

## ILCOR Summary Statement

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

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

Robert Greif, (EIT Chair); Janet E. Bray (BLS Chair); Therese Djärv (FA Chair); Ian R. Drennan  
(ALS Chair); Helen G Liley (Chair); Kee-Chong Ng (PLS Chair); Adam Cheng (EIT Vice  
Chair); Matthew J. Douma (FA Vice-Chair); Barnaby R. Scholefield (PLS Vice Chair); Michael  
Smyth (BLS Vice Chair); Gary Weiner (NLS Vice-Chair); Cristian Abelairas-Gómez; Jason  
Acworth; Natalie Anderson; Dianne L. Atkins; David Berry C.; Farhan Bhanji; Thomaz  
Bittencourt Couto; Bernd W. Böttiger; Richard N. Bradley; Jan Breckwoldt; Justin N. Carlson;  
Pascal Cassan; Wei-Tien Chang; Nathan P. Charlton; Christopher JD McKinlay; Sung Phil  
Chung; Julie Considine; Andrea Cortegiani; Daniele T. Costa-Nobre; Keith Couper; Katie  
Dainty; Vihara Dassanayake; Peter G. Davis; Jennifer A. Dawson; Maria Fernanda de Almeida;  
Allan R. de Caen; Charles D. Deakin; Guillaume Debaty; Jimena del Castillo; Maya Dewan;  
Bridget Dicker; Jana Djakow; Aaron J. Donoghue; Kathryn Eastwood; Walid El-Naggar; Raffo  
Escalante-Kanashiro; Jorge Fabres; Barbara Farquharson; Joe Fawke; Shannon M. Fernando;  
Emer Finan; Judith Finn; Gustavo E. Flores; Elizabeth E. Foglia; Fredrik Folke; Craig A.  
Goolsby\*; Asger Granfeldt; Anne-Marie Guerguerian; Ruth Guinsburg; Tetsuo Hatanaka; Karen  
G. Hirsch; Mathias J. Holmberg; Stuart Hooper; Amber V. Hoover; Ming-Ju Hsieh; Takanari  
Ikeyama; Tetsuya Isayama; Nicholas J. Johnson; Justin Josephsen; Anup Katheria; Mandira D

1 Kawakami; Monica Kleinman; David Kloeck; Ying-Chih Ko; Peter Kudenchuk; Amy Kule;  
2 Hiroshi Kurosawa; Jorien Laermans; Anthony Lagina; Kasper G Lauridsen; Eric J. Lavonas;  
3 Henry C. Lee; Swee Han Lim; Yiqun Lin; Andrew S. Lockey; Jesus Lopez-Herce; George  
4 Lukas; Finlay MacNeil; Ian K. Maconochie; John Madar; Carolina Malta Hansen; Abel  
5 Martinez-Mejas; Siobhan Masterson; Tasuku Matsuyama; Richard Mausling; Daniel Meyran;  
6 William Montgomery; Peter T. Morley; Laurie J. Morrison; Ari L. Moskowitz; Michelle  
7 Myburgh; Sabine Nabecker; Vinay Nadkarni; Firdose L. Nakwa; Kevin J. Nation; Ziad Nehme;  
8 Michael Nemeth; Tonia Nicholson; Nikolaos Nikolaou; Chika Nishiyama; Tatsuya Norii;  
9 Gabrielle Nuthall; Shinchiro Ohshimo; Theresa Olasveengen; Alexander Olausen; Gene Ong;  
10 Aaron Orkin; Michael J. Parr; Gavin D. Perkins; Helen Pocock; Yacov Rabi; Violetta Raffay;  
11 James Raitt; Tia Raymond; Giuseppe Ristagno; Antonio Rodriguez-Nunez; Joseph Rossano;  
12 Mario Rüdiger; Claudio Sandroni; Taylor L. Sawyer; Stephen M. Schexnayder; Georg  
13 Schmölzer; Sebastian Schnaubelt; Anna Lene Seidler; Federico Semeraro; Takahiro Sigiura;  
14 Eunice M. Singletary; Markus B. Skrifvars; Christopher M Smith; Jasmeet Soar; Anne Lee  
15 Solevåg; Roger Soll; Willem Stassen; Kaushila Thilakasiri; Janice Tijssen; Lokesh Kumar  
16 Tiwari; Alexis Topjian; Daniele Trevisanuto; Christian Vaillancourt; Michelle Welsford; Myra  
17 H. Wyckoff; Chih-Wei Yang; Joyce Yeung; Carolyn M. Zelop; David A. Zideman; Jerry P.  
18 Nolan, MBChB (Sr Editor); Katherine M. Berg, MD (Sr Editor)

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.

21

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  
14 support, neonatal, first aid

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

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

## 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.

11 Draft CoSTRs for all topics evaluated with SysRevs were posted on a rolling basis  
12 between December 1, 2023, and January 24, 2024, on the ILCOR website.<sup>1</sup> 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  $\approx$ 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)  
22 terminology,<sup>2</sup> making it more accessible to a wider audience, and in some cases only the high-  
23 priority outcomes are reported. The Justification and Evidence-to-Decision Framework

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

6 The CoSTRs are based on analysis of the data using the GRADE approach.<sup>2</sup> 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.

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.

11 The third and least rigorous form of evidence evaluation is the evidence update (EvUp),  
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<sup>3</sup> 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>

DRAFT

## 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  
5 reviewed since 2019.<sup>1,2</sup> Since the last systematic review (SysRev) of this topic,<sup>3</sup> the task force  
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  
8 for the 2020 CoSTR.<sup>1,2</sup> The SysRev was registered before initiation (International Prospective  
9 Register of Systematic Reviews [PROSPERO] CRD42017080475). The full online CoSTR can  
10 be found on the ILCOR website.<sup>4</sup>

#### 11 *Population, Intervention, Comparator, Outcome, Study Design, and Time Frame*

- 12 ● Population: For adults or children in cardiac arrest (OHCA and in-hospital cardiac arrest  
13 [IHCA])
- 14 ● Intervention: The performance of CPR using a hard surface (eg, backboard, floor, or  
15 deflatable or specialist mattress)
- 16 ● Comparators: The performance of CPR on a regular mattress or other soft surface
- 17 ● Outcomes: Survival with a favorable neurological outcome at hospital discharge/30 days  
18 (critical), survival at hospital discharge/30 days (critical), event survival (important),  
19 return of spontaneous circulation (ROSC) (important), CPR quality (eg, compression  
20 depth, compression rate, compression fraction) (important)
- 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<sup>5-15</sup> identified in the previous review,<sup>3</sup> we  
 8 identified 1 small observational study<sup>16</sup> and 6 additional manikin RCTs<sup>17-22</sup> 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.<sup>16</sup> Results of the meta-analysis of data from the manikin  
 16 simulation studies are given in Table 1.

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

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

|   |   |
|---|---|
|   | No meta-analysis performed. No significant difference.  |
| <b>Floor compared with firm home mattress</b> |   |
| Compression depth                             | 2 mannikin RCTs <sup>15,22</sup><br>Mean difference = 2.11 millimeters (95% CI -3.23 to 7.45) |
| Compression rate                              | 2 mannikin RCTs <sup>15,22</sup><br>No meta-analysis performed. No significant difference.    |

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

2 ***Prior Treatment Recommendations (2020<sup>1,2</sup>)***

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***

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

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

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

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

6 For health care systems that have not introduced backboards, the limited improvement in  
7 compression depth and uncertainty about harms seemed insufficient to justify the costs of  
8 purchasing backboards and training staff in their use (weak recommendation, very low–certainty  
9 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  
15 depth, with greater compression seen in softer mattresses.<sup>23-25</sup> This can lead to reduced spinal-  
16 sternal displacement and a reduction in effective chest compression depth. It is known that  
17 effective compression depths can be achieved on soft surfaces if the CPR provider increases  
18 overall compression depth to compensate for mattress compression.<sup>26-29</sup> 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  
21 depth when CPR is performed on a mattress.<sup>7,29-31</sup>

22 In making these recommendations, the task force considered the importance of high-  
23 quality chest compressions and minimizing delays to the initiation of CPR and the lack of human



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.<sup>32-35</sup>

## 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.<sup>1,2</sup> 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.<sup>36</sup>

### 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.<sup>37-96</sup> 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.<sup>36</sup>

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

| Categories  | Subcategories  |
|---|--|
| <b>Factors related to dispatcher-assisted recognition</b> |  |
| Communication between caller and dispatcher (n=16)        | 1. Caller’s emotional state<br>2. Caller’s proximity to OHCA patient |

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

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

3 ***Task Force Insights***

- 4 ● 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.
- 8 ● 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 *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.<sup>1,2</sup> Although the certainty of evidence was rated as very low at that time,  
5 dispatcher-assisted CPR (DA-CPR) has been implemented widely,<sup>97-100</sup> 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.<sup>101,102</sup> The full online  
10 CoSTR can be found on the ILCOR website.<sup>103</sup>

## 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.

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

#### ***Summary of Evidence***

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

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

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

The studies that focus on simplifying the compression instruction language (ie, “Push as hard as you can” versus “Push approximately 2 inches/5 cm”) suggest an improvement in the

1 quality of CPR.<sup>111,112,120,128</sup> 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).<sup>114-118,130</sup>

#### 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,<sup>134,135</sup> but use  
18 is currently infrequent.<sup>136</sup> 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<sup>100,137</sup> and the need  
20 to optimize systems to improve the public's AED use.<sup>138,139</sup> 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.<sup>140</sup>

## 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 OHCA<sup>s</sup><sup>141-145</sup> and 11 simulation studies (6 RCTs,<sup>146-151</sup> 1 nonrandomized trial,<sup>152</sup> and 4  
14 observational<sup>153-156</sup>).

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) OHCA<sup>s</sup>  
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.<sup>143</sup>

19 In systems using DA-AED retrieval and use, 5 observational studies reported low rates of  
20 AED retrieval (0.8%–5.8%<sup>141,142,144</sup>), pad application (0.4%–1.7%<sup>142,144,145</sup>), and shocks  
21 delivered (2.4%–11%<sup>141,143</sup>). 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  $p < 0.001$ ).<sup>143</sup> Another observational study reported confusion



1 and delays in the emergency call following a 3-part instruction to retrieve an AED.<sup>141</sup> Callers  
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,  
4 was longer when dispatcher assistance was provided than when there was no assistance.<sup>146,157</sup>  
5 However, when time to retrieve an AED was factored in, time to first shock was shorter.<sup>149,158</sup>

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

### 15 ***Task Force Insights***

- 16 ● There is limited published research in this area, particularly on the impact on patient  
17 outcomes.
- 18 ● Given the majority of OHCA's occur in the home, public-access AEDs are likely to be in  
19 close proximity in only a minority of cases, and fewer still are likely able to be located,  
20 retrieved, and attached to a patient in a meaningful time frame.
- 21 ● Research is emerging on the user-friendliness of different AED brands.<sup>162,163</sup>
- 22 ● There is a risk that by implementing dispatcher instructions to retrieve and use public-  
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

- 1       ● The risks associated with dispatcher instructions for public-access AED retrieval and use
- 2           during an emergency call
- 3       ● What contribution dispatcher instructions for public-access AED retrieval and use have in
- 4           the overall community and EMS response to OHCA
- 5       ● The barriers and facilitators to dispatcher instruction for public-access AED retrieval and
- 6           use
- 7       ● Which specific interventions will increase bystander retrieval and use of a public-access
- 8           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.<sup>1,2</sup> 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.<sup>164</sup>

### 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,<sup>165-174</sup> 5 RCTs,<sup>175-179</sup> 37  
 21 observational studies,<sup>180-215</sup> 2 case series,<sup>216,217</sup> and 1 commentary.<sup>218</sup> The patients included  
 22 varied widely between studies. Only 3 studies included children,<sup>209,211,219</sup> and most of the  
 23 evidence consisted of before-and-after studies.

1 The use of metronomes was examined in 1 SysRev from 2014<sup>174</sup> and 6 observational  
2 studies (3 OHCA and 3 IHCA).<sup>180-185</sup> This evidence suggests an associated improvement in CPR  
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,<sup>165-173</sup> 5 RCTs,<sup>175-179</sup> 31  
7 observational studies,<sup>186-215,219</sup> and 2 case series.<sup>216,217</sup> 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.<sup>1,2</sup>

### 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

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

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

### Knowledge Gaps

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

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

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

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

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

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



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

1 CPR indicates cardiopulmonary resuscitation; IHCA, in-hospital cardiac arrest; OHCA, out-of-hospital cardiac  
2 arrest; and RCT, randomized controlled trials.

3 \*High-performance training (audiovisual feedback, scenario-based training, checklist, team leader, and debriefing)

4 †Audiovisual feedback and debriefing

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

2 §High-performance CPR education and audiovisual feedback

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

#### 4 ***Rationale for Review***

5 Early defibrillation is associated with a large increase in survival from OHCA.<sup>220-223</sup> If  
6 defibrillation occurs within 3 to 5 minutes of collapse, survival rates as high as 50% to 70% have  
7 been reported.<sup>222,223</sup> EMS response times rarely enable delivery of defibrillation in such a short  
8 time.<sup>224</sup> 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.<sup>225</sup>

#### 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**

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

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

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

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

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

#### 4 ***Task Force Insights***

- 5
- 6 • Ultraportable or pocket AEDs are a new generation of defibrillators characterized by  
7 small size, being lightweight and easy to carry on one's person, and affordable for  
8 personal and home use.
  - 9 • We acknowledge that the development of ultraportable or pocket and more affordable  
10 AEDs offers the unique opportunity to develop more efficient public access defibrillation  
11 or community volunteer responder programs, increase home AED availability, and  
12 therefore improve outcomes.
  - 13 • Device registration with regulatory authorities alone does not provide evidence of device  
14 performance in real-world settings. Because the success of defibrillation is related to  
15 several factors, including shock energy, transthoracic impedance, defibrillator pad size  
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  
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.

2 **Table 6. BLS Topics Reviewed by Evidence Updates**

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

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

| 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 positioning (BLS 2502) | 2020              | We suggest performing chest compressions on the lower half of the sternum on adults in cardiac arrest (weak recommendation, very low certainty evidence).   | 0                      | 0                                       | No new studies.  | No                                 |
| Head-Up CPR (BLS 2503)      | 2021              | We suggest against the routine use of head-up CPR during CPR (weak recommendation, very-low-certainty evidence).<br><br>We suggest that the usefulness of head-up CPR during CPR be assessed in clinical trials or research initiatives (weak recommendation, very-low-certainty evidence). | 0                      | 2                                       | High risk of bias. No difference in outcomes in propensity-matched cohort. | No                                 |

1 BLS indicates basic life support; CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; PAD, public access defibrillation, PICO,  
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.0000000000000892
- 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-](https://costr.ilcor.org/document/firm-surface-for-cpr-an-updated-systematic-review-bls-2510)  
21 [cpr-an-updated-systematic-review-bls-2510](https://costr.ilcor.org/document/firm-surface-for-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, Komazawa 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. *PLoS 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, Houthoofd 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
- 17 23. Lin Y, Wan B, Belanger C, Hecker K, Gilfoyle E, Davidson J, Cheng A. Reducing the  
18 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 Berkomp 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. Beeseems 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. Hellevo H, Sainio M, Huhtala H, Olkkola KT, Tenhunen J, Hoppu S. The quality of  
19 manual chest compressions during transport--effect 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.0000000000000245
- 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:

- 1 [https://costr.ilcor.org/document/optimization-of-dispatcher-assisted-da-recognition-of-](https://costr.ilcor.org/document/optimization-of-dispatcher-assisted-da-recognition-of-ohca-a-scoping-review-bls-2102-scr)  
2 [ohca-a-scoping-review-bls-2102-scr.](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-of-  
8 hospital cardiac arrest recognition and dispatcher-assisted cardiopulmonary resuscitation.  
9 *Emerg Med J.* 2019;36:595-600. doi: 10.1136/emered-2018-208353
- 10 39. Missel AL, Dowker SR, Chiola M, Platt J, Tsutsui J, Kasten K, Swor R, Neumar RW,  
11 Hunt N, Herbert L, et al. Barriers to the Initiation of Telecommunicator-CPR during 9-1-  
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/emered-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? *Emerg Med J*. 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, Riesenber 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 Ghuyssen 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/emered-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. Schwarzkopf 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. Olsveengen 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. Olsveengen 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.0000000000000541

- 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-](https://costr.ilcor.org/document/optimization-of-dispatcher-assisted-cpr-instructions-a-scoping-review-bls-2113-scr)  
6 [assisted-cpr-instructions-a-scoping-review-bls-2113-scr](https://costr.ilcor.org/document/optimization-of-dispatcher-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. *Emergency medicine journal : EMJ*. 2013;30:657-661.  
19 doi: 10.1136/emered-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.0000000000002392

