JM, Woodin JA, First Aid Science C. 2020 International
20	Consensus on First Aid Science With Treatment Recommendations. Circulation.
21	2020;142:S284-S334. doi: 10.1161/CIR.000000000000897
22	6. Bierens J, Bray J, Abelairas-Gomez C, Barcala-Furelos R, Beerman S, Claesson A,
23	Dunne C, Fukuda T, Jayashree M, A TL, Li L, Mecrow T, Morgan P, Schmidt A, Seesink J,

1	Sempsrott J, Szpilman D, Thom O, Tobin J, Webber J, Johnson S, Perkins GD. A systematic
2	review of interventions for resuscitation following drowning. Resusc Plus. 2023;14:100406. doi:
3	10.1016/j.resplu.2023.100406
4	7. Wyckoff MH, Singletary EM, Soar J, Olasveengen TM, Greif R, Liley HG, Zideman D,
5	Bhanji F, Andersen LW, Avis SR, Aziz K, Bendall JC, Berry DC, Borra V, Bottiger BW,
6	Bradley R, Bray JE, Breckwoldt J, Carlson JN, Cassan P, Castren M, Chang WT, Charlton NP,
7	Cheng A, Chung SP, Considine J, Costa-Nobre DT, Couper K, Dainty KN, Davis PG, de
8	Almeida MF, de Caen AR, de Paiva EF, Deakin CD, Djarv T, Douma MJ, Drennan IR, Duff JP,
9	Eastwood KJ, El-Naggar W, Epstein JL, Escalante R, Fabres JG, Fawke J, Finn JC, Foglia EE,
10	Folke F, Freeman K, Gilfoyle E, Goolsby CA, Grove A, Guinsburg R, Hatanaka T, Hazinski
11	MF, Heriot GS, Hirsch KG, Holmberg MJ, Hosono S, Hsieh MJ, Hung KKC, Hsu CH, Ikeyama
12	T, Isayama T, Kapadia VS, Kawakami MD, Kim HS, Kloeck DA, Kudenchuk PJ, Lagina AT,
13	Lauridsen KG, Lavonas EJ, Lockey AS, Malta Hansen C, Markenson D, Matsuyama T,
14	McKinlay CJD, Mehrabian A, Merchant RM, Meyran D, Morley PT, Morrison LJ, Nation KJ,
15	Nemeth M, Neumar RW, Nicholson T, Niermeyer S, Nikolaou N, Nishiyama C, O'Neil BJ,
16	Orkin AM, Osemeke O, Parr MJ, Patocka C, Pellegrino JL, Perkins GD, Perlman JM, Rabi Y,
17	Reynolds JC, Ristagno G, Roehr CC, Sakamoto T, Sandroni C, Sawyer T, Schmolzer GM,
18	Schnaubelt S, Semeraro F, Skrifvars MB, Smith CM, Smyth MA, Soll RF, Sugiura T, Taylor-
19	Phillips S, Trevisanuto D, Vaillancourt C, Wang TL, Weiner GM, Welsford M, Wigginton J,
20	Wyllie JP, Yeung J, Nolan JP, Berg KM, Collaborators. 2021 International Consensus on
21	Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment
22	Recommendations: Summary From the Basic Life Support; Advanced Life Support; Neonatal

1	Life Support; Education, Implementation, and Teams; First Aid Task Forces; and the COVID-19
2	Working Group. Circulation. 2022;145:e645-e721. doi: 10.1161/CIR.000000000001017
3	8. Macneil F, Chang WT, Singletary EM, Djärv T, on behalf of the International Liaison
4	Committee on Resuscitation First Aid Task Force. Use of Supplementary Oxygen in First Aid.
5	First Aid Task Force Synthesis of a Scoping Review. 2023. https://costr.ilcor.org/document/use-
6	of-supplementary-oxygen-in-first-aidfa-1549-tf-scr. Updated January 2, 2024.
7	9. Green BA, Eismont FJ, O'Heir JT. Pre-hospital management of spinal cord injuries.
8	Paraplegia. 1987;25:229-238. doi: 10.1038/sc.1987.41
9	10. Austin M, Wood-Baker R. Oxygen therapy in the pre-hospital setting for acute
10	exacerbations of chronic obstructive pulmonary disease. Cochrane Database Syst Rev.
11	2006:Cd005534. doi: 10.1002/14651858.CD005534.pub2
12	11. Kopsaftis Z, Carson-Chahhoud KV, Austin MA, Wood-Baker R. Oxygen therapy in the
13	pre-hospital setting for acute exacerbations of chronic obstructive pulmonary disease. Cochrane
14	Database Syst Rev. 2020;1:Cd005534. doi: 10.1002/14651858.CD005534.pub3
15	12. Austin MA, Wills KE, Blizzard L, Walters EH, Wood-Baker R. Effect of high flow
16	oxygen on mortality in chronic obstructive pulmonary disease patients in prehospital setting:
17	randomised controlled trial. Bmj. 2010;341:c5462. doi: 10.1136/bmj.c5462
18	13. Ntoumenopoulos G. Using titrated oxygen instead of high flow oxygen during an acute
19	exacerbation of chronic obstructive pulmonary disease (COPD) saves lives. J Physiother.
20	2011;57:55. doi: 10.1016/S1836-9553(11)70008-X
21	14. Wijesinghe M, Perrin K, Healy B, Hart K, Clay J, Weatherall M, Beasley R. Pre-hospital
22	oxygen therapy in acute exacerbations of chronic obstructive pulmonary disease. Intern Med J.
23	2011;41:618-622. doi: 10.1111/j.1445-5994.2010.02207.x

