Appendix B

Advanced Life Support – 2026 Evidence Updates

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2026 Evidence Update

ALS 3511 (Part 1) – Prognostication EEG SSEP

Worksheet author(s): Claudio Sandroni, Sonia D'Arrigo
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Task Force: ALS
Date Submitted to SAC rep for peer review and approval: September 10, 2025
SAC rep: Erik Lavonas

PICOST / Research Question:
Population: Adults who are comatose after resuscitation from cardiac arrest (either in-hospital or out-of-hospital), regardless of target temperature.
Interventions: index test based on electrophysiology: short-latency somatosensory evoked potentials (SSEP)
Comparison: none.
Outcomes: poor neurological outcome, defined as Cerebral Performance Categories (CPC) 3-5 or Glasgow Outcome Scale (GOS) 1-3, or modified Rankin Score (mRS) 4-6 at hospital discharge/1 month or later.
Study designs: Prognostic accuracy studies where the 2x2 contingency table (ie, the number of true/false negatives and positives for prediction of poor outcome) was reported, or where those variables could be calculated from reported data, are eligible for inclusion. Unpublished studies, reviews, case reports, case series, studies including fewer than 10 patients, letters, editorials, conference abstracts, and studies published in abstract form were excluded.

Year of last full review: 2020

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST: COSTR 2024
We recommend that neuroprognostication always be undertaken by using a multimodal approach because no single test has sufficient specificity to eliminate false positives (strong recommendation, very low-certainty evidence).

We suggest using a bilaterally absent N20 wave of SSEP in combination with other indices to predict poor outcome in adult patients who are comatose after cardiac arrest (weak recommendation, very low–certainty evidence).

Database searched: PubMed. The references of full-text articles were screened for additional studies.

Time Frame: (existing PICOST) – April 2024 (prior EvUp) to Aug 2025
Date Search Completed: Aug 31, 2025
Search Results (Number of articles identified, and number identified as relevant): 25/2

Summary of Evidence Update:

Two studies **(Czimmeck 2025, Scarpino 2025)** evaluated **low SSEP amplitude** and its threshold for predicting poor neurological outcome. In one study (Scarpino 2025) in 65 patients, a bilaterally absent N20 wave **within 6 h after ROSC** predicted poor outcome with 100[89-100]% specificity and 67[48-82]% sensitivity.
Adding three additional criteria (low-amplitude [<1.2 μV] or prolonged [>10 milliseconds] N20 wave, absence of the N70 (middle-latency) SSEP wave) increased sensitivity to 93[79-99]% without reducing specificity. In the other study (Czimmeck 2025), in 116 patients an absent or low-amplitude (**<0.5 μV)** N20 wave **on day 3** predicted poor neurological outcome at hospital discharge with **100 [96-100]% specificity** and **56 [46-65]% sensitivity.**

Relevant Guidelines or Systematic Reviews: none

RCTs: none

Nonrandomized Trials, Observational Studies published

Study Acronym; Author; Year Published	Study Type/Design; Study Size (N)	Patient Population	Primary Endpoint and Results (include P value; OR or RR; & 95% CI)	Summary/Conclusion Comment(s)
Cortical somatosensory evoked potentials (SSEPs) amplitude				
Czimmeck et al. 2025	**Study Type:** retrospective, single-centre observational study. One hundred fifty-two patients were included in the study. SSEP amplitude was tested on 116 patients.	**Inclusion Criteria:** OHCA and IHCA patients with serum NFL testing within 24–96 h after CA. **Exclusion criteria:** N/A	The SSEP accuracy was not the primary endpoint of the study. **1° endpoint:** to evaluate NFL as a biomarker for neuroprognostication after CA in clinical routine. **2° endpoint:** to compare NFL to established prognostication methods. **Results: SSEP amplitude <0.5 µV at day 3** predicted poor neurological outcome (CPC 4-5) at hospital discharge with **100 [96-100]% specificity** and **56 [46-65]% sensitivity.**	The study identified a low-amplitude N20 SSEP wave as a highly specific predictor of poor neurological outcome, in line with previous studies (e.g., Scarpino, 2021). The amplitude threshold was <0.5 µV and includes an absent N20.
Scarpino et al. 2025	**Study Type:** Prospective single-center study. Six-five patients were included in the study. SSEP amplitude was tested in all patients.	**Inclusion Criteria:** Consecutive comatose adult patients (GCS<8) who received the first multimodal prognostic evaluation within 6 hours after CA, as well as the NSE dosage within 12 hours after CA.	**1° endpoint:** the accuracy of short- and middle-latency SSEPs recorded within 6 hours of ROSC in predicting both poor (CPC 3–5) and good (CPC 1–2) neurological outcomes at hospital discharge. **2° endpoint:** to evaluate the prognostic accuracy of other ERC-ESICM predictors. **Results:** **A bilaterally absent N20** wave **within 6 hours** from	This preliminary study indicates that an absent N20 SSEP wave predicts poor outcome with 100% specificity and high sensitivity as early as 6 hours after ROSC. Additional criteria based on the quantitative analysis of the N20 wave or on the absence of the middle-latency SSEP wave increase the SSEP sensitivity while maintaining 100%

		<u>Exclusion criteria:</u> traumatic or neurological causes of CA, pre-existing neurological disability, regain of consciousness or death before neurophysiological tests.	ROSC predicted poor outcome with 100[89-100]% specificity and 67[48-82]% sensitivity. Adding **low-amplitude (<1.2 µV),** prolonged (>10 milliseconds) N20 wave and the absence of the N70 (middle-latency) SSEP wave increased the sensitivity to 93[79-99]% without compromising specificity. SSEPs outperformed all other predictors for poor outcome prediction at the study time point.	specificity for poor outcome prediction. However, confirmation from larger and multicentre studies is necessary.

Reviewer Comments: ***(including whether this PICOST should have a systematic or scoping review*****)**

Two articles show that a low-amplitude N20 wave predicts poor outcome after cardiac arrest with 100% specificity. Results are in line with previous studies from the same author groups (Endisch, 2015, Scarpino, 2021). In a single-centre study, SSEPs analysed quantitatively within 6 hours after ROSC and combined with middle-latency SSEP outperformed all other predictors for poor outcome prediction at that early time point, but results need validation in larger cohorts.

The measuring methods and the thresholds of the N20 amplitude are not consistent in the literature, as shown by the previous 2022 and 2024 ILCOR Evidence Updates.

The task force is planning an updated systematic review of all modalities of neuroprognostication in the near future.

Note on the interpretation of test results

Neuroprognostic tests used in patients who are comatose after resuscitation from cardiac arrest measure the severity of brain injury. An abnormal response from these tests may be classified as "positive," and a normal response as "negative," or vice versa, depending on the prognostic perspective taken. Usually, as in this evidence review, a positive result of these tests indicates that the outcome of that patient will be poor. If this occurs, the prediction is correct, and the test result is a true positive. Conversely, if the outcome is good, the positive test result is a false positive. In this context, the false-positive rate (FPR) of a test is the proportion of patients with good outcome who are assigned a falsely pessimistic prediction. In other words, the FPR is the number of false positives divided by the total number of patients with a good outcome. FPR is also the complement of specificity, i.e., 100% − specificity. Therefore, a test with 100% specificity has 0% FPR. Ideally, all neuroprognostic tests predicting poor outcome should yield 100% specificity. While neuroprognostic tests predicting outcome should also ideally offer a reasonably high sensitivity when "negative" (in this case indicating that the outcome of the patient will be good), this is less important than their having a high specificity (low FPR), since the latter minimizes the risk of incorrectly predicting (and acting upon) a poor prognosis in a potentially viable patient.

In most neuroprognostic studies, as in prognostic studies in general, the treating team is aware of the results of the prognostic tests under investigation. Consequently, these results may affect their treating decisions, leading to a self-fulfilling prophecy bias that may overestimate the specificity of prognostic tests in predicting poor outcome. This bias contributes to the low certainty of the evidence of most neuroprognostic studies after cardiac arrest. For that reason, the ILCOR 2020 Consensus for this PICOST is that The decision to limit treatment of comatose post–cardiac arrest patients should never rely on a single prognostication element. The consensus of the task force was that in patients who remain comatose in the absence of confounders (eg, sedative drugs), a multimodal approach should be used, with all supplementary tests considered in the context of the clinical examination.

For further details on the methodology and interpretation of prognostic tests see Geocadin RG, Callaway CW, Fink EL, Golan E, Greer DM, Ko NU, Lang E, Licht DJ, Marino BS, McNair ND, Peberdy MA, Perman SM, Sims DB, Soar J, Sandroni C; American Heart Association Emergency Cardiovascular Care Committee. Standards for Studies of Neurological Prognostication in Comatose Survivors of Cardiac Arrest: A Scientific Statement From the American Heart Association. Circulation. 2019 Aug 27;140(9):e517-e542.).

Reference list:

Czimmeck C, Resuscitation 2025 Aug:213:110650. https://pubmed.ncbi.nlm.nih.gov/40409670/
Endisch C, Neurology 2015, 20: 1752-60. https://pubmed.ncbi.nlm.nih.gov/26491086/
Scarpino M, Resuscitation 2021; 163: 162-71. https://pubmed.ncbi.nlm.nih.gov/33819501/
Scarpino M, Resuscitation 2025 Sep 4:110801. https://pubmed.ncbi.nlm.nih.gov/40914341/

2026 Evidence Update

ALS 3511 (Part 2) – Prognostication EEG

Worksheet author(s): Claudio Sandroni, Sonia D'Arrigo
External Collaborator (data extraction and management): Sofia Cacciola
Task Force: ALS
Date Submitted to SAC rep for peer review and approval: September 10, 2025
SAC rep: Eric Lavonas

PICOST / Research Question:
Population: Adults who are comatose after resuscitation from cardiac arrest (either in-hospital or out-of-hospital), regardless of target temperature.
Interventions: index test based on electrophysiology: electroencephalogram (EEG)
Comparison: none.
Outcomes: poor neurological outcome, defined as Cerebral Performance Categories (CPC) 3-5 or Glasgow Outcome Scale (GOS) 1-3, or modified Rankin Score (mRS) 4-6 at hospital discharge/1 month or later.
Study designs: Prognostic accuracy studies where the 2x2 contingency table (ie, the number of true/false negatives and positives for prediction of poor outcome) was reported, or where those variables could be calculated from reported data, are eligible for inclusion. Unpublished studies, reviews, case reports, case series, studies including fewer than 10 patients, letters, editorials, conference abstracts, and studies published in abstract form were excluded.

Year of last full review: 2020

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
We recommend that neuroprognostication always be undertaken by using a multimodal approach because no single test has sufficient specificity to eliminate false positives (strong recommendation, very low-certainty evidence).
We suggest using "highly malignant" EEG patterns to predict poor outcome in adult patients who are comatose and who are off sedation after cardiac arrest (weak recommendation, very low-certainty evidence).
We suggest against EEG background reactivity alone to predict poor outcome in adult patients who are comatose after cardiac arrest (weak recommendation, very low-certainty evidence).

Database searched: PubMed. The references of full-text articles were screened for additional studies.

Time Frame: (existing PICOST) –April 2024 (prior EvUp) to Aug 2025
Time Frame: (new PICOST) – at the discretion of the Task Force (please specify)
Date Search Completed: Aug 31, 2025
Search Results (Number of articles identified, and number identified as relevant): 25/5

Summary of Evidence Update:
Five studies evaluated the **presence of "highly malignant" patterns on EEG** in 1409 patients (Admiraal 2025, Benghanem 2025, Czimmeck 2025, Scarpino 2025, Shivji 2025) between the early phase (within 6 or 12-24h) and 14 days after ROSC.

In one study (Scarpino 2025) in 65 patients, the early presence (within 6 h after ROSC) of "highly malignant" patterns (suppression and burst suppression) predicted poor neurological outcome at discharge with 78 [66-87]% and 100 [93-100]% specificity and 67 [53-78]% and 33 [22-46]% sensitivity, respectively.

In one study (Admiraal 2025) in 191 patients investigated the prognostic performance of "synchronous EEG patterns" within 24 h in addition to the late EEG predictors (>24 h) recommended in the European post-resuscitation guidelines. The presence of **synchronous EEG patterns** (suppression with GPDs, BS with identical or " epileptiform bursts) on early cEEG at **12-24h after ROSC** predicted poor neurological outcome at 6 months with 30 [23-37]% sensitivity and 100 [97-100]% specificity. **Late EEG predictors** (BS with heterogeneous bursts and suppression without discharges) **at 24-36 h, 36-48 h and 48-72 h** predicted poor neurological outcome at 6 months with 100 [96-100]% specificity and 42 [35-50]%, 29 [23-37]% and 34 [26-44]% sensitivity, respectively.
In one study (Shivji 2025) in 81 patients the presence of "highly malignant" patterns on EEG **at 2-14 days** after ROSC predicted poor neurological outcome at 3-6 months with 73 [62-82]% sensitivity and 100 [94-100]% specificity.
In one study (Benghanem 2025) in 966 patients, the presence of "highly malignant" EEG patterns **at 48-72 h** after ROSC predicted poor neurological outcome at 3-6 months with 100 [99-100]% specificity and 34 [31-37]% sensitivity.
In another study (Czimmeck 2025) in 106 patients, the presence of "highly malignant" patterns on EEG **at 4 days after ROSC** predicted poor neurological outcome at hospital discharge with 51 [41-61]% sensitivity and 100% specificity.

Only one study (Shivji 2025) in 81 patients evaluated the additional value of the **absence of reactivity on EEG** at 2-14 days, showing that it predicted poor neurological outcome at 3-6 months with 89 [80-95]% specificity and 86 [76-92]% sensitivity. FPR was about 10%.

In all studies, "highly malignant" EEG patterns were suppression (with or without superimposed discharges) or burst-suppression, defined according to the American Clinical Neurophysiology Society (ACNS) terminology (Hirsch LJ et al., 2012, 2021). Further details are provided in the note at the end of this document.

Relevant Guidelines or Systematic Reviews: none

RCT: none

Nonrandomized Trials, Observational Studies published Apr 30, 2024 to Aug 31, 2025

Study Acronym; Author; Year Published	**Study Type/Design; Study Size (N)**	**Patient Population**	**Primary Endpoint and Results (include P value; OR or RR; & 95% CI)**	**Summary/Conclusion Comment(s)**
"Highly Malignant" Patterns				
Admiraal et al. 2025	**Study Type:** retrospective observational substudy of the TTM2-trial. One hundred and ninety-one patients were included in the study. cEEG was performed on all patients.	**Inclusion Criteria:** OHCA of a presumed cardiac or unknown cause, sustained ROSC, unconsciousness defined as not being able to obey verbal commands after sustained ROSC.	**1° endpoint:** to investigate the prognostic performance of "synchronous EEG patterns" within 24 h in addition to the late EEG predictors (>24 h) recommended in the European post-resuscitation guidelines. **2° endpoint:** to investigate the added value of assessing consecutive time-epochs of	Suppression and burst-suppression ("highly malignant patterns") assessed on continuous EEG monitoring predicted poor neurological outcome at 6 months with 100% specificity and moderate sensitivity.

		Exclusion criteria: unwitnessed cardiac arrest with an initial rhythm of asystole, temperature on admission <30°C, on ECMO prior to ROSC, obvious or suspected pregnancy, intracranial bleeding, severe COPD with long-term home oxygen therapy.	the cEEG-recording, thus gradually collecting prognostic cEEG information during the first 72 h for prediction of poor outcome. **Results:** **synchronous EEG patterns present at 12-24 h (early)** (suppression with GPDs, BS with identical or highly epileptiform bursts) predicted poor neurological outcome at 6 months with 30 [23-37]% sensitivity and 100 [97-100]% specificity. **Late EEG predictors at 24-36 h, 36-48 h and 48-72 h** (BS with heterogeneous bursts and suppression without discharges) predicted poor neurological outcome at 6 months with **100% specificity and 42 [35-50]%, 29 [23-37]% and 34 [26-44]% sensitivity,** respectively.	The study suggests that 'synchronous' patterns (suppression with periodical discharges, burst-suppression with identical or epileptiform bursts) predict poor outcome early (at 12-24h after ROSC), while 'non-synchronous patterns' (suppression without discharges and burst-suppression with heterogeneous bursts) predict poor outcome later (24-72h after ROSC).
Benghanem et al. 2025	**Study Type:** prospective, bicentric study. Ninety hundred sixty-six patients were included in the study. EEG was performed on all patients.	**Inclusion Criteria:** comatose adult patients who had at least a serum NSE measurement at 48 hours and an EEG ≥ 24 hours after CA. **Exclusion criteria:** N/A	The EEG accuracy was not the primary endpoint of the study. **1° endpoint:** neurological recovery at 3 months. **2° endpoint:** to examine the relationship between markers of brain injury (NSE and EEG patterns) obtained in early post-resuscitation period and the subsequent degree of neurological recovery. **Results:** **"Highly malignant" EEG at 2.2 (1.8-3) days** predicted poor neurological outcome at 3 months with **100% specificity and 34 [31-37]% sensitivity.**	"Highly malignant" EEG at 36-72 h predicted poor neurological outcome at 3 months with 100% specificity and moderate sensitivity.
Czimmeck et al. 2025	**Study Type:**	**Inclusion Criteria:**	The EEG accuracy was not the primary endpoint of the study.	"Highly malignant" EEG at day

	retrospective, monocentric observational study. One-hundred and fifty-two patients were included in the study. EEG was performed on 106 patients.	OHCA and IHCA patients with serum NFL testing within 24–96 h after CA. **Exclusion criteria:** N/A	**1° endpoint:** to evaluate NFL as a biomarker for neuroprognostication after CA in clinical routine. **2° endpoint:** to compare NFL to established pr ognostication methods. **Results:** **"Highly malignant" EEG at day 4** predicted poor neurological outcome at hospital discharge with **100% specificity and 51 [41-61]% sensitivity.**	4 predicted poor neurological outcome at hospital discharge with 100% specificity and moderate sensitivity.
Scarpino et al. 2025	**Study Type:** Prospective single-centre study. Sixty-five patients were included in the study. EEG was performed in all patients.	**Inclusion Criteria:** Consecutive comatose adult patients (GCS<8) who received the first multimodal pr ognostic evaluation within 6 hours after CA, as well as the NSE dosage within 12 hours after CA. **Exclusion criteria:** traumatic or neurological causes of CA, pre-existing neurological disabil ity, regain of consciousness or death before neurophysiological tests.	EEG accuracy was not the primary endpoint of the study. **1° endpoint:** the accuracy of short- and middle-latency SSEPs recorded within 6 hours of ROSC in predicting both poor (CPC 3–5) and good (CPC 1–2) neurological outcomes at hospital discharge. **2° endpoint:** to evaluate the prognostic accuracy of other ERC-ESICM predictors early after CA. **Results:** **Suppression and burst suppression on EEG ("early malignant" patterns) within 6 h after ROSC** predicted poor neurological outcome at discharge with 78 [66-87]% and 100 [93-100]% specificity and 67 [53-78]% and 33 [22-46]% sensitivity, respectively.	"Highly malignant" EEG within 6 h after ROSC predicted poor neurological outcome at hospital discharge. Specificity was high for burst-suppression, but lower for suppression at this early time point.
Shivji et al. 2025	**Study Type:** retrospective, monocentric study. Eighty-one patients were included in the study. EEG was performed on all patients.	**Inclusion Criteria:** age $\geq$ 18 years, coma due to cardiac arrest. **Exclusion criteria:** N/A	**1° endpoint:** to retrospectively evaluate the patterns seen on EEG in patients with post-anoxic coma following cardiac arrest and their relationship to outcome. **Results:**	"Highly malignant" EEG at 2-14 days predicted poor neurological outcome at 3-6 months with 100% specificity and 73% sensitivity.

			"Highly malignant" EEG at 2-14 days predicted poor neurological outcome at 3-6 months with **100 [94-100]% specificity and 73 [62-82]% sensitivity.**	
Absence of reactivity on EEG				
Shivji et al. 2025	**Study Type:** retrospective, monocentric study. Eighty-one patients were included in the study. EEG was performed on all patients.	**Inclusion Criteria:** age ≥ 18 years, coma due to cardiac arrest. **Exclusion criteria:** N/A	**1° endpoint:** to retrospectively evaluate the patterns seen on EEG in patients with post-anoxic coma following cardiac arrest and their relationship to outcome. **Results:** **Unreactive EEG at 2-14 days** predicted poor neurological outcome at 3-6 months with **89 [80-95]% specificity and 86 [76-92]% sensitivity.** FPR was about 10%.	Unreactive EEG at 2-14 days predicted poor neurological outcome at 3-6 months with 89% specificity and 86% sensitivity.

Reviewer Comments: *(including whether this PICOST should have a systematic or scoping review*)
All five studies included in this review confirmed that "highly malignant" EEG patterns (suppression and burst suppression) recorded early (within 6 h) and after 24h predict poor outcome with 100% specificity after cardiac arrest, in line with the current ILCOR recommendation. Two studies (Admiraal 2025 and Scarpino 2025) suggest that "highly malignant" patterns with a synchronous component may accurately predict poor outcome before 24h. However, this study was conducted by experienced electrophysiologists who analysed continuous EEG records, and it deserves confirmation from further studies. One study (Shivij, 2025) confirmed that an unreactive EEG background does not reach 100% specificity for predicting poor outcome after cardiac arrest. The task force is planning an updated systematic review on all modalities for neuroprognostication in the near future.

Note: definition of "highly malignant" EEG patterns, EEG reactivity, early EEG predictors
In all studies included in this Evidence Update, "highly malignant" patterns included suppression or burst-suppression, defined according to the Standardized Critical Care EEG Terminology of the American Clinical Neurophysiology Society's (ACNS). The ACNS terminology was published in 2012 and 2021 (Hirsch LJ et al, J Clin Neurophysiol 30(1): 1-27; https://pubmed.ncbi.nlm.nih.gov/23377439/ Hirsch LJ et al., J Clin Neurophysiol 2021 Jan 1;38(1):1-29; https://pubmed.ncbi.nlm.nih.gov/33475321/). Based on the ACNS terminology, suppression occurs when the background voltage in the entire record is below 10 µV, and burst suppression occurs when >50% of the record consists of suppression, alternated with bursts. This definition was consistent with that used in the ILCOR 2024 CoSTR.
EEG background reactivity is defined by ACNS as "change in cerebral EEG activity to intense auditory and/or noxious stimuli. This may include change in amplitude or frequency, including attenuation of activity".
Early EEG predictors, including synchronuous patterns such as identical burst-suppression, evaluated in Admiraal et al. 2025 had the highest sensitivity at time-points before 24 h after CA and thereafter sensitivity declined

confirming previous studies (Ruijter BJ, Tjepkema-Cloostermans MC, Tromp SC, et al. Early electroencephalography for outcome prediction of postanoxic coma:
a prospective cohort study. Ann Neurol 2019;86(2):203–14; Hofmeijer J, Tjepkema-Cloostermans MC, Van Putten MJAM. Burstsuppression with identical bursts: a distinct EEG pattern with poor outcome in postanoxic coma. Clin Neurophysiol 2014;125
(5):947–54).
Guidelines recommended late EEG predictors, including non-identical/heterogenous burst-suppression and suppression, showed a relatively stable sensitivity between 24 and 72 h after CA, in line with
previous studys (Westhall E, Rossetti AO, van Rootselaar AF, et al. Standardized EEG interpretation accurately predicts prognosis after cardiac arrest.Neurology 2016;86(16):1482–90).
Searching for both early and late EEG predictors is a novel strategy which identified even more patients with poor outcome and performed best between 24 and 36 h after CA. Since EEG patterns are often transient, assessment of an individual time-window was less informative compared to continuously evaluating the EEG. When using this combined strategy and gradually adding EEG information from before 12 h up to 36 h after CA (requiring cEEG) sensitivity significantly increased and half of all patients with long-term poor outcome could be identified.

Note on the interpretation of test results
Neuroprognostic tests used in patients who are comatose after resuscitation from cardiac arrest measure the severity of brain injury. An abnormal response from these tests may be classified as “positive,” and a normal response as “negative,” or vice versa, depending on the prognostic perspective taken. Usually, as in this evidence review, a positive result of these tests indicates that the outcome of that patient will be poor. If this occurs, the prediction is correct, and the test result is a true positive. Conversely, if the outcome is good, the positive test result is a false positive. In this context, the false-positive rate (FPR) of a test is the proportion of patients with good outcome who are assigned a falsely pessimistic prediction. In other words, the FPR is the number of false positives divided by the total number of patients with a good outcome. FPR is also the complement of specificity, i.e., 100% − specificity. Therefore, a test with 100% specificity has 0% FPR. Ideally, all neuroprognostic tests predicting poor outcome should yield 100% specificity. While neuroprognostic tests predicting outcome should also ideally offer a reasonably high sensitivity when “negative” (in this case indicating that the outcome of the patient will be good), this is less important than their having a high specificity (low FPR), since the latter minimizes the risk of incorrectly predicting (and acting upon) a poor prognosis in a potentially viable patient.
In most neuroprognostic studies, as in prognostic studies in general, the treating team is aware of the results of the prognostic tests under investigation. Consequently, these results may affect their treating decisions, leading to a self-fulfilling prophecy bias that may overestimate the specificity of prognostic tests in predicting poor outcome. This bias contributes to the low certainty of the evidence of most neuroprognostic studies after cardiac arrest. For that reason, the ILCOR 2020 Consensus for this PICOST is that the decision to limit treatment of comatose post–cardiac arrest patients should never rely on a single prognostication element. The consensus of the task force was that in patients who remain comatose in the absence of confounders (eg, sedative drugs), a multimodal approach should be used, with all supplementary tests considered in the context of the clinical examination.
For further details on the methodology and interpretation of prognostic tests see Geocadin RG, Callaway CW, Fink EL, Golan E, Greer DM, Ko NU, Lang E, Licht DJ, Marino BS, McNair ND, Peberdy MA, Perman SM, Sims DB, Soar J, Sandroni C; American Heart Association Emergency Cardiovascular Care Committee. Standards for Studies of Neurological Prognostication in Comatose Survivors of Cardiac Arrest: A Scientific Statement From the American Heart Association. Circulation. 2019 Aug 27;140(9):e517-e542.).