- 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.00000000000022728
- 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.00000000000029298
- 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



- 1 Force, 2024 January 8. [https://costr.ilcor.org/document/optimization-of-dispatcher-](https://costr.ilcor.org/document/optimization-of-dispatcher-assisted-public-access-aed-retrieval-and-use-a-scoping-review-bls-2120)
- 2 [assisted-public-access-aed-retrieval-and-use-a-scoping-review-bls-2120](https://costr.ilcor.org/document/optimization-of-dispatcher-assisted-public-access-aed-retrieval-and-use-a-scoping-review-bls-2120).
- 3 141. Perera N, Ball S, Birnie T, Morgan A, Riou M, Whiteside A, Perkins GD, Bray J,  
4 Fatovich DM, Cameron P, et al. "Sorry, what did you say?" Communicating defibrillator  
5 retrieval and use in OHCA emergency calls. *Resuscitation*. 2020;156:182-189. doi:  
6 10.1016/j.resuscitation.2020.09.006
- 7 142. Gardett I, Broadbent M, Scott G, Clawson JJ, Olola C. Availability and Use of an  
8 Automated External Defibrillator at Emergency Medical Dispatch. *Prehosp Emerg Care*.  
9 2019;23:683-690. doi: 10.1080/10903127.2018.1559565
- 10 143. Kaneko T, Tanaka H, Uezono K. Dispatcher-assisted cardiopulmonary resuscitation  
11 improves the neurological outcomes of out-of-hospital cardiac arrest victims: a  
12 retrospective analysis of prehospitalization records in Kumamoto City. *Crit Care Shock*.  
13 2019;22:9-15.
- 14 144. Agerskov M, Nielsen AM, Hansen CM, Hansen MB, Lippert FK, Wissenberg M, Folke  
15 F, Rasmussen LS. Public Access Defibrillation: Great benefit and potential but  
16 infrequently used. *Resuscitation*. 2015;96:53-58. doi:  
17 papers3://publication/doi/10.1016/j.resuscitation.2015.07.021
- 18 145. Deakin CD, Shewry E, Gray HH. Public access defibrillation remains out of reach for  
19 most victims of out-of-hospital sudden cardiac arrest. *Heart*. 2014;100:619-623. doi:  
20 papers3://publication/doi/10.1136/heartjnl-2013-305030
- 21 146. Bang JY, Cho Y, Cho GC, Lee J, Kim IY. Can Mobile Videocall Assist Laypersons' Use  
22 of Automated External Defibrillators? A Randomized Simulation Study and Qualitative  
23 Analysis. *Biomed Res Int*. 2020;2020:4069749. doi: 10.1155/2020/4069749

- 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

- 1 Simulation Trial in a Community Setting. *Simul Healthc.* 2022;17:22-28. doi:  
2 10.1097/sih.0000000000000582
- 3 154. Maes F, Marchandise S, Boileau L, le Polain de Waroux J-B, Scavée C. Evaluation of a  
4 new semiautomated external defibrillator technology: a live cases video recording study.  
5 *Emerg Med J.* 2015;32:481-485. doi: papers3://publication/doi/10.1136/emered-2013-  
6 202962
- 7 155. Sanfridsson J, Sparrevik J, Hollenberg J, Nordberg P, Djärv T, Ringh M, Svensson L,  
8 Forsberg S, Nord A, Andersson-Hagiwara M, et al. Drone delivery of an automated  
9 external defibrillator – a mixed method simulation study of bystander experience. *Scand*  
10 *J Trauma Resusc Emerg Med.* 2019;27:40.
- 11 156. You JS, Park S, Chung SP, Park JW. Performance of cellular phones with video  
12 telephony in the use of automated external defibrillators by untrained laypersons. *Emerg*  
13 *Med J.* 2008;25:597-600.
- 14 157. Ecker R, Rea TD, Meischke H, Schaeffer SM, Kudenchuk P, Eisenberg MS. Dispatcher  
15 assistance and automated external defibrillator performance among elders. *Academic*  
16 *emergency medicine : official journal of the Society for Academic Emergency Medicine.*  
17 2001;8:968-973. doi: papers3://publication/uuid/275C498E-E077-40BE-AD77-  
18 3E46023597A5
- 19 158. Riyapan S, Lubin J. Emergency dispatcher assistance decreases time to defibrillation in a  
20 public venue: a randomized controlled trial. *The American journal of emergency*  
21 *medicine.* 2016;34:590-593. doi: papers3://publication/doi/10.1016/j.ajem.2015.12.015
- 22 159. Kim HJ, Kim JH, Park D. Comparing audio- and video-delivered instructions in  
23 dispatcher-assisted cardiopulmonary resuscitation with drone-delivered automatic

- 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/emmermed-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, Nikolettou 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

- 1 review and meta-analysis. *Medicine (Baltimore)*. 2022;101:e30438. doi:  
2 10.1097/md.00000000000030438
- 3 172. Wang SA, Su CP, Fan HY, Hou WH, Chen YC. Effects of real-time feedback on  
4 cardiopulmonary resuscitation quality on outcomes in adult patients with cardiac arrest:  
5 A systematic review and meta-analysis. *Resuscitation*. 2020;155:82-90. doi:  
6 10.1016/j.resuscitation.2020.07.024
- 7 173. Schultz RB, B.; Bhanji F.; Lang, E. Plenary Oral Presentations. *CJEM*. 2015;17:S41-S42.  
8 doi: 10.1017/cem.2015.50
- 9 174. Targett C, Harris T. Towards evidence-based emergency medicine: Best BETs from the  
10 Manchester Royal Infirmary. BET 3: Can metronomes improve CPR quality? *Emerg Med*  
11 *J*. 2014;31:251-254. doi: 10.1136/emered-2014-203617.3
- 12 175. Bohn A, Weber TP, Wecker S, Harding U, Osada N, Van Aken H, Lukas RP. The  
13 addition of voice prompts to audiovisual feedback and debriefing does not modify CPR  
14 quality or outcomes in out of hospital cardiac arrest--a prospective, randomized trial.  
15 *Resuscitation*. 2011;82:257-262. doi: 10.1016/j.resuscitation.2010.11.006
- 16 176. Hostler D, Everson-Stewart S, Rea TD, Stiell IG, Callaway CW, Kudenchuk PJ, Sears  
17 GK, Emerson SS, Nichol G. Effect of real-time feedback during cardiopulmonary  
18 resuscitation outside hospital: prospective, cluster-randomised trial. *Bmj*. 2011;342:d512.  
19 doi: 10.1136/bmj.d512
- 20 177. Vahedian-Azimi A, Rahimibashar F, Miller AC. A comparison of cardiopulmonary  
21 resuscitation with standard manual compressions versus compressions with real-time  
22 audiovisual feedback: A randomized controlled pilot study. *Int J Crit Illn Inj Sci*.  
23 2020;10:32-37. doi: 10.4103/ijciis.ijciis\_84\_19

- 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, Dhmoon 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.0000000000001202
- 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, Sørebo 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, Nikoietou 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: *Resuscitation*. 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](https://costr.ilcor.org/document/effectiveness-of-ultra-portable-or-pocket-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**

### 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).<sup>1-3</sup> 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.<sup>4</sup>

#### 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<sub>2</sub>, PaO<sub>2</sub>,  
14            and/or PaCO<sub>2</sub>
- 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.

- 4 • 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.<sup>5-9</sup> These studies add to the  
 7 previous SysRev, which included 7 RCTs.<sup>2,10-16</sup> Studies used a variety of specific oxygen and  
 8 carbon dioxide strategies or targets, as defined in Table 7.

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

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

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

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

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

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

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

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

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

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

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

### 3 *Prior Treatment Recommendations (2020)*<sup>1,3</sup>

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 ( $\approx 10\text{--}13$  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  $\approx 4.7\text{--}6.0$  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.<sup>5</sup> 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 PaO<sub>2</sub> 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 that targeting an oxygen saturation of 94% to 98% or a PaO<sub>2</sub> target of 75 to 100 mm Hg  
2 (10–13 kPa) is reasonable.

- 3 ● While studies evaluating the accuracy of pulse oximetry in people with different degrees  
4 of skin pigmentation were not part of this SysRev, the SysRev team and task forces were  
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  
7 saturation by blood gas is <88%) in people with dark skin.<sup>17-19</sup> While none of these  
8 studies were done in cardiac arrest patients, the task forces concluded that it was  
9 important to make medical professionals treating cardiac arrest patients aware of this  
10 issue because this knowledge could inform decision-making about whether to titrate  
11 supplemental oxygen. The task forces, therefore, provided a good practice statement to  
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 CO<sub>2</sub> targets. Considering the lack of evidence for benefit  
16 or harm from targeting CO<sub>2</sub> values above or below the normal range, the task forces  
17 deemed it reasonable to target normocapnia, generally defined as a PaCO<sub>2</sub> of 35 to 45 mm  
18 Hg, in both RCTs and observational studies. Notably, the task forces are aware of  
19 unpublished data from one RCT<sup>5</sup> as well observational studies not included in this  
20 review,<sup>20-23</sup> suggesting that ETCO<sub>2</sub> values may not accurately reflect PaCO<sub>2</sub> values, which  
21 may be an important consideration in the prehospital setting. As with all critically ill  
22 patients, there may be specific scenarios in which CO<sub>2</sub> 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<sub>2</sub> retention might respond differently to different CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> with PaCO<sub>2</sub> values
- 13 ● The effects of manipulating PaCO<sub>2</sub> on cerebral blood flow in post–cardiac arrest patients
- 14 ● How PaCO<sub>2</sub> targets should be adjusted in patients with chronic CO<sub>2</sub> 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,<sup>24,25</sup> and an EvUp was conducted in 2020.<sup>1,3</sup> 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



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 adoption.<sup>26</sup> The complete CoSTR can be found online.<sup>27</sup>

#### 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.<sup>28-31</sup> 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

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)***<sup>24,25</sup>

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 ● The 4 RCTs conducted since the prior review provide significant new evidence but have  
23 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,<sup>32-34</sup> 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.<sup>35</sup>
- 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,<sup>36</sup> 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.<sup>37</sup>

1 ***Population, 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

- Study designs: Controlled trials in humans, including RCTs and nonrandomized trials (eg, pseudorandomized trials), were included. Observational studies, ecological studies, case series, case reports, reviews, abstracts, editorials, comments, letters to the editor, and unpublished studies were excluded. Studies assessing cost-effectiveness were included for a descriptive summary. Unpublished studies (eg, conference abstracts, trial protocols) were excluded. All languages were included if there was an English abstract.
- Time frame: The original literature search was performed on October 30, 2020, and updated for clinical trials on June 17, 2021. The literature search was conducted on May 31, 2023, for the updated SysRev and on June 3, 2023, for ongoing clinical trials.

## *Consensus on Science*

### *Note on Terminology*

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

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

This updated search yielded 6 new trials investigating different aspects of post-cardiac arrest temperature control, adding to the 32 trials identified in the previous review. Comparisons included temperature control versus no temperature control, timing of temperature control, specific temperature targets, durations of temperature control, methods of temperature control,

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)                                     |
|--|--------------------------------------|------------------------------|-------------------|--|
| <b>Hypothermia (32–34 °C) compared with normothermia or fever prevention</b>             |                                      |                              |                   |  |
| Survival to hospital discharge (critical)  | 3074 (6 RCTs) <sup>38-43</sup>       | Low                          | 1.07 (0.91-1.25)  | 32 more per 1000 patients (41 fewer to 114 more) |
| Survival with favorable neurological outcome at hospital discharge or 30 days (critical) | 2377 (4 RCTs) <sup>38,39,42,43</sup> | Low                          | 1.16 (0.81-1.66)  | 59 more per 1000 patients (70 fewer to 243 more) |
| Survival to 90 or 180 days (critical)  | 3014 (6 RCTs) <sup>39-44</sup>       | Low                          | 1.06 (0.91, 1.23) | 25 more per 1000 patients (38 fewer to 97 more)  |
| Survival with favorable neurological outcome at 90 or 180 days (critical)                | 2991 (6 RCTs) <sup>39-44</sup>       | Low                          | 1.16 (0.92, 1.47) | 57 more per 1000 patients (28 fewer to 166 more) |
| <b>33 °C compared with 36 °C</b>   |                                      |                              |                   |  |
| Survival with favorable neurological   | 938 (1 RCT) <sup>45</sup>            | Low                          | 0.96 (0.83, 1.11) | 18 fewer per 1000 patients (78 fewer to 50 more) |

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



| Outcome (importance)   | Participants, n (studies)     | Certainty of evidence, GRADE | RR (95% CI)       | ARD (95% CI)                                       |
|--|-------------------------------|------------------------------|-------------------|--|
| Favorable neurological outcome at hospital discharge or 28 days (critical) | 523 (3 RCTs) <sup>49-51</sup> | Low                          | 1.22 (0.95, 1.56) | 64 more per 1000 patients (15 fewer to 163 more)   |
| <b>Rewarming rate (0.25 °C/h compared with 0.50 °C/h)</b>                  |                               |                              |                   |  |
| Survival at 90 days (critical)   | 50 (1 RCT) <sup>52</sup>      | Low                          | 0.88 (0.56, 1.38) | 77 fewer per 1000 patients (282 fewer to 243 more) |
| Favorable neurological outcome at 90 days                                  | 50 (1 RCT) <sup>52</sup>      | Low                          | 1.00 (0.59, 1.70) | 0 fewer per 1000 patients (213 fewer to 364 more)  |
| <b>Duration of fever prevention after initial temperature control</b>      |                               |                              |                   |  |
| Survival at 90 days (critical)   | 789 (1 RCT) <sup>53</sup>     | Low                          | 0.99 (0.90, 1.08) | 7 fewer per 1000 patients (80 fewer to 56 more)    |
| Favorable neurological outcome at 90 days (critical)                       | 789 (1 RCT) <sup>53</sup>     | Low                          | 0.98 (0.89, 1.08) | 14 fewer per 1000 patients (74 fewer to 54 more)   |

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

### 3 **2024 Treatment Recommendations and Good Practice Statements (Unchanged)**

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

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<sup>54,55</sup>)***

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.
- 4 ● The task force acknowledged that the SysRev found no difference in overall outcomes  
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  
8 SysRevs and because this intervention requires fewer resources and had fewer side  
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  
11 include findings of a single trial suggesting benefit in those with a nonshockable initial  
12 rhythm<sup>41</sup> and the relatively few data in patients with cardiac arrest of a noncardiac  
13 etiology.
- 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  
16 achieve this.
- 17 ● Although there was no direct evidence in our SysRevs, the task force maintained the  
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,<sup>56</sup>  
12 while the other found no association with survival or neurological outcomes.<sup>57</sup>

### 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,<sup>48</sup> and  
17 another found no difference between 12 to 24 and 36 hours of hypothermia.<sup>47</sup>
- 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.<sup>53</sup> 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.<sup>1,3</sup> 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.<sup>58</sup>

### 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.

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.<sup>59,60</sup> Agents used for prophylaxis  
10 included thiopentone,<sup>59</sup> magnesium, diazepam, and the combination of magnesium and  
11 diazepam,<sup>60</sup> 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.<sup>61</sup>

##### 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]).<sup>62</sup> There was  
22 also no difference in survival.