1	15.	Cameron L, Pilcher J, Weatherall M, Beasley R, Perrin K. The risk of serious adverse
2	outcor	nes associated with hypoxaemia and hyperoxaemia in acute exacerbations of COPD.
3	Postgr	rad Med J. 2012;88:684-689. doi: 10.1136/postgradmedj-2012-130809
4	16.	Ringbaek TJ, Terkelsen J, Lange P. Outcomes of acute exacerbations in COPD in relation
5	to pre-	hospital oxygen therapy. Eur Clin Respir J. 2015;2 doi: 10.3402/ecrj.v2.27283
6	17.	Lumholdt M, Cresciolo E, Monti A, Sørensen LR, Damgaard KA. Abstract 19: Pre-
7	hospit	al oxygen therapy and CO2 retention in patients admitted through the emergency
8	depart	ment. BMJ Open. 2017;7:A1 - A18.
9	18.	Bentsen LP, Lassen AT, Titlestad IL, Brabrand M. A change from high-flow to titrated
10	oxyge	n therapy in the prehospital setting is associated with lower mortality in COPD patients
11	with a	cute exacerbations: an observational cohort study. Acute Med. 2020;19:76-82.
12	19.	Pilcher J, Weatherall M, Perrin K, Beasley R. Oxygen therapy in acute exacerbations of
13	chroni	c obstructive pulmonary disease. Expert Rev Respir Med. 2015;9:287-293. doi:
14	10.158	86/17476348.2015.1016503
15	20.	Hodroge SS, Glenn M, Breyre A, Lee B, Aldridge NR, Sporer KA, Koenig KL, Gausche-
16	Hill M	I, Salvucci AA, Rudnick EM, Brown JF, Gilbert GH. Adult Patients with Respiratory
17	Distre	ss: Current Evidence-based Recommendations for Prehospital Care. West J Emerg Med.
18	2020;2	21:849-857. doi: 10.5811/westjem.2020.2.43896
19	21.	Gottlieb J, Capetian P, Hamsen U, Janssens U, Karagiannidis C, Kluge S, Nothacker M,
20	Roiter	S, Volk T, Worth H, Fühner T. German S3 Guideline: Oxygen Therapy in the Acute Care
21	of Adı	ult Patients. Respiration. 2022;101:214-252. doi: 10.1159/000520294
22	22.	Barnett A, Beasley R, Buchan C, Chien J, Farah CS, King G, McDonald CF, Miller B,
23	Munsi	f M, Psirides A, Reid L, Roberts M, Smallwood N, Smith S. Thoracic Society of Australia