Reference list: ***(List by ILCOR ref standard (last name first author, year of publication, first page number) and insert hyperlink to all articles identified as relevant (if available on PubMed)***

Admiraal M, Resuscitation 2025 Aug 7:215:110762. https://pubmed.ncbi.nlm.nih.gov/40783100/
Benghanem S, Resuscitation 2025 Aug 6:110757. https://pubmed.ncbi.nlm.nih.gov/40780697/
Czimmeck C, Resuscitation 2025 Aug:213:110650. https://pubmed.ncbi.nlm.nih.gov/40409670/

Shivji Z, Brain Sci 2024 Dec 17;14(12):1264. https://pubmed.ncbi.nlm.nih.gov/39766463/
Scarpino M, Resuscitation 2025 Sep 4:110801. https://pubmed.ncbi.nlm.nih.gov/40914341/

2026 Evidence Update

ALS 3513 – Prognostication Clinical Examination

Worksheet author(s): Claudio Sandroni, Sonia D'Arrigo
External Collaborator (data extraction and management): Sofia Cacciola
Task Force: ALS
Date Submitted to SAC rep for peer review and approval: September 10, 2025
SAC rep: Eric Lavonas

PICOST / Research Question:
Population: Adults who are comatose after resuscitation from cardiac arrest (either in-hospital or out-of-hospital), regardless of target temperature.
Interventions: index tests based on clinical examination
Comparison: none.
Outcomes: poor neurological outcome, defined as **Cerebral Performance Categories (CPC) 3-5** or Glasgow Outcome Scale (GOS) 1-3, or modified Rankin Score (mRS) 4-6 at hospital discharge/1 month or later.
Study designs: Prognostic accuracy studies where the 2x2 contingency table (ie, the number of true/false negatives and positives for prediction of poor outcome) was reported, or where those variables could be calculated from reported data, are eligible for inclusion. Unpublished studies, reviews, case reports, case series, studies including fewer than 10 patients, letters, editorials, conference abstracts, and studies published in abstract form were excluded.

Year of last full review: 2020

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST: COSTR 2024
We recommend that neuroprognostication always be undertaken by using a multimodal approach because no single test has sufficient specificity to eliminate false positives (strong recommendation, very low-certainty evidence).
We suggest using PLR at 72 hours or more after ROSC for predicting neurological outcome of adults who are comatose after cardiac arrest (weak recommendation, very low-certainty evidence).
We suggest using quantitative pupillometry at 72 hours or more after ROSC for predicting neurological outcome of adults who are comatose after cardiac arrest (weak recommendation, low-certainty evidence).
We suggest using bilateral absence of corneal reflex at 72 hours or more after ROSC for predicting poor neurological outcome in adults who are comatose after cardiac arrest (weak recommendation, very low-certainty evidence).
We suggest using presence of myoclonus or status myoclonus within 7 days after ROSC, in combination with other tests, for predicting poor neurological outcome in adults who are comatose after cardiac arrest (weak recommendation, very low-certainty evidence). We also suggest recording EEG in the presence of myoclonic jerks to detect any associated epileptiform activity (weak recommendation, very low-certainty evidence).

Database searched: PubMed. The references of full-text articles were screened for additional studies.

Time Frame: (existing PICOST) –April 2024 (last EvUp) to Aug 2025
Date Search Completed: Aug 31, 2025
Search Results (Number of articles identified and number identified as relevant): 25/4

Summary of Evidence Update:
This update identified **4 relevant studies** that were not included in the 2024 ILCOR evidence update.

Regarding **clinical examination**, three studies (Bae 2025, Beekman 2025, Scarpino 2025) assessed the absence of **standard pupillary light reflex (PLR) immediately after ROSC or within 6 h** as a predictor of poor neurological

outcome at hospital discharge, showing a specificity ranging from **82 [68-91]%** to **100 [93-100]%** and sensitivity ranging from **44 [31-59]%** to **88 [77-94]%.**
None of the included studies were designed to investigate PLR as the primary endpoint of the study.

Automated pupillometry showed greater specificity for predicting poor neurological outcomes compared to standard PLR. Only one study (Nyholm 2024) in 710 patients performed an external validation. The proposed thresholds for neurological pupil index (NPi) and quantitative pupillary light reflex (qPLR) were ≤2 and <4%, respectively. An **NPi ≤2 measured at admission and 48 h** predicted poor neurological outcome at 3 months with **100 [99-100]% specificity** and **10 [8-13]% and 9 [7-12]% sensitivity**, respectively. **A qPLR <4% measured at admission and 48 h** predicted poor neurological outcome at 3 months with **95 [93-96]% and 99.7 [98.6-100]% specificity** and **31 [27-34]% and 21 [17-24]% sensitivity,** respectively.

Corneal reflex (CR) was evaluated in one study (Bae 2025), where CR accuracy was not the primary endpoint. The **absence of CR measured immediately after ROSC** predicted poor neurological outcome at hospital discharge with **46 [31-62]% specificity** and **92 [78-98]% sensitivity.**

One study (Scarpino 2025) evaluated the accuracy of status myoclonus in 65 patients, showing that its presence within 6 h after ROSC predicted poor neurological outcome at hospital discharge with 100 [93-100]% specificity and 21 [12-33]% sensitivity.

Relevant Guidelines or Systematic Reviews: none

RCT: none

Nonrandomized Trials, Observational Studies

Study Acronym; Author; Year Published	**Study Type/Design; Study Size (N)**	**Patient Population**	**Primary Endpoint and Results (include P value; OR or RR; & 95% CI)**	**Summary/Conclusion Comment(s)**
Pupillary Light Reflex (PLR)				
Bae et al. 2025	**Study Type:** retrospective study of prospectively collected data. Fifty-one patients were included in the study. PLR was measured in all patients.	**Inclusion Criteria:** adult CA survivors treated with TTM and underwent brain CT within 2 h and brain MRI within 3 days of ROSC. **Exclusion criteria:** brain edema due to acute intracerebral hemorrhage and previous strokes, acquired CT images technically unsuitable for fusion with MRI, patients with a	The PLR accuracy was not the primary endpoint of the study. **1° endpoint:** validate the prognostic value of the GWR measured by MRI-based CT structures compared to conventional measures in adult patients after cardiac arrest. **Results:** the **absence of PLR measured immediately after ROSC** predicted poor neurological outcome at	The absence of PLR immediately after ROSC predicted poor neurological outcome at hospital discharge with 82% specificity and 44% sensitivity.

		pre-cardiac arrest CPC score of 3 or 4.	hospital discharge with **82 [68-91]% specificity** and **44 [31-59]% sensitivity**.	
Beekman et al. 2025	**Study Type:** retrospective, single-center study. Three hundred eighty-two patients were included in the study. PLR was measured in all patients.	**Inclusion Criteria:** OHCA, age ≥ 18 years, sustained ROSC, and admission to an ICU following ROSC. **Exclusion criteria:** missing pupil size data, inconsistent pupil size documentation, bilateral surgical pupils.	The PLR accuracy was not the primary endpoint of the study. **1° endpoint:** brain death/death based on neurologic criteria. **2° endpoint:** the association between pupil size and reactivity immediately following ROSC and neurological outcome and mortality at hospital discharge. **Results:** the **absence of PLR measured immediately after ROSC** predicted poor neurological outcome at hospital discharge with **94 [91-96]% specificity** and **60 [55-65]% sensitivity**.	The absence of visually-assessed (non-quantitative) PLR immediately after ROSC predicted poor neurological outcome at hospital discharge with 94% specificity and 60% sensitivity.
Scarpino et al. 2025	**Study Type:** Prospective single-centre study. Sixty-five patients were included in the study. PLR was performed in all patients.	**Inclusion Criteria:** Consecutive comatose adult patients (GCS<8) who received the first multimodal prognostic evaluation within 6 hours after CA, as well as the NSE dosage within 12 hours after CA. **Exclusion criteria:** traumatic or neurological causes of CA, pre-existing neurological disability, regain of consciousness or death before neurophysiological tests.	The PLR accuracy was not the primary endpoint of the study. **1° endpoint:** the accuracy of short- and middle-latency SSEPs recorded within 6 hours of ROSC in predicting both poor (CPC 3–5) and good (CPC 1–2) neurological outcomes at hospital discharge. **2° endpoint:** to evaluate the prognostic accuracy of other ERC-ESICM predictors. **Results:** the **absence of PLR within 6 h after ROSC** predicted poor neurological outcome at hospital discharge with **100 [93-100]% specificity** and **88 [72-96]% sensitivity**.	The absence of PLR within 6h after ROSC predicted poor neurological outcome at hospital discharge with 100% specificity and 88% sensitivity.
Corneal Reflex (CR)				

Bae et al. 2025	**Study Type:** retrospective study of prospectively collected data Fifty-one patients were included in the study. PLR was measured in all patients.	**Inclusion Criteria:** adult CA survivors treated with TTM and underwent brain CT within 2 h and brain MRI within 3 days of return of ROSC. **Exclusion criteria:** brain edema due to acute intracerebral hemorrhage and previous strokes, acquired CT images technically unsuitable for fusion with MRI, patients with a pre-cardiac arrest CPC score of 3 or 4.	The CR accuracy was not the primary endpoint of the study. **1° endpoint:** to validate the prognostic value of the GWR measured by MRI-based CT structures compared to conventional measures in adult patients after cardiac arrest. **Results:** the **absence of CR measured immediately after ROSC** predicted poor neurological outcome at hospital discharge with **46 [31-62]% specificity** and **92 [78-98]% sensitivity**.	The absence of CR immediately after ROSC predicted poor neurological outcome at hospital discharge with 46% specificity and 92% sensitivity.
Pupillometry: Neurological Pupil index (NPi)				
Nyholm et al. 2024	**Study Type:** prospective, multi- center prognostic sub-study within the Blood Pressure and Oxygenation Targets after Cardiac Arrest (BOX) trial. Seven hundred and ten patients were included in the study. NPi was measured in all patients included.	**Inclusion Criteria:** Age ≥18 years, OHCA of presumed cardiac cause, sustained ROSC, GCS <8 after sustained ROSC. **Exclusion criteria:** conscious patients, IHCA, OHCA of presumed non-cardiac cause, suspected or confirmed acute intracranial bleeding or acute stroke, unwitnessed asystole, DNR order, known pre-arrest CPC 3 or 4.	**1° endpoint:** to perform an external validation with a similar methodology of the previous studies proposing pupillometry thresholds of qPLR <4% and NPi ≤2, shown to predict unfavorable outcomes from admission to 72 h with 0% FPR in comatose OHCA survivors. **Results:** **Npi ≤2 measured at admission and 48 h** predicted poor neurological outcome at 3 months with **100 [99-100]% specificity** and **10 [8-13]% and 9 [7-12]% sensitivity**, respectively.	An NPi value ≤2 at admission and 48 h after ROSC predicted a poor neurological outcome at 3 months with 100% specificity but very low sensitivity.
Pupillomentry: Quantitative Pupillary Light Reflex (qPLR)				
Nyholm et al. 2024	**Study Type:** prospective, multi- center prognostic sub-study within the Blood Pressure and Oxygenation	**Inclusion Criteria:** Age ≥18 years, OHCA of presumed cardiac cause, sustained ROSC, GCS < 8 after sustained ROSC. **Exclusion criteria:**	**1° endpoint:** to perform an external validation with a similar methodology of the previous studies proposing pupillometry thresholds of qPLR <4% and NPi ≤2, shown to predict	A qPLR <4% at admission and 48 h after ROSC predicted a poor neurological outcome at 3 months with 95% and 99.7% specificity, respectively.

	Targets after Cardiac Arrest (BOX) trial. Seven hundred and ten patients were included in the study. qPLR was measured in all patients included at admission and in 543 patients at 48 h.	conscious patients, IHCA, OHCA of presumed non-cardiac cause, suspected or confirmed acute intracranial bleeding or acute stroke, unwitnessed asystole, Do Not Resuscitate-order, known pre-arrest CPC 3 or 4.	unfavorable outcomes from admission to 72 h with 0% FPR in comatose OHCA survivors. **Results:** **qPLR <4% measured at admission and 48 h** predicted poor neurological outcome at 3 months with **95 [93-96]% and 99.7 [98.6-100]% specificity** and **31 [27-34]% and 21 [17-24]% sensitivity,** respectively.	The sensitivity was low at both time points.
Status myoclonus				
Scarpino et al. 2025	**Study Type:** Prospective single-center study. Six-five patients were included in the study.	**Inclusion Criteria:** Consecutive comatose adult patients (GCS<8) who received the first multimodal prognostic evaluation within 6 hours after CA, as well as the NSE dosage within 12 hours after CA. **Exclusion criteria:** traumatic or neurological causes of CA, pre-existing neurological disability, regain of consciousness or death before neurophysiological tests.	The accuracy of status myoclonus was not the study's primary endpoint. **1° endpoint:** the accuracy of short- and middle-latency SSEPs recorded within 6 hours of ROSC in predicting both poor (CPC 3–5) and good (CPC 1–2) neurological outcomes at hospital discharge. **2° endpoint:** to evaluate the prognostic accuracy of other ERC-ESICM predictors. **Results:** The presence of status myoclonus within 6h after ROSC predicted poor neurological outcome at hospital discharge with 100 [93-100]% specificity and 21 [12-33]%	The presence of status myoclonus within 6 h after ROSC predicted poor neurological outcomes with 100% specificity and 21% sensitivity.

Reviewer Comments: *(including whether this PICOST should have a systematic or scoping review*)
The fours studies included in this evidence update largely confirmed the results of both the ILCOR 2024 evidence update and the 2020 systematic review. The only study assessing corneal reflex (CR) showed that CR has low specificity for predicting poor outcome immediately after cardiac arrest. However, this early timing is not recommended by the current guidelines.
Four studies assessed pupillary light reflex (PLR) immediately or within 6 h after ROSC. Results showed that specificity was highest (100%), with low sensitivity, for the pupillometry-assessed NPi index, followed by the pupillometry-assessed qPLR index (95% specificity) and visually assessed, non-quantitative PLR (94% specificity). Unlike pupillometry-based indices, visual PLR assessment is operator-dependent. The ability of quantitative pupillometry to yield 100% specificity from day 1 after cardiac arrest is in line with previous multicentre studies (Oddo et al, 2018).

The task force is planning an updated systematic review on all modalities for neuroprognostication in the near future

Note on the interpretation of test results

Neuroprognostic tests used in patients who are comatose after resuscitation from cardiac arrest measure the severity of brain injury. An abnormal response from these tests may be classified as "positive," and a normal response as "negative," or vice versa, depending on the prognostic perspective taken. Usually, as in this evidence review, a positive result of these tests indicates that the outcome of that patient will be poor. If this occurs, the prediction is correct, and the test result is a true positive. Conversely, if the outcome is good, the positive test result is a false positive. In this context, the false-positive rate (FPR) of a test is the proportion of patients with good outcome who are assigned a falsely pessimistic prediction. In other words, the FPR is the number of false positives divided by the total number of patients with a good outcome. FPR is also the complement of specificity, i.e., 100% − specificity. Therefore, a test with 100% specificity has 0% FPR. Ideally, all neuroprognostic tests predicting poor outcome should yield 100% specificity. While neuroprognostic tests predicting outcome should also ideally offer a reasonably high sensitivity when "negative" (in this case indicating that the outcome of the patient will be good), this is less important than their having a high specificity (low FPR), since the latter minimizes the risk of incorrectly predicting (and acting upon) a poor prognosis in a potentially viable patient.

In most neuroprognostic studies, as in prognostic studies in general, the treating team is aware of the results of the prognostic tests under investigation. Consequently, these results may affect their treating decisions, leading to a self-fulfilling prophecy bias that may overestimate the specificity of prognostic tests in predicting poor outcome. This bias contributes to the low certainty of the evidence of most neuroprognostic studies after cardiac arrest. For that reason, the ILCOR 2020 Consensus for this PICOST is that The decision to limit treatment of comatose post–cardiac arrest patients should never rely on a single prognostication element. The consensus of the task force was that in patients who remain comatose in the absence of confounders (eg, sedative drugs), a multimodal approach should be used, with all supplementary tests considered in the context of the clinical examination.

For further details on the methodology and interpretation of prognostic tests see Geocadin RG, Callaway CW, Fink EL, Golan E, Greer DM, Ko NU, Lang E, Licht DJ, Marino BS, McNair ND, Peberdy MA, Perman SM, Sims DB, Soar J, Sandroni C; American Heart Association Emergency Cardiovascular Care Committee. Standards for Studies of Neurological Prognostication in Comatose Survivors of Cardiac Arrest: A Scientific Statement From the American Heart Association. Circulation. 2019 Aug 27;140(9):e517-e542.).

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2026 Evidence Update

ALS 3512 (Part 1) – Prognostication Biomarkers NfL

Worksheet author(s): Claudio Sandroni, Sonia D'Arrigo
External Collaborator (data extraction and management): Sofia Cacciola
Task Force: ALS
Date Submitted to SAC rep for peer review and approval: September 10, 2025
SAC rep: Eric Lavonas

PICOST / Research Question:
Population: Adults who are comatose after resuscitation from cardiac arrest (either in-hospital or out-of-hospital), regardless of target temperature.
Interventions: index test based on biomarkers: **neurofilament light chain (NfL)**
Comparison: none.
Outcomes: poor neurological outcome, defined as Cerebral Performance Categories (CPC) 3-5 or Glasgow Outcome Scale (GOS) 1-3, or modified Rankin Score (mRS) 4-6 at hospital discharge/1 month or later.
Study designs: Prognostic accuracy studies where the 2x2 contingency table (ie, the number of true/false negatives and positives for prediction of poor outcome) was reported, or where those variables could be calculated from reported data, are eligible for inclusion. Unpublished studies, reviews, case reports, case series, studies including fewer than 10 patients, letters, editorials, conference abstracts, and studies published in abstract form were excluded.

Year of last full review: 2020

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
We suggest against using serum levels of glial fibrillary acidic protein, serum tau protein, or neurofilament light chain for predicting poor neurological outcome of adults who are comatose after cardiac arrest (weak recommendation, very low-certainty evidence).

Database searched: PubMed. The references of full-text articles were screened for additional studies.

Time Frame: (existing PICOST) –Apr 2024 (last EvUp) to Aug 2025
Date Search Completed: Aug 31, 2025
Search Results (Number of articles identified, and number identified as relevant): 24/3

Summary of Evidence Update:
Three studies evaluated the ability of blood levels of NfL measured between 24h and 72h after ROSC to predict poor neurological outcome in comatose patients after CA (Ayasse 2025, Czimmeck 2025, Meyer 2025). Two studies (Ayasse 2025, Meyer 2025), which included a total of 590 patients, investigated NfL at 24 hours **after ROSC**. In these studies, NfL levels of 1121 pg/mL and 5811 pg/mL predicted poor neurological outcome at 3 and 12 months, respectively, with a specificity of 100% (95% CIs 93-100% and 99-100%, respectively). The corresponding sensitivities were 14[7-26]% and 41[37-45]%, respectively.

The study from Ayasse et al (Ayasse 2025) also investigated NfL **48 hours after ROSC** in 48 patients. In that study, NfL levels of 1324 pg/mL predicted poor neurological outcome at 3 months with a specificity of 100 [91-100]%, and sensitivity of 56 [41-70]%. The same study (Ayasse 2025) investigated NfL **72h after ROSC** in 35 patients. In that study, NfL levels of 510 pg/mL predicted poor neurological outcome at 3 months with a specificity of 100 [88-100]%, respectively, and 74 [56-87]% sensitivity.

The study by Ayasse et al. also reported the optimal threshold, defined as the one that balances optimised sensitivity with a specificity greater than 90%. Optimised sensitivity was not defined in the study. These thresholds were 250 pg/mL, 383 pg/mL, and 406 pg/mL at 24h, 48h, and 72h, respectively. The corresponding specificities were 90[75-90]%, 94[82-98]%, and 92[76-98]%, respectively.

One study (Czimmeck, 2025) in 152 patients investigated NfL **at 1-4 days after ROSC**. NfL levels more than 2000 pg/mL predicted poor neurological outcome at hospital discharge with 100 [97-100]% specificity and 53 [45-61]% sensitivity.

Relevant Guidelines or Systematic Reviews: none

RCT: none

Nonrandomized Trials, Observational Studies published Apr 30, 2024 to Aug 31, 2025

Study Acronym; Author; Year Published	**Study Type/Design; Study Size (N)**	**Patient Population**	**Primary Endpoint and Results (include P value; OR or RR; & 95% CI)**	**Summary/Conclusion Comment(s)**
Ayasse et al. 2025	**Study Type:** prospective, monocentric study. Sixty-seven patients were included in the study. NfL was measured in all patients.	**Inclusion Criteria:** GCS<8 at ICU admission after an IHCA or OHCA and who had at least one serum NfL level measurement at 24, 48 and/or 72 h after ROSC. **Exclusion criteria:** age < 18 years, established brain death.	**1° endpoint:** to evaluate the prognostic value of NfL measured at 24, 48 and 72 h after CA for predicting unfavorable and favorable neurological outcome. **2° endpoint:** to assess the prognostic value of NfL trends over time for predicting outcomes; to compare the prognostic accuracy of NFL and NSE. **Results: NfL > 1121 pg/mL at 24 h, NfL >1324 pg/mL at 48 h and NfL >510 pg/mL at 72 h** after CA predicted poor neurological outcome at 3 months with **100% specificity** and **14 [7-25]%, 56 [41-70]% and 74 [56-87]% sensitivity, respectively**.	NfL levels >1121 ng/mL at 24h, >1324 pg/mL at 48h and >510 pg/mL at 72h predicted poor neurological outcome with high specificity (100%) and moderate sensitivity (56% and 74%, respectively). Confidence intervals were wide, due to the small study sample. Unlike NSE, the NfL value trend between 24h and 72h did not predict functional outcome. The authors used the Lumipulse G600 chemiluminescent enzyme immunoassay (CLEIA) by Fujirebio to measure NFL. This assay has been utilised in clinical

			An NfL increase was not associated with neurological outcomes (AUC 0.50), whereas an increase of NSE measured between 24 and 72 h predicted poor outcome with an AUC of 0.92.	studies involving patients with multiple sclerosis, demonstrating str ong agreement with the SIMOA platform. Validat ed reference ranges for routine clinical use are still lacking. The assay is not explicitly labelled as diagnostic, suggesting it is still in the research or pre-clinical validation phase. NSE was measured using the Cobas® immunochemiluminescent El ecsys assay.
Czimme ck et al. 2025	**Study Type:** retrospective, monocentric observational study. One-hundred and fifty-two patients were included in the study. NfL was measured in all patients.	**Inclusion Criteria:** OHCA and IHCA patients with serum NfL testing within 24–96 h after CA. **Exclusion criteria:** N/A	**1° endpoint:** to evaluate NfL as a biomarker for neuroprognostication afte r CA. **2° endpoint:** to compare NfL to established pr ognostication methods. **Results:** **NfL >2000 pg/mL at Days 1-4** after CA predicted poor neurological outcome (CPC 4-5) at hospital discharge with **100 [97-100] % specificity** and **53 [45-61] % sensitivity**.	NfL levels above 2000 pg/mL at Days 1-4 after CA predicted poor neurological outcome (CPC 4-5) at hospital discharge with 100% specificity and moderate sensitivity. The NfL threshol d was pre-defined. The authors used the Quanterix SIMOA assay for measuring NfL. This assay is for research use only. The timing of NfL measurement was only reported as a range. The use of a 4-5 CPC threshold instead of 3-5 CPC for defining poor neurological outcome prevents a direct comparison with the outcome of other studies.
Meyer et al. 2025	**Study Type:** Sub-study of the prospective randomise d controlled BOX trial (Blood Pressure and Oxygenation targets in post-resuscitation care).	**Inclusion Criteria:** Adult OHCA with p resumed cardiac cause of the arrest, and coma at admission. **Exclusion criteria:** N/A	**1° endpoint:** to validate the NfL cut-offs previously suggested by Moseby-Knappe et al. 2019 for predicting poor functional outcome (1232 pg/ ml at 24h and 1539 pg/ml at 48h after CA).	The assay used by the authors (MSD ELISA QuickPlex) differed from the Quanterix SIMOA assay used by Moseby-Knappe et al. This may have contributed to differences in accuracy of the cut-offs used in the

	Six thousand and thirty-eight patients were included in the analysis. 523 were included at 24 h. NfL was measured in all patients, at least once at 24 or 48h.		**<u>Results:</u>** At 24 h, a cut-off of 1232 pg/mL had a specificity of 98 [96-99]%, for prediction of poor neurologic outcome. False-positive results occurred in 7 patients (1.4%). In a sensitivity analysis, the **NfL cut-off levels at 24 h** after CA, **corresponding to a specificity of 100%, 99% and 98%** for predicting poor neurological outcome at 1 year were **5811 pg/mL, 4372 pg/mL and 1966 pg/mL** respectively. Sensitivity ranged from 41% to 66%.	two studies. Both QuickPlex and SIMOA assays are for research use only. The authors measured NfL at 48h as well. However, 311/638 patients (49%) were awake at 48h. For this reason, we included only accuracy data at 24h. The authors reported AUROCs of 0.96 (0.94–0.98) in the subpopulation of patients who did not awake by 48 h (n=300), but did not report the relevant contingency table.