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).<sup>1,3</sup>

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).<sup>63</sup>

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

| Category                           | Definition   |
|------------------------------------|--|
| Electrographic seizure             | <ul style="list-style-type: none"> <li>● Epileptiform discharges averaging &gt;2.5 Hz for <math>\geq 10</math> s (&gt;25 discharges in 10 s)</li> </ul> <p style="text-align: center;"><i>or</i></p> <ul style="list-style-type: none"> <li>● Any pattern with definite evolution as defined above and lasting <math>\geq 10</math> s</li> </ul>             |
| Electroclinical seizure            | <p>Any EEG pattern with either</p> <ul style="list-style-type: none"> <li>● Definite clinical correlate time-locked to the pattern (of any duration)</li> </ul> <p style="text-align: center;"><i>or</i></p> <ul style="list-style-type: none"> <li>● EEG <b>and</b> clinical improvement with a parenteral (typically IV) antiseizure medication</li> </ul> |
| Electroclinical status epilepticus | <p>An electroclinical seizure for</p> <ul style="list-style-type: none"> <li>● <math>\geq 10</math> continuous min</li> </ul> <p style="text-align: center;"><i>or</i></p> <ul style="list-style-type: none"> <li>● A total duration of <math>\geq 20\%</math> of any 60-min period of recording <i>or</i></li> </ul>  |

| Category                   | Definition  |
|----------------------------|---|
|                            | <ul style="list-style-type: none"> <li>• <math>\geq 5</math> 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 <math>&gt;10</math> min</li> </ul> <p><i>Possible ECSE:</i> A pattern on the ictal-interictal continuum that is present for <math>\geq 10</math> continuous min or for a total duration of <math>&gt;20\%</math> of any 60-min period of recording, which shows EEG improvement with a parenteral antiseizure medication <b>but</b> without clinical improvement</p>  |
| Ictal-interictal continuum | <ul style="list-style-type: none"> <li>• Any PD or SW pattern that averages <math>&gt;1.0</math> Hz and <math>&lt;2.5</math> Hz over 10 s (<math>&gt;10</math> and <math>&lt;25</math> discharges in 10 s)</li> </ul> <p><i>or</i></p> <ul style="list-style-type: none"> <li>• Any PD or SW pattern that averages <math>&gt;0.5</math> Hz and <math>&lt;1</math> Hz over 10 s (<math>&gt;5</math> and <math>&lt;10</math> discharges in 10 s) and has a plus modifier or fluctuation</li> </ul> <p><i>or</i></p> <ul style="list-style-type: none"> <li>• Any lateralized RDA averaging <math>&gt;1</math> Hz for at least 10 s (at least 10 waves in 10 s) with a plus modifier or fluctuation</li> </ul> <p><i>and</i></p> <ul style="list-style-type: none"> <li>• Does not qualify as an electrographic seizure or electroclinical status epilepticus</li> </ul> |

1 ACNS indicates American Clinical Neurophysiology Society; ECSE, electroclinical status epilepticus; EEG,  
2 electroencephalogram; IV, intravenous; PD, periodic discharge; RDA, rhythmic delta activity; SE, status epilepticus;  
3 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.<sup>62</sup>
- 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.<sup>64</sup>
- 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.<sup>65</sup> 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).<sup>66,67</sup> 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.<sup>68</sup>

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

- 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.<sup>69</sup> This adds to the 3 RCTs identified in the previous

20 review.<sup>67,70-72</sup> 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.

DRAFT

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

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

3 \*Favorable functional outcome defined as mRS score of 0 to 3 or CPC score of 1 to 2.

4 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<sup>70</sup> enrolled  
3 OHCA patients with an initial shockable rhythm and randomized patients upon hospital  
4 arrival, whereas the trials by Hsu et al<sup>71</sup> and Belohlavek et al<sup>72</sup> enrolled OHCA with any  
5 initial rhythm and randomized patients in the prehospital setting. The trial by Suverein et  
6 al<sup>69</sup> 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

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

## 6   **Cardiac Arrest During Pregnancy (ALS 3401: ScopRev)**

### 7   ***Rationale for Review***

8           Cardiac arrest during pregnancy is a rare but catastrophic event. Physiologic changes

9   during pregnancy and concerns about both maternal and fetal survival bring additional

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

13   ScopRev, including detailed tables describing the individual studies, can be found online.<sup>73</sup>

### 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)
- 17       ● Intervention: Any specific intervention(s)
- 18       ● Comparators: Standard care or usual resuscitation practice
- 19       ● Outcomes:
- 20           – Maternal
- 21           Critical: Survival and favorable functional outcome at hospital discharge, 30 days, 60
- 22           days, 180 days, or 1 year
- 23           Important: ROSC

1 – Neonatal

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

4 Important: ROSC

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

13 ***Summary of Evidence***

14 This ScopRev identified 8 heterogeneous studies describing several interventions for  
15 cardiac arrest during pregnancy.<sup>74-81</sup> The studies are substantially limited by lack of granularity,  
16 small sample sizes, indirect measures of interventional effects, and high degrees of bias and  
17 confounding.

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

22 Indirect data from a porcine model demonstrated significantly higher coronary perfusion  
23 pressures during resuscitation with supine positioning with left-lateral uterine displacement

1 compared with left-lateral tilt positioning (perfusion pressure of 20 mm Hg compared with 5  
2 mm Hg,  $P < 0.05$ ).<sup>76</sup> Five observational studies reported data supporting performing perimortem  
3 cesarean or resuscitative delivery when ROSC does not occur early during resuscitation of  
4 cardiac arrest in a pregnant person with a uterine size  $\geq 20$  weeks' gestation.<sup>77-81</sup> The median  
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  
9 cardiac arrest, despite the potential of bleeding and clotting complications.<sup>74,75</sup>

#### 10 ***Task Force Insights***

11 The task force prioritized this topic because of the ongoing burden of mortality during  
12 pregnancy (estimated at 287 000 deaths globally in 2020, with mortality increasing in some  
13 countries, such as the United States).<sup>82,83</sup> The prevalence of cardiac arrest during hospitalizations  
14 for delivery in the United States from 2017 to 2019 rose to 1/9000, previously reported as  
15 1/12 000 in 2014 using the US National Inpatient Sample database.<sup>84</sup> Cardiac arrest is the final  
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.<sup>85</sup>

### 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<sup>86</sup> and 68 observational studies from prehospital, in-  
20 hospital, and military settings.<sup>87-154</sup> No studies specifically focused on cardiac arrest.

21 The RCT compared emergency cricothyrotomy and emergency percutaneous dilational  
22 tracheostomy in 169 patients (9 with cardiac arrest) with failed airway management in the

1 emergency department.<sup>86</sup> 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**

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

| 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 consciousness (ALS 3004) | 2021              | <p>In settings in which it is feasible, rescuers may consider using sedative or analgesic drugs (or both) in very small doses to prevent pain and distress to patients who are conscious during CPR (good practice statement).</p> <p>Neuromuscular-blocking drugs alone should not be given to conscious patients (good practice statement).</p> <p>The optimal drug regimen for sedation and analgesia during CPR is uncertain. Regimens can be based on those used in critically ill patients and according to local protocols (good practice statement).</p> | 0                      | 5                                       | Incidence of CPRIC appears to be high, with 57% of UK paramedics witnessing CPRIC. CPRIC is associated with memory and awareness of events and may have longer-lasting psychological sequelae (depression, anxiety, PTSD). It is unclear how to best treat CPRIC or whether treatment improves patient care and outcomes. | No                                 |

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

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

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

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.0000000000000893
- 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-](https://costr.ilcor.org/document/oxygen-and-carbon-dioxide-targets-in-patients-with-return-of-spontaneous-circulation-after-cardiac-arrest-als-sr)  
8 [spontaneous-circulation-after-cardiac-arrest-als-sr](https://costr.ilcor.org/document/oxygen-and-carbon-dioxide-targets-in-patients-with-return-of-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.  
13 *JAMA*. 2022;328:1818-1826. doi: 10.1001/jama.2022.17701
- 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  
18 GO, Qvigstad E, Flaa A, Thomas M, Sweet K, Bewley J, Backlund M, Tiainen M, Iten M, Levis  
19 A, Peck L, Walsham J, Deane A, Ghosh A, Annoni F, Chen Y, Knight D, Lesona E, Tlayjeh H,  
20 Svensen 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, Venø 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, Bengler 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 CO<sub>2</sub>  
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, Schriebl C, Clodi C,  
17 Koch M, Ettl F, Holzer M, Losert H. The difference between arterial pCO<sub>2</sub> and etCO<sub>2</sub> 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 23. Abrahamowicz AA, Counts CR, Danielson KR, Bulger NE, Maynard C, Carlbom DJ,  
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.0000000000000273
- 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](https://costr.ilcor.org/document/mean-arterial-blood-pressure-target-in-post-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

- 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.0000000000000691
- 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, Rochweg B, Rubenfeld GD, Angus DC, Annane D,  
17 Beale RJ, Bellingham 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,  
20 Mehta S, Moreno RP, Myburgh J, Navalesi P, Nishida O, Osborn TM, Perner A, Plunkett CM,  
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

- 1 Management for Cardiac Arrest with Nonshockable Rhythm. *N Engl J Med.* 2019;381:2327-  
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, Stammer 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, Schratler 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, Pothiwala 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, Venø 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.0000000000001095  
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, Oh SH, Do Shin S, Kirkegaard H, Nichol G. Systematic review and meta-  
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-](https://costr.ilcor.org/document/effect-of-prophylaxis-and-treatment-of-seizures-on-outcome-of-adults-following-cardiac-arrest-als-tfsr)  
13 [adults-following-cardiac-arrest-als-tfsr](https://costr.ilcor.org/document/effect-of-prophylaxis-and-treatment-of-seizures-on-outcome-of-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 Foudraïne NA, Kornips FHM, van Kranen-Mastenbroek V, Rouhl RPW, Thomeer EC,  
4 Moudrós W, Nijhuis FAP, Booij SJ, Hoedemaekers CWE, Doorduín 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 Rodríguez-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 Task F. Extracorporeal cardiopulmonary resuscitation for cardiac arrest: 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-](https://costr.ilcor.org/document/extracorporeal-cardiopulmonary-resuscitation-ecpr-for-cardiac-arrest-als-sr)  
10 [arrest-als-sr](https://costr.ilcor.org/document/extracorporeal-cardiopulmonary-resuscitation-ecpr-for-cardiac-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, Nallamotheu 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-pregnancy-](https://costr.ilcor.org/document/resuscitation-interventions-for-cardiac-arrest-during-pregnancy-als-scr)  
21 [als-scr](https://costr.ilcor.org/document/resuscitation-interventions-for-cardiac-arrest-during-pregnancy-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.00000000000006210
- 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 minute 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 10.1016/S0140-6736(23)00385-9
- 5 83. Thoma ME, Declercq ER. Changes in Pregnancy-Related Mortality Associated With the  
6 Coronavirus Disease 2019 (COVID-19) Pandemic in the United States. *Obstet Gynecol*.  
7 2023;141:911-917. doi: 10.1097/AOG.0000000000005182
- 8 84. Ford ND, DeSisto CL, Galang RR, Kuklina EV, Sperling LS, Ko JY. Cardiac Arrest  
9 During Delivery Hospitalization : A Cohort Study. *Ann Intern Med*. 2023;176:472-479. doi:  
10 10.7326/M22-2750
- 11 85. Aljanoubi M, Almazrua M, Drennan I, Reynolds, J, Soar J, Couper K; on behalf of the  
12 International Liaison Committee on Resuscitation Advanced Life Support Task Force.  
13 Emergency front of neck airway access in adult cardiac arrest: Consensus on Science With  
14 Treatment Recommendations. Accessed February 8, 2024.  
15 [https://costr.ilcor.org/document/emergency-front-of-neck-airway-access-in-adult-cardiac-arrest-](https://costr.ilcor.org/document/emergency-front-of-neck-airway-access-in-adult-cardiac-arrest-als-tf-scr)  
16 [als-tf-scr](https://costr.ilcor.org/document/emergency-front-of-neck-airway-access-in-adult-cardiac-arrest-als-tf-scr)
- 17 86. Beshey BN, Helmy TA, Asaad HS. Emergency percutaneous tracheotomy in failed  
18 intubation. *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 arriving at combat hospitals. *J Trauma*. 2008;64:1548-1554. doi:  
21 10.1097/TA.0b013e3181728c41
- 22 88. Alkhouri H, Richards C, Miers J, Fogg T, McCarthy S. Case series and review of  
23 emergency 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/emered-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.0000000000002217

- 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(93)90008-u
- 4 97. Brown CA, 3rd, Cox K, Hurwitz S, Walls RM. 4,871 Emergency airway encounters by  
5 air medical providers: a report of the air transport emergency airway management (NEAR VI:  
6 "A-TEAM") 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 advanced 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 management in the UK: results of the Fourth National Audit Project of the Royal College of  
12 Anaesthetists and the Difficult Airway Society. Part 1: anaesthesia. *Br J Anaesth.* 2011;106:617-  
13 631. doi: 10.1093/bja/aer058
- 14 100. Cook TM, Woodall N, Harper J, Benger J, Fourth National Audit P. Major complications  
15 of airway management in the UK: results of the Fourth National Audit Project of the Royal  
16 College of Anaesthetists and the Difficult Airway Society. Part 2: intensive care and emergency  
17 departments. *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 Surgical Airways Following Activation of a Difficult Airway Management Team in Hospitalized  
20 Critically Ill Patients: A Case Series. *J Intensive Care Med.* 2018;33:517-526. doi:  
21 10.1177/0885066616680594
- 22 102. DeLaurier GA, Hawkins ML, Treat RC, Mansberger AR, Jr. Acute airway management.  
23 Role 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
- 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, Brywczyński 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 Anesthesiol.* 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.00000000000017713
- 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. Lairt JR, Bebart VS, Burns CJ, Lairt 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 Blackburne 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 cricothyroidotomy 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 Afghanistan. *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 Outcomes 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 *Trauma.* 2008;64:1543-1547. doi: 10.1097/TA.0b013e3181271b60
- 12 130. Moroco AE, Armen SB, Goldenberg D. Emergency Cricothyrotomy: A 10-Year Single  
13 Institution 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 acceptable success and complication rates? *Ann Emerg Med.* 1991;20:367-370. doi:  
16 10.1016/s0196-0644(05)81656-7
- 17 132. Offenbacher J, Nikolla DA, Carlson JN, Smith SW, Genes N, Boatright DH, Brown CA,  
18 3rd. Incidence of rescue surgical airways after attempted orotracheal intubation in the emergency  
19 department: 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 emergency 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.0000000000000161
- 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.0000000000000213
- 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, Bebart 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.0000000000000906
- 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

## 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  
11 association is causal or a surrogate marker of more severe postresuscitation syndrome. To answer  
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  
14 CRD42023483865). The full CoSTR can be found online.<sup>1</sup>

#### 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  
17 arrest) after ROC
- 18 ● Intervention: A specific BP target
- 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 Arrest<sup>2</sup>

- 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.<sup>3-8</sup> 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<sup>4,5,7,8</sup> examining the BP targets of systolic BP >5th percentile for  
13 age compared with systolic BP ≤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<sup>3</sup> 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 ≤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.

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

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

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

1 ***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).<sup>9</sup>

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 percentile) or the cutoff value was derived

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.<sup>3</sup>
- 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%.<sup>10-12</sup> Seizures and abnormalities on EEG post–cardiac arrest are associated with poor  
 2 neurologic outcome in children.<sup>12-15</sup> 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.<sup>16</sup>

### 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 *or* seizure treatment
- 10 ● Comparator: Another strategy or no prophylactic antiseizure medication *or* seizure  
 11 treatment
- 12 ● Outcome
  - 13 – Critical: Survival or survival with favorable neurological outcome as per Pediatric Core  
 14 Outcome Set for Cardiac Arrest<sup>2</sup>
  - 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<sup>17,18</sup> and a single nonrandomized study<sup>19</sup> enrolling adult patients  
3 only. No studies reported improvement in survival with favorable neurological outcome or  
4 survival with prophylactic antiseizure medication.

DRAFT

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

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

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

## 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<sup>20</sup> 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)<sup>21</sup> is not associated with improved long-term outcomes.  
8 Although prophylactic antiseizure medication is recommended following traumatic brain  
9 injury in children,<sup>22</sup> the evidence of benefit for early seizure prevention is of very low  
10 certainty and there is no evidence of improved long-term outcomes.<sup>23</sup>

- 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.<sup>24,25</sup> There are safe and effective antiseizure medications that can reduce seizure

1           burden in children with status epilepticus, which, in turn, may benefit longer-term  
2           outcomes.<sup>26-28</sup>

- 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;  
8           however, EEG may not be available in many clinical settings because it requires  
9           significant resources, including neurophysiology equipment, training, and expertise.  
10          Continuous EEG monitoring is labor intensive and likely to add significant cost to patient  
11          care. The cost-effectiveness of this approach is controversial and may depend on the  
12          setting. The relative benefit of continuous EEG compared with intermittent EEG  
13          monitoring was not reviewed.
- 14          ● There is insufficient evidence to suggest for or against the treatment of rhythmic and  
15          periodic EEG patterns in children post-cardiac arrest. One RCT in adults<sup>20</sup> did not find a  
16          difference in the primary outcome with 1 therapeutic approach to treatment of rhythmic  
17          and periodic EEG patterns. However, no significant harm was noted in adults assigned to  
18          the treatment or control arm. Further research is required in children to evaluate the  
19          impact on treating specific EEG patterns and electrographic seizures.
- 20          ● Medication for sedation (eg, benzodiazepines and propofol) and use of hypothermic  
21          temperature control after cardiac arrest may also affect seizure burden, timing, and detection.  
22          Evaluation of the use of prophylactic antiseizure medication and seizure treatment in the  
23          context of these therapies is important.

## 1 *Knowledge Gaps*

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

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

### 12 *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,  
16 even in skilled hands. Placement of an advanced airway device, such as a supraglottic airway  
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).