- 1 and New Zealand Position Statement on Acute Oxygen Use in Adults: 'Swimming between the
- 2 flags'. Respirology. 2022;27:262-276. doi: 10.1111/resp.14218
- 3 23. Gude MF, Jensen AS. Standard vs Targeted Oxygen Therapy Prehospital for Chronic
- 4 Obstructive Pulmonary Disease (STOP-COPD): NCT05703919. 2023.
- 5 https://classic.clinicaltrials.gov/ct2/show/NCT05703919. Updated Nov 30, 2023. Accessed
- 6 December 26.
- 7 24. Jensen AS, Valentin JB, Mulvad MG, Hagenau VH, Skaarup AH, Johnsen SP,
- 8 Vaeggemose U, Gude MF. Standard vs. Targeted Oxygen Therapy Prehospitally for Chronic
- 9 Obstructive Pulmonary Disease (STOP-COPD); study protocol for a randomised controlled trial.
- 10 2023. https://assets.researchsquare.com/files/rs-2760789/v1/6878e346-9818-471a-a140-
- 11 051b8f6d41f1.pdf?c=1684531312. Accessed December 26.
- 12 25. Smith JS, Brandon S. Acute carbon monoxide poisoning--3 years experience in a defined
- 13 population. Postgrad Med J. 1970;46:65-70. doi: 10.1136/pgmj.46.532.65
- 14 26. Olson KR. Carbon monoxide poisoning: mechanisms, presentation, and controversies in
- 15 management. J Emerg Med. 1984;1:233-243. doi: 10.1016/0736-4679(84)90078-7
- 16 27. Kao LW, Nanagas KA. Toxicity associated with carbon monoxide. *Clin Lab Med.*
- 17 2006;26:99-125. doi: 10.1016/j.cll.2006.01.005
- 18 28. Koster LA, Rupp T. The silent killer: recognizing & treating carbon monoxide poisoning.
- 19 *JEMS*. 2003;28:80-87; quiz 88-89.
- 20 29. Winter PM, Miller JN. Carbon monoxide poisoning. Jama. 1976;236:1502.
- 21 30. Juttner B, Busch HJ, Callies A, Dormann H, Janisch T, Kaiser G, Korner-Gobel H, Kluba
- 22 K, Kluge S, Leidel BA, Muller O, Naser J, Pohl C, Reiter K, Schneider D, Staps E, Welslau W,

1	Wissuwa H, Wobker G, Muche-Borowski C. S2k guideline diagnosis and treatment of carbon
2	monoxide poisoning. Ger Med Sci. 2021;19:Doc13. doi: 10.3205/000300
3	31. Dick AP, Massey EW. Neurologic presentation of decompression sickness and air
4	embolism in sport divers. Neurology. 1985;35:667-671. doi: 10.1212/wnl.35.5.667
5	32. Liow MH, Chong SJ, Kang WL. A tale of three divers: recompression therapy for divers
6	with severe Type II decompression sickness with neurological deficits. Singapore Med J.
7	2009;50:e173-175.
8	33. Longphre JM, Denoble PJ, Moon RE, Vann RD, Freiberger JJ. First aid normobaric
9	oxygen for the treatment of recreational diving injuries. Undersea Hyperb Med. 2007;34:43-49.
10	34. Shinnick MA. Recognition of scuba diving accidents and the importance of oxygen first
11	aid. J Emerg Nurs. 1994;20:105-110.
12	35. Spira A. Diving and marine medicine review part II: diving diseases. <i>J Travel Med</i> .
13	1999;6:180-198. doi: 10.1111/j.1708-8305.1999.tb00857.x
14	36. Vann RD, Butler FK, Mitchell SJ, Moon RE. Decompression illness. <i>Lancet</i> .
15	2011;377:153-164. doi: 10.1016/s0140-6736(10)61085-9
16	37. Moon RE. Adjunctive therapy for decompression illness: a review and update. <i>Diving</i>
17	Hyperb Med. 2009;39:81-87.
18	38. Pollock NW, Buteau D. Updates in Decompression Illness. <i>Emerg Med Clin North Am.</i>
19	2017;35:301-319. doi: 10.1016/j.emc.2016.12.002
20	39. Whayne TF. Medical Management and Risk Reduction of the Cardiovascular Effects of
21	Underwater Diving. Curr Vasc Pharmacol. 2018;16:344-354. doi:
22	10.2174/1570161115666170621084316

- 1 40. Lippmann J. First aid oxygen administration for divers. *South Pacific Underwater*
- 2 Medicine Society Journal. 2003.
- 3 https://www.dhmjournal.com/images/33/DHM_Vol33_No4.pdf. Accessed December 28, 2023.
- 4 41. Blake DF, Crowe M, Lindsay D, Brouff A, Mitchell SJ, Leggat PA, Pollock NW.
- 5 Comparison of tissue oxygenation achieved breathing oxygen using different delivery devices
- 6 and flow rates. *Diving Hyperb Med*. 2020;50:34-42. doi: 10.28920/dhm50.1.34-42
- 7 42. Kule A, Bradley R, Flores-Bauer G, Stassen W, Djarv T; on behalf of the International
- 8 Liaison Committee on Resuscitation First Aid Task Force. First aid recognition of sepsis: a
- 9 scoping review. 2023. https://costr.ilcor.org/document/first-aid-recognition-of-sepsis-a-scoping-
- 10 review. Updated January 11, 2024. Accessed January 31, 2024.
- 11