Reviewer Comments: *(including whether this PICOST should have a systematic or scoping review*)

There is considerable heterogeneity in the methodologies employed for neurofilament light chain (NfL) quantification across studies, ranging from ELISA to ultra-sensitive platforms such as SIMOA (Single Molecule Array). This heterogeneity might have led to significant variation in NfL measured levels, thereby preventing direct comparisons between studies.

One of the three included studies assessed NfL over a wide temporal range, from days 1 to 4 after CA. The authors of that study evaluated the ability of NfL to predict a CPC 4-5, therefore including awakening with severe neurological disability (CPC 3) among good functional outcomes. This prevents a direct comparison with the vast majority of neuroprognostic studies, which use a CPC 3-5 threshold. From the accuracy standpoint, using a CPC 4-5 instead of a CPC 3-5 threshold for defining poor outcome is likely to increase the NfL threshold for poor outcome prediction and reduce measured sensitivity, all other things being equal.

Limited evidence suggests that NfL and NSE have distinct kinetic profiles. NfL levels show a sustained increase following HIBI, possibly reflecting axonal degeneration over time, whereas NSE levels decrease more rapidly than NfL.

The task force is planning an updated systematic review on all modalities for neuroprognostication in the near future.

Note on the interpretation of test results

Neuroprognostic tests used in patients who are comatose after resuscitation from cardiac arrest measure the severity of brain injury. An abnormal response from these tests may be classified as “positive,” and a normal response as “negative,” or vice versa, depending on the prognostic perspective taken. Usually, as in this evidence review, a positive result of these tests indicates that the outcome of that patient will be poor. If this occurs, the prediction is correct, and the test result is a true positive. Conversely, if the outcome is good, the positive test result is a false positive. In this context, the false-positive rate (FPR) of a test is the proportion of patients with good outcome who are assigned a falsely pessimistic prediction. In other words, the FPR is the number of false positives divided by the total number of patients with a good outcome. FPR is also the complement of specificity, i.e., 100% − specificity. Therefore, a test with 100% specificity has 0% FPR. Ideally, all neuroprognostic tests predicting poor outcome should yield 100% specificity. While neuroprognostic tests predicting outcome should

also ideally offer a reasonably high sensitivity when “negative” (in this case indicating that the outcome of the patient will be good), this is less important than their having a high specificity (low FPR), since the latter minimizes the risk of incorrectly predicting (and acting upon) a poor prognosis in a potentially viable patient.
In most neuroprognostic studies, as in prognostic studies in general, the treating team is aware of the results of the prognostic tests under investigation. Consequently, these results may affect their treating decisions, leading to a self-fulfilling prophecy bias that may overestimate the specificity of prognostic tests in predicting poor outcome. This bias contributes to the low certainty of the evidence of most neuroprognostic studies after cardiac arrest. For that reason, the ILCOR 2024 Consensus for this PICOST is that the decision to limit treatment of comatose post–cardiac arrest patients should never rely on a single prognostication element. The consensus of the task force was that in patients who remain comatose in the absence of confounders (eg, sedative drugs), a multimodal approach should be used, with all supplementary tests considered in the context of the clinical examination.

Notes on the interpretation of biomarkers
Unlike the results of other neuroprognostic tests (e.g., clinical examination), biomarker blood levels are continuous rather than dichotomous (categorical) variables. Results are dichotomised to calculate the sensitivity and specificity of these biomarkers by establishing a threshold that divides positive from negative results. Consequently, test sensitivity and specificity depend on the threshold chosen: a high threshold increases the specificity of the test and decreases the sensitivity, and vice versa.
The kinetics of NfL after cardiac arrest are only incompletely known but are likely different from those of NSE. An important source of confounding for NfL is the presence of different assays, which can yield varying results across measurement methods. Moreover, all studies included in this and previous Evidence Updates employed NfL assays that are for research use only.
An important advantage of biomarkers is that – unlike other outcome predictors after cardiac arrest – they can be easily assessed in a blinded fashion, therefore reducing the risk of a self-fulfilling prophecy bias.
For further details on the methodology and interpretation of prognostic tests see Geocadin RG, Callaway CW, Fink EL, Golan E, Greer DM, Ko NU, Lang E, Licht DJ, Marino BS, McNair ND, Peberdy MA, Perman SM, Sims DB, Soar J, Sandroni C; American Heart Association Emergency Cardiovascular Care Committee. Standards for Studies of Neurological Prognostication in Comatose Survivors of Cardiac Arrest: A Scientific Statement From the American Heart Association. Circulation. 2019 Aug 27;140(9):e517-e542.).

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Meyer MAS, Crit Care 2025 Aug 6;29(1):348. https://pubmed.ncbi.nlm.nih.gov/40770665/

2026 Evidence Update

ALS 3512 (Part 2) – Prognostication Biomarkers NSE

Worksheet author(s): Claudio Sandroni, Sonia D'Arrigo
External Collaborator (data extraction and management): Sofia Cacciola
Task Force: ALS
Date Submitted to SAC rep for peer review and approval: September 10, 2025
SAC rep: Eric Lavonas

PICOST / Research Question:
Population: Adults who are comatose after resuscitation from cardiac arrest (either in-hospital or out-of-hospital), regardless of target temperature.
Interventions: index test based on biomarkers: **neuron-specific enolase (NSE)**
Comparison: none.
Outcomes: poor neurological outcome, defined as Cerebral Performance Categories (CPC) 3-5 or Glasgow Outcome Scale (GOS) 1-3, or modified Rankin Score (mRS) 4-6 at hospital discharge/1 month or later.
Study designs: Prognostic accuracy studies where the 2x2 contingency table (ie, the number of true/false negatives and positives for prediction of poor outcome) was reported, or where those variables could be calculated from reported data, are eligible for inclusion. Unpublished studies, reviews, case reports, case series, studies including fewer than 10 patients, letters, editorials, conference abstracts, and studies published in abstract form were excluded.

Year of last full review: 2020

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
We suggest using NSE within 72 hours after ROSC, in combination with other tests, for predicting neurological outcome of adults who are comatose after cardiac arrest (weak recommendation, very low-certainty evidence).

Database searched: PubMed. The references of full-text articles were screened for additional studies.

Time Frame: (existing PICOST) –Apr 2024 (last EvUp) to Aug 2025
Date Search Completed: Aug 31, 2025
Search Results (Number of articles identified, and number identified as relevant): 25/3

Summary of Evidence Update:
This update identified **3 relevant studies** that were not included in the 2024 ILCOR evidence update (Benghanem 2025, Czimmeck 2025, Scarpino 2025).

One study (Scarpino 2025) in 65 patients evaluated the ability of NSE measured within 12 h after ROSC, showing that an NSE higher than **60 mcg/L** predicted poor neurological outcome at hospital discharge with 100 [93-100]% specificity and 67 [54-78]% sensitivity. Two studies evaluated the ability of **NSE** blood levels **at 48-72 h after ROSC** to predict poor neurological outcome in comatose patients after CA (Benghanem 2025, Czimmeck 2025). One study (Benghanem 2025) in 966 patients investigated **NSE at 48 h after ROSC**, showing that **NSE levels >60 mcg/L** predicted poor neurological outcome at 3 months with 98 [97-99] % specificity and 52 [49-55] % sensitivity. The other study (Czimmeck 2025) in 114 patients showed that **NSE levels >90 mcg/L at 48-72 h** after CA predicted poor neurological outcome at hospital discharge with **100[96-100] % specificity** and **56 [46-65] % sensitivity**.

Relevant Guidelines or Systematic Reviews: none

RCT: none

Nonrandomized Trials, Observational Studies

Study Acronym; Author; Year Published	**Study Type/Design; Study Size (N)**	**Patient Population**	**Primary Endpoint and Results (include P value; OR or RR; & 95% CI)**	**Summary/Conclusion Comment(s)**
Benghanem et al. 2025	**Study Type:** cohort study analysing two prospective registries. Nine hundred sixty-six patients were included in the study. NSE was measured in all patients.	**Inclusion Criteria:** comatose adult patients who had at least a serum NSE measurement at 48 hours and an EEG ≥ 24 hours after CA. **Exclusion criteria:** N/A	**1° endpoint:** to examine the relationship between markers of brain injury (NSE and EEG patterns) obtained in early post-resuscitation period and the subsequent degree of neurological recovery. **Results:** **NSE >60 mcg/L at 48 h** after CA predicted poor neurological outcome at 3 months with **98 [97-99] % specificity** and **52 [49-55] % sensitivity**.	NSE >60 mcg/L at 48 h after CA predicted poor neurological outcome at 3 months with high specificity and moderate sensitivity.
Czimmeck et al. 2025	**Study Type:** retrospective, single-centre observational study. One-hundred and fifty-two patients were included. NSE was measured in 114 patients.	**Inclusion Criteria:** adult out-of-hospital (OHCA) and in-hospital-CA (IHCA) patients with serum NFL testing within 24–96 h after CA **Exclusion criteria:** N/A	The NSE accuracy was not the primary endpoint of the study. **1° endpoint:** to evaluate NfL as a biomarker for neuroprognostication after CA in clinical routine. **2° endpoint:** to compare NFL to established prognostication methods. **Results:** **NSE >90 mcg/L at 48-72 h** after CA predicted poor neurological outcome at hospital discharge with **100 [96-100] % specificity** and **56 [46-65] % sensitivity**.	NSE >90 mcg/L at 48-72 h after CA predicted poor neurological outcome (**CPC 4-5**) at hospital discharge with 100% specificity and moderate sensitivity.
Scarpino et al. 2025	**Study Type:**	**Inclusion Criteria:**	The NSE accuracy was not the primary endpoint of the study.	NSE >60 mcg/L within 12 h after CA predicted

	Prospective single-centre study. Sixty-five patients were included in the study. NSE was measured in all patients.	Consecutive comatose adult patients (GCS<8) who received the first multimodal pro gnostic evaluation within 6 hours after CA, as well as the NSE dosage within 12 hours after CA. **Exclusion criteria:** traumatic or neurological causes of CA, pre-existing neurological disability, regain of consciousness or death before neurophysiological tests.	**1° endpoint:** the accuracy of short- and middle-latency SSEPs recorded within 6 hours of ROSC in predicting both poor (CPC 3–5) and good (CPC 1–2) neurological outcomes at hospital discharge. **2° endpoint:** to evaluate the prognostic accuracy of other ERC-ESICM predictors. **Results:** NSE > **60 mcg/L within 12 h** after ROSC predicted poor neurological outcome at hospital discharge with 100 [93-100]% specificity and 67 [54-78]% sensitivity.	poor neurological outcome at hospital discharge with high specificity and moderate sensitivity.

Reviewer Comments: *(including whether this PICOST should have a systematic or scoping review*)
We included only three studies in this evidence update, all confirmed that high NSE levels predict poor outcome with high specificity not only at 48 or 72h after ROSC, but also within 12 h. Two studies confirmed the 60 mcg/L threshold recommended by the European Resuscitation Council in 2021. The other study found a 90 mcg/L threshold for 100% specificity, but the definition of good functional outcome included severe neurological disability (CPC 3), which may have affected the NSE threshold.
The task force is planning an updated systematic review on all modalities for neuroprognostication in the near future.

Note on the interpretation of test results
Neuroprognostic tests used in patients who are comatose after resuscitation from cardiac arrest measure the severity of brain injury. An abnormal response from these tests may be classified as "positive," and a normal response as "negative," or vice versa, depending on the prognostic perspective taken. Usually, as in this evidence review, a positive result of these tests indicates that the outcome of that patient will be poor. If this occurs, the prediction is correct, and the test result is a true positive. Conversely, if the outcome is good, the positive test result is a false positive. In this context, the false-positive rate (FPR) of a test is the proportion of patients with good outcome who are assigned a falsely pessimistic prediction. In other words, the FPR is the number of false positives divided by the total number of patients with a good outcome. FPR is also the complement of specificity, i.e., 100% − specificity. Therefore, a test with 100% specificity has 0% FPR. Ideally, all neuroprognostic tests predicting poor outcome should yield 100% specificity. While neuroprognostic tests predicting outcome should also ideally offer a reasonably high sensitivity when "negative" (in this case indicating that the outcome of the patient will be good), this is less important than their having a high specificity (low FPR), since the latter minimizes the risk of incorrectly predicting (and acting upon) a poor prognosis in a potentially viable patient.
In most neuroprognostic studies, as in prognostic studies in general, the treating team is aware of the results of the prognostic tests under investigation. Consequently, these results may affect their treating decisions, leading to a self-fulfilling prophecy bias that may overestimate the specificity of prognostic tests in predicting poor outcome.

This bias contributes to the low certainty of the evidence of most neuroprognostic studies after cardiac arrest. For that reason, the ILCOR 2020 Consensus for this PICOST is that the decision to limit treatment of comatose post–cardiac arrest patients should never rely on a single prognostication element. The consensus of the task force was that in patients who remain comatose in the absence of confounders (eg, sedative drugs), a multimodal approach should be used, with all supplementary tests considered in the context of the clinical examination.

Notes on the interpretation of biomarkers

Unlike the results of other neuroprognostic tests (e.g., clinical examination), biomarker blood levels are continuous rather than dichotomous (categorical) variables. Results are dichotomized to calculate the sensitivity and specificity of these biomarkers by establishing a threshold that divides positive from negative results. Consequently, test sensitivity and specificity depend on the threshold chosen: a high threshold increases the specificity of the test and decreases the sensitivity, and vice versa.

Biomarkers are released with different latency and speed following acute brain injury. Although the kinetics of NSE after cardiac arrest is incompletely known, studies have shown that NSE blood levels increase up to 72h in patients with unfavourable outcome and tend to decrease in patients with favourable outcome (Martìnez-Losas P Rev Esp Cardiol (Engl Ed) 73(2): 123-130. https://www.ncbi.nlm.nih.gov/pubmed/30857978). Ryczek R, Kardiol Pol. 2021;79(5):546-553. https://pubmed.ncbi.nlm.nih.gov/34125928/)

NSE is released from red blood cells following haemolysis and from neuroendocrine tumours. Both these conditions may, therefore, cause falsely pessimistic predictions in patients resuscitated from cardiac arrest (Czimmeck C, Resuscitation 2023 Nov; 192:109964. https://pubmed.ncbi.nlm.nih.gov/37683997/). A final source of confounding for biomarkers is the presence of different assays, which may create different results across measuring methods (Rundgren M, BMC Research Notes 2014, 7:726. http://www.ncbi.nlm.nih.gov/pubmed/25319200).

An important advantage of biomarkers is that – unlike other outcome predictors after cardiac arrest – they can be easily assessed in a blinded fashion, reducing the risk of a self-fulfilling prophecy bias.

For further details on the methodology and interpretation of prognostic tests see Geocadin RG, Callaway CW, Fink EL, Golan E, Greer DM, Ko NU, Lang E, Licht DJ, Marino BS, McNair ND, Peberdy MA, Perman SM, Sims DB, Soar J, Sandroni C; American Heart Association Emergency Cardiovascular Care Committee. Standards for Studies of Neurological Prognostication in Comatose Survivors of Cardiac Arrest: A Scientific Statement From the American Heart Association. Circulation. 2019 Aug 27;140(9):e517-e542.).

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Benghanem S, Resuscitation 2025 Aug 6:110757. https://pubmed.ncbi.nlm.nih.gov/40780697/

Czimmeck C, Resuscitation 2025 Aug:213:110650. https://pubmed.ncbi.nlm.nih.gov/40409670/

Scarpino M, Resuscitation 2025 Sep 4:110801. https://pubmed.ncbi.nlm.nih.gov/40914341/

2026 Evidence Update

ALS 3510 (Part 1) – Prognostication Brain CT

Worksheet author(s): Claudio Sandroni, Sonia D'Arrigo
External Collaborator (data extraction and management): Sofia Cacciola
Task Force: ALS
Date Submitted to SAC rep for peer review and approval: September 10, 2025
SAC rep: Eric Lavonas

PICOST / Research Question:
Population: Adults who are comatose after resuscitation from cardiac arrest (either in-hospital or out-of-hospital), regardless of target temperature.
Intervention: **brain computed tomography (CT)**
Comparison: none
Outcomes: poor neurological outcome, defined as Cerebral Performance Categories (CPC) 3-5 or Glasgow Outcome Scale (GOS) 1-3, or modified Rankin Score (mRS) 4-6 at hospital discharge/1 month or later.
Study designs: Prognostic accuracy studies where the 2x2 contingency table (ie, the number of true/false negatives and positives for prediction of poor outcome) was reported, or where those variables could be calculated from reported data, are eligible for inclusion. Unpublished studies, reviews, case reports, case series, studies including fewer than 10 patients, letters, editorials, conference abstracts, and studies published in abstract form were excluded.

Year of last full review: 2020

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
We suggest using GWR on brain CT for predicting neurological outcome of adults who are comatose after cardiac arrest (weak recommendation, very low-certainty evidence). However, no GWR threshold for 100% specificity can be recommended.

Database searched: PubMed. The references of full-text articles were screened for additional studies.

Time Frame: (existing PICOST) –Jul 2024 (prior EvUp) to Aug 2025
Date Search Completed: Aug 31, 2025
Search Results (Number of articles identified, and number identified as relevant): 25/4

Summary of Evidence Update:
This update identified **5 relevant studies** that were not included in the 2024 ILCOR evidence update.

Two studies evaluated the ability of the grey matter/white matter ratio (GWR) basal ganglia (BG) on brain CT after ROSC to predict poor neurological outcome in comatose survivors after CA (Czimmeck 2025, Scarpino 2025).

One study (Scarpino 2025) in 65 patients showed that a GWR <1.21 within 6 h after ROSC predicted poor neurological outcome at hospital discharge, with 100% specificity and 45% [28-63] sensitivity.
Another study (Czimmeck 2025) in 69 patients investigated **GWR-basal ganglia at 4 days after ROSC.** In that study, GWR-basal ganglia with a threshold value of 1.10 predicted poor neurological outcome (CPC 4-5) at hospital discharge with 100 [93-100]% specificity and 41 [30-54]% sensitivity. The lower GWR thresholds, compared with the other study, could be at least partly because only CPC 4 and 5 were considered as poor neurological outcomes in the Czimmeck study.

One study (Kenda 2024) in 81 patients assessed the ability of **net water uptake (NWU)** in different brain regions to predict neurological outcome after CA. NWU consists of changes in brain radiodensity over time, and it was calculated as the change in HU
between early and late CT for each anatomical region using the following formula: 1- (HU region late/HU region early), where HU are the Hounsfield units (HU). An NWU greater than 8% in either the caudate nucleus or in the putamen on brain CT performed at 24h-7 days (late) vs. within 6 h (early) predicted poor neurological outcome (CPC 4-5) with 100 [86-100]% specificity and 43 [31-56]% sensitivity (identical values for caudate nucleus and putamen). The area under the curve (AUC) for outcome prediction was 0.81 [0.71–0.90] for the caudate nucleus and 0.78 [0.69–0.88] for the putamen. Sensitivity was lower for thalamic NWU (25 [15–39]%) and pallidus NWU (19 [11–31]%). White matter NWU was not helpful to predict functional outcome (AUC 0.54 [0.40–0.68]).

One study (Lang 2025) evaluated in 140 patients the ability of five **qualitative (visually assessed) signs of hypoxic-ischemic injury on CT performed at 84 (66-109) hours** to predict poor neurological outcome at 6 months. The **loss of grey/white matter distinction** in the corona radiata and the high convexity area predicted poor neurological outcome with 100 [97-100]% specificity and 46 [37-54]% and 51 [42-59]% sensitivity, respectively. The **presence of sulcal effacement** in different regions (basal cisterns, basal ganglia, corona radiata and high convexity) predicted poor neurological outcome at 6 months with specificity ranging from 94 [89-97]% to 100 [97-100]% and sensitivity ranging from 29 [21-37]% and 49 [40-57]%. The **presence of the pseudo-subarachnoid haemorrhage** and **white cerebellum signs** predicted poor neurological outcome at 6 months with 100 [97-100]% specificity
and sensitivity of 8 [4-14]% and 11 [7-18]%, respectively. The **presence of signs of reversal** predicted poor neurological outcome at 6 months with 100 [97-100]% specificity and 9 [5-15]% sensitivity.

Relevant Guidelines or Systematic Reviews: none

RCTs: None

Nonrandomized Trials, Observational Studies

Study Acronym; Author; Year Published	**Study Type/Design; Study Size (N)**	**Patient Population**	**Primary Endpoint and Results (include P value; OR or RR; & 95% CI)**	**Summary/Conclusion Comment(s)**
Grey-White matter Ratio (GWR) - Basal Ganglia (BG)				
Czimmeck et al. 2025	**Study Type:** retrospective, monocentric observational study. One-hundred and fifty-two patients were included in the study. CT scan was performed in sixty-nine patients.	**Inclusion Criteria:** adult OHCA and in-hospital-CA (IHCA) patients with serum NfL testing within 24–96 h after CA. **Exclusion criteria:** N/A	The brain CT accuracy was not the primary endpoint of the study. **1° endpoint:** to evaluate NfL as a biomarker for neuroprognostication after CA in clinical routine. **2° endpoint:** to compare NfL to established prognostication methods. **Results:**	In comatose survivors after CA a GWR-BG <1.10 on brain CT performed on day 4 predicted poor neurological outcome (CPC 4-5) at hospital discharge with 100% specificity and moderate sensitivity.