20 Since the last review of this topic,<sup>29</sup> the PLS Task Force was aware of new data,  
21 prompting this updated SysRev (PROSPERO registration CRD42023482459). The full CoSTR  
22 can be found online.<sup>30</sup>



## 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<sup>2</sup>
- 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.<sup>31</sup> Five studies  
22 provided propensity-adjusted cohort data.<sup>32-36</sup> Nine other studies provided retrospective cohort  
23 data amenable to meta-analysis.<sup>37-45</sup> Four studies provided retrospective cohort data in adjusted

1 form only, not amenable to meta-analysis.<sup>46-49</sup> One study<sup>50</sup> that was included in the original  
2 SysRev<sup>29</sup> was excluded from this updated SysRev because it overlapped with a newer study.<sup>36</sup>  
3 Summative results from 15 of the studies are included in Table 16; the 4 cohort studies with  
4 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.

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

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

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

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

1 ARD indicates absolute risk difference; BMV, bag-mask ventilation; C, comparator; GRADE, Grading of Recommendations Assessment, Development, and  
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.<sup>32,40-42</sup> 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.<sup>52,53</sup> However,  
21 the appropriate ventilatory rate for children and infants during CPR remains a topic of ongoing  
22 debate and investigation.<sup>54</sup> 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.<sup>52</sup> 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.<sup>55</sup> 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.<sup>56</sup>

### 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<sup>2</sup>
- 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.<sup>55</sup>

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

18 In 2015, the American Heart Association and the American Thoracic Society published a  
19 guideline on the management of pediatric pulmonary hypertension.<sup>58</sup> In 2018, the American  
20 Heart Association published a statement on the management of CPR in infants and children with  
21 cardiac disease that included a section on pulmonary hypertension.<sup>59</sup> In 2018, the American Heart  
22 Association published a statement on right-sided heart failure and its management, but this

1 statement focused on adults and did not include content for children.<sup>60</sup> The 2019 ILCOR EvUps  
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.<sup>61</sup>

### 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

- 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  
10 on the acute management of children with pulmonary hypertension,<sup>57-59,62-74</sup> and 3 presented data  
11 on the management of cardiac arrest in children with pulmonary hypertension.<sup>75-77</sup> Most did not  
12 report patient-level data in children with pulmonary hypertension and cardiac arrest. These  
13 articles collectively highlight the increased risk of death in children with pulmonary hypertension  
14 and the results of recent international efforts in establishing a pediatric pulmonary hypertension  
15 classification to support future international and multisite research and general therapeutic  
16 management.

### 17 *Definition and Classification of Pediatric Pulmonary Hypertension*

18 During the 6th World Symposium on Pulmonary Hypertension, the hemodynamic  
19 definition for pulmonary hypertension in children was aligned with the adult definition as a mean  
20 pulmonary artery pressure of >20 mm Hg<sup>78-80</sup> from being previously  $\geq 25$  mm Hg.<sup>58</sup>  
21 Five large clinical groups were updated—(1) pulmonary arterial hypertension, which includes  
22 pulmonary hypertension associated with congenital heart disease and persistent pulmonary  
23 hypertension of the newborn syndrome (the most frequent cause of transient pulmonary

1 hypertension)<sup>79</sup>; (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  
9 risk of death for children with pulmonary hypertension was higher compared with all other  
10 medical cardiac admissions (10% versus 3.9%). Importantly, 6.1% of these admissions with  
11 pulmonary hypertension experienced a CPR event. Among this cohort, the receipt of mechanical  
12 ventilation and vasoactive therapies within the first 2 days of ICU admission were associated  
13 with increased mortality.<sup>67</sup>

14 A study using the Virtual Pediatric Intensive Care Unit database included over 160 ICUs,  
15 focused on children with an IHCA, and compared patients with and without pulmonary  
16 hypertension. Using propensity matching, the study showed that patients with pulmonary  
17 hypertension were less likely to survive to hospital discharge (adjusted OR, 0.83 [95% CI, 0.72–  
18 0.95;  $P=0.01$ ]). The pulmonary hypertension group with an IHCA had a predicted survival rate of  
19 59.1% (56.5%–61.8%) compared with 61.6% (60.0%–63.2%) in the group without pulmonary  
20 hypertension with an IHCA.<sup>57</sup>

21 More recently, an analysis of 1129 pediatric IHCA events from the prospective  
22 multicenter ICU-RESUS (Improving Outcomes from Pediatric Cardiac Arrest—the ICU-  
23 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.<sup>81</sup>

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  
8 nitric oxide and mechanical ventilation with general measures are insufficient.<sup>58</sup>

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

11 Only 3 articles presented data on the management of cardiac arrest in children with  
12 pulmonary hypertension (Table 17).<sup>75-77</sup> Two of these studies included ECMO cannulation as  
13 intervention.<sup>75,77</sup>

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

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

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



## 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.<sup>58,80,82</sup>

## 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  
3 cardiac arrest or for refractory cardiac arrest as a bridge to recovery or as a bridge to the  
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
- 10      ● Optimal approaches to mechanical ventilation during the resuscitation of children with  
11      pulmonary hypertension (eg, timing of the advanced airway; the use of oxygen therapy in  
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  
21      data should receive personalized resuscitation measures instead of standard measures

- 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)<sup>83</sup>
- 4 • Optimal diagnostic and severity classification systems to improve knowledge of pediatric  
5 pulmonary hypertension patients who suffer cardiopulmonary arrest<sup>82</sup>
- 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,<sup>67</sup> (3) hospitalizations with deteriorations associated with clinical worsening  
9 events.<sup>84</sup> 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 Appendix B3.

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

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

| Topic/PICO | Year last updated | Existing treatment recommendation | RCTs since last review | Observational studies since last review | Key findings   | Sufficient data to warrant SysRev? |
|------------|-------------------|-----------------------------------|------------------------|---|--|------------------------------------|
|            |                   |                                   |                        |   | <p>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.</p> <p>There remains insufficient evidence to make a recommendation on ventilation rates when a perfusing rhythm is present.</p> |                                    |

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

## 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-](https://costr.ilcor.org/document/blood-pressure-targets-following-return-of-circulation-after-pediatric-cardiac-arrest-pls-4190-01-sr)  
7 [pediatric-cardiac-arrest-pls-4190-01-sr](https://costr.ilcor.org/document/blood-pressure-targets-following-return-of-circulation-after-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.0000000000002119
- 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.0000000000000216
- 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.0000000000000894
- 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



- 1 predictors of rewarming seizures in children after resuscitation. *Journal of Clinical Medicine*.  
2 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.0000000000000791  
6 10.1097/PCC.0000000000000791.
- 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.0000000000000740  
10 10.1097/PCC.0000000000000740.
- 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-](https://costr.ilcor.org/document/effect-of-prophylactic-anti-seizure-medication-and-treatment-of-seizures-on-outcome-of-pediatric-patients-following-cardiac-arrest)  
17 [seizures-on-outcome-of-pediatric-patients-following-cardiac-arrest](https://costr.ilcor.org/document/effect-of-prophylactic-anti-seizure-medication-and-treatment-of-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, Kisson 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](https://costr.ilcor.org/document/advanced-airway-interventions-in-pediatric-cardiac-arrest-pls-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.0000000000001520
- 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 Health and Human Development Collaborative Pediatric Critical Care  
2 Research Network. Ventilation Rates and Pediatric In-Hospital Cardiac Arrest Survival Outcomes. *Crit*  
3 *Care Med.* 2019;47:1627-1636. doi: 10.1097/CCM.0000000000003898
- 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 February 14, 2024.  
14 [https://costr.ilcor.org/document/ventilation-rates-in-pediatric-cpr-with-an-advanced-airway-pls-](https://costr.ilcor.org/document/ventilation-rates-in-pediatric-cpr-with-an-advanced-airway-pls-1587-tf-sr)  
15 [1587-tf-sr](https://costr.ilcor.org/document/ventilation-rates-in-pediatric-cpr-with-an-advanced-airway-pls-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.0000000000000329
- 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.0000000000000524
- 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.0000000000000560
- 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-](https://costr.ilcor.org/document/management-of-pulmonary-hypertension-with-cardiac-arrest-in-infants-and-children-in-the-hospital-setting-pls-scr)  
20 [pulmonary-hypertension-with-cardiac-arrest-in-infants-and-children-in-the-hospital-setting-pls-](https://costr.ilcor.org/document/management-of-pulmonary-hypertension-with-cardiac-arrest-in-infants-and-children-in-the-hospital-setting-pls-scr)  
21 [scr](https://costr.ilcor.org/document/management-of-pulmonary-hypertension-with-cardiac-arrest-in-infants-and-children-in-the-hospital-setting-pls-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.0000000000002187
- 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.0000000000000419
- 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, Hoepfer  
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, Hoepfer 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, Pieleles G, Quandt D, Sallmon H, Schranz D, Tran-  
4 Lundmark K, Tulloh RMR, Warnecke G, Wähler 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.0000000000002127

- 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, Schneider 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, I 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, Roofthoof  
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, Sheno 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 Ill  
16 Children Is Associated With a Lower Occurrence of Adverse Hemodynamic Events. *Crit Care*  
17 *Med*. 2020;48:e489-e497. doi: 10.1097/CCM.0000000000004314
- 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, Balcels 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,

1 Garcia-Guereta L. Short- and long-term survival of children treated with ventricular assist  
2 devices in Spain, based on 15 years' experience. *Eur J Cardiothorac Surg.* 2023;63 doi:  
3 10.1093/ejcts/ezad050

4 88. Holmberg MJ, Nicholson T, Nolan JP, Schexnayder S, Reynolds J, Nation K, Welsford  
5 M, Morley P, Soar J, Berg KM, Adult Pediatric Advanced Life Support Task Forces at the  
6 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

DRAFT

## 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.<sup>1</sup> 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  
9 the placenta via the umbilical vein and ductus venosus, thereby maintaining left ventricular  
10 filling and output (vital for coronary and cerebral perfusion).<sup>2</sup> Both milking the intact (not  
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  
13 cord management can critically influence the cardiorespiratory adaptation after birth,<sup>3,4</sup> how and  
14 when other resuscitation interventions are provided, and mortality during subsequent  
15 hospitalization, particularly among preterm infants.<sup>5</sup>

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

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

8 *Individual Patient Data Pairwise Meta-Analysis*<sup>5,8</sup>

- 9 ● Population: Preterm infants born at <37+0 weeks' gestation and their mothers
- 10 ● Interventions:
  - 11 – Deferred (delayed/late) 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 guidelines<sup>11,12</sup>):
    - 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.<sup>8</sup> 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,"<sup>5</sup> 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.<sup>13</sup> 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.<sup>5</sup>

## Consensus on Science

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

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

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

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

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

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

7 *Comparison 2: Umbilical cord milking compared with immediate cord clamping.* The  
 8 pairwise IPD meta-analysis<sup>5</sup> identified 18 trials including 1565 infants.<sup>18,20,25,35-49</sup> The median  
 9 study sample size was 60 (IQR, 45–122). The median gestational age at birth was 29 (IQR, 27–  
 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 Cord**  
 16 **Clamping**

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

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

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

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

1            *Comparison 3: Umbilical cord milking compared with deferred cord clamping.* The  
 2 pairwise IPD meta-analysis<sup>5</sup> identified 15 trials including 1655 infants.<sup>18,20,25,51-62</sup> The median  
 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  
 5 in 1 study including 6 infants. Deferral times in the deferred cord clamping group ranged from  
 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**

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

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

1 DCC indicates deferred cord clamping; GRADE, Grading of Recommendations, Assessment, Development, and  
2 Evaluation; ICC, immediate cord clamping; IVH, intraventricular hemorrhage; NNTB, number needed to treat to  
3 benefit; NNTH, number needed to treat to harm; OR, odds ratio; RCT, randomized controlled trial; RD, risk  
4 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*

- 12 ● Population: Preterm infants born at <37+0 weeks' gestation and their mothers.
- 13 ● Interventions:



- 1 – Immediate (early) cord clamping at  $\leq 15$  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  $\geq 120$  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,<sup>5</sup> 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.<sup>9</sup>
- 20 ● Time frame: As for the pairwise IPD meta-analysis<sup>5,9</sup>
- 21 Certainty of evidence was assessed using the Confidence in Network Meta-Analysis  
22 (CINeMA) framework, which is based on the GRADE framework but is adapted for network  
23 meta-analysis.<sup>65</sup>

1 ***Consensus on Science***

2 The IPD NMA<sup>9</sup> identified 47 eligible studies including 6094 infants.<sup>14-18,20-32,34,35,37-</sup>  
3 <sup>39,41,43,44,49,52-59,62,66-75</sup> 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 ( $\geq 15$  seconds– $< 45$  seconds)
- 11 3. Medium deferral of cord clamping ( $\geq 45$  seconds– $< 120$  seconds)
- 12 4. Long deferral of cord clamping ( $\geq 120$  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.<sup>9</sup> 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.<sup>9</sup> Key results are presented in Table 22.

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

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

2 GRADE indicates Grading of Recommendations, Assessment, Development, and Evaluation; NA, not applicable;  
3 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.<sup>10</sup>

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.<sup>9</sup>

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).<sup>6,7</sup>

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).<sup>6,7</sup>

8 We suggest against intact-cord milking for infants born at <28 weeks' gestational age  
9 (weak recommendation, very low-certainty evidence).<sup>6,7</sup>

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.<sup>6,7</sup>

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).<sup>6,7</sup>

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

1 infant circumstances should be taken into account (conditional recommendation, low-certainty  
2 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.<sup>5,10</sup> The reduction in mortality was robust across  
24 several participant-level and trial-level subgroups (including gestational age at birth,

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

- 3 ● We place high value on the outcome of mortality, and this has guided the strong  
4 treatment recommendation. The certainty of evidence for other outcomes varied from low  
5 to moderate, and, therefore, we concluded that the overall certainty of evidence is  
6 moderate.
- 7 ● There was moderate-certainty evidence in infants <32 weeks' gestation for fewer red cell  
8 transfusions and in infants both < and  $\geq$ 32 weeks' gestation for higher hemoglobin  
9 concentrations within the first 24 hours after birth after deferred cord clamping compared  
10 with immediate cord clamping.
- 11 ● Sixty seconds or more was chosen as the recommended interval for deferred cord  
12 clamping because that threshold defined 80% of infants who received deferred clamping  
13 in the combined studies. The evidence for medium (60–119 seconds) or long (>120  
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  
18 67% (compared with about 80% for medium deferral and 95% for immediate cord  
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  
22 long delay.<sup>26,27</sup>

- 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  $<36.5^{\circ}\text{C}$ ) 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.<sup>80</sup>
- 10      ● Parents report that deferred cord clamping provides a positive experience, with the  
11      mothers feeling closer and more attached to their infants.<sup>81</sup>

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  $\geq 32$   
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  $\geq 32$  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.<sup>54</sup>
- 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.<sup>82</sup> 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.<sup>5</sup> 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.<sup>5</sup>

- 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

- 1 ● Optimal cord management of preterm infants who are not breathing after initial steps of  
2 resuscitation
- 3 ● Optimal cord management for preterm infants born with specific maternal, fetal, and  
4 placental conditions that led to exclusion from RCTs
- 5 ● Optimal measures to prevent hypothermia during deferred cord clamping
- 6 ● 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*

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

1 sufficient new studies to consider updating the systematic review.<sup>97</sup> The SysRev was registered  
2 before initiation (PROSPERO Registration CRD42022359005). The full online CoSTR can be  
3 found on the ILCOR website.<sup>98</sup>

#### 4 ***Population, Intervention, Comparator, Outcome, Study Design, and Time Frame***

- 5 ● Population: Newborn infants who are hypothermic (<36.0°C) on admission
- 6 ● Intervention: Rapid rewarming ( $\geq 0.5^{\circ}\text{C}/\text{hour}$ )
- 7 ● Comparators: Slow rewarming (<0.5°C/hour)
- 8 ● Outcomes (importance assigned by task force consensus, in accord with available  
9 guidelines<sup>11,12</sup>):
  - 10 – Mortality rate (critical)
  - 11 – Neurodevelopmental impairment (critical)
  - 12 – Need for respiratory support during the first 48 hours of life (important)
  - 13 – Hypoglycemia during the first week of life (important)
  - 14 – Convulsions/seizures during hospital stay (important)
  - 15 – Length of hospital stay (important)
  - 16 – In addition, for preterm infants born at <34 weeks:
    - 17 ▪ Intraventricular hemorrhage (all grades—important; severe [III or IV]—  
18 critical)
    - 19 ▪ Periventricular leukomalacia (critical)
    - 20 ▪ Necrotizing enterocolitis (important)
- 21 ● Study designs: RCTs and nonrandomized studies (nonrandomized controlled trials,  
22 interrupted time series, controlled before-and-after studies, cohort studies) were eligible

1 for inclusion. Unpublished studies (eg, conference abstracts, trial protocols), case series,  
2 case reports, and animal studies were excluded.

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

4 The search strategy designed for the 2020 evidence update was rerun in July 2022 and  
5 updated in July 2023.

### 6 ***Consensus on Science***

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

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

### 18 ***Prior Treatment Recommendations (2015)***

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

## 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 ( $\geq 0.5^{\circ}\text{C}/\text{hour}$ ) or slow  
4 ( $< 0.5^{\circ}\text{C}/\text{hour}$ ) 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.<sup>100</sup>  
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 operating in servo mode and disposable temperature probes may be unaffordable in  
2 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 ( $>37.5^{\circ}\text{C}$ ).<sup>103</sup> 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.<sup>104,105</sup> Future studies  
14 should consider this important outcome.

### 15 *Knowledge 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 ● 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  
4 of moderate or severe hypoxic ischemic encephalopathy in term and near-term infants.<sup>106</sup>  
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.  
9 The treatment shown to be effective in high-income countries generally consists of cooling to  
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  
12 consistent adherence to target temperatures,<sup>107</sup> although effective cooling can be accomplished  
13 by removal of heat sources and clothing and by applying refrigerated gel packs, making the  
14 treatment feasible in low-resource settings.<sup>108</sup> The topic was last reviewed by the task force in  
15 2015, with an emphasis on the use of passive hypothermia and/or cold packs.<sup>1</sup> An evidence  
16 update in 2020<sup>97</sup> identified new studies and an ongoing large multicenter RCT that has since  
17 been published.<sup>109</sup>

18 The SysRev was registered before initiation (PROSPERO Registration  
19 CRD42022360554). The full online CoSTR can be found on the ILCOR website.<sup>110</sup>

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

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

- 1       ● Intervention: Therapeutic hypothermia to a specified target temperature for a defined
- 2       duration
- 3       ● Comparators: Standard care
- 4       ● Outcomes (importance assigned by task force consensus, in accord with available
- 5       guidelines<sup>11,12</sup>):
- 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.
- 17      ● 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.
- 21      ● Time frame: Databases were searched from inception until September 2022, and the
- 22      search was updated to July 2023.



1 **Consensus on Science**

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

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

| Outcomes (importance)   | Participants (studies)                                       | Certainty of the evidence (GRADE) | RR (95% CI)      | Anticipated absolute effect |   |
|---|--|-----------------------------------|------------------|-----------------------------|---|
|   |  |                                   |                  | Risk with standard care     | RD with therapeutic hypothermia; NNTB if applicable                                     |
| Death or NDI at 18–24 months (critical)                             | 813 (5 RCTs) <sup>112,121,128,130,131</sup>                  | Moderate                          | 0.67 (0.45–0.99) | 458/1000                    | 151 fewer infants died or had NDI per 1000 (5 fewer–252 fewer); NNTB, 7 (4–200) infants |
| Death or NDI at any time of follow-up (critical) (post-hoc outcome) | 1168 (9 RCTs) <sup>112,114,117,118,121,126,128,130,131</sup> | Low                               | 0.50 (0.35–0.71) | 474/1000                    | 237 fewer infants died or had NDI per 1000 (138 fewer–308 fewer); NNTB, 5 (4–8) infants |
| Death at hospital   | 1488 (15 RCTs) <sup>112-116,120,122-129,131</sup>            | Moderate                          | 0.70 (0.47–1.02) | 215/1000                    | 64 fewer infants died per 1000 (114   |

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

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

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

4           Apart from persistent pulmonary hypertension, reporting of adverse events during  
5 therapeutic hypothermia was inconsistent between studies. Subgroup analysis suggested that  
6 non-servo-controlled methods were more efficacious, although the task force considered that  
7 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).<sup>102</sup>

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,

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

### 3 ***2024 Treatment Recommendations***

4 We suggest the use of therapeutic hypothermia in comparison with standard care alone  
5 for term ( $\geq 37+0$  weeks' gestational age) newborn infants with evolving moderate-to-severe  
6 hypoxic-ischemic encephalopathy in low- and middle-income countries in settings where a  
7 suitable level of supportive neonatal care is available (weak recommendation, low-certainty  
8 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.

11 Therapeutic hypothermia should only be considered, initiated, and conducted under  
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°C–34°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.

- 1       ● The largest included (multicenter) RCT found that therapeutic hypothermia significantly  
2       increased mortality and did not reduce the combined outcome of death or disability at 18  
3       months.<sup>128</sup>
- 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  
6       hypothermia reduced neurodevelopmental impairment without increasing mortality. For  
7       several of the critical outcomes, there was high heterogeneity, which together with the  
8       preponderance of smaller, single-center trials mostly reporting benefit, raised the  
9       possibility of publication bias. For some studies, concerns have been raised about study  
10      methodology underlying participant heterogeneity, including methods of patient  
11      selection, as well as consistency of diagnosis and etiology.<sup>132</sup> Therefore, the task force  
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.
- 15     ● Although the PICOST intended to evaluate infants  $\geq 34+0$  weeks of gestational age, 15 of  
16     the 21 included studies specified  $\geq 37$  weeks of gestational age as an inclusion criterion,  
17     making the data for late preterm infants insufficient to support a treatment  
18     recommendation.
- 19     ● Distinction between low- and middle-income countries versus high-income countries,  
20     based on World Bank determinations, is straightforward.<sup>133</sup> However, the hospitals in the  
21     included studies (all in low- and middle-income countries) could provide neonatal ICU  
22     care, including advanced respiratory support, indicating a high level of resources despite  
23     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 ***Knowledge 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 ***References***

- 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.0000000000000276
- 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. *Pediatrics*. 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, Bérigamo 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

- 1 and Late Preterm Infants. *Front Pediatr.* 2022;10:838444. doi:  
2 10.3389/fped.2022.838444
- 3 26. Rana A, Agarwal K, Ramji S, Gandhi G, Sahu L. Safety of delayed umbilical cord  
4 clamping in preterm neonates of less than 34 weeks of gestation: a randomized controlled  
5 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  
7 Early versus Delayed Cord Clamping on Hematological Status of Preterm Infants at 6 wk  
8 of Age. *Indian J Pediatr.* 2015;82:29-34.
- 9 28. Ruangkit C, Bumrunghuet 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
- 13 29. Sahoo T, Thukral A, Sankar MJ, Gupta SK, Agarwal R, Deorari AK, Paul VK. Delayed  
14 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
- 16 30. Salae R, Tanprasertkul C, Somprasit C, Bhamarapratana K, Suwannarurk K. Efficacy  
17 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, Gebiski 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  $\leq 1500$  g: a  
15 prospective, randomized, controlled trial. *J Pediatr Hematol Oncol*.  
16 2014;36:e493-498. doi: 10.1097/mp.0000000000000143
- 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-](https://doi.org/10.1136/archdischild-2022-rcpch.286)  
21 [rcpch.286](https://doi.org/10.1136/archdischild-2022-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, Armbrrecht 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=trialssearch&smenu=fulltext&task=search](https://clinicaltrials.in.th/index.php?tp=regtrials&menu=trialssearch&smenu=fulltext&task=search&task2=view1&id=2347)  
21        [h&task2=view1&id=2347](https://clinicaltrials.in.th/index.php?tp=regtrials&menu=trialssearch&smenu=fulltext&task=search&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, Schwabegger 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, Osoi 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](http://ctri.nic.in/Clinicaltrials/pmaindet2.php?trialid=39871&EncHid=&userName=CTRI). 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. *Clinicaltrials.gov*.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  $\geq 32+0$  weeks  
23 gestation: A randomised clinical trial and reference percentiles

- 1 for heart rate and oxygen saturation for infants  $\geq 35+0$  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 cesarean delivery (CordClamp). *Clinicaltrials.gov*.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, Osofi 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;

- 1 Pediatric Life Support; Neonatal Life Support; Education, Implementation, and Teams;  
2 and First Aid Task Forces. *Circulation*. 2023;148:e187-e280. doi:  
3 10.1161/cir.0000000000001179
- 4 81. Bradshaw L, Sawyer A, Mitchell E, Armstrong-Buisseret L, Ayers S, Duley L. Women's  
5 experiences of participating in a randomised trial comparing alternative policies for  
6 timing of cord clamping at very preterm birth: a questionnaire study. *Trials*. 2019;20:225.  
7 doi: 10.1186/s13063-019-3325-4
- 8 82. Katheria AC, Clark E, Yoder B, Schmölzer GM, Yan Law BH, El-Naggar W, Rittenberg  
9 D, Sheth S, Mohamed MA, Martin C, et al. Umbilical cord milking in nonvigorous  
10 infants: a cluster-randomized crossover trial. *Am J Obstet Gynecol*. 2023;228:217.e211-  
11 217.e214. doi: 10.1016/j.ajog.2022.08.015
- 12 83. McCall EM, Alderdice F, Halliday HL, Vohra S, Johnston L. Interventions to prevent  
13 hypothermia at birth in preterm and/or low birth weight infants. *Cochrane Database Syst*  
14 *Rev*. 2018;2:Cd004210. doi: 10.1002/14651858.CD004210.pub5
- 15 84. Ramaswamy VV, Dawson JA, de Almeida MF, Trevisanuto D, Nakwa FL, Kamlin COF,  
16 Trang J, Wyckoff MH, Weiner GM, Liley HG. Maintaining normothermia immediately  
17 after birth in preterm infants <34 weeks' gestation: A systematic review and meta-  
18 analysis. *Resuscitation*. 2023;191:c. doi: 10.1016/j.resuscitation.2023.109934
- 19 85. Ramaswamy VV, de Almeida MF, Dawson JA, Trevisanuto D, Nakwa FL, Kamlin CO,  
20 Hosono S, Wyckoff MH, Liley HG. Maintaining normal temperature immediately after  
21 birth in late preterm and term infants: A systematic review and meta-analysis.  
22 *Resuscitation*. 2022;180:81-98. doi: 10.1016/j.resuscitation.2022.09.014

- 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, Khatri 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

- 1 93. Zayeri F, Kazemnejad A, Ganjali M, Babaei G, Khanafshar N, Nayeri F. Hypothermia in  
2 Iranian newborns. Incidence, risk factors and related complications. *Saudi Med J*.  
3 2005;26:1367-1371.
- 4 94. Elliott RI, Mann TP. Neonatal cold injury due to accidental exposure to cold. *Lancet*.  
5 1957;272:229-234.
- 6 95. Stephenson JM, Du JN, Oliver TK, Jr. The effect of cooling on blood gas tensions in  
7 newborn infants. *J Pediatr*. 1970;76:848-852. doi: 10.1016/s0022-3476(70)80364-x
- 8 96. Wassink G, Davidson JO, Dhillon SK, Zhou K, Bennet L, Thoresen M, Gunn AJ.  
9 Therapeutic Hypothermia in Neonatal Hypoxic-Ischemic Encephalopathy. *Curr Neurol*  
10 *Neurosci Rep*. 2019;19:2. doi: 10.1007/s11910-019-0916-0
- 11 97. Wyckoff MH, Wyllie J, Aziz K, de Almeida MF, Fabres J, Fawke J, Guinsburg R,  
12 Hosono S, Isayama T, Kapadia VS, et al. Neonatal Life Support: 2020 International  
13 Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care  
14 Science With Treatment Recommendations. *Circulation*. 2020;142:S185-s221. doi:  
15 10.1161/cir.0000000000000895
- 16 98. Rüdiger M, Kawakami MD, Madar J, Finan E, Hooper SB, Schmölzer G, Weiner G,  
17 Liley HG, on behalf of the Neonatal Life Support Task Force International Liaison  
18 Committee on Resuscitation. Effect of rewarming rate on outcomes for newborn infants  
19 who are unintentionally hypothermic after delivery. . International Liaison Committee on  
20 Resuscitation. <https://costr.ilcor.org>. 2023.
- 21 99. Motil KJ, Blackburn MG, Pleasure JR. The effects of four different radiant warmer  
22 temperature set-points used for rewarming neonates. *J Pediatr*. 1974;85:546-550. doi:  
23 10.1016/s0022-3476(74)80467-1

- 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.0000000000000276
- 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*

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

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

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

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

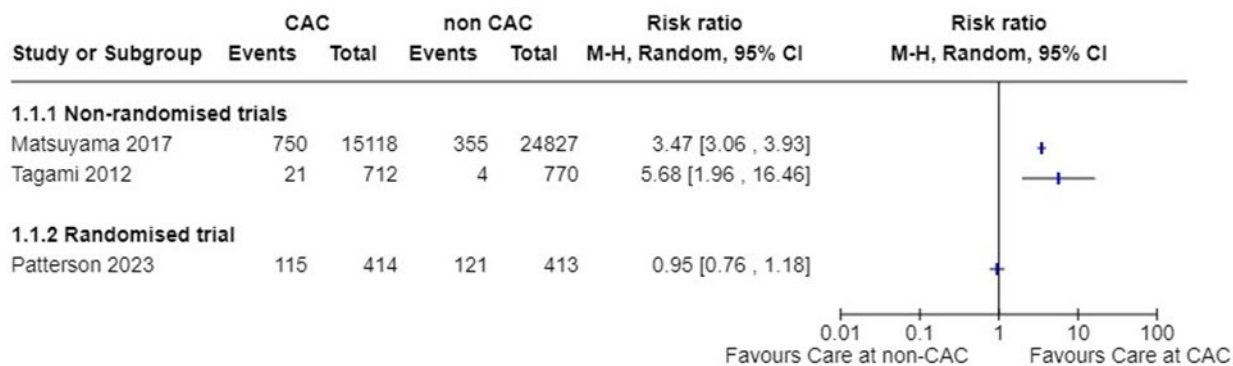
- 1     • Comparator: Care in an institute not designated as a specialized CAC
- 2     • Outcome:
- 3       – Critical: Survival at 30 days with favorable neurological outcome, survival at hospital
- 4       discharge with favorable neurological outcome, survival at 30 days, and survival at
- 5       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*

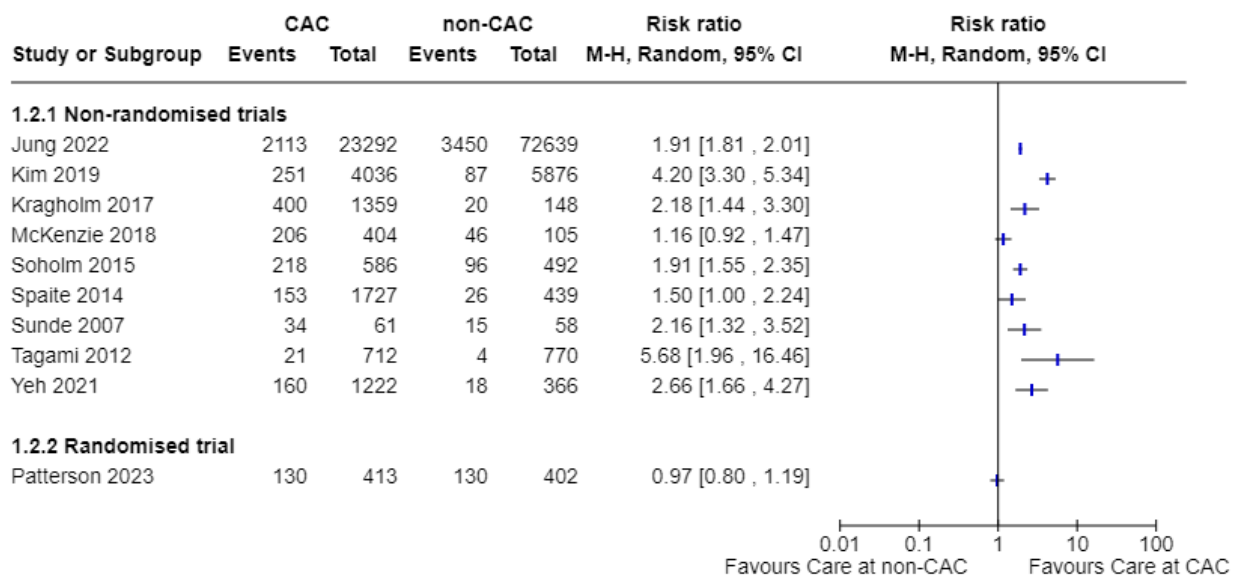
14       Sixteen studies were included in our review.<sup>6-21</sup> All studies had moderate to serious risk  
15 of bias from confounding, and the certainty of evidence was rated as low. Because of substantial  
16 heterogeneity, no meta-analyses could be performed.