			A GWR-BG <1.10 on CT performed on day 4 predicted poor neurological outcome (CPC 4-5) at hospital discharge **with 100 [93-100]% specificity and 41 [30-54]% sensitivity.**	
Scarpino et al. 2025	**Study Type:** Prospective single-centre study. Sixty-five patients were included in the study. Brain CT was performed in all patients.	**Inclusion Criteria:** Consecutive comatose (GCS<8) adult patients who were prognostically assessed within 6 hours after CA, except for the NSE, which was measured within 12 hours after CA. **Exclusion criteria:** traumatic or neurological causes of CA, pre-existing neurological disability, regain of consciousness or death before neurophysiological tests.	The brain CT accuracy was not the primary endpoint of the study. **1° endpoint:** the accuracy of short- and middle-latency SSEPs recorded within 6 hours of ROSC in predicting both poor (CPC 3–5) and good (CPC 1–2) neurological outcomes at hospital discharge. **2° endpoint:** the prognostic accuracy of other ERC-ESICM predictors. **Results:** GWR <1.21 within 6 h after ROSC predicted poor neurological outcome at hospital discharge with 100% specificity and 45 [28-63]% sensitivity.	In comatose survivors after CA a GWR <1.21 on brain CT performed within 6 h after ROSC predicted poor neurological outcome at hospital discharge with 100% specificity and moderate sensitivity.
Net Water Uptake (NWU)				
Kenda et al., 2024	**Study Type:** a multicentre observational study. Eighty-one patients were included in the derivation cohort of the study. CT scan was performed in all patients.	**Inclusion Criteria:** Adult, non-traumatic IHCA and OHCA, sustained ROSC, both received a first CT within the first 6 h after CA and a second CT between 24 h and 7 days after CA. **Exclusion criteria:** at least one image containing larger structural lesions that could confound image analysis, presence of residual contrast agent from previous coronary or CT-angiography.	**1° endpoint:** to use automated analysis of consecutive CT imaging to calculate net water uptake (NWU) in different brain regions and assess it as a prognostic marker after CA. **Results:** A NWU of greater than 8% in either the caudate nucleus or in the putamen on brain CT performed within 6 h (early) and at 24h-7 days (late) predicted poor neurological outcome (CPC 4-5) with 100 [86-100]% specificity and 43 [31-56]% sensitivity	In comatose survivors after CA a NWU >8% in different brain regions on early and late brain CT scan predicted poor neurological outcome (CPC 4-5) at hospital discharge with high specificity, but low sensitivity. The study showed that cytotoxic oedema at the

			(identical values for caudate nucleus and putamen). Sensitivity was lower for thalamic NWU (25 [15–39]%) and pallidum NWU (19 [11–31]%). Outcome prediction was not useful using white matter NWU (AUC 0.54 [0.40–0.68].	basal ganglia level increases between six hours and 24 hours – seven days after cardiac arrest. These changes do not occur at the level of the white matter.
Loss of Grey-White matter distinction				
Lang et al., 2025	**Study Type:** in-depth analysis of a prospective observational international sub-study within the TTM2 trial. One-hundred-forty patients were included in the study. CT scan was performed on all patients.	**Inclusion Criteria:** adult, unconscious (not obeying verbal commands) at 48 hours post cardiac arrest, CT >48 hours ≤7 days post-arrest. **Exclusion criteria:** no CT available, withdrawn consent, CT >7days and/or <48h after CA, technical requirements unfulfilled, large ischaemic lesion, intracranial haemorrhage, artefacts interfering with evaluation.	**1° endpoint:** to make improvements in interrater variability of a standardized qualitative CT assessment. **2° endpoint:** to examine which anatomical regions provided the most accurate standardized assessment of loss of grey-white distinction and sulcal effacement. **Results:** **The loss of GW matter distinction at 84 (66-109) h in corona radiata and in high convexity** predicted poor neurological outcome at 6 months with **100 [97-100]% specificity** and **46 [37-54]% and 51 [42-59]% sensitivity,** respectively.	In comatose survivors after CA, the loss of GW matter distinction in the corona radiata and in high convexity at 72-96 h after CA predicted poor neurological outcome at 6 months with 100% specificity and moderate sensitivity.
Sulcal effacement				
Lang et al., 2025	**Study Type:** in-depth analysis of a prospective observational international sub-study within the TTM2 trial. One hundred forty patients were included in the study.	**Inclusion Criteria:** adult, unconscious (not obeying verbal commands) at 48 hours post cardiac arrest, CT >48 hours ≤7 days post-arrest. **Exclusion criteria:** no CT available, withdrawn consent, CT >7days and/or <48h after CA, technical requirements unfulfilled, large ischaemic lesion, intracranial	**1° endpoint:** to make improvements in interrater variability of a standardized qualitative CT assessment. **2° endpoint:** to examine which anatomical regions provided the most accurate standardized assessment of loss of grey-white distinction and sulcal effacement.	In comatose survivors after CA the presence of sulcal effacement in different regions at 72-96 h after CA predicted poor neurological outcome at 6 months with 100% specificity

	CT scan was performed on all patients.	haemorrhage, artefacts interfering with evaluation.	**Results:** **The presence of sulcal effacement at 84 (66-109) h in different regions (basal cisterns, basal ganglia, corona radiata and high convexity)** predicted poor neurological outcome at 6 months with **specificity ranging from 94 [89-97]% to 100 [97-100]%** and **sensitivity ranging from 29 [21-37]% and 49 [40-57]% sensitivity.**	and moderate sensitivity.
Pseudo Subarachnoid Haemorrhage Sign				
Lang et al., 2025	**Study Type:** in-depth analysis of a prospective observational international sub-study within the TTM2 trial. One-hundred-forty patients were included in the study. CT scan was performed on all patients.	**Inclusion Criteria:** adult, unconscious (not obeying verbal commands) at 48 hours post cardiac arrest, CT >48 hours ≤7 days post-arrest. **Exclusion criteria:** no CT available, withdrawn consent, CT >7days and/or <48h after CA, technical requirements unfulfilled, large ischaemic lesion, intracranial haemorrhage, artefacts interfering with evaluation.	**1° endpoint:** to make improvements in interrater variability of a standardised qualitative CT assessment. **2° endpoint:** to examine which anatomical regions provided the most accurate standardized assessment of loss of grey-white distinction and sulcal effacement. **Results:** **The presence of Pseudo Subarachnoid Haemorrhage at 84 (66-109) h** predicted poor neurological outcome at 6 months with **100 [97-100]% specificity** and **8 [4-14]% sensitivity.**	In comatose survivors after CA the presence of Pseudo Subarachnoid Haemorrhage at 72-96 h after CA predicted poor neurological outcome at 6 months with 100% specificity and very low sensitivity.
White Cerebellum Sign				
Lang et al., 2025	**Study Type:** in-depth analysis of a prospective observational international sub-study within the TTM2 trial. One hundred forty patients were included in the study.	**Inclusion Criteria:** adult, unconscious (not obeying verbal commands) at 48 hours post cardiac arrest, CT >48 hours ≤7 days post-arrest. **Exclusion criteria:** no CT available, withdrawn consent, CT >7days and/or <48h after CA, technical requirements unfulfilled, large ischaemic	**1° endpoint:** to make improvements in interrater variability of a standardized qualitative CT assessment. **2° endpoint:** to examine which anatomical regions provided the most accurate standardized assessment of loss of grey-	In comatose survivors after CA the presence of signs of white cerebellum at 72-96 h after CA predicted poor neurological outcome at 6 months with 100% specificity

	CT scan was performed on all patients.	lesion, intracranial haemorrhage, artefacts interfering with evaluation.	white distinction and sulcal effacement. **Results:** **The presence of signs of white cerebellum at 84 (66-109) h** predicted poor neurological outcome at 6 months with **100 [97-100]% specificity** and **11 [7-18]% sensitivity.**	and very low sensitivity.
Reversal Sign				
Lang et al., 2025	**Study Type:** in-depth analysis of a prospective observational international sub-study within the TTM2 trial. One hundred forty patients were included in the study. CT scan was performed on all patients.	**Inclusion Criteria:** adult, unconscious (not obeying verbal commands) at 48 hours post cardiac arrest, CT >48 hours ≤7 days post-arrest. **Exclusion criteria:** no CT available, withdrawn consent, CT >7days and/or <48h after CA, technical requirements unfulfilled, large ischaemic lesion, intracranial haemorrhage, artefacts interfering with evaluation.	**1° endpoint:** to make improvements in interrater variability of a standardised qualitative CT assessment. **2° endpoint:** to examine which anatomical regions provided the most accurate standardized assessment of loss of grey-white distinction and sulcal effacement. **Results:** **The presence of signs of reversal at 84 (66-109) h** predicted poor neurological outcome at 6 months with **100 [97-100]% specificity** and **9 [5-15]% sensitivity.**	In comatose survivors after CA the presence of signs of reversal at 72-96 h after CA predicted poor neurological outcome at 6 months with 100% specificity and very low sensitivity.

Reviewer Comments:
The five studies we included assessed changes on brain CT due to HIBI with different modalities and timings. Three studies assessed the grey matter/white matter ratio (GWR), a measure of cytotoxic brain oedema, within six hours (two studies) or four days (one study) after ROSC. GWR has been employed in several studies included in previous ILCOR reviews and evidence updates. Another study assessed the difference in brain radiodensity over time after ROSC using NWU, a method based on brain mapping, which appears to be suitable for research only at the moment. The last study assessed different qualitative changes in brain CT due to cytotoxic or vasogenic oedema resulting from HIBI. The results of these last two studies deserve further validation.
The task force is planning an updated systematic review on all modalities for neuroprognostication in the near future.

Note on the interpretation of test results
Neuroprognostic tests used in patients who are comatose after resuscitation from cardiac arrest measure the severity of brain injury. An abnormal response from these tests may be classified as “positive,” and a normal

response as “negative,” or vice versa, depending on the prognostic perspective taken. Usually, as in this evidence review, a positive result of these tests indicates that the outcome of that patient will be poor. If this occurs, the prediction is correct, and the test result is a true positive. Conversely, if the outcome is good, the positive test result is a false positive. In this context, the false-positive rate (FPR) of a test is the proportion of patients with good outcome who are assigned a falsely pessimistic prediction. In other words, the FPR is the number of false positives divided by the total number of patients with a good outcome. FPR is also the complement of specificity, i.e., 100% − specificity. Therefore, a test with 100% specificity has 0% FPR. Ideally, all neuroprognostic tests predicting poor outcome should yield 100% specificity. While neuroprognostic tests predicting outcome should also ideally offer a reasonably high sensitivity when “negative” (in this case indicating that the outcome of the patient will be good), this is less important than their having a high specificity (low FPR), since the latter minimizes the risk of incorrectly predicting (and acting upon) a poor prognosis in a potentially viable patient.
In most neuroprognostic studies, as in prognostic studies in general, the treating team is aware of the results of the prognostic tests under investigation. Consequently, these results may affect their treatment decisions, leading to a self-fulfilling prophecy bias that may overestimate the specificity of prognostic tests in predicting poor outcome. This bias contributes to the low certainty of the evidence of most neuroprognostic studies after cardiac arrest. For that reason, the ILCOR 2020 Consensus for this PICOST is that the decision to limit the treatment of comatose post–cardiac arrest patients should never rely on a single prognostication element. The consensus of the task force was that in patients who remain comatose in the absence of confounders (e.g., sedative drugs), a multimodal approach should be used, with all supplementary tests considered in the context of the clinical examination.
For further details on the methodology and interpretation of prognostic tests see Geocadin RG, Callaway CW, Fink EL, Golan E, Greer DM, Ko NU, Lang E, Licht DJ, Marino BS, McNair ND, Peberdy MA, Perman SM, Sims DB, Soar J, Sandroni C; American Heart Association Emergency Cardiovascular Care Committee. Standards for Studies of Neurological Prognostication in Comatose Survivors of Cardiac Arrest: A Scientific Statement From the American Heart Association. Circulation. 2019 Aug 27;140(9):e517-e542.).

Notes on the interpretation of neuroprognostic tests based on brain CT

The grey matter/white matter ratio on brain CT (**GWR**) is calculated by measuring the density of specific regions of interest (ROIs) in the grey matter (most often, the caudate nucleus and the putamen) and dividing it by the density of ROIs in the white matter (most often, corpus callosum and the posterior limb of the internal capsule). Unlike the results of other neuroprognostic tests (e.g., clinical examination), GWR is a continuous rather than dichotomous (categorical) variable. Results are dichotomized to calculate the sensitivity and specificity of GWR by establishing a threshold that divides positive from negative results. Consequently, test sensitivity and specificity depend on the threshold chosen: a high threshold increases the test's specificity and decreases the sensitivity, and vice versa.
A source of heterogeneity for neuroprognostication based on GWR is the presence of different calculation methods. They depend on which and how many regions of the grey or the white matter are sampled. This may create different results across measuring methods. Another potential source of heterogeneity is the use of different equipment and different acquisition techniques.
Net water uptake (**NWU**) measures the changes in brain radiodensity over time, and it is calculated as the change in HU
between early and late CT for each anatomical region using the following formula: 1- (HU region late/HU region early), where HU are the Hounsfield units (HU).
Qualitative, visually assessed signs of HIBI on brain CT detect either early cytotoxic oedema, seen as a reduced distinction between the grey and white matter radiodensity, or later vasogenic oedema with a displacement of cerebrospinal fluid/effacement of sulci and basal cisterns.
The “Pseudo Subarachnoid Haemorrhage Sign” is seen as high radiodensity along sulci and cisterns from distension of superficial veins, while the “White Cerebellum Sign” is seen as decreased radiodensity in the supratentorial brain in comparison to cerebellum, and the “Reversal Sign” is seen as higher radiodensity in white matter in comparison to grey matter.

Reference list: ***(List by ILCOR ref standard (last name first author, year of publication, first page number) and insert hyperlink to all articles identified as relevant (if available on PubMed)***

Czimmeck C, Resuscitation 2025 Aug:213:110650. https://pubmed.ncbi.nlm.nih.gov/40409670/

Kenda M, Resuscitation 2024 Jul:200:110243. https://pubmed.ncbi.nlm.nih.gov/38796092/

Lang M, Resuscitation 2025 Sep:214:110675. https://pubmed.ncbi.nlm.nih.gov/40499676/

Scarpino M, Resuscitation 2025 Sep 4:110801. https://pubmed.ncbi.nlm.nih.gov/40914341/

2026 Evidence Update

ALS 3510 (Part 2) – Prognostication Brain MRI

Worksheet author(s): Claudio Sandroni, Sonia D'Arrigo
External Collaborator (data extraction and management): Sofia Cacciola
Task Force: Advanced Life Support (ALS)
Date Submitted to SAC rep for peer review and approval: September 10, 2025
SAC rep: Eric Lavonas

PICOST / Research Question:
Population: Adults who are comatose after resuscitation from cardiac arrest (either in-hospital or out-of-hospital), regardless of target temperature**.**
Interventions: index test based on imaging: **Magnetic Resonance Imaging (MRI)**
Comparison: none.
Outcomes: poor neurological outcome, defined as Cerebral Performance Categories (CPC) 3-5 or Glasgow Outcome Scale (GOS) 1-3, or modified Rankin Score (mRS) 4-6 at hospital discharge/1 month or later.
Study designs: Prognostic accuracy studies where the 2x2 contingency table (ie, the number of true/false negatives and positives for prediction of poor outcome) was reported, or where those variables could be calculated from reported data, are eligible for inclusion. Unpublished studies, reviews, case reports, case series, studies including fewer than 10 patients, letters, editorials, conference abstracts, and studies published in abstract form were excluded.

Year of last full review: 2020

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
We suggest using diffusion-weighted brain MRI for predicting neurological outcome of adults who are comatose after cardiac arrest (weak recommendation, very low-certainty evidence).
We suggest using ADC on brain MRI for predicting neurological outcome of adults who are comatose after cardiac arrest (weak recommendation, very low-certainty evidence).

Database searched: PubMed. The references of full-text articles were screened for additional studies.

Time Frame: (existing PICOST) –Jul 2024 (last EvUp) to Aug 2025
Date Search Completed: Aug 31, 2025
Search Results (Number of articles identified, and number identified as relevant): 24/1

Summary of Evidence Update:

This update identified **1 relevant study** that was not included in the 2024 ILCOR evidence update. This study evaluated the ability of **MRI at 96 h after ROSC** to predict poor neurological outcome in comatose patients after CA (Chan 2024). This study assessed a simplified version of a validated qualitative regional MRI scoring system. Twelve predefined regions were scored on an ordinal scale with 0 representing no abnormality, 1 representing focal abnormality (involving <50% of the structure), and 2 representing widespread abnormality (involving >50% of the structure). On MRI performed at 96 (81-110) h, a hypoxic-ischemic brain injury (HIBI) score >19 in the cortex region and >9 in the deep grey nuclei (DGN) predicted poor neurological outcome at hospital discharge with 100% specificity and 34 [28-41]% and 47 [41-54]% sensitivity, respectively. A HIBI score combined cortex-DGN >27 predicted poor neurological outcome at hospital discharge with 100% specificity and 39 [32-46]% sensitivity.

Relevant Guidelines or Systematic Reviews: none

RCT: none

Nonrandomized Trials, Observational Studies published Jun 30, 2024 to Aug 31, 2025

Study Acronym; Author; Year Published	**Study Type/Design; Study Size (N)**	**Patient Population**	**Primary Endpoint and Results (include P value; OR or RR; & 95% CI)**	**Summary/Conclusion Comment(s)**
Hypoxic-ischemic brain injury (HIBI) MRI score				
Chan et al., 2024	**Study Type:** retrospective, single-centre. Two hundred-nineteen patients were included in the study. MRI was performed in all patients.	**Inclusion Criteria:** age >18 years, initially comatose following CA, with ROSC, MRI between 2 days and 7 days post-CA **Exclusion criteria:** N/A	**1° endpoint:** to test a simplified version of a validated qualitative regional MRI scoring system for classification of poor neurologic outcome following CA. **Results:** Twelve predefined regions were scored on an ordinal scale with 0 representing no abnormality, 1 representing focal abnormality (involving <50% of the structure), and 2 representing widespread abnormality (involving >50% of the structure). Abnormalities were tested on both diffusion weighted imaging (DWI) and fluid-attenuated inversion recovery (FLAIR) sequences. On MRI performed **at 96 (81-110) h**, the **HIBI score >19 in the cortex region** and **>9 in the deep grey nuclei (DGN)** predicted poor neurological outcome at hospital discharge with **100% specificity and 34 [28-41]% and 47 [41-54]% sensitivity, respectively. A HIBI score combined cortex-DGN >27** predicted poor neurological outcome at hospital discharge with **100%**	This single-centre study showed that a high score quantifying the severity of HIBI changes on brain MRI can predict poor outcome with 100% specificity. Sensitivity was higher at the level of deep grey nuclei.

			specificity and 39 [32-46]% sensitivity.	

Reviewer Comments: *(including whether this PICOST should have a systematic or scoping review*)
The task force is planning an update of the systematic review of all modalities for neuroprognostication in the near future.

Note on the interpretation of test results
Neuroprognostic tests used in patients who are comatose after resuscitation from cardiac arrest measure the severity of brain injury. An abnormal response from these tests may be classified as "positive," and a normal response as "negative," or vice versa, depending on the prognostic perspective taken. Usually, as in this evidence review, a positive result of these tests indicates that the outcome of that patient will be poor. If this occurs, the prediction is correct, and the test result is a true positive. Conversely, if the outcome is good, the positive test result is a false positive. In this context, the false-positive rate (FPR) of a test is the proportion of patients with good outcome who are assigned a falsely pessimistic prediction. In other words, the FPR is the number of false positives divided by the total number of patients with a good outcome. FPR is also the complement of specificity, i.e., 100% − specificity. Therefore, a test with 100% specificity has 0% FPR. Ideally, all neuroprognostic tests predicting poor outcome should yield 100% specificity. While neuroprognostic tests predicting outcome should also ideally offer a reasonably high sensitivity when "negative" (in this case indicating that the outcome of the patient will be good), this is less important than their having a high specificity (low FPR), since the latter minimizes the risk of incorrectly predicting (and acting upon) a poor prognosis in a potentially viable patient.
In most neuroprognostic studies, as in prognostic studies in general, the treating team is aware of the results of the prognostic tests under investigation. Consequently, these results may affect their treating decisions, leading to a self-fulfilling prophecy bias that may overestimate the specificity of prognostic tests in predicting poor outcome. This bias contributes to the low certainty of the evidence of most neuroprognostic studies after cardiac arrest. For that reason, the ILCOR 2020 Consensus for this PICOST is that the decision to limit treatment of comatose post–cardiac arrest patients should never rely on a single prognostication element. The consensus of the task force was that in patients who remain comatose in the absence of confounders (eg, sedative drugs), a multimodal approach should be used, with all supplementary tests considered in the context of the clinical examination.

Notes on the interpretation of MRI
In patients with hypoxic-ischaemic brain injury (HIBI), diffusion-weighted Imaging (DWI) changes on brain MRI detect reduced water diffusion in the brain tissue due to cellular swelling. Fluid-attenuation inversion recovery (FLAIR) mainly reflects vasogenic oedema, and it is used less often than DWI to assess HIBI after cardiac arrest. The study included in this evidence update assessed a simplified score, based on both DWI and FLAIR, to evaluate the severity of MRI changes from HBI after cardiac arrest and found two different thresholds for 100% specificity: one for the cortical score and the other for the deep grey nuclei. Sensitivity was higher with the deep grey nuclei score. Three previous studies we assessed in the 2024 Evidence Update of imaging studies also found thresholds for 100% specificity for MRI scores (An C. 2020; Keijzer HM, 2022; Vanden Berghe S, 2020). All studies, including the one in the present Evidence Update, employed different methods to calculate the scores, which prevented a direct comparison across study results.

For further details on the methodology and interpretation of prognostic tests see Geocadin RG, Callaway CW, Fink EL, Golan E, Greer DM, Ko NU, Lang E, Licht DJ, Marino BS, McNair ND, Peberdy MA, Perman SM, Sims DB, Soar J, Sandroni C; American Heart Association Emergency Cardiovascular Care Committee. Standards for Studies of Neurological Prognostication in Comatose Survivors of Cardiac Arrest: A Scientific Statement From the American Heart Association. Circulation. 2019 Aug 27;140(9):e517-e542.).

Reference list:

Chan WP, Resuscitation 2024 Sep:202:110370. https://pubmed.ncbi.nlm.nih.gov/39178939/

An C, Resuscitation 2020 Dec:157:202-210. https://pubmed.ncbi.nlm.nih.gov/32931850/

Keijzer HM, Neurocrit Care 2022 Aug;37(1):302-313. https://pubmed.ncbi.nlm.nih.gov/35469391/

Vanden Berghe S, Neuroradiology 2020 Nov;62(11):1361-1369. https://pubmed.ncbi.nlm.nih.gov/32500276/

Appendix B

Basic Life Support – 2026 Evidence Updates

Table of Contents

2026 Evidence Update

BLS 2702-2703 – Immediate Resuscitation in Water or on Boat in Drowning

Worksheet author(s): Janet Bray
Task Force: BLS
Date Submitted to SAC rep for peer review and approval:
SAC rep: Siobhan Masterson

PICOST / Research Question:

PICOST	Description
Population	In adults and children who are submerged in water
Intervention	Immediate resuscitation in-water[a]
Comparison	Delaying resuscitation until on land[b]
Outcomes	Survival with favourable neurological outcome to discharge / 30 days or later Survival to discharge / 30 days or later Return of spontaneous circulation (ROSC)
Study Design	Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. Manikin studies will only be included if no human studies are available.
Timeframe	From April 2024 onward. All languages were included as long as there was an English abstract; unpublished studies (e.g., conference abstracts, trial protocols) were excluded

[a] Immediate resuscitation in-water resuscitation is defined as delivering ventilations only to a non-breathing casualty while still in the water.

[b] Land is defined as a firm, stable surface out of the water (e.g., wharf, pontoon, beach) with sufficient space for rescuers to safely perform CPR.

Year of last full review: 2023

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
We suggest in-water resuscitation (ventilations only) may be considered in situations where a trained rescuer determines that the rescuer safety, equipment available and distance to shore warrant its use (Weak recommendation, very low certainty evidence).
We suggest on-boat resuscitation (ventilations only or standard CPR) may be considered in situations where there is sufficient space for rescuers to safely perform resuscitation. (Good practice statement)
At any point during the rescue attempt, if the rescuer/rescuers feels that the application of immediate resuscitation is too difficult or affecting personal safety, then the rescuer(s) may opt to forgo its application. (Good practice statement)

Current Search Strategy (for an existing PICOST) included in the attached approved PICOST
Available in the systematic review.[1]

Database searched: Medline
Time Frame: April 2024-December 2025
Date Search Completed: 5th December 2025
Search Results: Articles identified by the search: 669; relevant articles: 1 scientific statement[2] and 1 manikin RCT.[3]

Summary of Evidence Update:

Relevant Guidelines or Systematic Reviews

Organization (if relevant); Author; Year Published	Guideline or systematic review	Topic addressed or PICO(S)T	Number of articles identified	Key findings	Treatment recommendations
Dezfulia (2024)	Scientific statement - pediatrics	In-water resuscitation	1	Same as ILCOR CoSTR	Same as ILCOR TR

RCT: No new studies
Observational: no new studies

Reviewer Comments:
There is no new data to warrant an update to the existing systematic review at this time. One simulation RCT by Barcala-Furelos (2025) supports current treatment recommendation.

Reference list:

1. Bierens J, Bray J, Abelairas-Gomez C, et al. A systematic review of interventions for resuscitation following drowning. *Resuscitation Plus*. 2023;14:100406.
2. Dezfulian C, McCallin TE, Bierens J, et al. 2024 American Heart Association and American Academy of Pediatrics Focused Update on Special Circumstances: Resuscitation Following Drowning: An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2024;150:e501-e516.
3. Barcala-Furelos R, de Oliveira J, Duro-Pichel P, et al. In-water resuscitation during a surf rescue: Time lost or breaths gained? A pilot study. *Am J Emerg Med*. 2024;79:48-51.

2026 Evidence Update

BLS 2704 – Circulation-Airway-Breathing (CAB) vs Airway-Breathing-Circulation (ABC) Approach to CPR in Drowning

Worksheet author(s): Janet Bray
Task Force: BLS
Date Submitted to SAC rep for peer review and approval:
SAC rep: Siobhan Masterson

PICOST / Research Question:

PICOST	Description
Population	In adults and children who are submerged in water
Intervention	Compression-first strategy (CAB)
Comparison	Resuscitation that starts with ventilation (ABC)
Outcomes	Survival with favourable neurological outcome to discharge / 30 days or later Survival to discharge / 30 days or later Return of spontaneous circulation (ROSC)
Study Design	Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. Manikin studies will only be included if no human studies are available.
Timeframe	From April 2024 to December 2025. All languages were included as long as there was an English abstract; unpublished studies (e.g., conference abstracts, trial protocols) were excluded

Year of last full review: 2023

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
We recommend a compression-first strategy (CAB) for laypeople providing resuscitation for adults in cardiac arrest caused by drowning (good practice statement).
Health care professionals and those trained and with a duty to respond to drowning (eg, lifeguards) should consider providing rescue breaths/ventilation first (ABC) before chest compressions (good practice statement).

Current Search Strategy (for an existing PICOST) included in the attached approved PICOST
Available in the systematic review.[1]

Database searched: Medline
Time Frame: April 2024-December 2025
Date Search Completed: 5th December 2025
Search Results: Articles identified by the search: 669; relevant articles: 1 scientific statement.[2]

Summary of Evidence Update:

Relevant Guidelines or Systematic Reviews

Organization (if relevant); Author;	Guideline or systematic review	Topic addressed or PICO(S)T	Number of articles identified	Key findings	Treatment recommendations

Year Published					
Dezfulia (2024)	Scientific statement - pediatrics	Compression-only CPR vs conventional CPR	7 studies	Similar to ILCOR CoSTR	Similar to ILCOR TR

RCT: No Studies
Observational studies: No studies

Reviewer Comments:
No new data.