17       Individual study details are provided in the published SysRev and online.<sup>5</sup> 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),<sup>6-8</sup> 10 for hospital discharge  
20 with favorable neurological outcomes (Figure 2),<sup>6,7,9-16</sup> and 3 for survival to 30 days (Figure  
21 3).<sup>6,8,12</sup>

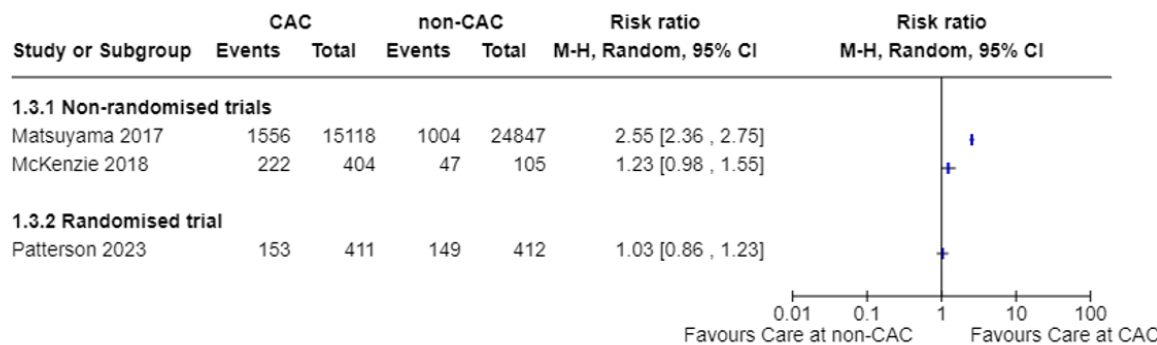
1 The only RCT identified did not show any difference in outcomes, but its results were  
 2 limited to non-ST-segment elevation myocardial infarction (non-STEMI) patients with  
 3 prehospital ROSC in an urban setting. Findings were not generalizable to other patient cohorts.<sup>6</sup>



4 **Figure 1. Survival to 30 days with favorable neurological outcomes.**<sup>6-8</sup>  
 5 CAC indicates cardiac arrest center.  
 6

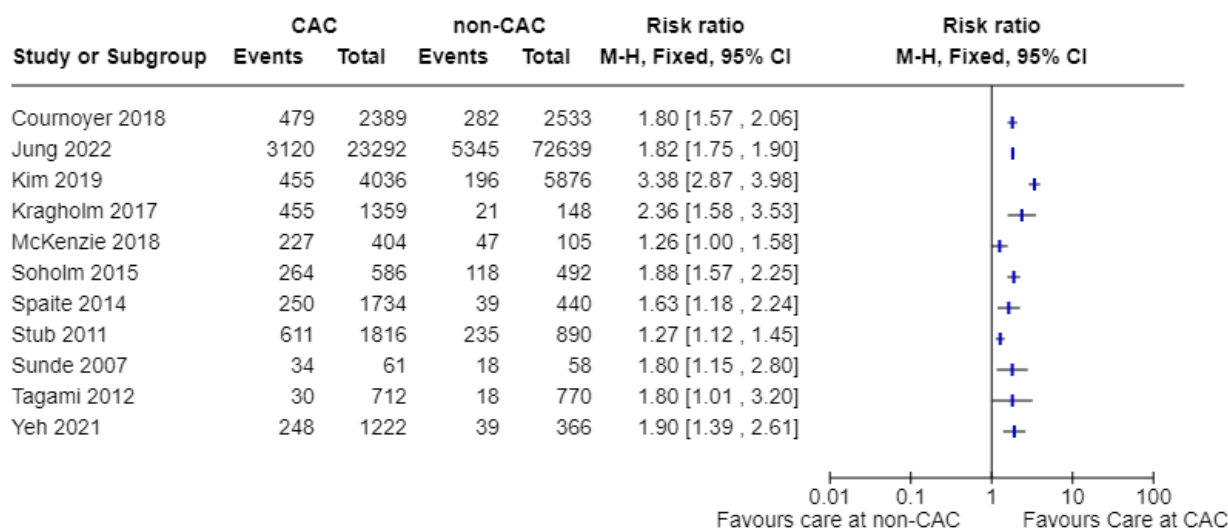


7 **Figure 2. Hospital discharge with favorable neurological outcomes.**<sup>6,7,9-16</sup>  
 8 CAC indicates cardiac arrest center.  
 9



1  
2 **Figure 3. Survival to 30 days.**<sup>6,8,12</sup>  
3 CAC indicates cardiac arrest center.

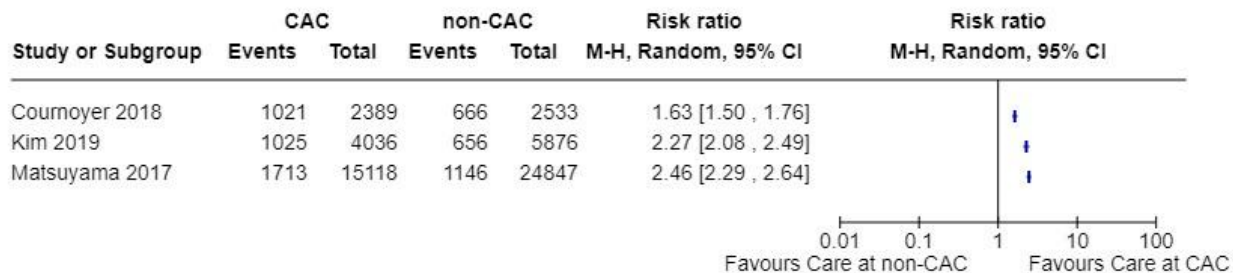
4 Eleven observational studies showed improved outcome of survival to hospital discharge  
5 associated with care at a CAC (Figure 4).<sup>7,9-18</sup>



6  
7 **Figure 4. Survival to hospital discharge.**  
8 CAC indicates cardiac arrest center.

9 Three observational studies showed improved outcome for ROSC associated with care at  
10 a CAC (Figure 5).<sup>8,10,17</sup>





1  
2 **Figure 5. Return of spontaneous circulation.**  
3 CAC indicates cardiac arrest center.

4 ***Prior Treatment Recommendation (2019)***

5 We suggest adult patients with nontraumatic OHCA be cared for in CACs rather than in  
6 non-CACs (weak recommendation, very low–certainty evidence).<sup>22</sup>

7 ***2024 Treatment Recommendation***

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

10 ***Justification and Evidence-to-Decision Framework Highlights***

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

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

- 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<sup>23</sup>
- 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
- 3       ● There are insufficient data from large RCTs, including a broad variety of populations and
- 4       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  
11 cognitive aids during training and clinical practice in the form of algorithms, flow charts,  
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  
16 care professionals.<sup>24,25</sup> Since then, new evidence has been published, triggering this update of the  
17 SysRev (PROSPERO registration CRD42020159162). The complete CoSTR can be found  
18 online.<sup>26</sup>

### 19 *Population, Intervention, Comparator, Outcome, Study Design, and Time Frame*

- 20       ● Population: Adults, children, and neonates in any setting (in-hospital or out-of-hospital)
- 21       requiring resuscitation, or laypersons and health care professionals providing
- 22       resuscitation or learning to provide resuscitation
- 23       ● 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.<sup>26</sup>

20       Four simulation studies<sup>27-30</sup> 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 tool using augmented reality (AR),<sup>30</sup> fewer deviations from a  
23    resuscitation algorithm with a decision support tool with auditory and visual prompts,<sup>28</sup> and

1 improved adherence to a resuscitation algorithm and performance to a guideline with audio voice  
2 guidance.<sup>29</sup> A poster of an algorithm demonstrated no difference in performance.<sup>27</sup>

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

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

12 Five studies<sup>42-46</sup> 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,<sup>44</sup> failure to adhere to critical steps was reduced,<sup>42</sup> use of a  
15 medical emergency checklist improved adherence to guideline-adherent critical process steps,<sup>45</sup>  
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.<sup>46</sup> Access to crisis checklists  
18 shortened time to adequate administration of glucose in a hypoglycemic coma scenario.<sup>43</sup>

19 Seven RCTs<sup>47-53</sup> and 2 observational studies<sup>54,55</sup> investigated the effects of cognitive aids  
20 used by lay rescuers during simulated resuscitation. Three RCTs<sup>48,49,51</sup> of mobile phone  
21 applications found improved adherence to clinical processes, while another mobile phone  
22 application RCT<sup>53</sup> found no improvement. Other RCTs found that using instruction cards  
23 improved adherence to AED sequences and time to shock,<sup>47</sup> a voice-activated visual and

1 auditory-assisted decision device improved adherence to a 30:2 CPR ratio,<sup>50</sup> and use of a  
2 flowchart demonstrated reduced hands-off time during CPR.<sup>52</sup>

3 An observational study<sup>54</sup> 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<sup>55</sup> 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<sup>50,52</sup> and delays in calling emergency services.<sup>51</sup>

### 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).<sup>24,25</sup>

### 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).

- 1       ● We did not examine the use of cognitive aids in health professional or lay rescuer training  
2       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.

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

- 1       ● For health care professionals, sufficient new studies provided the evidence to issue a  
2       recommendation for the use of cognitive aids during resuscitation. Because no study  
3       reported the use of cognitive aids during patient resuscitation, results from simulation  
4       studies might be used as a surrogate to justify the use of cognitive aids, as these have  
5       been used over decades by all resuscitation councils.
- 6       ● Because no studies on resuscitation were found in the review in 2019, the task force  
7       previously considered the trauma resuscitation environment sufficiently similar to the  
8       CPR environment to extrapolate evidence that shows that trauma resuscitation teams  
9       generally adhere to resuscitation guidelines better, make fewer errors, and perform key  
10      clinical tasks more frequently if they use cognitive aids. In this review, sufficient new  
11      studies addressed the use of cognitive aids in resuscitation (however, only in a simulated  
12      environment) that the task force decided to exclude trauma studies from this review.
- 13     ● There were several studies that used composite scores as their primary outcome (eg, score  
14     calculated on the basis of completing several clinical tasks). We included these studies  
15     for this SysRev; however, given their heterogeneity, comparing and pooling the results  
16     were not possible.
- 17     ● Even though all studies were simulation studies, none specifically investigated the use of  
18     cognitive aids as an educational tool. Therefore, we could not examine the use of  
19     cognitive aids for health care professionals or lay rescuer training in resuscitation. This  
20     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



- 1 ● Effective strategies for implementation of cognitive aids during training and real-life
- 2 resuscitation for health care professionals
- 3 ● The most effective type of cognitive aid
- 4 ● 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  
11 patient outcomes from cardiac arrest. Immersive technologies, such as virtual reality (VR)  
12 (defined as real-time simulation and interactions through sensorial channels created by a  
13 computer and displayed on a head-mounted or smartphone device)<sup>56</sup> and AR (defined as  
14 computer-generated holographic images overlaid into the real environment enabling users to  
15 interact with both the hologram and real objects),<sup>57</sup> 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  
23 online.<sup>58</sup>

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.<sup>58</sup>

18 Out of 18 studies<sup>56,57,59-74</sup> included in this review, 3 studies used AR in BLS

19 training.<sup>56,57,60</sup> 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.<sup>56,60</sup> The third study used AR to

21 provide clinical guidance during training, and results favored the AR intervention but were not

22 significant.<sup>57</sup>

1 VR for BLS was explored in 9 studies assessing laypersons<sup>59,61-67,74</sup> and 3 studies of  
2 health care professionals.<sup>68-70</sup> All featured VR as the primary instructional methodology. An  
3 additional 3 studies described VR use for ALS training in health care professionals.<sup>71-73</sup> 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.<sup>56,57</sup> One study reported better CPR  
8 depth compliance with the use of AR during training.<sup>60</sup> Two studies showed no difference in  
9 CPR-quality parameters (compression depth and rate),<sup>56,57</sup> while an additional study found no  
10 difference in compression rate but a difference in depth with the use of AR during training.<sup>60</sup>  
11 Overall CPR performance was assessed in 2 studies<sup>56,60</sup> 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,<sup>68</sup> e-learning with  
14 video,<sup>63</sup> and video-based training.<sup>64</sup> Two studies showed no difference compared with traditional  
15 training<sup>66</sup> or video-based training.<sup>65</sup> Knowledge retention with kindergarten teachers improved at  
16 5 weeks after training with VR.<sup>64</sup> Two other studies showed no difference at 6 months.<sup>62,66</sup>

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.<sup>59</sup> Results for no-flow time were mixed. One study favored VR over web-based BLS  
20 training,<sup>70</sup> and the other favored conventional BLS training over VR.<sup>69</sup>

21 Three studies in adult laypersons showed significantly better CPR depth in the control  
22 group compared with VR.<sup>59,61,74</sup> Two other studies showed no difference in CPR depth between  
23 groups.<sup>66,67</sup> Participants in instructor-led CPR training had significantly better CPR depth

1 compliance compared with VR.<sup>59,74</sup> One study demonstrated higher CPR rates with VR  
2 (however, both groups were within the suggested guideline range for CPR rate).<sup>59</sup> Two other  
3 studies found no difference in CPR rate.<sup>61,67</sup> CPR rate compliance was not better with VR; CPR  
4 rate compliance was either better for instructor-led training,<sup>59,74</sup> or no difference was found.<sup>66</sup>  
5 One study reported better chest recoil compliance with VR,<sup>59</sup> but 3 studies demonstrated no  
6 difference.<sup>66,67,74</sup> For overall CPR performance after training, 3 studies found no difference when  
7 comparing VR with instructor-led training<sup>67,74</sup> or video-based training.<sup>65</sup> Two studies measured  
8 retention of CPR skills at 6 months<sup>66</sup> and 3 months<sup>74</sup> after training and found no difference in  
9 CPR depth, rate, or chest recoil when comparing traditional training and VR.<sup>66,74</sup>

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,  $P=0.02$ ].<sup>62</sup>

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.<sup>73</sup> 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.<sup>71</sup> 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.<sup>72</sup>

## 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<sup>56,60</sup> and 1 for clinical guidance<sup>57</sup> (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)

- 1 • The impact of immersive technology on the acquisition and retention of knowledge and  
2 skills
- 3 • The effect of immersive technology–based training on team-based skill performance and  
4 process measures (eg, time to epinephrine, time to defibrillation)
- 5 • The role of the instructor when immersive technology is being used (eg, when it is  
6 beneficial for the instructor to provide feedback and the type of training the instructor  
7 requires when using immersive technology in resuscitation courses)
- 8 • The costs associated with implementing and maintaining AR and VR devices as well as  
9 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  
23 online.<sup>75</sup>

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

## *Consensus on Science*

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

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

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

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.<sup>79,88</sup> A card game to enhance Neonatal Resuscitation



1 Program knowledge reported high levels of perceived usefulness.<sup>80</sup> Another observational study  
2 found improved skills scores and faster time to positive pressure ventilation in a neonatal  
3 scenario that followed gamified learning.<sup>76</sup>

4 For ALS knowledge, 2 RCTs in health care professionals showed improvements with  
5 smartphone-based games.<sup>84,87</sup> 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<sup>81</sup> 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 *gamification* 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.<sup>89</sup> 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.<sup>90</sup>

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

- 2 ● Population: Learners training in BLS or ALS
- 3 ● Intervention: Instruction that uses RCDP
- 4 ● Comparator: Traditional instruction or other forms of learning without RCDP
- 5 ● Outcome: Knowledge acquisition and retention, skills acquisition and retention, skill
- 6 performance in real CPR, attitudes, willingness to help, and patients' survival
- 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 years
- 10 and all languages were included as long as there was an English abstract available.
- 11 ● Time frame: All years up to November 1, 2023

12 *Consensus on Science*

13 Seven RCTs<sup>91-97</sup> and 1 observational before-after study<sup>89</sup> were identified.<sup>89,91-97</sup> The

14 studies included medical students,<sup>96</sup> interns,<sup>93,94</sup> residents,<sup>89,92,97</sup> physicians,<sup>95</sup> and a mix of

15 fellows, nurses, and respiratory therapists<sup>91</sup>—all involved in adult,<sup>95,96</sup> pediatric,<sup>89,91,92,94,97</sup> and

16 neonatal<sup>93</sup> simulated scenarios. Seven of them referred directly to RCDP<sup>89,91-95,97</sup>; 1 used “in-

17 simulation debriefing” during the clinical scenario, which contained the key components of

18 RCDP.<sup>96</sup>

19 Details of individual studies are presented in the published review and online.<sup>90</sup> No

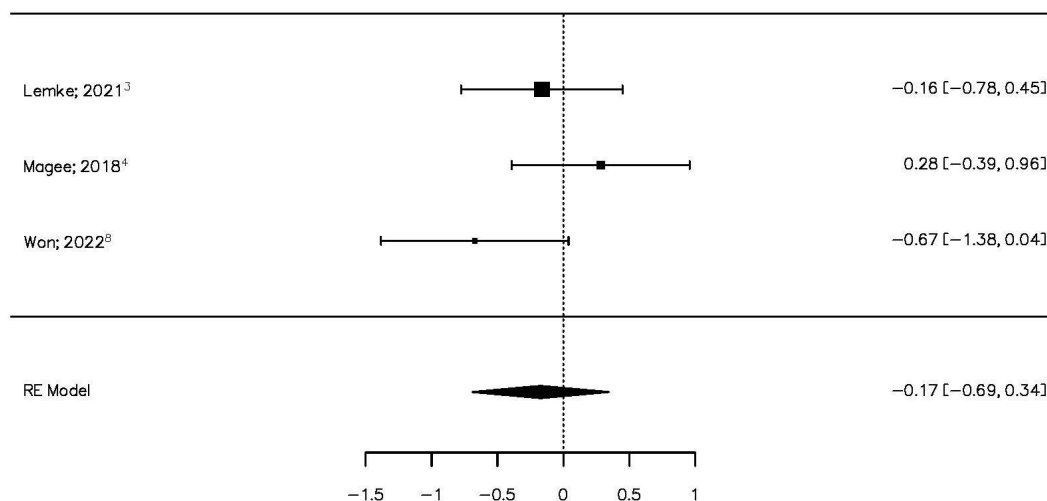
20 studies reported clinical or patient outcomes, and meta-analysis was only possible for time to

21 chest compressions.

22 For time to chest compressions, 2 pediatric<sup>92,97</sup> studies and 1 neonatal<sup>93</sup> study provided

23 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.<sup>89</sup>



3  
 4 **Figure 6. Meta-analysis forest plot for time to chest compressions comparing RCDP with**  
 5 **after-event debriefing. Data are given for the estimated standardized mean difference in**  
 6 **seconds using a random effects model ( $P=0.5105$ ).**

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

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

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

#### 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 *deliberate*
- 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.<sup>24</sup> 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.<sup>98</sup>

### 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  $\geq 1$  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.<sup>98-115</sup> No evidence was identified for CPR-skill quality and  
14 performance, confidence, and team competencies beyond 1 year. One RCT<sup>104</sup> 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<sup>99,109</sup> reported shorter time to at  
18 least 1 CPR-skills performance. One nonrandomized study for pediatric ALS<sup>105</sup> reported higher  
19 checklist scores for CPR skills with team training, and 1 RCT<sup>103</sup> found greater adherence to ALS  
20 guidelines. Nine studies (1 observational,<sup>105</sup> 8 RCTs<sup>101,104,108-110,112,114,115</sup>) reporting CPR  
21 performance found no effect from team competence training. One RCT<sup>100</sup> reported shorter no-  
22 flow time, whereas another found no difference.<sup>103</sup> Two studies found no difference in hands-on  
23 time or compression rate<sup>108</sup> or chest compression quality.<sup>107</sup>

1 Two RCTs found no difference in CPR performance at 4 months<sup>115</sup> and 6 months.<sup>110</sup>  
2 Another RCT<sup>108</sup> 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.<sup>101</sup>

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

10 Decision-making improved in 1 RCT.<sup>107</sup> Leadership behavior was better in 2 RCTs,<sup>104,106</sup>  
11 with 1 also reporting increased correction of improper chest compressions. A nonrandomized  
12 study<sup>111</sup> reported no difference in leadership behavior.

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

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

### 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).<sup>24</sup>



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.<sup>116-118</sup> 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.<sup>119</sup>

### 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  $n \geq 5$ ), 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)

## 1 *Summary of Evidence*

2           Details of the included studies and findings are presented in the published review and  
3 online.<sup>119</sup> Most studies addressed training in those with disabilities, including Down  
4 syndrome,<sup>120,121</sup> blindness,<sup>122,123</sup> and deafness or hearing impairment.<sup>124-126</sup> No studies comparing  
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  
8 elements).<sup>120,121</sup> Two studies assessed CPR education for blind learners, which resulted in chest  
9 compression–only CPR similar to other BLS providers<sup>122</sup>; supervisors with special pedagogic  
10 training were able to teach rescue breaths.<sup>123</sup> Tailored courses for trainees with hearing  
11 impairment<sup>124-126</sup> incorporated sign language interpreters without altering the 30:2 approach.  
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.<sup>127</sup>

## 16 *Task Force Insights*

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

1 tailoring has to address the needs of the special learners, include the specific populations in such  
2 developments, and undergo proper validation to ensure benefits to the learners.

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

### 8 ***Knowledge Gaps***

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

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

#### 16 ***Rationale for Review***

17 The term *Chain of Survival* is widely used in literature, scientific presentations,  
18 education, and awareness campaigns, with significant heterogeneity. This leads to confusion on  
19 which version should be used for which purpose, and the educational and clinical impacts of this  
20 heterogeneity are unclear. The American Heart Association issued various iterations of the Chain  
21 of Survival in their latest guidelines.<sup>117</sup> The European Resuscitation Council switched to the  
22 concept of Systems Saving Lives, and, while still mentioning the Chain of Survival, no longer

1 uses a depiction of the Chain of Survival.<sup>118</sup> No review of this topic has been done by ILCOR  
 2 previously. The full report of the ScopRev can be found online.<sup>128</sup>

### 3 ***Population, Intervention, Comparator, Outcome, Study Design, and Time Frame***

- 4 ● Population: Literature using the term *Chain of Survival* or similar terms (eg, *survival*  
 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.<sup>128</sup> We grouped  
 23 the publications into novel concepts related to resuscitation (n=8),<sup>117,129-135</sup> novel concepts not

1 directly related to resuscitation (n=23),<sup>136-158</sup> simple adaptations of the original Chain of Survival  
2 (n=9),<sup>159-167</sup> and impact on outcomes (n=3).<sup>168-170</sup>

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

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

### 21 *Task Force Insights*

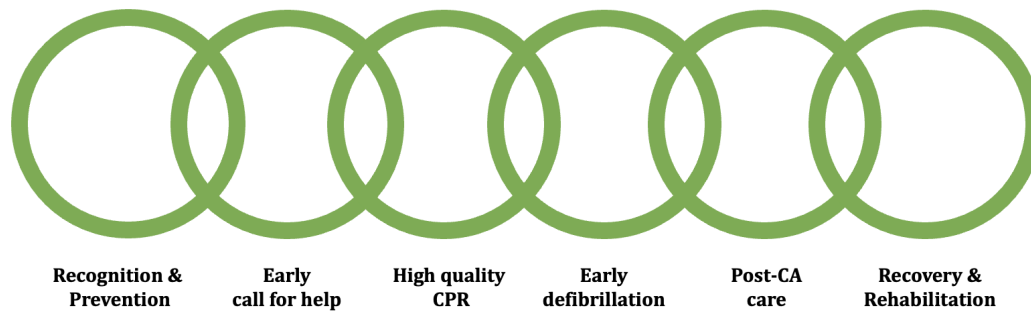
22 Chains of Survival range from classic versions used by resuscitation councils with minor  
23 adaptations to completely novel versions covering a variety of pathologies or situations. Most

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  
9 impact of the Chain of Survival on outcomes,<sup>168-170</sup> but the exact role the chain played in altering  
10 outcomes, if any, is unclear.

11 The EIT Task Force concluded that a version of the classic Chain of Survival with 6 links  
12 (as currently proposed by the American Heart Association)<sup>117</sup> (Figure 7) is a sensible choice as a  
13 cognitive aid for laypersons in education, awareness campaigns, etc to convey the message of  
14 needed actions to save lives. If needed, modified versions of the chain for specific situations like  
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.  
17 Regional resuscitation councils can provide regional applications for their implementation  
18 strategies.





1  
2 **Figure 7. The basic Chain of Survival with 6 links.**

3 CA indicates cardiac arrest; CPR, cardiopulmonary resuscitation.

4 ***Knowledge Gaps***

- 5
- 6 • Whether there is a need for revising the classic Chain of Survival
  - 7 • Who the Chain of Survival is targeted toward (clinicians, scientists, laypeople,
  - 8 stakeholders, or all of them), if laypersons need a simpler Chain of Survival than health
  - 9 care professionals do, and how it should be used optimally (a depiction of local systems
  - 10 to save lives, an educational framework, a cognitive aid, etc)
  - 11 • Which of the various published Chains of Survival should be used by default; a
  - 12 comprehensive system could be evaluated for applicability in the future
  - 13 • The impact of various kinds of Chains of Survival on educational outcomes, clinical
  - 14 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.<sup>171,172</sup>

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.<sup>173</sup>

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,<sup>37,45,174-193</sup> including 17 RCTs,<sup>37,45,175,177-183,185-188,191-193</sup> 2  
17 nonrandomized trials,<sup>190</sup> and 2 observational studies.<sup>174,189</sup> 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.<sup>173</sup> All but 2 studies<sup>174,189</sup>  
20 were simulation studies.

21 The NASA Task Load Index<sup>37,175,177-180,183,185-194</sup> was used to measure subjective  
22 workload, and the State-Trait Anxiety Inventory,<sup>182</sup> visual analog scale,<sup>195</sup> and structured survey  
23 questions<sup>45</sup> were used to measure stress. Physiologic stress markers included salivary cortisol,  $\alpha$ -

1 amylase levels, heart rate, and BP.<sup>176,188</sup> 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.<sup>193</sup> CPR coaches decreased mental workload  
7 and increased physical workload among CPR providers<sup>187</sup> but did not impact the team  
8 leader's workload.<sup>180,187</sup> In real pediatric resuscitations, the team leader reported higher  
9 mental load, whereas chest compressors had higher physical workload.<sup>174</sup>
- 10 ● Telemedicine: Remotely led resuscitation teams experienced higher-overall workload and  
11 mental demand compared with on-site leading.<sup>178</sup> Active remote team leaders versus a  
12 remote consultant on request increased workload for team members with teleconsulting  
13 only.<sup>191</sup>
- 14 ● Workflows: Adjustment of workflows (prioritizing chest compression automation with  
15 mechanical CPR device<sup>192</sup>), or deliberate reorientation with task-focusing questions,<sup>181</sup>  
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.<sup>175</sup> Real-time feedback devices had no effect on  
19 team leaders, while chest-compressing CPR providers reported higher workloads.<sup>183</sup>  
20 Interestingly, equipment failure (defective defibrillator) in simulation did not increase  
21 stress for the team.<sup>188</sup>
- 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.<sup>182</sup> A smart app with a

1 resuscitation algorithm did not increase workload for team leaders.<sup>190</sup> A tablet-based  
2 decision support tool's effect on workload was inconclusive because the increase in  
3 workload disappeared later during simulation.<sup>185</sup>

- 4 ● Family presence and socioemotional stress: Presence of next of kin increased mental  
5 demands but did not change physical demands in simulation.<sup>179</sup> An observational study of  
6 real pediatric resuscitations showed lower workload when at least 1 parent was present.<sup>189</sup>  
7 This is in accordance with an ILCOR CoSTR on family presence during resuscitation in  
8 pediatric and neonatal cardiac arrest.<sup>196,197</sup>
- 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.<sup>176</sup>

### 12 *Task Force Insights*

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

21 The factors identified in this review (team composition and roles, workflows, tools,  
22 telemedicine, cognitive aids, smart apps, and socioemotional stress) represent potential  
23 modifiable elements. Adjusting these factors could alleviate or increase their impact on

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.<sup>198</sup>

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.<sup>199-204</sup> Studies assessing the impact of  
22 debriefing after cardiac arrest events demonstrate improved provider performance,<sup>205,206</sup> while  
23 debriefings informed by clinical data have been associated with enhanced survival outcomes

1 from cardiac arrest.<sup>207,208</sup> Many different debriefing frameworks have been developed and  
2 implemented, leading to variability in how debriefing is conducted across programs and  
3 institutions.<sup>209</sup>

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<sup>210,211</sup> and clinical settings,<sup>212-214</sup> the benefits of debriefing scripts in resuscitation  
7 education have not been clearly delineated, prompting this ScopRev.<sup>215</sup> The full report of the  
8 ScopRev can be found online.<sup>216</sup>

### 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

## 1 *Summary of Evidence*

2 Six studies (5 RCTs<sup>210,217-220</sup> and 1 quasi-experimental study<sup>221</sup>) were included in this  
3 review. Details of the included studies are summarized in the published review and online.<sup>215,216</sup>

4 No studies evaluated patient outcomes or provider performance on real patients.

5 Three studies used pediatric resuscitation scenarios<sup>210,218,219</sup> and 3 others adult  
6 scenarios<sup>217,220,221</sup> as the trigger for the debriefing. Five studies<sup>210,217-219,221</sup> used a debriefing  
7 script, including debriefing framework, topics for discussion, and suggested phrasing; the other  
8 RCT<sup>220</sup> did not use suggested phrases. Only 1 study incorporated CPR-quality parameters as  
9 objective data.<sup>219</sup> Only 4 studies trained the debriefer in the use of the script.<sup>217-219,221</sup> The  
10 PEARLS tool (Promoting Excellence and Reflective Learning in Simulation)<sup>217,219,221</sup> was used  
11 most often, followed by advocacy-inquiry,<sup>210,218</sup> and then the gather-analyze-summarize  
12 model.<sup>220</sup> A multicenter trial reported that scripting led to debriefings of higher quality, with  
13 significant effects in novices,<sup>218</sup> whereas another RCT found no difference when using a  
14 PEARLS script.<sup>217</sup> 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 learning outcomes (excellent CPR, guideline-compliant depth, chest  
18 compression fraction, perishock pause) in 1 RCT.<sup>219</sup> A study including medical and nursing  
19 students showed no difference in teamwork performance comparing scripted with nonscripted  
20 debriefings.<sup>220</sup> 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.<sup>210</sup>

## 1 *Task Force Insights*

2 All studies had significant heterogeneity in design and implementation of scripted  
3 debriefing interventions (eg, blended method and framework of debriefing,<sup>217,219,221</sup> single  
4 debriefing method like advocacy inquiry<sup>210,218</sup>). There were differences in the methods of  
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  
10 script,<sup>219</sup> enabling a direct link between debriefing to clinically relevant performance metrics,  
11 which might enhance the overall impact of debriefing during resuscitation education.<sup>219</sup>

## 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
- 21 ● The impact of scripted debriefing during training on patient or process outcomes in real  
22 resuscitations



- 1       ● The importance of debriefer adherence to debriefing scripts and its influence on learning  
2           and performance outcomes
- 3       ● 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.