Reference list:

1. Bierens J, Bray J, Abelairas-Gomez C, et al. A systematic review of interventions for resuscitation following drowning. *Resuscitation Plus*. 2023;14:100406.
2. Dezfulian C, McCallin TE, Bierens J, et al. 2024 American Heart Association and American Academy of Pediatrics Focused Update on Special Circumstances: Resuscitation Following Drowning: An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2024;150:e501-e516.

2026 Evidence Update

BLS 2705 – Chest Compression-only CPR in drowning

Worksheet author(s): Janet Bray
Task Force: BLS
Date Submitted to SAC rep for peer review and approval:
SAC rep: Siobhan Masterson

PICOST / Research Question:

PICOST	Description
Population	In adults and children who are submerged in water
Intervention	Chest compression-only CPR
Comparison	Conventional CPR (compressions and ventilations)
Outcomes	Survival with favourable neurological outcome to discharge / 30 days or later Survival to discharge / 30 days or later Return of spontaneous circulation (ROSC)
Study Design	Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. Manikin studies will only be included if no human studies are available.
Timeframe	From April 2024 to December 2025. All languages were included as long as there was an English abstract; unpublished studies (e.g., conference abstracts, trial protocols) were excluded

Year of last full review: 2023

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
For lay responders, the treatment recommendations for CPR in drowned OHCA patients who have been removed from the water remain consistent with CPR for all patients in cardiac arrest (good practice statement).
Adults: We recommend that bystanders perform chest compressions for all patients in cardiac arrest. We suggest that bystanders who are trained, able, and willing to give rescue breaths and chest compressions do so for adults in cardiac arrest.
Children: We suggest that bystanders provide CPR with ventilation for infants and children younger than 18 years with OHCA.
We recommend that if bystanders cannot provide rescue breaths as part of CPR for infants and children younger than 18 years with OHCA, they should at least provide chest compressions.

For health care professionals and those with a duty to respond to drowning (eg, lifeguards), we recommend providing ventilation in addition to chest compressions if they have been trained and are able and willing to do so (good practice statement).

Current Search Strategy (for an existing PICOST) included in the attached approved PICOST
Available in the systematic review.[1]

Database searched: Medline
Time Frame: April 2024-December 2025
Date Search Completed: 5th December 2025
Search Results: Articles identified by the search: 669; relevant articles: 1 scientific statement[2] and 1 observational study.[3]

Summary of Evidence Update:

Relevant Guidelines or Systematic Reviews

Organization (if relevant); Author; Year Published	Guideline or systematic review	Topic addressed or PICO(S)T	Number of articles identified	Key findings	Treatment recommendations
Dezfulia (2024)	Scientific statement - pediatrics	Compression-only CPR vs conventional CPR	7 studies	Similar to ILCOR CoSTR	Similar to ILCOR TR

RCT: No new studies.
Observational: 1 new study[3]:

Study Acronym; Author; Year Published	Aim of Study; Study Type; Study Size (N)	Patient Population	Study Intervention (# patients) / Study Comparator (# patients)	Endpoint Results (Absolute Event Rates, P value; OR or RR; & 95% CI)	Relevant 2° Endpoint (if any); Study Limitations; Adverse Events
Kaneto (2025)[3]	**Study Aim:** conventional CPR vs. CCO CPR and whether it differs by age and aetioglogy **Study Type:** Observational (retrospective)	**Inclusion Criteria:** drowning OHCA 2016-2019	**Intervention:** conventional CPR **Comparison:** CCO CPR	**1° endpoint:** Matched analysis: improved neurological outcomes with conventional CPR in ages <35 years and accidental drowning OHCA. No significant difference age >/=35 years.	**Study Limitations:** Retrospective, confounding.

Reviewer Comments:
The new data does not warrant an update to the existing systematic review at this time.

Reference list:

1. Bierens J, Bray J, Abelairas-Gomez C, et al. A systematic review of interventions for resuscitation following drowning. *Resuscitation Plus*. 2023;14:100406.
2. Dezfulian C, McCallin TE, Bierens J, et al. 2024 American Heart Association and American Academy of Pediatrics Focused Update on Special Circumstances: Resuscitation Following Drowning: An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2024;150:e501-e516.
3. Kaneto Y, Owada H, Kamikura T, et al. Advantages of bystander-performed conventional cardiopulmonary resuscitation in out-of-hospital cardiac arrest presumably caused by drowning in Japan: a propensity score-matching analysis using an extended nationwide database. *BMJ Open*. 2024;14:e080579.

2026 Evidence Update

BLS 2706 – Ventilation Equipment in Drowning

Worksheet author(s): Janet Bray
Task Force: BLS
Date Submitted to SAC rep for peer review and approval:
SAC rep: Siobhan Masterson

PICOST / Research Question:

PICOST	Description
Population	In adults and children who are submerged in water
Intervention	Ventilation with equipment before hospital arrival
Comparison	No ventilation with equipment before hospital arrival
Outcomes	Survival with favourable neurological outcome to discharge / 30 days or later Survival to discharge / 30 days or later Return of spontaneous circulation (ROSC)
Study Design	Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. Manikin studies will only be included if no human studies are available.
Timeframe	From April 2024 onward. All languages were included as long as there was an English abstract; unpublished studies (e.g., conference abstracts, trial protocols) were excluded

Year of last full review: 2023

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
We recommend using mouth-to-mouth, mouth-to-nose, or pocket-mask ventilation by BLS providers and laypeople
for adults and children in cardiac arrest caused by drowning (good practice statement).
We suggest that bag-mask ventilation can be used by lifeguards or other BLS providers with a duty to respond, on the condition that it is part of a competency-based training program with regular retraining and maintenance of equipment (good practice
statement).
We recommend that health care professionals follow the ALS treatment recommendations for airway management
for adults and children in cardiac arrest caused by drowning.

Current Search Strategy (for an existing PICOST) included in the attached approved PICOST
Available in the systematic review.[1]

Database searched: Medline
Time Frame: April 2024-December 2025
Date Search Completed: 5th December 2025
Search Results: Articles identified by the search: 669; relevant articles: 1 scientific statement[2] and 1 observational study.[3]

Summary of Evidence Update:

Relevant Guidelines or Systematic Reviews

Organization (if relevant); Author; Year Published	Guideline or systematic review	Topic addressed or PICO(S)T	Number of articles identified	Key findings	Treatment recommendations
Dezfulia (2024)	Scientific statement - pediatrics	AED use	3	Same ILCOR CoSTR	It is reasonable for trained rescuers to provide rescue breaths by the first means available (mouth-to-mouth, pocket mask, or bag-mask ventilation) for persons in cardiac arrest following drowning to avoid any delay in ventilation. Provision of rescue breathing using equipment (bag-mask or advanced airways) should be optimized by providing rescuers a competency based training program with regular retraining and maintenance of equipment.

RCTs: No new studies.
Observational: 1 new study[3]

Study Acronym; Author; Year Published	Aim of Study; Study Type; Study Size (N)	Patient Population	Study Intervention (# patients) / Study Comparator (# patients)	Endpoint Results (Absolute Event Rates, P value; OR or RR; & 95% CI)	Relevant 2° Endpoint (if any); Study Limitations; Adverse Events
Yoshimura (2024)[3]	**Study Aim:** Airway management during CPR **Study Type:** Retrospective observational (propensity matching)	**Inclusion Criteria:** OHCA drowning 2014-2020	**Intervention:** EIT **Comparison:** SGA	**1° endpoint:** No difference in one-month survival or favourable neurological outcome. The ROSC rate was higher in those treated with ETI versus SGA (207/3,566 [5.8%] versus 167/3,566 [4.7%], respectively; adjusted odds ratio, 1.25; 95% confidence interval [CI], 1.02–1.55).	**Study Limitations:** resuscitation time bias, retrospective

Reviewer Comments:
New data unlikely to change TR. No need to update SR at this time.

Reference list:

1. Bierens J, Bray J, Abelairas-Gomez C, et al. A systematic review of interventions for resuscitation following drowning. *Resuscitation Plus*. 2023;14:100406.
2. Dezfulian C, McCallin TE, Bierens J, et al. 2024 American Heart Association and American Academy of Pediatrics Focused Update on Special Circumstances: Resuscitation Following Drowning: An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2024;150:e501-e516.
3. Yoshimura S, Kiguchi T, Nishioka N, et al. Association of pre-hospital tracheal intubation with outcomes after out-of-hospital cardiac arrest by drowning comparing to supraglottic airway device: A nationwide propensity score-matched cohort study. *Resuscitation*. 2024;197:110129.

2026 Evidence Update

BLS 2707 – Prehospital Oxygen Administration Following Drowning

Worksheet author(s): Janet Bray
Task Force: BLS
Date Submitted to SAC rep for peer review and approval:
SAC rep: Siobhan Masterson

PICOST / Research Question:

PICOST	Description
Population	In adults and children who are submerged in water
Intervention	Oxygen administration before hospital arrival
Comparison	No oxygen administration before hospital arrival
Outcomes	Survival with favourable neurological outcome to discharge / 30 days or later Survival to discharge / 30 days or later Return of spontaneous circulation (ROSC)
Study Design	Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. Manikin studies will only be included if no human studies are available.
Timeframe	From April 2024 onward. All languages were included as long as there was an English abstract; unpublished studies (e.g., conference abstracts, trial protocols) were excluded

Year of last full review: 2023

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
When available, we recommend trained providers use the highest possible inspired oxygen concentration during resuscitation for adults and children in cardiac arrest following drowning (good practice statement).

Current Search Strategy (for an existing PICOST) included in the attached approved PICOST
Available in the systematic review.[1]

Database searched: Medline
Time Frame: April 2024-December 2025
Date Search Completed: 5th December 2025
Search Results: Articles identified by the search: 669; relevant articles: 1 scientific statement[2] and 2 observational studies.[3,4]

Summary of Evidence Update:

Relevant Guidelines or Systematic Reviews

Organization (if relevant); Author; Year Published	Guideline or systematic review	Topic addressed or PICO(S)T	Number of articles identified	Key findings	Treatment recommendations

Dezfulia (2024)	Scientific statement - pediatrics	In-water resuscitation	1	Same ILCOR CoSTR	Similar to ILCOR TR

Study Acronym; Author; Year Published	**Aim of Study; Study Type; Study Size (N)**	**Patient Population**	**Study Intervention (# patients) / Study Comparator (# patients)**	**Endpoint Results (Absolute Event Rates, P value; OR or RR; & 95% CI)**	**Relevant 2° Endpoint (if any); Study Limitations; Adverse Events**
Reid (2025)	**Study Aim:** to evaluate the use of oxygen by lifeguards **Study Type:** Retrospective observational	**Inclusion Criteria:** CPR provided by lifeguards 2000-2020	**Intervention:** Oxygen therapy by lifeguards **Comparison:** No oxygen therapy by lifeguards	**1° endpoint:** Increased ROSC with oxygen therapy (unadjusted OR =3.23 [95 % CI: 1.31 to 7.94], p < 0.01).	**Study Limitations:** retrospective, case ascertainment, confounding and no adjustment, small sample (n=158), temporal confounding, large number oxygen therapy unknown
Thom (2024)	**Study Aim:** to evaluate the use of oxygen by lifeguards **Study Type:** Retrospective observational (case matched)	**Inclusion Criteria:** treatment provided by lifeguards 2015-2022 and transported to ED (n=32 in OHCA)	**Intervention:** Oxygen therapy by lifeguards **Comparison:** No oxygen therapy by lifeguards	**1° endpoint:** No difference in survival to discharge with lifeguard oxygen (data not reported separately for OHCA).	**Study Limitations:** retrospective, case ascertainment, confounding and no adjustment, small sample (n=32/216 in OHCA), ED transported cases.

Reviewer Comments:
New data at high risk of bias and unlikely to change TR. No need to update SR at this time.

Reference list:

1. Bierens J, Bray J, Abelairas-Gomez C, et al. A systematic review of interventions for resuscitation following drowning. *Resuscitation Plus*. 2023;14:100406.
2. Dezfulian C, McCallin TE, Bierens J, et al. 2024 American Heart Association and American Academy of Pediatrics Focused Update on Special Circumstances: Resuscitation Following Drowning: An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2024;150:e501-e516.
3. Reid D, Bostwick K, Lawes JC, et al. Cardiac arrest events on Australian beaches. *Resusc Plus*. 2025;26:101092.
4. Thom O, Roberts K, Devine S, et al. Impact of lifeguard oxygen therapy on the resuscitation of drowning victims: Results from an Utstein Style for Drowning Study. *Emerg Med Australas*. 2024;36:841-848.

2026 Evidence Update

BLS 2708 – AED First vs CPR First in Drowning

Worksheet author(s): Janet Bray
Task Force: BLS
Date Submitted to SAC rep for peer review and approval:
SAC rep: Siobhan Masterson

PICOST / Research Question:

PICOST	Description
Population	In adults and children who are submerged in water
Intervention	AED administered before CPR
Comparison	CPR administered before AED
Outcomes	Survival with favourable neurological outcome to discharge / 30 days or later Survival to discharge / 30 days or later Return of spontaneous circulation (ROSC)
Study Design	Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. Manikin studies will only be included if no human studies are available.
Timeframe	From April 2024 onward. All languages were included as long as there was an English abstract; unpublished studies (e.g., conference abstracts, trial protocols) were excluded

Year of last full review: 2023

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
We recommend that CPR should be started first and continued until an AED has been obtained and is ready for use for adults and children in cardiac arrest caused by drowning (good practice statement).
When available, we recommend an AED is used in cardiac arrest caused by drowning in adults and children (good practice statement).

Current Search Strategy (for an existing PICOST) included in the attached approved PICOST
Available in the systematic review.[1]

Database searched: Medline
Time Frame: April 2024-December 2025
Date Search Completed: 5th December 2025
Search Results: Articles identified by the search: 669; relevant articles: 1 scientific statement[2] and 1 observational study.[3]

Summary of Evidence Update:

Relevant Guidelines or Systematic Reviews

Organization (if relevant); Author; Year Published	Guideline or systematic review	Topic addressed or PICO(S)T	Number of articles identified	Key findings	Treatment recommendations

Dezfulia (2024)	Scientific statement - pediatrics	AED use	3	Same ILCOR CoSTR	In cardiac arrest following drowning, CPR with rescue breaths should be started before AED application. The initiation of CPR should not be delayed to obtain or apply an AED in cardiac arrest following drowning.

RCTs: no new studies
Observational: 1 new study[3]

Study Acronym; Author; Year Published	**Aim of Study; Study Type; Study Size (N)**	**Patient Population**	**Study Intervention (# patients) / Study Comparator (# patients)**	**Endpoint Results (Absolute Event Rates, P value; OR or RR; & 95% CI)**	**Relevant 2° Endpoint (if any); Study Limitations; Adverse Events**
Reid (2025)[3]	**Study Aim:** AED use **Study Type:** Retrospective observational	**Inclusion Criteria:** CPR provided by lifeguards 2000-2020	**Intervention:** AED use **Comparison:** No AED use	**1° endpoint:** ROSC no difference (AED applied in 27%, shock in 4%)	**Study Limitations:** retrospective, case ascertainment, confounding and no adjustment, small sample (n=158), unclear when AED was applied.

Reviewer Comments:
New data at high risk of bias and unlikely to change TR. No need to update SR at this time.

Reference list:

1. Bierens J, Bray J, Abelairas-Gomez C, et al. A systematic review of interventions for resuscitation following drowning. *Resuscitation Plus*. 2023;14:100406.
2. Dezfulian C, McCallin TE, Bierens J, et al. 2024 American Heart Association and American Academy of Pediatrics Focused Update on Special Circumstances: Resuscitation Following Drowning: An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2024;150:e501-e516.
3. Reid D, Bostwick K, Lawes JC, et al. Cardiac arrest events on Australian beaches. *Resusc Plus*. 2025;26:101092.

2026 Evidence Update

BLS 2709 – Public Access Defibrillator (PAD) Programs for Drowning

Worksheet author(s): Janet Bray
Task Force: BLS
Date Submitted to SAC rep for peer review and approval:
SAC rep: Siobhan Masterson

PICOST / Research Question:

PICOST	Description
Population	In adults and children who are submerged in water
Intervention	PAD program
Comparison	No PAD program
Outcomes	Survival with favourable neurological outcome to discharge / 30 days or later Survival to discharge / 30 days or later Return of spontaneous circulation (ROSC)
Study Design	Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. Manikin studies will only be included if no human studies are available.
Timeframe	From April 2024 onward. All languages were included as long as there was an English abstract; unpublished studies (e.g., conference abstracts, trial protocols) were excluded

Year of last full review: 2023

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
This treatment recommendation is unchanged from the standing recommendation for all OHCAs.
We recommend implementing PAD programs for all patients with OHCA (strong recommendation, low-certainty evidence).

Current Search Strategy (for an existing PICOST) included in the attached approved PICOST
Available in the systematic review.[1]

Database searched: Medline
Time Frame: April 2024-December 2025
Date Search Completed: 5th December 2025
Search Results: Articles identified by the search: 669; relevant articles: 1 scientific statement.[2]

Summary of Evidence Update:

Relevant Guidelines or Systematic Reviews

Organization (if relevant); Author; Year Published	Guideline or systematic review	Topic addressed or PICO(S)T	Number of articles identified	Key findings	Treatment recommendations
Dezfulia (2024)	Scientific statement - pediatrics	AED use	1	Same ILCOR CoSTR	Implementation of PAD programs is reasonable in areas where there is a high

					risk of cardiac arrest, including aquatic environments (eg, areas with high population density, frequent utilization, other forms of exercise, long distances or response times to nearest AED).

RCTs: No new studies
Observational: No new studies.

Reviewer Comments:
No new studies.

Reference list:

1. Bierens J, Bray J, Abelairas-Gomez C, et al. A systematic review of interventions for resuscitation following drowning. *Resuscitation Plus*. 2023;14:100406.
2. Dezfulian C, McCallin TE, Bierens J, et al. 2024 American Heart Association and American Academy of Pediatrics Focused Update on Special Circumstances: Resuscitation Following Drowning: An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2024;150:e501-e516.

Appendix B

Pediatric Life Support – 2026 Evidence Updates

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2026 Evidence Update

PLS 4190.02 – Interventions to Treat Hypotension

Worksheet author(s): Leandra Rech, Andrea Christoff, Gabrielle Nuthall, Barnaby R Scholefield
Task Force: PLS TF
Date Submitted to SAC rep for peer review and approval: Dec 2nd 2025
SAC rep: Laurie Morrison

PICOST / Research Question:

PICOST	Description
Population	Children (>24 hours to 18 years of age) with sustained ROSC (Return of spontaneous circulation) following cardiac arrest
Intervention	Intervention to treat hypotension. (Interventions include medication and/or fluid; exclude mechanical circulatory support devices.)
Comparison	No intervention or an alternative intervention.
Outcomes	Any clinical outcome. The task force prioritizes outcome as defined in P-COSCA [1]
Study Design	Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are included. Case series may be included in the initial search and the minimal number of case studies is greater or equal to 5. Unpublished studies (e.g., conference abstracts, trial protocols) are excluded. All relevant publications in any language are included as long as there is an English abstract. All relevant publications in any language are included as long as there is an English abstract.
Timeframe	All years from inception

Year of last full review: No previous review on this topic

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST: No current recommendation on this topic

Database searched: Medline

Time Frame: (new PICOST) – all years, from inception to November 14th, 2025

Date Search Completed: November 14th, 2025

Search Results (Number of articles identified and number identified as relevant): 968/8

Summary of Evidence Update:

Post cardiac arrest hypotension is associated with increased hospital mortality. Current recommendations suggest that, in infants and children post cardiac arrest (CA) with a return of spontaneous circulation (ROSC), a systolic or mean arterial blood pressure greater than 10th percentile for age should be targeted[2] There is no previous ILCOR review or recommendation on how to achieve the targeted blood pressure in children.

The evidence update identified eight studies: six observational studies[3-8], one systematic review[9], and one ongoing clinical trial[10]. Two additional studies, although not directly aligned with the PICOST question, were considered relevant by the task force: a systematic review evaluating vasopressor selection after cardiac arrest in adults [11] and an ongoing pediatric trial investigating blood pressure targets in critically ill children[12].

Conlon et al evaluated children after out-of-hospital cardiac arrest (OHCA) who underwent transthoracic echocardiography (TTE), 41% showed evidence of decreased systolic function. Sixty-two percent of patients received inotropic support, most commonly dopamine (69%) and epinephrine (11%). A higher vasoactive–inotropic score (VIS) was associated with increased mortality[3].

The remaining observational studies did not specify which inotropes were used to manage postcardiac arrest hypotension. The studies demonstrated an association between the duration of hypotension and the amount of vasoactive support (measured by VIS) with outcomes. Two studies including children with IHCA and OHCA who had ROSC demonstrated that higher VIS [5, 7] and longer duration of vasoactive medication use [7] were independently associated with increased mortality. Unfavorable neurological outcomes were also associated with higher VIS in both IHCA and OHCA pediatric patients[6] . Some studies reported the proportion of patients receiving inotropic support during the post–cardiac arrest phase, ranging from 41% [7]to 62% [3]

Nuthall et al. conducted a systematic review of 11 studies and concluded that maintaining systolic or mean arterial blood pressure above the 10th percentiles for age is associated with improved survival to hospital discharge and favorable neurological outcomes[9].Prasad et al is conducting the first randomized controlled trial comparing norepinephrine and epinephrine in hypotensive children following cardiac arrest[10].

The evidence update highlighted a paucity of literature on this topic, identifying only one ongoing trial in children comparing inotropes for the treatment of hypotension post–cardiac arrest. Existing evidence demonstrates a high prevalence of cardiac dysfunction in children post cardiac arrest. However, it does not provide evidence favoring any specific strategy to prevent hypotension.

Relevant Guidelines or Systematic Reviews

Author; Year Published	Guideline or systematic review	Topic addressed or PICO(S)T	Number of articles identified	Key findings	Treatment recommendations
Nuthall, 2025[9]	Systematic Review	Blood pressure target in pediatric patients post cardiac arrest and ROSC	11 observational studies	Early hypotension after return of circulation post cardiac arrest is associated with worse outcomes in infants and children after cardiac arrest.	Systolic or mean arterial blood pressure targets >5th and >10th percentile for age are associated with improved survival to hospital discharge and survival with favorable neurologic outcomes at hospital discharge.
Niemela, 2025 [11]	Systematic Review	Vasopressor choice in adult patients with hypotension following cardiac arrest and ROSC	8 (one RCT, 7 nonrandomized trials)	Included studies compare noradrenaline vs adrenaline (6 studies), noradrenaline vs dopamine (1), noradrenaline vs noradrenaline and dopamine (1), and dopamine vs noradrenaline and adrenaline (1). The single RCT found no difference in outcomes between noradrenaline and adrenaline. Results from other studies comparing noradrenaline and adrenaline were inconsistent. Some studies found no difference in outcomes, while others suggested association between adrenaline use and worse outcomes	Existing evidence does not support the use of any specific vasopressor to treat hypotension following cardiac arrest and return of spontaneous circulation

Ongoing RCTs:

Study Acronym; Author; Year Published; Location	Aim of Study; Study Type; Sample Size (N)	Patient Population	Study Intervention / Comparator	Outcomes	Study Limitations; Adverse Events
Prasad, 2025[10] Patna, India	**Study Aim:** To compare epinephrine vs norepinephrine in pediatric post cardiac arrest shock **Study Type:** Ongoing study: single center, double blind RCT N= 250 (125 per group)	Children aged 1 month to 18 yo who experienced CA for non-cardiac causes, achieve ROSC and develop post resuscitation shock	Epinephrine VS norepinephrine	**Primary:** in hospital mortality **Secondary**: duration of vasopressor use, MAP response, neurological outcomes, arrhythmias.	Ongoing study
PRESSURE trial; Darnell, 2024[12] United Kingdom (eighteen PICUs)	**Study Aim:** Adjustment of hemodynamic support to achieve a permissive MAP target greater than fifth centile for age during invasive mechanical ventilation. **Study Type:** Pragmatic, open, multicenter, parallel group randomized control trial (RCT) N= 1900	Infants and children older than 37 weeks corrected gestational age to 16 years accepted to a participating PICU, on mechanical ventilation and receiving vasoactive drugs for hypotension.	Permissive MAP target VS usual care	**Primary:** composite of death and days of ventilatory support at 30 days **Secondary** Several secondary outcomes, including Mortality at PICU discharge, 30d, 90d, 12m Time to fist liberation from invasive ventilation Length of stay	Ongoing study; Not post cardiac arrest population, but aims to determine clinical and cost-effectiveness of a permissive mean arterial pressure (MAP) target of greater than a fifth centile for age in ventilated PICU patients

Observational Studies

Author; Year Published	Study Type/Design; Study Size (N)	Patient Population	Primary Endpoint of study	Findings related to use of inotropes / Vasoactive inotropic score (VIS)
Chun, 2024[7]	**Study type:** Single center, retrospective, observational study **Study size:** n= 106	Pediatric patients with IHCA or OHCA and ROSC admitted to a 14 bed PICU	This study identified diastolic blood pressure (DBP) within one-hour post-ROSC as the most significant hemodynamic determinant of survival to intensive care unit discharge among resuscitated pediatric patients.	Survival was 63,2% (67/106). VIS within 24 hours was higher in non survivors compared to survivors (19,7± 32 vs 94,7 ± 75, p <0,01). Duration of vasoactive drugs was higher in non survivors compared to survivors (5,8 +- 10,9 vs 36,5 +- 75,7, p < 0,01). Hypotension defined as blood pressure below the normal range for age (not defined).

Conlon, 2015[3]	**Study type:** Retrospective case series **Study size:** N= 58	Pediatric patients <18 yo with OHCA and ROSC admitted to a PICU and who had TTE within 24h of ROSC. 45% had pre-existing conditions. 43% received therapeutic hypothermia (32 - 34o target)	In patients receiving TTE within the first 24 hours following ROSC after pediatric OHCA, decreased LV systolic function and vasopressor use were common. Decreased LV systolic function was associated with increased mortality.	Median time from ROSC to TTE was 6,5h. 41% of patients had decreased LV systolic function, and 79% had any abnormality on TTE. Thirty-six patients (62%) were treated with vasopressor support at the time of TTE. Of those on support, 27 patients (75%) were treated with dopamine, 25 (69%) with epinephrine, 4 (11%) with vasopressin, 2 (6%) with norepinephrine, 2 (6%) with dobutamine, 2 (6%) with phenylephrine, and 1 (3%) with milrinone. VIS at the time of TTE was not associated with LV systolic function
Gardner, 2023[4]	**Study type:** Secondary analysis of prospectively collected data **Study size:** 693 index events	Patients 37w GA to 18yo with IHCA admitted to PICU	The absence of SBP below the 10th percentile and DBP below the 50th percentile during the first 6 h after ROSC were associated with higher rates of survival to hospital discharge with favorable neurologic outcome and survival to hospital discharge.	VIS score was lower in patients with SBP higher than the 10th percentile at 6h and 24h post cardiac arrest. VIS was lower in patients with DBP > 50th percentile at 6h, but not at 24h. Study does not describe inotropes used in the post CA phase. Hypotension was defined as SBP < 10th percentile and DBP lower that the 50th percentile for age.
Laverriere, 2020[5]	**Study type:** Retrospective cohort study **Study size:** N= 116	Patients between 1 day and 18yo who had CA (at least 2 min) and sustained ROSC for more than 20 minutes and received ICU support.	A higher burden of post resuscitation hypotension within the first 72 hours of ICU post resuscitation care is significantly associated with decreased discharge survival in a single-center cohort. Importantly, this study characterized the burden of hypotension based on frequent blood pressure measurements and evaluated vasoactive infusion dosing with the VIS.	In the first 72 hours of ICU postarrest care, patients who had "any hypotension" and survived to discharge had a median VIS of 3.1 (IQR, 0.005–8.6), while those who did not survive to discharge had a median VIS of 14.9 (IQR, 4.6–61.6). 84% of patients with at least a single episode of hypotension received inotropes. Hypotension was defined as SBP < 5th percentile for age.
Liu, 2024[6]	**Study type:** Retrospective observational study **Study size:** N=140	Patients <18yo who experienced IHCA or OHCA, received post arrest care in a PICU and had continuous BP monitoring (arterial line).	At the 5th percentile-for-age, hypotension burden, duration, and magnitude were all associated with unfavorable outcomes.	Median vasoactive inotropic score was significantly greater for patients with unfavorable compared to favorable outcomes at 6 hours post-ROC (7.75 [0,20.1] vs 0 [0,6]; p=0.012), and at 24 hours post-ROC (4 [0,17.8] vs 0 [0,7.3]; p=0.040). Hypotension burden was calculated using area between patient's MAP and the 5th percentile for age form MAP.
Topjian, 2014[8]	**Study type:** Retrospective cohort study **Study size:**	Pediatric patients (1 day to 18yo) who had cardiac arrest and ROSC who had SBP documented within 6h of CA.	early post-resuscitation hypotension is associated with increased hospital discharge mortality in children after successful resuscitation from cardiac arrest. Among children	Forty one percent of patients received vasopressors infusion within the first 6h after ROSC. Among patients who received post-ROSC vasopressors, there was no difference in discharge outcomes between

	N= 383		with documented early post-ROSC hypotension, 53% died in the hospital compared to 41% without documented early post-ROSC hypotension.	hypotension and no hypotension groups (p=0.18). However, among patients who did not receive vasopressors within six hours post-ROSC, those with no post-ROSC hypotension were less likely to die than those with hypotension (OR=2.12; 95% CI, 1.18–3.81). Thirty-three patients (8.6%) were initiated on a new vasopressor following resuscitation. Three hundred fifty patients did not have the initiation or addition of a new vasopressor following ROSC. Mortality rate for both groups was 48%. Of the 214 with early post-resuscitation hypotension, 73 continued to receive preexisting vasopressor support, while 15 were initiated on vasopressor support. More than half (126/214) were not treated with a continuous vasopressor infusion. Hypotension was defined as SBP < 5th percentile for age.

Reviewer Comments:

There is limited pediatric evidence on how to prevent hypotension in children in post–cardiac arrest. One ongoing trial comparing epinephrine to norepinephrine (9) may provide additional insights, but at present, the available evidence does not justify a systematic review on this topic, nor a good practice statement.

Reference List

1. Topjian AA, Scholefield BR, Pinto NP, Fink EL, Buysse CMP, Haywood K, et al. P-COSCA (Pediatric Core Outcome Set for Cardiac Arrest) in Children: An Advisory Statement From the International Liaison Committee on Resuscitation. Resuscitation. 2021;162:351–64.
2. Greif R, Bray JE, Djarv T, Drennan IR, Liley HG, Ng KC, et al. 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. Circulation. 2024;150(24):e580–e687.
3. Conlon TW, Falkensammer CB, Hammond RS, Nadkarni VM, Berg RA, Topjian AA. Association of left ventricular systolic function and vasopressor support with survival following pediatric out-of-hospital cardiac arrest. Pediatr Crit Care Med. 2015;16(2):146–54.
4. Gardner MM, Hehir DA, Reeder RW, Ahmed T, Bell MJ, Berg RA, et al. Identification of post-cardiac arrest blood pressure thresholds associated with outcomes in children: an ICU-Resuscitation study. Crit Care. 2023;27(1):388.
5. Laverriere EK, Polansky M, French B, Nadkarni VM, Berg RA, Topjian AA. Association of Duration of Hypotension With Survival After Pediatric Cardiac Arrest. Pediatr Crit Care Med. 2020;21(2):143–9.
6. Liu R, Majumdar T, Gardner MM, Burnett R, Graham K, Beaulieu F, et al. Association of Postarrest Hypotension Burden With Unfavorable Neurologic Outcome After Pediatric Cardiac Arrest. Crit Care Med. 2024;52(9):1402–13.

7. Chun MK, Park JS, Han J, Jhang WK, Kim DH. The association between initial post-resuscitation diastolic blood pressure and survival after pediatric cardiac arrest: a retrospective study. BMC Pediatr. 2024;24(1):563.
8. Topjian AA, French B, Sutton RM, Conlon T, Nadkarni VM, Moler FW, et al. Early postresuscitation hypotension is associated with increased mortality following pediatric cardiac arrest. Crit Care Med. 2014;42(6):1518–23.
9. Nuthall G, Christoff A, Morrison LJ, Acworth J, Gray JM, Rossano J, et al. Blood pressure targets after return of circulation following cardiac arrest in infants and children: a systematic review and meta-analysis. Resuscitation. 2025;216:110825.
10. Prasad A, Ghorui A, Kumar P, Halder P. Comparison of the Efficacy of Epinephrine vs Norepinephrine in Clinical Outcomes among Children with Postcardiac Arrest Shock: A Hospital-based, Double Blind, Randomized Controlled Trial. Indian J Crit Care Med. 2025;29(10):868–73.
11. Niemela VH, Jousi M, Petersen JJ, Sillassen C, Faltermeier P, Juul S, et al. The impact of vasopressor choice in patients with hypotension after cardiac arrest: a systematic review. Resuscitation. 2025;217:110892.
12. Darnell R, Brown A, Laing E, Edwards J, Harrison DA, Manning JC, et al. Protocol for a Randomized Controlled Trial to Evaluate a Permissive Blood Pressure Target Versus Usual Care in Critically Ill Children with Hypotension (PRESSURE). Pediatr Crit Care Med. 2024;25(7):629–37.

Appendix B

Education Implementation and Teams – 2026 Evidence Updates

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2026 Evidence Update

EIT 6406 – Self-instruction vs Instructor Guided Training

Worksheet author(s): Kathryn Eastwood
Task Force: EIT
Date Submitted: November 2025

PICO / Research Question: EIT 6406
Should self-directed digital vs. instructor-led training be used to teach adults and children basic life support skills?
Population: Adults and children undertaking BLS training.
Intervention: Self-directed digitally-based BLS training.
Comparators: Instructor-led BLS training.
Outcomes: Patient outcomes: Good neurological outcome at hospital discharge/30-days; Survival at hospital discharge/30-days; Return of spontaneous circulation (ROSC); Rates of bystander CPR; Bystander CPR quality during an OHCA (any available CPR metrics); Rates of automated external defibrillator (AED) use.
Educational outcomes at the end of training and within 12 months: CPR quality (chest compression depth and rate; chest compression fraction; full chest recoil, ventilation rate, overall CPR competency) and AED competency; CPR and AED knowledge; Confidence and willingness to perform CPR.
Study Designs: Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies and case series where n>5 are eligible for inclusion. Unpublished studies (e.g., conference abstracts, trial protocols) commentary and editorial papers, reviews and animal studies were excluded.
Timeframe: March 28, 2024 to October 22, 2025

Conflicts of Interest (financial/intellectual, specific to this question): None
Year of last full review: 2024

Current ILCOR Consensus on Science and Treatment Recommendation:
We suggest the use of either instructor-led training or self-directed digital training for the acquisition of CPR or AED skills in lay adults and high school-aged (>10 years) children (weak recommendation, very low certainty evidence).
We suggest self-directed digital training be used when instructor-led training is not accessible, or when quantity over quality of CPR training is needed in adults and children (weak recommendation, very low certainty evidence).
There was insufficient evidence to make a recommendation on game-in-film, virtual reality, computer programs, online tutorials or app-based training as a CPR or AED training method.

Databases searched: Ovid MEDLINE(R) and Epub Ahead of Print, In-Process, In-Data-Review & Other Non-Indexed Citations, Daily and Versions, CINAHL, EMBASE, and the Cochrane Central Register of Controlled Trials.
Timeframe:
Date Search Completed: 22th October 2025
Search Results (Number of articles identified / number identified as relevant): 1019 / 2

Summary of Evidence Update:

Relevant Guidelines or Systematic Reviews: 0
RCTs: 0
Nonrandomized Trials, Observational Studies: 2

Study Acronym; Author; Year Published	Study Type/Design; Study Size (N)	Patient Population	Primary Endpoint and Results (include P value; OR or RR; & 95% CI)	Summary/Conclusion Comment(s)
Gupta et al, 2025	Randomized Cross-Sectional Study n=108	Undergraduate medical students Students with medical conditions that may restrict their training and those with prior exposure were excluded.	• There was a significant difference between compression rates between the intervention and instructor-led groups (median: 110 (IQR:88 to 129) versus 123 (111 to 132.5), P = 0.012). • The instructor-led group achieved significantly better chest compression depths (mean, SD) compared with the intervention group (51.6mm (8.7) versus 36.28 mm (13.8); P < 0.001). • Chest recoil was significantly better in instructor-led group (93% vs. 57%; P<0.001). • There was no significant difference between the groups for any of the assessed aspects of AED usage. • Before the BLS training there was no difference in knowledge, however after training the instructor-led group demonstrated significantly better knowledge scores (12.8 vs. 11, P<0.001).	In this study, hands-on mannequin-based training was significantly more effective than online training in teaching BLS skills to novice medical students, particularly in achieving correct chest compression depth and rate.

Alcazar Artero et al, 2024	A randomized multicenter, comparative and cross-sectional study N=63	Coaches selected from 15 different football clubs from the Region of Murcia (Spain). In the case of minors, the parent or tutors provided a signature. Exclusion criteria: eye pathologies (i.e. correction glasses), neurological pathologies (i.e. epilepsy), age £ 13 years, or abandoning the study.	• Mean chest compression rate was significantly better in the VR group compared to the instructor-led group (102.1 versus 89.0; p<0.001); as was the percentage of participants who provided CPR at the correct rate (54.5% (18/33) versus 25.8% (8/31)). • Chest compression depth was also significantly better in the VR group compared to the instructor-led group (mean 4.1cm versus 3.3cm; p=0.001). • The percentage of chest compressions at the correct depth was also better in the VR group (18.0% (6/33) versus 6.4% (2/31)).	This study found that virtual reality and serious games can improve the quality parameters of chest compressions compared to traditional training.

Reviewer Comments (including whether meet criteria for formal review):
There were 1019 new articles identified in the Medline search of which two were relevant to the PICO. One of these studies supports the intervention and the other supports the control. A systematic review is currently underway for this PICOST.

References:

1. Nishkarsh Gupta, Bhavik Bansal, Anju Gupta, Dhruv Jindal, Madhur Singhal, Amritesh Grewal, Maanit Matravadia, Hardik Gupta, Gyanendra Pal Singh, Arindam Choudhury, Rashmi Ramachandran, Ambuj Roy. Comparison of online content-based training with hands-on mannequin-based skill training on basic life support knowledge and skills among medical students. J Educ Health Promot. 2025 Feb 28:14:55. PMID: 40144185

2. Alcazar Artero, PM; Greif R; Ceron Madrigal, JJ; Escribano, D; Perez Rubio, MT; Alcazar Artero, ME; Lopez Guardiola, P; Mendoza Lopez, M; Melendreras Ruiz, R; Pardo Rios, M. Teaching Cardiopulmonary resuscitation using virtual reality: a randomized study. Australas Emerg Care. March 2024; 27(1): 57-62. PMID: 37666723

2026 Evidence Update

EIT 6408 – Spaced Learning

Worksheet author(s): Adam Boulton, Joyce Yeung, Barbara Farquharson, Marc Auerbach, Tasuku Matsuyama, Jeffrey Lin
Task Force: EIT
Date Submitted to SAC rep for peer review and approval: March 4 2025
SAC rep: Andy Lockey

PICOST / Research Question:

PICOST	**Description** *(with recommended text)*
Population	Learners undertaking resuscitation courses (all course types and all age groups) and/or first aid courses.
Intervention	Training or retraining which is distributed over time ("spaced" learning).
Comparison	Training provided at one single time point ("massed" learning).
Outcomes	Educational outcomes (skill performance 1 year after course conclusion; skill performance between course conclusion and 1 year; knowledge at course conclusion) and clinical outcome (quality of performance in actual resuscitations; patient survival with favorable neurologic outcome)
Study Design	Randomised controlled trials (RCTs) and non-randomised studies (non-randomised controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. All original research articles (both prospective and retrospective) will be included with no language restrictions (so long as abstract in English). Unpublished studies (e.g., conference abstracts, trial protocols) will be excluded.
Timeframe	All years

Year of last full review: 2022
Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
For learners undertaking resuscitation courses, we suggest that spaced learning (training or retraining distributed over time) may be used instead of massed learning (training provided at one single time point) (weak recommendation, very low certainty of evidence).

Databases searched:
MEDLINE, EMBASE, CINAHL, Cochrane Reviews, Cochrane CENTRAL
Time Frame: January 2, 2022-February 17, 2025
Date Search Completed: 17th February 2025
Search Results (Number of articles identified and number identified as relevant): 2316/2

Summary of Evidence Update:
Relevant Guidelines or Systematic Reviews: None
RCT:

Study Acronym; Author; Year Published	**Aim of Study; Study Type; Study Size (N)**	**Patient Population**	**Intervention (# patients)/ Comparator**	**Endpoint Results (Absolute Event Rates, P value; OR/RR; 95% CI)**	**Relevant 2° Endpoint (if any); Study Limitations; Adverse Events**

			(# patients)		
Ranjbar 2024	**Study Aim:** To evaluate the impact of BLS Spaced E-learning versus Massed E-Learning on the knowledge and satisfaction of first-year undergraduate nursing students in Iran. **Study Type:** Randomised study, single centre **Study Size:** N=106	**Inclusion Criteria:** Under-graduate nursing students.	**Intervention:** 59 **Comparison:** 47	**1° endpoint:** Significantly improved scores with intervention immediately after test, after two weeks, and one month.	**Study Limitations:** Single centre No skills assessment
Soares 2024	**Study Aim:** Compare the effectiveness of combined spacing and testing versus single single-session training for BLS and ALS simulation. **Study Type:** Quasi-randomised. Allocation based on student schedule availability. **Study Size:** 31	**Inclusion Criteria:** Under-graduate nursing students year 3-5	**Intervention:** 18 **Comparison:** 13	**1° endpoint:** Improved skill retention in the spaced group at three months.	**Study Limitations:** Single centre, small sample. high rate of attrition (study began with 53 participants) Quasi-randomised introduces risk of bias

Nonrandomized Trials, Observational Studies: none

Reviewer Comments:
Only two further studies were found. Both studies were single centre. Both studies were supportive of spaced learning compared to massed learning; a finding consistent with the previous CoSTR and evidence update. We do not recommend a further systematic review.

References:

1. Ranjbar F, Sharif-Nia H, Shiri M, Rahmatpour P. The effect of spaced E-Learning on knowledge of basic life support and satisfaction of nursing students: a quasi-experimental study. BMC Med Educ. 2024 May 15;24(1):537. doi: 10.1186/s12909-024-05533-9. PMID: 38750506; PMCID: PMC11097522.
2. Soares RV, Pedrosa RBDS, Sandars J, Cecilio-Fernandes D. The importance of combined use of spacing and testing effects for complex skills training: A quasi-experimental study. Med Teach. 2024 Nov 13:1-8. doi: 10.1080/0142159X.2024.2427735. Epub ahead of print. PMID: 39535960.

2026 Evidence Update

EIT 6412 – Gamified Learning vs. Non-Gamified Learning

Worksheet author(s): Aaron Donoghue, Alexander Olausson, Lorrel Toft, Adam Cheng
Task Force: EIT

PICOST / Research Question:

PICOST	**Description** *(with recommended text)*
Population	Learners training in basic or advanced life support
Intervention	Instruction using gamified learning (use of game-like elements in the context of training (e.g. point systems, intergroup competition, leaderboards, scaffolded learning with increasing challenge, 'medals' or 'badges')
Comparison	Traditional instruction or other forms of non-gamified learning
Outcomes	Educational outcomes: *Skill* (e.g. CPR performance, other procedural performance, scores in scenarios, time to task performance) immediately following training (e.g. end of course), at 3 months, 6 months, 1 year *Knowledge* e.g. test scores immediately following training (e.g. end of course), at 3 months, 6 months, 1 year *Attitudes*: Participant satisfaction, learner preference, learner confidence Clinical outcomes: change in healthcare practitioner behavior at resuscitation in case of real cardiac arrest (CPR quality, time to task completion, teamwork/crisis resource management) Patient outcomes: ROSC, survival to hospital d/c; neurologic intact survival Process: costs and resources utilization
Study Design	Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. Unpublished studies (e.g., conference abstracts, trial protocols) are excluded.
Timeframe	May 30, 2023 to November 20, 2025 and all languages are included if there is an English abstract

Year of last full review: 2023
Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
It may be reasonable to consider the use of Gamified Learning (GL) elements as a component of resuscitation training (weak recommendation, very low quality of evidence).

Databases searched: Medline, Embase, Cochrane
Time Frame: May 30, 2023 to November 20, 2025
Date Search Completed: November 20, 2025
Search Results (Number of articles identified and number identified as relevant): 565/7

Summary of Evidence Update:
Relevant Guidelines or Systematic Reviews

Organization (if relevant); Author; Year Published	**Guideline or systematic review**	**Topic addressed or PICO(S)T**	**Number of articles identified**	**Key findings**	**Treatment recommendations**
Cheng, 2024 (China)[1]	Systematic review	Effect of serious	6	RCTs only; CPR skill as outcome measures only;	Serious games are equally effective as

		games on CPR training and education		No significant difference between serious games and traditional learning on CPR skill performance	traditional training methods in CPR training
Donoghue, 2024 (ILCOR)[2]	Systematic review	Gamified learning in resuscitation training	13	7 RCTs, 6 observational studies; 12 of 13 demonstrated improvement in one domain (skill, knowledge, attitude) with GL; no studies showed a negative effect	It may be reasonable to consider the use of Gamified Learning (GL) elements as a component of resuscitation training (weak recommendation, very low certainty of evidence).

RCT:

Study Acronym; Author; Year Published	**Aim of Study; Study Type; Study Size (N)**	**Patient Population**	**Study Intervention (# patients) / Study Comparator (# patients)**	**Endpoint Results (Absolute Event Rates, P value; OR or RR; & 95% CI)**	**Relevant 2° Endpoint (if any); Study Limitations; Adverse Events**
Bilodeau, 2024 (Canada)[3]	Study Aim: whether the digital game simulation instructional method was at least as good as a more traditional alternative (video lecture) at updating and maintaining participants' neonatal resuscitation knowledge Study Type: RCT Sample size: IG 21, CG 21	Inclusion Criteria: Labor and delivery healthcare personnel	Intervention: digital game simulator for NRP (RETAIN) Comparison: 20-30 minute NRP instructional video	1° endpoint: Clinical performance immediately post-training No difference between groups (ANOVA, p=0.6) 2° endpoints: Clinical checklist 2 months post-training No difference btw groups (p=0.5) Attitudes towards RETAIN simulator; range of 3.29 to 3.86 on 5-point Likert scale items regarding realism and usefulness	Study Limitations: Small sample size Limited untested clinical assessment (checklist)
Cutumisu, 2024 (Canada)[4]	Study Aim: whether the digital game simulation instructional method was at least as good as a more traditional alternative (video lecture) at updating and maintaining participants' neonatal resuscitation knowledge Study Type: RCT	Inclusion Criteria: Paramedics	Intervention: digital game simulator for NRP (RETAIN) Comparison: 20-30 minute NRP instructional video	1° endpoint: Clinical performance immediately post-training No difference between groups (scored on scale of 0-14) IG: pre 10 + 2.2 to post 10.7 + 2 vs. CG pre 9.6 + 2.3 to post 11.5+1.8) 2° endpoint: Attitudes towards RETAIN simulator; range of 3.53 to 4.00 on 5-point Likert	Study Limitations: Small sample size Limited untested clinical assessment (checklist)

	Sample size: IG 21, CG 21			scale items regarding realism and usefulness	
Kim, 2024 (South Korea)[5]	Study Aim: whether GL in KALS (Korean Advanced Life Support) leads to better outcomes than traditional KALS Study Type: RCT Sample size: IG 139, CG 148	Inclusion Criteria: Healthcare personnel (physician, nurse, paramedic, medical/nursing student)	Intervention: digital game (Kahoot! Software) used during "reminder" session (roundtable discussion with images of CA scenario pre assessment) Comparison: standard "reminder" session (without gamification)	1° endpoint: Immediate post-training MCQ assessments (algorithm, rhythm analysis, teamwork) Algorithm (5 points): CG better than IG (4.88 vs 4.70, p=0.002) Rhythm (3 pts): NSD Teamwork (2 points) NSD	Study Limitations: Limited untested clinical assessment (checklist) Comparisons of point scores on outcomes analyzed as means; difference btw algorithm score 4.7 and 4.88 unlikely to be practically significant

Abbreviations: CG= control group; IG=intervention group; MCQ=multiple choice question; NRP=neonatal resuscitation program; NSD=no significant difference

Nonrandomized Trials, Observational Studies

Study Acronym; Author; Year Published	**Study Type/Design; Study Size (N)**	**Subject Population**	**Gamification element(s)**	**Comparator**	**Primary Endpoint and Results (include P value; OR or RR; & 95% CI)**	**Summary/Conclusion Comment(s)**
Khaledi, 2024 (Iran)[6]	Quasi-experimental (3 groups) N= 154	Nursing students	Kahoot! Software during CPR training	Standard training (3rd group: role-playing during training)	Basic Resuscitation Skills Self-efficacy Scale (self-reported) Greater reported self efficacy in GL group than control (p<0.01)	
Rodriguez-Garcia, 2024 (Spain)[7]	Observational N=68	Laypeople (secondary	'Survivor" game (digital interface, teams	Traditional training	CPR skills Mean depth: NSD	

		school students)	compete for badges, certificates) *both groups with identical 10 mins hands-on training		Correct compression %: GL: 67.8 + 41.3 versus Ctrl: 90.7 + 14.7, p=0.004) Correct release %: NSD Total CC in 2 min: NSD Overall CPR quality (Laerdal manikin algorithm): GL 61.4% + 31.9% versus Ctrl 89.2% + 13.5%, p<0.001) Correct AED application: NSD Time to AED application: GL 82 + 27 sec versus Ctrl 40 + 11 sec, p<0.001	
Flato, 2025 (Brazil)[8]	Observational N=336	Laypeople (schoolchildren aged 7 to 17 years)	Children Save Hearts gameplay followed by video-based CPR training	Knowledge (CSH game based test) immediately before and immediately post training	Post training scores > pre-training scores p<0.001 (boxplot displayed but median and SD of scores not presented)	

Abbreviations: AED=automated external defibrillator; GL=gamified learning; NSD=no significant difference; CSH=Children Save Hearts

Reviewer Comments:

A total of 8 new studies were included in this update.[1-8] In addition to the publication of the ILCOR systematic review on this PICOST, another systematic review was included.[1, 2] This latter review focused on RCTs only, and only included studies where the outcome(s) were metrics of CPR psychomotor skill performance.[1] The authors identified 9 RCTs with the exposure and comparator of interest which reported results allowing meta-

analysis to be performed on at least one outcome measure. Four outcomes (theory assessment (knowledge), CPR skill assessment, chest compression depth, and chest compression rate) were identified and meta-analysis of 6 studies for each of the four outcomes was performed. None of the meta-analyses demonstrated a significant association with their outcomes, and a high degree of heterogeneity was noted in all four (I^2 ranging from 56% to 95%). GRADE analysis performed on the four groups of studies yielded low to very low-certaintyevidence, with all four groups of studies being downgraded for inconsistency, three for indirectness, and one for accuracy.
The authors concluded that gamified learning (discussed in their review as "Serious games") is equally effective as traditional training methods in CPR training. Importantly, the inclusion criteria for their review did not give an explicit definition of what was considered a serious game. All of the included studies were based on a digital platform; however, additional criteria such as the use of point systems, leaderboards, team competition, or scoring/scaffolding of cases were not mentioned (these were inclusion criteria in the ILCOR systematic review published in 2024).