10

DRAFT

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

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

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

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

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

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

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

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



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

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

7

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, Kutiyifa 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 AXG, 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, Olausson 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 <https://costr.ilcor.org/document/cardiac-arrest-centers-eit-6301-tf-sr>
- 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  
19 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: <https://dx.doi.org/10.3390/jcm11041033>

- 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  
11 adult out-of-hospital cardiac arrest of medical aetiology. *Resuscitation*. 2018;128:76-82. doi:  
12 <https://dx.doi.org/10.1016/j.resuscitation.2018.04.039>
- 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, Karlsten 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  
9 JM, Piette É, Paquet J, Cavayas YA, de Champlain F, Segal E, Albert M, Guertin MC, Denault  
10 A. Impact of the direct transfer to percutaneous coronary intervention-capable hospitals on  
11 survival to hospital discharge for patients with out-of-hospital cardiac arrest. *Resuscitation*.  
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
- 16 19. 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 <https://dx.doi.org/10.1161/JAHA.119.015544>

- 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

3 23. Haywood K, Whitehead L, Nadkarni VM, Achana F, Beesems S, Böttiger BW, Brooks  
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 24. Greif R, Bhanji F, Bigham BL, Bray J, Breckwoldt J, Cheng A, Duff JP, Gilfoyle E,  
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.0000000000000896

14 25. 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  
18 I, Krob JL, Kuzovlev A, Ko YC, Leary M, Lin Y, Mancini ME, Matsuyama T, Navarro K,  
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: <https://doi.org/10.1016/j.auec.2022.07.005>
- 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 <https://doi.org/10.1002/aet2.10880>
- 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  
15 advanced cardiac life support. *The American Journal of Emergency Medicine*. 2021;43:217-223.  
16 doi: <https://doi.org/10.1016/j.ajem.2020.03.007>
- 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  
22 high-fidelity simulation. *Resuscitation Plus*. 2021;7:100152. doi:  
23 <https://doi.org/10.1016/j.resplu.2021.100152>

- 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 44. Knoche BB, Busche C, Grodd M, Busch H-J, Lienkamp SS. A simulation-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: <https://doi.org/10.1111/jpc.12968>
- 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/emered-  
2 2013-202867
- 3 51. Paal P, Pircher I, Baur T, Gruber E, Strasak AM, Herff H, Brugger H, Wenzel V,  
4 Mitterlechner T. Mobile Phone-assisted Basic Life Support Augmented with a metronome  
5 *Journal 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 flowchart improve the quality of bystander cardiopulmonary resuscitation? *Resuscitation*.  
8 2013;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 application for mobile phones. *Resuscitation*. 2007;74:487-494. doi:  
11 10.1016/j.resuscitation.2007.02.004
- 12 54. Ertl L, Christ F. Significant improvement of the quality of bystander first aid using an  
13 expert system with a mobile multimedia device. *Resuscitation*. 2007;74:286-295. doi:  
14 10.1016/j.resuscitation.2007.01.006
- 15 55. Otero-Agra M, Jorge-Soto C, Cosido-Cobos ÓJ, Blanco-Prieto J, Alfaya-Fernández C,  
16 García-Ordóñez E, Barcala-Furelos R. Can a voice assistant help bystanders save lives? A  
17 feasibility pilot study chatbot in beta version to assist OHCA bystanders. *The American Journal*  
18 *of Emergency 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 Comparing an Augmented Reality Application vs. a Standard Audio-Visual Feedback Manikin.  
21 *Frontiers 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-](https://costr.ilcor.org/document/immersive-technologies-for-resuscitation-education-eit-6405-tf-sr)  
7 [eit-6405-tf-sr](https://costr.ilcor.org/document/immersive-technologies-for-resuscitation-education-eit-6405-tf-sr)
- 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 <https://doi.org/10.1111/bjet.13237>
- 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-Higuera 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  
14 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: <https://doi.org/10.1016/j.nedt.2022.105464>

- 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, Schmölder 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/emered-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: <https://doi.org/10.1016/j.jacc.2022.09.040>

- 1 87. Gutiérrez-Puertas L, García-Viola A, Márquez-Hernández VV, Garrido-Molina JM,  
2 Granados-Gómez 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](https://doi.org/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-](https://costr.ilcor.org/document/rapid-cycle-deliberate-practice-in-resuscitation-training-eit6414-tf-sr)  
16 [training-eit6414-tf-sr](https://costr.ilcor.org/document/rapid-cycle-deliberate-practice-in-resuscitation-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: <https://doi.org/10.1002/aet2.10702>

- 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-](https://costr.ilcor.org/document/teaching-teamwork-competencies-for-resuscitation-eit-6415-tfsr)  
20 [6415-tfsr](https://costr.ilcor.org/document/teaching-teamwork-competencies-for-resuscitation-eit-6415-tfsr)
- 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, Misco A, Broliar 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, Vääntinen O, Koskela J, Perkonen  
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 multidisciplinary 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, Tyson 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.0000000000000899
- 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. [https://costr.ilcor.org/document/basic-life-](https://costr.ilcor.org/document/basic-life-support-training-for-specific-layperson-populations-eit6108-tf-scr)  
5 [support-training-for-specific-layperson-populations-eit6108-tf-scr](https://costr.ilcor.org/document/basic-life-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-González 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, Schriegl 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 Olausen 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-](https://costr.ilcor.org/document/eit-6311-international-facets-of-the-chain-of-survival-eit-6311-tf-scr)  
16 [survival-eit-6311-tf-scr](https://costr.ilcor.org/document/eit-6311-international-facets-of-the-chain-of-survival-eit-6311-tf-scr)
- 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  
15 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, Turrís 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](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-](https://www.hmpgloballearningnetwork.com/site/emsworld/article/10321382/its-time-create-survival-ladder)  
3 [time-create-survival-ladder](https://www.hmpgloballearningnetwork.com/site/emsworld/article/10321382/its-time-create-survival-ladder)
- 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 intentional injury 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. *Arq 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: <https://doi.org/10.1111/acem.14569>
- 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](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. *Emergency Medicine Journal*. 2021;38:572.  
7 doi: 10.1136/emered-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-  
14 neonatal-costr](https://costr.ilcor.org/document/systematic-review-nls-family-presence-during-resus-<br/>13 neonatal-costr)  
15 198. Lauridsen KG, Krogh K, Müller SD, Schmidt AS, Nadkarni VM, Berg RA, Bach L, Dodt  
16 KK, Maack TC, Møller DS, Qvortrup M, Nielsen RP, Højbjerg R, Kirkegaard H, Løfgren B.  
17 Barriers and facilitators for in-hospital resuscitation: A prospective clinical study. *Resuscitation*.  
18 2021;164:70-78. doi: 10.1016/j.resuscitation.2021.05.007  
19 199. Cheng A, Eppich W, Grant V, Sherbino J, Zendejas B, Cook DA. Debriefing for  
20 technology-enhanced simulation: a systematic review and meta-analysis. *Medical Education*.  
21 2014;48:657-666. doi: <https://doi.org/10.1111/medu.12432>  
22 200. Fanning RM, Gaba DM. The Role of Debriefing in Simulation-Based Learning.  
*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 <https://doi.org/10.1016/j.nedt.2013.09.020>
- 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-](https://costr.ilcor.org/document/scripted-debriefing-for-resuscitation-training-a-scoping-review-eit-6413-tf-scr)  
11 [eit-6413-tf-scr](https://costr.ilcor.org/document/scripted-debriefing-for-resuscitation-training-a-scoping-review-eit-6413-tf-scr)

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>

- 1 220. Freytag J, Stroben F, Hautz WE, Penders D, Kämmer JE. Effects of using a cognitive aid  
2 on content and feasibility of debriefings of simulated emergencies. *GMS J Med Educ.*  
3 2021;38:Doc95. doi: 10.3205/zma001491
- 4 221. Høegh-Larsen AM, Ravik M, Reiersen IÅ, Husebø SIE, Gonzalez MT. PEARLS  
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

DRAFT

## 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,  
7 and during cardiac arrest. A 2015 CoSTR<sup>1,2</sup> followed by a 2022 ScopRev<sup>3</sup> identified evidence of  
8 potential harm with oxygen use in acute exacerbations of chronic obstructive pulmonary disease  
9 (COPD) but used limited search dates and broad exclusion criteria. The current ScopRev  
10 expands the search dates and inclusion criteria. Topics recently reviewed were once again  
11 excluded, such as the use of supplemental oxygen in acute coronary syndrome,<sup>4</sup> suspected  
12 stroke,<sup>5</sup> drowning,<sup>6</sup> and after the return of spontaneous circulation following cardiac arrest.<sup>7</sup> The  
13 full online ScopRev can be found online.<sup>8</sup>

#### 14 ***Population, Intervention, Comparator, Outcome, Study Design, and Time Frame***

- 15 ● Population: Adults and children who exhibit symptoms or signs of shortness of breath,  
16 difficulty breathing, or hypoxia outside of a hospital
- 17 ● Intervention: Administration of oxygen by a first aid provider
- 18 ● Comparator: No administration of oxygen
- 19 ● Outcomes: Functional outcome at discharge, 30 days, 60 days, 180 days, or 1 year;  
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.<sup>9</sup>

16 For the use of supplemental oxygen in acute exacerbations of COPD, we identified 2  
17 SysRevs,<sup>10,11</sup> 1 cluster RCT,<sup>12</sup> 1 commentary on the same RCT,<sup>13</sup> 5 observational studies,<sup>14-18</sup> 1  
18 literature review,<sup>19</sup> 3 evidence-based guidelines,<sup>20-22</sup> and 1 registered with associated published  
19 study protocol for an ongoing trial.<sup>23,24</sup> In the cluster RCT,<sup>12</sup> 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

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  
3 high-flow arm compared with 2% (2 deaths) in the titrated oxygen group (RR, 0.22; 95% CI,  
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  
7 within-study confounders and heterogeneity between the studies.<sup>14-18</sup>

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

14 For the use of supplemental oxygen for diving emergencies, 3 case series<sup>31-33</sup> described  
15 use of oxygen in decompression sickness, with 1 case series<sup>33</sup> specifically describing the use of  
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  
21 remaining articles identified in the search were literature reviews,<sup>34-39</sup> a medical journal  
22 summarizing other articles<sup>40</sup>, and 1 experimental study<sup>41</sup> in healthy divers to compare tissue

1 oxygenation levels while breathing oxygen by using different noninvasive delivery devices and  
2 oxygen flow rates.

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

#### 4 ***Task Force Insights***

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

11 The 1 RCT<sup>12</sup> that identified evaluating the use of out-of-hospital titrated versus high-flow  
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  
17 oxygen may be necessary if oxygen saturations are less than 88%. An update to the good practice  
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.

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).<sup>3</sup>

5 ***2024 Good Practice Statement***

6           When a first aid provider trained in oxygen use administers oxygen to a person with acute  
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.<sup>42</sup>

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 ( $\geq 38^{\circ}$  C,  $100.4^{\circ}$  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

1 subjective (feeling very unwell or impending sense of doom). However, there was variability as  
2 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.

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? |
|------------------------------|-------------------|--|------------------------|---|---|------------------------------------|
| Stroke recognition (FA 7170) | 2020              | <p>We recommend that first aid providers use stroke assessment scales/tools for adults with suspected acute stroke (strong recommendation, low-certainty evidence).</p> <p>For first aid, we suggest the use of FAST, MASS, CPSS or LAPSS scales/tools for stroke assessment (weak recommendation, low-certainty evidence).</p> <p>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</p> | 0                      | 4                                       | None of the new studies of established stroke scoring systems, or of new stroke scoring systems, offer any improvement in the public recognition of stroke by lay public or first aid provider. | No                                 |

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



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

| Topic/PICO  | Year last updated | Existing treatment recommendation  | RCTs since last review | Observational studies since last review | Key findings   | Sufficient data to warrant SysRev? |
|---|-------------------|--|------------------------|---|--|------------------------------------|
|   |                   | <p>There is insufficient evidence to recommend for or against temporary storage of an avulsed tooth in saliva compared with alternative solutions.</p> <p>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.</p> |                        |   |  |                                    |
| <p>Second dose of epinephrine for anaphylaxis (FA 7111)</p> | <p>2021</p>       | <p>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).</p>   | <p>0</p>               | <p>1</p>                                | <p>Observational study identifying that 29% (n=11) needed 2 doses and 5% (n=2) needed 3 doses of epinephrine</p> | <p>No</p>                          |

| <b>Topic/PICO</b>                                     | <b>Year last updated</b> | <b>Existing treatment recommendation</b>   | <b>RCTs since last review</b> | <b>Observational studies since last review</b> | <b>Key findings</b>   | <b>Sufficient data to warrant SysRev?</b> |
|---|--------------------------|--|-------------------------------|--|---|---|
| Naloxone for opioid emergencies (FA7442)              | 2020                     | We suggest that CPR be started without delay in any unconscious person not breathing normally and that naloxone be used by lay rescuers in suspected opioid-related respiratory or circulatory arrest (weak recommendation based on expert consensus).   | 0                             | 0  | N/A   | No  |
| Exertion-related dehydration and rehydration (FA7241) | 2022                     | We recommend the use of any readily available rehydration drink or water for treating exertion-related dehydration in the first aid setting (good practice statement).<br>We suggest rehydration for exertion-related dehydration with a 4% to 9% CED. Alternative rehydration options include 0% to 3.9% CEDs, water, coconut water, or skim or low-fat | 2                             | 0  | One RCT found that the percentage of fluid retained at 3.5 hours after ingestion of a sports drink was statistically significantly higher than after ingestion of water.<br>In a second RCT that compared green tea with water, no differences in | 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? |
|--|-------------------|--|------------------------|---|--|------------------------------------|
|  |                   | <p>cow's milk (weak recommendation, very low–certainty evidence).<br/>There is insufficient evidence to recommend for or against rehydration with beer (0%–5% alcohol).</p>  |                        |   | body fluid balance and cumulative urine output were observed.                                |                                    |
| Counter-pressure maneuvers for prevention of syncope<br>FA7550 | 2021              | <p>We recommend the use of any type of physical counter-pressure maneuver by individuals with acute symptoms of presyncope due to vasovagal or orthostatic causes in the first aid setting (strong recommendation, low-certainty and very low–certainty evidence).<br/>We suggest that lower body physical counter-pressure maneuvers are preferable to upper body and abdominal physical counter-pressure</p> | 1                      | 0                                       | 1 unblinded RCT; 0/15 using physical maneuvers had syncope compared with 5/15 in control arm | 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? |
|----------------------------|-------------------|--|------------------------|---|--------------|------------------------------------|
|                            |                   | maneuvers (weak recommendation, very low–certainty evidence).  |                        |   |              |                                    |
| Recovery position (FA7040) | 2021              | <p>When providing first aid to a person with a decreased level of responsiveness of nontraumatic etiology and who does not require immediate resuscitative interventions, we suggest the use of the recovery position (weak recommendation, very low–certainty evidence).</p> <p>When the recovery position is used, monitoring should continue for signs of airway occlusion, inadequate or agonal breathing, and unresponsiveness (good practice statement).</p> <p>If body position, including the recovery position, is a factor</p> | 0                      | 0                                       |              | No                                 |

| Topic/PICO | Year last updated | Existing treatment recommendation   | RCTs since last review | Observational studies since last review | Key findings | Sufficient data to warrant SysRev? |
|------------|-------------------|---|------------------------|---|--------------|------------------------------------|
|            |                   | <p>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).</p> <p>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).</p> |                        |   |              |                                    |

1 Abbreviations: CED, carbohydrate-electrolyte drink; CPR, cardiopulmonary resuscitation; CPSS, Cincinnati Prehospital Stroke Scale; FAST, Face, Arm, Speech,  
 2 Time to call; HBSS, Hank’s Balanced Salt Solution; LAPSS, Los Angeles Prehospital Stroke Scale; MASS, Melbourne Ambulance Stroke Screen; PDL,  
 3 periodontal ligament; RCT, randomized controlled trial.  
 4

5 **Acknowledgments**

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

1 **Collaborators**

2 Zehra Al-Hilali; Mohammed Aljanoubi; Abdulkarim A. Almazrua; Luke Andrea; Huba Atiq; Arna Banerjee; Adam  
3 Boulton; Maaret Castreen; Nino Fijačko; Juul Grabmayr; Kevin Kai-Wei Lin; Elina Koota; Sol Libesman; Joel Kian-Boon  
4 Lim; Kai-Wei Lin; Cheng-Heng Liu; Marco Neymayer; Justine Odakha; Leandra Rech; Josh Reynolds; Eitan Schachna; Amir  
5 Shamshiraz; Erwin Snijders; Lucas Snow; James Sotiropoulos; Devita Stallings; Lorrel Toft; James Whiting; Dyan Zhe-Wei  
6 Zhang

7

DRAFT

- 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.0000000000000278
- 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.0000000000001179
- 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.0000000000000897
- 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 Sempstrott 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, Patoocka 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.0000000000001017
- 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-](https://costr.ilcor.org/document/use-of-supplementary-oxygen-in-first-aidfa-1549-tf-scr)  
6 [of-supplementary-oxygen-in-first-aidfa-1549-tf-scr](https://costr.ilcor.org/document/use-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 outcomes associated with hypoxaemia and hyperoxaemia in acute exacerbations of COPD.  
3 *Postgrad 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 hospital oxygen therapy and CO2 retention in patients admitted through the emergency  
8 department. *BMJ Open.* 2017;7:A1 - A18.
- 9 18. Bentsen LP, Lassen AT, Titlestad IL, Brabrand M. A change from high-flow to titrated  
10 oxygen therapy in the prehospital setting is associated with lower mortality in COPD patients  
11 with acute 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 chronic obstructive pulmonary disease. *Expert Rev Respir Med.* 2015;9:287-293. doi:  
14 10.1586/17476348.2015.1016503
- 15 20. Hodroge SS, Glenn M, Breyre A, Lee B, Aldridge NR, Sporer KA, Koenig KL, Gausche-  
16 Hill M, Salvucci AA, Rudnick EM, Brown JF, Gilbert GH. Adult Patients with Respiratory  
17 Distress: Current Evidence-based Recommendations for Prehospital Care. *West J Emerg Med.*  
18 2020;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 Adult 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 Munsif 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](https://assets.researchsquare.com/files/rs-2760789/v1/6878e346-9818-471a-a140-051b8f6d41f1.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. *J Travel Med.*  
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. *Lancet.*  
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. *Diving*  
17 *Hyperb Med.* 2009;39:81-87.
- 18 38. Pollock NW, Buteau D. Updates in Decompression Illness. *Emerg Med Clin North Am.*  
19 2017;35:301-319. doi: 10.1016/j.emc.2016.12.002
- 20 39. Wayne 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](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-](https://costr.ilcor.org/document/first-aid-recognition-of-sepsis-a-scoping-review)  
10 [review](https://costr.ilcor.org/document/first-aid-recognition-of-sepsis-a-scoping-review). Updated January 11, 2024. Accessed January 31, 2024.

11