We included three new RCTs in this update.[3-5] Two RCTs examined the impact of a digital-based game for neonatal resuscitation training on educational outcomes, one in labor and delivery room staff and one in paramedics. Bilodeau et al enrolled 42 labor and delivery staff (21 per group) and compared a digital game (RETAIN) to a standard instructional video. Subjects were tested immediately post training and at 2 months post training with a 12-item task checklist. No significant difference in score was found between the groups at either timepoint.[3]
Cutumisu et al enrolled 42 paramedics (21 per group) and compared the same digital game (RETAIN) to a standard instructional video. Subjects were tested immediately post training with a 12-item task checklist. No significant difference in score was found between the groups.[4]
In a third RCT, Kim et al enrolled 287 healthcare personnel (physicians, nurses, students, paramedics) in a trial comparing a locally created advanced life support course (KALS (Korean Advanced Life Support)) taught in standard fashion to the same course with gamified learning elements included. 148 subjects in the control group went through the standard course, which ends with a "reminder" session where learners participate in a round table discussion while reviewing a video-based case of cardiac arrest. 139 subjects in the intervention group went through the same course, but completed the "reminder" session using a digital gaming platform (Kahoot!). Three outcomes were examined by question-based checklist: knowledge of ALS algorithm, rhythm analysis, and teamwork. There were no significant differences between the groups in the rhythm and teamwork assessment; the CG had higher mean score than the IG in the algorithm assessment (4.88 out of 5 versus 4.70 out of 5, p=0.002).[5]

We included three new observational studies in this update.[6-8] Rodriguez-Garcia et al reported a study where groups of secondary school students underwent a CPR training session and were assessed performing CPR on a manikin. The control group (n=34) received a traditional slide-based didactic session with 10 minutes of hands-on training; the gamified group received a training session using a digital game (using competition between teams and 'badges') with 10 minutes of hands-on training. There was no difference between groups in compression depth, release, total compressions in 2 minutes, or frequency of AED application; the gamification group performed worse than the traditional group in fraction of correct compressions (68% + 41% vs 91% + 15%, p=0.004); overall CPR quality (61% + 31.9% vs 89% + 14%, p<0.001); and time to AED application (82 + 27 sec vs 40 + 11 sec, p<0.001).[7]
In a second observational study. Khaledi et al reported on nursing students' reported self-efficacy (Basic Resuscitation Skills Self-efficacy Scale) at CPR following training in either standard fashion or with gamification (Kahoot! Software); self-efficacy was greater in the gamification group (p<0.01).[6] In a third observational study, Flato et al reported on school children ages 7 through 17 completing a serious game based CPR training sessions with post training scores significantly improved from pre-training scores (p<0.001).[8]

Summary
In a summary assessment of these new studies, we do not believe that a new systematic review is warranted. In making this recommendation, we consider that, between the previous SysRev and this EvUp, a total of 10 RCTs have been identified, with 8 finding a benefit from gamified learning and one finding no benefit. Importantly, one RCT found that subjects taught with GL elements scored worse than non-GL counterparts on a post-training

assessment of ALS algorithm knowledge[5]; however, given that the assessment consisted of a score out of 5 total possible points, we do not believe the difference between a mean score of 4.88 and 4.70 is likely to be a meaningful difference.

Among 9 observational studies between the previous SysRev and the current EvUp, 8 studies found a benefit to GL. One newly included observational study found that GL was associated with worse outcomes in secondary school students performing simulated CPR.[7] Given that this one study is the only one to find a negative effect of GL, we do not believe it warrants changing the current recommendation.

Finally, the newly included studies exhibit the same high degree of heterogeneity in terms of intervention, outcome, and subject inclusion that we do not believe including these studies would alter the strength of the existing recommendation.

References

1. Cheng P, Huang Y, Yang P, Wang H, Xu B, Qu C, et al. The Effects of Serious Games on Cardiopulmonary Resuscitation Training and Education: Systematic Review With Meta-Analysis of Randomized Controlled Trials. JMIR Serious Games. 2024;12:e52990.
2. Donoghue A, Sawyer T, Olaussen A, Greif R, Toft L. Gamified learning for resuscitation education: A systematic review. Resusc Plus. 2024;18:100640.
3. Bilodeau C, Schmolzer GM, Cutumisu M. A Randomized Controlled Simulation Trial of a Neonatal Resuscitation Digital Game Simulator for Labour and Delivery Room Staff. Children (Basel). 2024;11(7).
4. Cutumisu M, Schmolzer GM. The Effects of a Digital Game Simulator versus a Traditional Intervention on Paramedics' Neonatal Resuscitation Performance. Children (Basel). 2024;11(2).
5. Kim K, Choi D, Shim H, Lee CA. Effects of gamification in advanced life support training for clinical nurses: A cluster randomized controlled trial. Nurse Educ Today. 2024;140:106263.
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2026 Evidence Update

EIT 6414 – Deliberate Practice Design vs. Non-Deliberate Practice Training

Worksheet author(s): Cristian Abelairas-Gómez; Aaron Donoghue
Date Submitted: December 2025
SAC rep: Andrew Lockey

PICO / Research Question:
Population: Learners training in basic or advanced life support (laypersons/students/healthcare providers
Intervention: Instruction using Rapid Cycle Deliberate Practice (RCDP)
Comparator: Traditional instruction or other forms of learning without RCDP
Outcomes: Patients' survival (CRITICAL), knowledge acquisition and retention (IMPORTANT), skills acquisition and retention (IMPORTANT), skill performance in real CPR (IMPORTANT), process outcomes such as costs, resources (NOT IMPORTANT).
Study Designs: Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. Unpublished studies (e.g., conference abstracts, trial protocols) are excluded.
Time frame: October 2023-November 2025

Year of last full review: 2024
Conflicts of Interest (financial/intellectual, specific to this question): None

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

Databases searched: Medline, Embase, Cochrane
Time Frame : From October 2023 to November 2025
Date Search Completed: Nov 1 2025
Search Results (Number of articles identified and number identified as relevant): 902/2 guidelines papers

Summary of Evidence Update:
Relevant Guidelines or Systematic Reviews: 2

Organization (if relevant); Author; Year Published	Guideline or systematic review	Topic addressed or PICO(S)T	Number of articles identified	Key findings	Treatment recommendations
Donoghue; 2025	2025 American Heart Association Guidelines: Part 12: Resuscitation	Rapid Cycle Deliberate Practice in Resuscitation Training	8	RCDP showed shorter times to start compressions, ventilation, defibrillation, and epinephrine delivery; higher compression	It may be reasonable to incorporate RCDP as part of BLS and ALS training for health care personnel.

	Education Science			fractions; better timely defibrillation; lower workload (NASA-TLX); but lower perceived teaching effectiveness compared to controls.	
Nabecker; 2025	European Resuscitation Council Guidelines 2025: Education for Resuscitation	Rapid Cycle Deliberate Practice in Resuscitation Training	10	It reduces pauses for defibrillation and medication in simulated ALS, is mainly used for HCP training, not yet tested in laypeople or low-resource settings, and shows mixed long-term skill retention.	Use RCDP as an effective learning strategy to master skills rapidly for all types of basic and advanced life support courses.

RCT: 0
Nonrandomized Trials, Observational Studies: 0

Reviewer Comments: *(including whether this PICOST should have a systematic or scoping review*)
There were 902 new articles identified of which none were relevant to the PICO. We recommend that the existing treatment recommendations for this PICO remain unchanged.

Reference List:
Donoghue A, et al. Part 12: Resuscitation Education Science: 2025 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2025;152;S719–50. Doi: https://doi.org/10.1161/CIR.0000000000000137
Nabecker S, de Raad T et al. European Resuscitation Council Guidelines 2025: Education for Resuscitation. Resuscitation. 2025;215:110739. Doi: https://doi.org/10.1016/j.resuscitation.2025.110739

Appendix B
First Aid – 2026 Evidence Updates

Table of Contents

2026 Evidence Update
FA 7010 – Pulse Oximetry

Worksheet author(s): Finlay Macneil
Task Force: First Aid
Date Submitted to SAC rep for peer review and approval: Aug 25
SAC rep: Nici Singletary
PICOST / Research Question:
Population: Adults and children in the out-of-hospital or home setting with an acute illness or injury
Intervention: Use of pulse oximetry in addition to standard first aid assessment
Comparators: Standard first aid assessment without the use of pulse oximetry
Outcomes: Any clinical outcome
Study Designs: Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. Grey literature, social media and non-peer reviewed studies, unpublished studies, conference abstracts and trial protocols are eligible for inclusion.
Timeframe: All years.
Literature search updated to November 16, 2022

Year of last full review: 2022
Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
Good Practice Statements:
First aid providers who use pulse oximeters for the assessment of acute illness or injuries should be proficient in their use and understand their limitations, including equipment factors, environmental considerations, and patient-specific factors that may produce inaccurate and unreliable readings.
The use of a pulse oximeter for first aid assessment should not supersede or replace physical assessment.

Database searched: Medline and Embase
Time Frame: (existing PICOST) – 2022-July 25
Date Search Completed: July 25
Search Results (Number of articles identified and number identified as relevant): 1572/8
Narrative Summary of Evidence Update:
Eight new studies identified, all experimental examining the accuracy of consumer oximeters against a reference hospital grade oximeter, one also had some observational clinical outcome components. These studies were undertaken in adult subjects in 5 studies, children in 2 and a bench simulation in one study. There were no studies of use of pulse oximetry in First Aid.
Experimental Studies:

- Four of the studies {Hundessa 2022 841; Kosevi 2024 387; Metlay 2024 2747; Swamy 2024 1971} looked at the accuracy of 6 fingertip pulse oximeters, 5 of which were stand alone, 3 of these were bench tests on simulated degrees of hypoxia with SpO2 from 70-100% and different skin tones, and one connected to a smartphone for power. These studies showed a range of accuracy for the consumer grade oximeters as detailed in the table below. Some showed acceptable accuracy, but usually in the range of normal SpO2, from 90 to 100%, and some were often outside the acceptable range of within 3% of the true reading.
- Two of the studies {Dcruz 2024 e5536; Kosevi 2024 387} looked at the accuracy of propriety computer algorithms applied to a 60 sec capture of the face with camera in a device. Dcruz' study looked at 100 adults and found "the HR, BP, SpO2, and RR values raised by the Docsun Telehealth Portal compared against the clinically approved medical devices, proved to be accurate by meeting predefined accuracy guidelines." Kosevi looked at recordings in 74 children and found that the both

the fingertip and camera based oximeters were particularly inaccurate in children under 30 Kg weight.

- Two of the studies {Weis 2024 1971; Ghaly 2022 5304} looked at the accuracy of wearables, Apple watch in both studies as well as the Withings Scanwatch in Ghaly's study. Both studies found that the wearables did not have acceptable sensitivity for hypoxia.
- One study {Salton 2022 3115} looked at a relatively expensive but portable handheld device which measured heart rate, respiratory rate, temperature, SpO2 and BP. This study found that there was poor correlation between the handheld device (Buttterflife™) and hospital grade oximeter for SpO2 in 42 patients in an acute care setting, with a Spearman's rho of 0.24, The device did detect deterioration in outpatients in the observational component of the study noted below.
- One study {Swamy 2025 1931} undertook bench testing of 3 consumer grade oximeters and 3 hospital grade oximeters with a simulated SpO2 between 70 and 100% and a range of simulated skin tones. This study was unable to say if skin tone affects SpO2 measurements, but had high concordance for SpO2 >90 and significant variation for SpO2 <90%

Observational Study

- One study { Salton 2022 3115} looked at the collection of vital signs in 8 polycomorbid patients with remote monitoring and found 100% sensitivity and 89% specificity for detecting acute deterioration by the combination of vital signs, most often an abnormal ECG. The influence of SpO2 measurements was not started in this setting.

In summary, the studies of accuracy found that some consumer grade oximeters performed well within the normal range of SpO2 but were increasingly inaccurate below this range. Some studies found discrepancies even within the range of normal SpO2 up to a median of 2 percentage points out, usually an overestimate.
None of these studies warrant a change in the existing Good Practice Statements (above).
Relevant Guidelines or Systematic Reviews: none

RCT: none

Nonrandomized Trials, Observational Studies

Study Acronym; Author; Year Published	**Study Type/Design; Study Size (N)**	**Patient Population**	**Primary Endpoint and Results (include P value; OR or RR; & 95% CI)**	**Summary/Conclusion Comment(s)**
Metlay 2024 (Appears in Experimental studies as well)	**Observational (n=300)**	300 adults >20 yrs with symptoms ARI, ED and primary care clinic in Mass Gen. Av age 53, 64% female, 10% non-hispanic black, 35% ARI, MS complaint 18%, cardiac 11%	Accuracy of vital signs Sats high correlation in range 90-100%, out by up to 2 percentage points either way across this range	Collection of vital signs by patients was inaccurate, especially for heart rate, and the most accurate values required equipment (digital thermometer and pulse oximeter) that are often absent in the home. Future research should examine whether the accurate provision of vital sign information is required to generate appropriate triage and treat- ment decisions during telehealth visits for ARIs and test interventions that provide more accurate measurement

				tools for remote monitoring of high-risk individuals. **However, t**his device is accurate for clinical purposes in this population for SpO2
Salton 2022 (Appears in Experimental studies as well)	**Observational (n=42)**	42 acute respiratory patients in HDU then 8 "chronic" patients in community. Sex distribution not stated	accuracy of vital signs, then identification of conditions requiring medical attention rate in "chronic" patients SpO2 poor correlation with standard, _8 to +5 percentage points out over range of sats 94-100, even spread across Bland-Altman plots. But 100% sensitivity and 89% specificity for 7 conditions identified in 8 chronic patients	poor correlation for SpO2, Spearman's rho 0.24

Experimental Studies:

Study Acronym; Author; Year Published	**Study Type/Design; Study Size (N)**	**Patient Population**	**Primary Endpoint and Results (include P value; OR or RR; & 95% CI)**	**Summary/Conclusion Comment(s)**
Dcruz 2024	**Experimental (n=100)**	100 adults, M:F = 58:42, ethnicity not stated	Validation of Docsun Telehealth Portal on internet connected device with camera for measuring HR, RR, SpO2, BP. Correlation within 2.8SDs of reference from conventional measurement, specifically SpO2 mean was 0.6% below standard and all measurements within 2.8SDs of mean viz =/- 3 percentage points from standard (accepted as standard in UK)	This algorithm provides accurate assessment of HR, RR, SpO2 and BP

Ghaly 2022	**Experimental (n=123)**	123 patients (male 53.7%, age 63619 years)	assess accuracy of smartwatch SpO2 For detection of hypoxia, compared to ward-based PPG, the Apple Watch had a sensitivity and specificity of 30.5% and 92.9% respectively, with a positive predictive value (PPV) of 64.1% and negative predictive value (NPV) of 76.2%. The Withings ScanWatch had a sensitivity and specificity of 62.2% and 69.9% respectively with a PPV 46.4% and NPV 81.6%. Overall accuracy was 74.5% for the Apple Watch and 67.6% for the Withings watch.	While smartwatch technology is able to provide SpO2 readings, its accuracy does not appear to be sufficient to replace standard PPG technology in monitoring hypoxia in home-based COVID-19 patients. This is indirect but still applicable to first aid
Hundessa 2022	**Experimental (n=15**	15 "healthy volunteers, age and sex not stated	assess accuracy of novel consumer grade pulse oximeter Very low error, max 2% for SpO2	Experimental, in vivo, 15 healthy volunteers, sats 95-99%, single device sensor plugged into phone for power supply, good correlation with unspecified Lower grade oximeter ("standard hand held"). Significant because testing in dark pigmented skin (Ethiopia), but very limited applicability due to narrow range sats, test possibly by healthcare professional and imprecision in methods
Kosevi 2024	**Experimental (n=74)**	74 children, 54% female, 54 <30kg	Accuracy of consumer grade adult and paediatric pulse oximeters in children (<CA$40). Adult oximeter worked well on children >30 kg, but all methods for smaller children were inaccurate; Android phone app worst	Pulse ox with consumer grade oximeter inaccurate in children under 30 kg
Metlay 2024 Also in observational studies	**Experimental (n=300)**	300 adults >20 yrs with symptoms ARI, ED and primary care	Accuracy of vital signs including SpO2, HR, RR, and temperature. SpO2 high correlation in range 90-100%, off by up	Patient-collection of vital signs by patients was inaccurate, especially for heart rate, and the most accurate values required equipment (digital

		clinic in Mass Gen. Av age 53, 64% female, 10% non-hispanic black, 35% ARI, MS complaint 18%, cardiac 11%	to 2 percentage points either way across this range	thermometer and pulse oximeter) that are often absent in the home. Future research should examine whether the accurate provision of vital sign information is required to generate appropriate triage and treatment decisions during telehealth visits for ARIs and test interventions that provide more accurate measurement tools for remote monitoring of high-risk individuals. However, this device is accurate for clinical purposes in this population for SpO2.
Salton 2022 Also in observational studies above	**Experimental (n=42)**	42 acute respiratory patients in HDU then 8 "chronic" patients in community. Sex distribution not stated	Accuracy of handheld vital observations monitor including SpO2. SpO2 had poor correlation with standard, -8 to +5 percentage points out of range of sats 94-100, even spread across Bland-Altman plots. But 100% sensitivity and 89% specificity for 7 conditions identified in 8 chronic patients	poor correlation for SpO2, Spearman's rho 0.24
Swamy 2025	**Experimental**	Bench testing	Accuracy of 3 consumer grade oximeters and 3 hospital grade oximeters with different simulated skin tones and different SpO2 72-100%. Unable to say if skin tone affects SpO2 measurements, high concordance for SpO2 >90, significant variation for SpO2 <90%.	Consumer grade oximeters not accurate for SpO2<90%
Weis 2024	**Experimental (n=36)**	Children with congenital heart disease, n=36, 42% female, median age 9.2 (IQR 5.7-	Determine accuracy of Applewatch pulse oximeter. Applewatch reading median 2 percentage points higher SpO2	In children with moderate or severe cyanosis transcutaneous oxygen saturation, measurement with the Apple watch® was not reliable and cannot be recommended

		13.8), SpO2 measured before and after 6 min walk test	than Nellcor and narrower IQR, unable to read SpO2 <85%	to monitor oxygen saturation at home.

Reviewer Comments: *(including whether this PICOST should have a systematic or scoping review*)
These studies do not warrant a change in the current Good Practice Statements for this PICOST. The question of a review of accuracy of consumer grade oximeters will need to be considered by the task force.

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8. Weis A, Leroy M, Jux C, Rupp S, Backhoff D. Oxygen saturation measurement in cyanotic heart disease with the Apple watch. Cardiology in the Young. 2024;34:1971-3.

2026 Evidence Update

FA 7040 – Recovery Position

Worksheet author(s): Abel Martínez-Mejias
Task Force: First Aid
Date Submitted to SAC rep for peer review and approval: November 2025
SAC rep: E.M. Singletary

PICOST / Research Question:

PICOST	**Description** *(with recommended text)*
Population	Adults and children in the first aid setting, with a reduced level of responsiveness of non-traumatic aetiology, who do not require resuscitative interventions (chest compressions, rescue breathing, defibrillation).
Intervention	Any specific positioning (recovery positioning i.e. various semi-prone, lateral recumbent, side-lying or three-quarters prone positions of the body).
Comparison	Any other positioning (Compared with supine or other position)
Outcomes	Any relevant clinical outcomes including but not limited to: **Critical** - survival - incidence of cardiac arrest - delayed detection of apnoea and cardiac arrest, - need for airway opening maneuvers (i.e. head tilt chin lift and jaw thrust), - incidence of aspiration - Hypoxia **Important** - Likelihood of cervical spine injury - complications (venous occlusion, arterial insufficiency, discomfort/pain, aspiration pneumonia)
Study Design	Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. Case series and case reports will also be considered for inclusion. As it is anticipated that there will be insufficient studies from which to draw a conclusion, the minimum number of cases for a case series to be included has been reduced for the default of 5 to 1 by the TFSR team.
Timeframe	All years and all languages are included as long as there is an English abstract. Literature search updated to November 18, 2025

Type (intervention, diagnosis, and prognosis):

- Recovery position in people with reduced level of responsiveness of nontraumatic origin and do not require resuscitative interventions
- The assessment and reassessment of warning signs during Recovery Position to change to supine position or maintain it.
- Different positions in infants, traumatic situations, pregnancy, greater or smaller body habitus, disabled people or others special situations
- Special considerations for:
    - Gender bias
    - Limited resource setting (LRS)

Exclusion Criteria:

- Children and adults with non-effective breathing
- Children and adults in cardiac arrest
- Children and adults with traumatic aetiology
- Neonates

Additional Evidence Reviewer(s): none

Conflicts of Interest (financial/intellectual, specific to this question): None

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:

2022 Treatment Recommendations

When providing first aid to a person with a decreased level of responsiveness of non-traumatic etiology and who does not require immediate resuscitative interventions, we suggest the use of the recovery position. (Weak recommendation, very low certainty evidence)

When the recovery position is used, monitoring should continue for signs of airway occlusion, inadequate or agonal breathing and unresponsiveness. (Good Practice Statement)

If body position, including the recovery position, is a factor impairing the first aid provider's ability to determine the presence or absence of signs of life, the person should be immediately positioned supine and re-assessed. (Good Practice Statement)

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

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

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

Search Results: 12 relevant articles (4 SR/Guidelines + 3 Scoping Reviews + 3 RCT +1 NRCT/OS+ 1CS)

2025 Summary of Evidence Update:

The 2025 Evidence Update identified four guideline documents, three non-systematic reviews, three RCTs, one observational study and a single case report. All five studies evaluated outcomes with different types of lateral recovery positions. The largest RCT (Ye 2025), with 2143 patients, found that placing sedated adults in the lateral position significantly reduced the incidence and severity of hypoxemia and decreased the need for airway rescue interventions without compromising safety. One observational study (Li 2025) with 28 sedated children under five years of age analyzed the effect of position on the airway and reported beneficial outcomes in pediatric patients placed in the lateral recovery position. Two smaller RCTs in young adults, one with 8 volunteers analyzing the effect of the recovery position on vascular flow to the arms (De Buck 2024) and another with 20 volunteers assessed the hemodynamics of both cerebral hemispheres when placed in a lateral position (Kamiya 2022). Both studies seem to continue supporting the use of the recovery position in first aid. No complications

were observed from its use. The case report (Meena 2025) describes a case of penetrating abdominal trauma that could not be managed in the supine position, finding clear benefits in airway management, reducing the risk of aspiration, and generally improved in the lateral position.
Thus, the identified studies support the current ILCOR treatment recommendation for use of the recovery position.

Meena 2025 about Airway Management in Trauma (Non-Supine Position): This case highlights the successful airway management of an 18-year-old man with penetrating abdominal trauma (embedded metal knife) who required lateral decubitus positioning due to contraindications for the traditional supine approach, such as continuous bleeding and hemodynamic instability. The presence of a protruding foreign body precluded supine positioning, necessitating meticulous planning. Airway management was successfully achieved on the first attempt using a C-MAC® videolaryngoscope (VL) and bougie guidance in the left lateral decubitus position. The case underscores the importance of adaptability, advanced tools (VL), and multidisciplinary collaboration in complex trauma scenarios involving non-conventional positioning, in this case, the lateral position.

Kamiya 2023 about cerebral Hemodynamics in Lateral Position: A study on healthy adult volunteers found that moving from the supine position to the lateral decubitus position does not cause any difference in cerebral hemodynamic (measured by regional oxygen saturation, rSO2) between the left and right cerebral hemispheres. This suggests the existence of a specific cerebrovascular regulatory mechanism that maintains perfusion distribution despite systemic circulatory changes caused by the posture shift. Systolic blood pressure decreased significantly in the left lateral position (measured at the right upper arm), demonstrating transient systemic changes, but rSO2 remained balanced.

Birkun 2025: About the controversy in Seizure Positioning: Guidelines present conflicting recommendations regarding the use of the recovery position (RP) for generalized seizures. Some advised placement during the convulsion, others only after it stops. This review concludes that placing a person with continuing seizures in the RP should be avoided and actively discouraged due to the lack of confirmed benefits (like reducing respiratory disturbances or aspiration risk) and the risks of severe skeletal trauma (e.g., shoulder dislocations) and delayed recognition of cardiac arrest, But RP is advisable in the postictal period for unresponsive, normally breathing individuals.

Hui Ye 2025 about Hypoxemia Prevention in Sedated Adults: This large multicenter randomized controlled trial found that placing sedated adults in the lateral position significantly reduces the incidence and severity of hypoxaemia (defined as SpO2 ≤90%) compared with conventional supine positioning. The incidence of hypoxaemia was significantly lower in the lateral group (5.4%) versus the supine group (15.0%). Lateral positioning also decreased the need for airway rescue interventions (6.3% vs 13.8%) and severe hypoxaemia (SpO2 ≤85%: 0.7% vs 4.8%). Given its simplicity and low cost, lateral positioning is a promising respiratory management strategy for sedated adults, potentially by mitigating gravitational effects on the upper airway.

Hui Li 2025 about Airway Patency in Sedated Children: This retrospective study utilizing 3D MRI reconstructions found that lateral positioning significantly enlarges the upper airway morphology in sedated children under five compared to the supine position. Specifically, lateral positioning increased the narrowest cross-sectional area by 49.21% and airway volume by 65.64%. These findings provide clinical evidence supporting the use of the lateral position to enhance airway patency in younger, sedated patients who are at high risk for upper airway obstruction due to unique anatomical characteristics.

De Buck 2024 about Comparison of Recovery Arm Positions: This study compared two variations of the lateral recovery position in healthy volunteers: one with the dependent arm bent (traditional) and one with the arm extended (newer recommendation). It found no statistically significant difference between the two positions concerning perfusion indicators in the dependent arm (systolic peripheral arterial pressure, venous pressure, oxygen saturation) or subjective pain and discomfort. The conclusion is that, since perfusion was similar, both recovery positions can be used.

Hewett-Brumberg (2024) advocates for the benefits of the recovery position but also warns of its dangers in its recommendations. The position of a sick or injured person is an important first aid intervention that can affect their safety, airway patency, and the extent of their injuries. The recovery position, also known as semi-prone, lateral decubitus, and three-quarter prone, has long been recommended for people with a decreased level of consciousness. Its expected benefits are maintaining an open airway, preventing aspiration, and providing stability and comfort. In addition, in certain circumstances, the lateral decubitus position may be preferable to the supine position for comfort (pregnant women, obese individuals, etc.). However, the recovery position is associated with a delay in recognizing respiratory arrest and in initiating chest compressions. Therefore, it must be carefully monitored.

Djärv in ERC 2025 recommends placing adults and children with decreased responsiveness who do NOT meet CPR criteria in the lateral recovery position (lying on their side), warning that in cases of agonal breathing or trauma, this position should NOT be used.

Djakow 2025 recommends that an unresponsive child who is clearly breathing effectively keep the airway open by continued head tilt chin lift or positioning the child in a recovery position, but not in trauma. In RP providers must check the breathing continuously or at least every minute. If in doubt about the stability of the position or the quality of the breathing, turn the child onto their back and open the airway with the head tilt chin lift maneuver.

Habibi 2022 in this scoping review evaluated prehospital care for potential traumatic spinal cord injury (TSCI), noting that there is no uniform opinion on spinal immobilization. Regarding positioning, the novel lateral trauma position (LTP) and one of the two High Arm IN Endangered Spine (HAINES) methods are preferred for unconscious patients. These lateral positions are considered superior to the standard recovery position and suitable for airway management in unconscious, non-intubated trauma patients. The study also suggests avoiding the log-roll maneuver as it causes significantly more motion in the unstable spine than alternatives.

Shaw 2024, in this article details changes to the Tactical Combat Casualty Care (TCCC) guidelines regarding airway management for battlefield trauma. The new guidelines recommend placing casualties who are unconscious but do not have a traumatic airway obstruction in the recovery position with the chin tilted away from the chest. Furthermore, the "jaw thrust" maneuver is no longer recommended. The guidelines retain the recommendation for the "Sit-Up and Lean-Forward" positioning for conscious casualties with direct maxillofacial trauma.

Steinberg 2025 in this review addresses the risk of sudden death associated with in-custody prone restraint, where a subject is placed face-down and controlled. The estimated mortality rate is approximately one death per 4.4 million people per year, primarily attributed to prone restraint cardiac arrest. The authors argue that prospective studies reporting no deaths were underpowered, while retrospective data consistently indicate substantial risk, as prone positioning decreases ventilation and cardiac output. It is recommended that prone restraint be used only when necessary and discontinued as quickly as possible.

There are no studies about:

- There are no clinical studies that include children and especially infants.
- No studies describe movement-related adverse effects.
- Additional data is needed from out-of-hospital studies.
- There are no recommendations on how to transition from prone to RP.

Relevant Guidelines or Systematic Reviews

Organization (if relevant); Author; Year Published	**Guideline or systematic review**	**Topic addressed or PICO(S)T**	**Number of articles identified**	**Key findings**	**Treatment recommendations**

Hewett-Brumberg 2024 Doi: 10.1161/CIR.0000000000001281	2024 American Heart Association and American Red Cross Guidelines for First Aid. Circulation	Positioning of the Ill or Injured Person	N/A	The positioning of the ill or injured person is an important first aid intervention that may affect their safety, airway patency, and sustained injuries. The recovery position, also described as semiprone, lateral recumbent, side lying, and three-quarters prone, has long been recommended for individuals with decreased level of consciousness.	Although the recovery position has been the subject of little formal study, its anticipated benefits are to maintain an open airway, prevent aspiration, and provide stability and comfort. (Douma 2022) However, the recovery position may not be ideal if there are injuries to the spine, hip, or pelvis; if breathing is abnormal; or if CPR is needed. The recovery position may reduce the risk for airway obstruction, facilitate drainage of airway secretions, and reduce the risk of aspiration in a person with a decreased level of responsiveness, particularly if the airway cannot be closely monitored by a first aid provider. In addition, a side-lying position may be preferred for comfort over the supine position by individuals in certain circumstances such as pregnant individuals, those with respiratory difficulties, or those with a greater or smaller body habitus.(Douma 2022) A left-side lying position improves blood circulation for people in the later stages of pregnancy (hankins 1996; Sommers 2011) However, the recovery position is associated with delayed recognition of respiratory arrest and delayed initiation of chest compressions. (Freire Tellado 2017)
Djärv 2025 DOI: 10.1016/j.resuscitation.2025.110752	Practice Guidelines ERC	First Aid Recovery position	N/A	Based on the ILCOR scoping review, the ERC recommends positioning the person in a lateral, side-lying recovery (lateral recumbent)	Place adults and children with decreased level of responsiveness who do NOT meet the criteria for CPR into a lateral (side-lying) recovery position.

				position as opposed to leaving the person supine. A person placed in the recovery position should be monitored for continued airway patency, breathing and their level of responsiveness. If these critical signs deteriorate th e person should be repositioned into a supine position and, if required, CPR initiated. For a person with agonal breathing or who has suffered trauma, you should not use the recovery position. Persons with a known trauma should be kept in supine position.	In cases of agonal breathing or trauma, do NOT move the person into a recovery position.
Djakow 2025 Doi: 10.1016/j.resuscitation.2025.110767	Practice Guideline European Resuscitation Council Guidelines 2025 Paediatric L ife Support	Recovery position in pediatric populatio n	5		In an unresponsive child who is clearly breathing effectively, keep the airway open by continued head tilt- chin lift or positioning the child in a recovery position, especially if there is a risk of vomiting, but not in trauma. Check breathing continuously or at least every minute if the child is placed in a recovery position. If in doubt about the stability of the position or the quality of the breathing, turn the child onto their back and open the airway with the head tilt chin lift manoeuvre.

Shaw 2024 DOI: 10.55460/C0YI-YZNK	Airway Management in Tactical Combat Casualty Care: TCCC Change 24-1	In 2024, the Committee on TCCC approved a change to the recommended management of the airway in TCCC			Continues the recommendation for use of the "Sit-Up and Lean-Forward" positioning to keep the airway clear in casualties with direct maxillofacial trauma when conscious and able to do so.

					Recommends that casualties who are unconscious without traumatic airway obstruction be placed in the recovery position with the chin tilted away from the chest. There is no longer a recommendation to use a "jaw thrust."

Non Systematic Reviews

Organization (if relevant); Author; Year Published	No Systematic Review	Topic addressed or PICO(S)T	Number of articles identified	Key findings	Treatment recommendations
Birkun 2025 DOI:10.1016/j.ajem.2025.08.031	Recovery position for generalised seizures: A focused scoping review of guidelines and original research	To explore corresponding recommendations presented in first aid guidelines and to review original research that may support or refute the application of this manoeuvre for seizures.	26 guidelines	13 provided recommendations on first aid for seizures. The recommendations for the use of the RP were conflicting. Five guidelines advised putting the person on their side during the convulsion; 5 recommended positioning only after the seizure stops. There is no evidence confirming that lateral positioning of a person with continuing seizures reduces the severity of respiratory disturbances or the likelihood of aspiration. Putting the person with ongoing convulsions on their side can result in shoulder dislocations and hinder recognition of cardiac arrest.	Unless compelling new evidence proves otherwise, recommending the placement of a person with continuing seizures in the RP should be avoided and actively discouraged. In the postictal period, the use of the RP for an unresponsive, normally breathing person is advisable as it can prevent life-threatening respiratory disturbances.
Steinberg 2025 DOI: 10.1016/j.forsciint.2025.112652	Mortality associated with in-custody prone restraint: A review.	Sudden and unexpected arrest-related deaths. The use of prone restraint, wherein a subject is placed face-down and controlled in this position.		They estimate the mortality rate with use of in-custody prone restraint is at approximately 1 per 4.4 million individuals per year, or 0.023 per 100,000 population annually.	These findings underscore the need for more rigorous, large-scale, and transparent epidemiologic

					al studies. The potential lethality of prone restraint must be recognized, and its use re-evaluated.
Habibi Arejan 2022 DOI: 10.1007/s00586-022-07164-4	Evaluating prehospital care of patients with potential traumatic spinal cord injury: scoping review	Purpose To gain insight into current research regarding prehospital care (PHC) in patients with potential traumatic spinal cord injury (TSCI) and to disseminate the findings to the research community	42 studies: 18 articles on immobilization; 12 on movement, positioning, transport; 4 on spinal clearance; 3 on airway protection; 2 on role of PHC providers	There was no uniform opinion about spinal immobilization of patients with suspected TSCI. The novel lateral trauma position and one of two High Arm IN Endangered Spine (HAINES) methods are preferred methods for unconscious patients. Controlled self-extrication for patients with stable hemodynamic status is recommended.	Future prospective studies with a large sample size in real-life settings are needed to provide clear and evidence-based data in PHC of patients with suspected TSCI

RCT:

Study Acronym; Author; Year Published	**Aim of Study; Study Type; Study Size (N)**	**Patient Population**	**Study Intervention (# patients) / Study Comparator (# patients)**	**Endpoint Results (Absolute Event Rates, P value; OR or RR; & 95% CI)**	**Relevant 2° Endpoint (if any); Study Limitations; Adverse Events**
De Buck 2024 DOI: 10.1016/j.resplu.2024.100722	The impact of different recovery positions on the perfusion of the lower forearm and comfort: A cross-over randomized controlled trial Aim: to evaluate the effect of recovery positions with bent or extended arm on perfusion of the lower forearm and comfort. Study size: 18	18 healthy volunteers aged >18 years and <65 years	In random order, with an interval of 15 min in supine position. Various perfusion indices of the dependent arm were assessed, as well as discomfort, pain and skin discoloration. One of the recovery positions tested extended the dependent arm aligned next to the upper lying arm supporting the head.	The study found no statistically significant difference in systolic peripheral arterial pressure in the radial artery, peripheral venous pressure at the back of the hand, oxygen saturation, heart rate, subjective pain and discomfort, when comparing both postures. Participants slightly experienced more skin discoloration in the position with extended arm. The study concluded that since perfusion of the dependent arm was shown to be similar in both positions, both recovery positions can be used.	Regarding pain and discomfort no statistically significant difference was found between the two positions. Several limitations complicate the interpretation of data.

			The other recovery position was the lateral side-lying recovery position with bent arms.		
Kamiya 2022 DOI: 10.14814/phy2.15685	Lateral position does not cause an interhemicerebral difference of cerebral hemodynamic in healthy adult volunteers	20 healthy volunteers (7 males and 13 females). Mean age 28.9 ± 8.9 years.	The effects of the lateral decubitus position on heart rate, blood pressure, and hemodynamic in the left and right cerebral hemispheres were investigated in healthy adults tested in three postures: 1. Sitting position: supine (control)- sitting position- supine. (2) Right lateral position: supine (control)- right lateral position- supine. (3) Left lateral position: supine (control)- left lateral position- supine.	Although the lateral decubitus position causes systemic circulatory changes, it may not cause any difference in hemodynamics between the left and right cerebral hemispheres. Cerebral hemodynamics are maintained during postural changes among the sitting, supine, and lateral decubitus position	Whether the lateral decubitus position causes differences in cerebral hemodynamic between the left and right cerebral hemispheres was investigated by measuring rSO2. It was not possible to demonstrate that the lateral decubitus position causes any difference in cerebral hemodynamic between the two cerebral hemispheres.
Ye 2025 DOI: 10.1136/bmj-2025-084539	Effect of lateral versus supine positioning on hypoxaemia in sedated adults: multicentre randomised controlled trial DESIGN Prospective, multicentre, randomised controlled trial 2143 patients were included in the primary analysis.	SETTING: 14 tertiary hospitals in China, July to November 2024. Of 2143 patients, mean age was 53.1 years, mean body mass index was 23.9, and 53.7% (1150/2143) were women.	Sedated patients were randomly assigned (1:1) to receive either lateral positioning or conventional supine positioning. Analyses were performed on an intention-to-treat basis.	The incidence of hypoxaemia was significantly lower in the lateral position group compared with supine group (5.4% (58/1073) v 15.0% (161/1070); adjusted risk ratio 0.36, 95% confidence interval (CI) 0.27 to 0.49; P<0.001). Patients in the lateral group required fewer airway rescue interventions (6.3% (68/1073) v 13.8% (148/1070); adjusted risk ratio 0.46, 0.34 to 0.61; P<0.001), had a lower incidence of severe hypoxaemia (0.7% (8/1073) v 4.8% (51/1070); adjusted risk ratio 0.16, 0.07 to 0.33; P<0.001), and had a	Placing sedated adults in the lateral position significantly reduces the incidence and severity of hypoxaemia and decreases the need for airway rescue interventions without compromising safety. Given its simplicity and low cost, lateral positioning could offer advantages in remote or resource constrained clinical settings. Further

				higher mean lowest SpO2 level (96.9% v 95.7%, absolute adjusted mean difference 1.20%, 95% CI 0.87% to 1.54%; P<0.001). Safety outcomes were comparable between the groups, but tachycardia was less frequent in the lateral group.	replication studies targeting patients with advanced age and high body mass index are needed to improve the generalisability of the findings

Nonrandomized Trials, Observational Studies

Study Acronym; Author; Year Published	Study Type/Design; Study Size (N)	Patient Population	Primary Endpoint and Results (include P value; OR or RR; & 95% CI)	Summary/Conclusion Comment(s)
Li 2025 DOI: 10.1007/s12519-025-00910-w	Impact of lateral positioning on upper airway morphology in sedated children under five A retrospective study This study aimed to analyze the impact of lateral positioning on the upper airway of sedated children under five. N = 24 (15 girls, 9 boys ages 0 to 5 years	Pediatric patients who underwent MRI in both the supine and lateral positions at Children's Hospital, Zhejiang University School of Medicine. Upper airway morphology was reconstructed using 3D Slicer software. Python was employed to estimate cross-sectional areas via pixel analysis. The narrowest cross-sectional area, minimal transverse and anteroposterior diameters, airway length, and airway volume were measured and stratified by age.	In sedated children under 5 years old and when compared to the supine position, lateral positioning increased minimal transverse diameter by 18.70% (P = 0.001), narrowest cross-sectional area by 49.21% (P < 0.001), anteroposterior diameter by 25.54% (P < 0.001), airway volume by 65.64% (P < 0.001), and airway length by 11.93% (P < 0.001). In all subgroups, lateral positioning significantly increased the narrowest cross-sectional area, airway length, and airway volume.	Lateral position significantly enlarges the upper airway in sedated children under five. These findings support using lateral position to enhance airway patency in younger patients.
Meena 2025 DOI: 10.7759/cureus.78466	Lateral Positioning and Airway Management in Penetrating Abdominal Trauma: A Case Report	An 18-year-old male was taken to the operating theater with a penetrating abdominal injury necessitating lateral positioning due to ongoing bleeding and hemodynamic instability.	The lateral approach enabled optimal management of both the penetrating injury and airway compromise, preventing further exacerbation of the injury and reducing aspiration risks.	This case highlights the challenges and considerations in managing airways in trauma patients who cannot tolerate supine positioning.

Reviewer Comments:

Studies identified for this PICOST did not question the use and indications for the recovery position, adding data on its safety in some cases. However, the current systematic review could benefit from a parallel review of airway management techniques by first responders in individuals with decreased responsiveness of any etiology, or from an updated systematic review of the techniques used to place a person in the recovery position and their impact.

Therefore, the 2022 ILCOR CoSTR conclusions on the use of the recovery position remain unchanged while the other potential revisions are discussed.

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2026 Evidence Update

FA 7442 – Resuscitation Care for Suspected Opioid-Associated Emergencies

Worksheet author(s): Jessica Rogers and Phuong Thao Nguyen
Task Force: First Aid
SAC rep: Terese Djärv

PICOST / Research Question:

PICOST (Population, Intervention, Comparator, Outcome, Study Designs and Timeframe)
Population: Adults and children with suspected opioid-associated cardio / respiratory arrest in the pre-hospital setting
Intervention: Bystander naloxone administration (intramuscular or intranasal), in addition to standard CPR
Comparators: Standard CPR only
Outcomes: Any clinical outcome
Study Designs: Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. Unpublished studies (e.g., conference abstracts, trial protocols) are excluded.
Timeframe: All years and all languages were included as long as there was an English abstract. Unpublished studies (e.g., conference abstracts, trial protocols), animal studies, manikin studies, cadaver studies were excluded. Literature searched to 29 September 2025.

Year of last full review:
2023

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:
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).

Databases searched: PubMed and Embase
Time Frame: (existing PICOST): 12 December 2023 - 29 September 2025
Date Search Completed: 29 September 2025
Search Results (Number of articles identified and number identified as relevant): 1423/3

Summary of Evidence Update:

Relevant Guidelines or Systematic Reviews

Organization (if relevant); Author; Year Published	Guideline or systematic review	Topic addressed or PICO(S)T	Number of articles identified	Key findings	Treatment recommendations
Grunau 2025 (ILCOR Systematic Review)	Systematic Review	In adults and children experiencing cardiac arrest (in or out of hospital) secondary to suspected opioid poisoning, do opioids	1051 studies screened, 6 observational studies met criteria for analysis (4 full	5 studies reported the association of naloxone administration with	There is currently no evidence demonstrating benefit for any advanced life support interventions specific to

		specific ALS-level therapies (e.g. naloxone, bicarbonate, or other drugs or ALS-level interventions), in comparison to standard advanced life support management, would improved outcomes at hospital discharge, at 30-days, or longer follow up?	text manuscripts and 2 conference abstracts).	outcomes, and one study reported the association of bicarbonate with outcomes. In the naloxone literature, 2 reported that naloxone was associated with improved outcomes, and 3 did not detect an association. All studies were limited by serious risk of bias and indirectness, with the certainty of evidence judged to be very low.	treating cardiac arrest from opioid toxicity.

RCT: none

Nonrandomized Trials, Observational Studies

Study Acronym; Author; Year Published	**Study Type/Design; Study Size (N)**	**Patient Population**	**Primary Endpoint and Results (include P value; OR or RR; & 95% CI)**	**Summary/Conclusion Comment(s)**
Strong, 2024	Retrospective observational study (n =1807)	<u>Inclusion Criteria:</u> All non-traumatic OHCA in registry in Oregon from January 1st 2018 to December 31st 2021.	<u>1° endpoint:</u> Presence of a pulse at ED arrival. Secondary outcomes: ROSC at any time, survival to admission, survival to hospital discharge, good neurologic status at discharge. <u>Results:</u>	Authors suggest that if findings could be demonstrated in a larger dataset or prospective studies, it could support a trial to evaluate the benefit of naloxone in the resuscitative algorithm for non-shockable OHCA.

		Age 18 years old or over. OHCA with non-shockable initial rhythm. Excluded: patients with DNR, cases with shockable rhythms, EMS-witnessed arrest cases, cases where ROSC achieved before naloxone given, cases where bystander CPR given with no EMS CPR. Primary exposure of interest was administration of naloxone prior to vascular access attempts.	Patients receiving naloxone prior to vascular access had higher adjusted odds (aOR [95% CI]) of ROSC at any time (2.14 [1.20 – 3.81]), pulses at ED arrival (2.14 [1.18 – 3.88]), survival to admission (2.86 [1.60 – 5.09]), survival to discharge (4.41 [1.78 – 10.97]), and good neurologic outcome (4.61 [1.74 – 12.19]). Subgroup analysis of cases of non-shockable rhythms, in cases with presumed respiratory arrest, substance use history or overdose cardiac arrest etiology, in cases with at least 10 mins of EMS resuscitation on scene before ROSC found results consistent with the main analysis.	
Quinn 2024	Retrospective observational study (n=769)	<u>Inclusion criteria</u> All patients who had an OHCA between January 1 2017 to June 30, 2022. Excluded: Under	<u>1° endpoint:</u> ROSC and survival to hospital discharge <u>Results:</u> 790 patients initially included, 21 excluded. 175/769 (23%) received naloxone; 594/769 (77%) no naloxone. Patients who received naloxone had fewer comorbidities than those who did	In this single urban EMS system with high rates of opioid overdose, there was no difference in outcomes between OHCA patients who received naloxone and those who did not. The paper concludes that it does not support the routine administration of naloxone in OHCA patients.

		18years, traumatic OHCA, no attempted resuscitation.	not except for psychiatric disease and OUD. No significant difference in outcomes between the two groups; no naloxone group had 8.6% survival to hospital discharge rate compared to a rate of 4.6% in the naloxone group (p=0.064). No significant difference in prehospital ROSC rate, ED RSOC rate or survival to admission. There was no significantly different rate of ROSC between matched cohorts of 159 patients in each group. No naloxone group had a 45.3% ROSC rate compared to 34% in the naloxone group (p=0.09). No difference in survival to hospital discharge (p=0.23).	

Reviewer Comments: New evidence has been identified with conflicting conclusions. There is an ILCOR systematic review focusing on naloxone in ALS where the paper concludes that there is no evidence to support specific opioid toxicity treatments in ALS. Strong et al. suggest that there could be a role for naloxone in non-shockable cardiac arrest but larger studies are needed. Quinn et al. do not support naloxone in out of hospital cardiac arrest. In terms of first aid, and the difficulties posed to the first aider in recognising true cardiac arrest in the presumed opioid overdoses, the evidence here is unlikely to change current recommendations.

Reference list:

Quinn E, Murphy E, Du Pont D, Comber P, Blood M, Shah A, Kuc A, Hunter K, Carroll G. Outcomes of Out-of-Hospital Cardiac Arrest Patients Who Received Naloxone in an Emergency Medical Services System With a High Prevalence Of Opioid Overdose.The Journal of emergency medicine. 2024;.Volume 67, Issue 3, pp. e249-e258

Strong NH, Daya MR, Neth MR, Noble M, Sahni R, Jui J, Lupton JR. The association of early naloxone use with outcomes in non-shockable out-of-hospital cardiac arrest.Resuscitation. 2024; Volume 201, Issue , pp. 110263

Grunau B, O'Neil BJ, Giustini D, Drennan IR, Lavonas EJ. Opioid-associated cardiac arrest: A systematic review of intra-arrest naloxone and other opioid-specific advanced life-support therapies. Resuscitation plus. 2025; Volume 22, Issue , pp. 100906

2026 Evidence Update

FA 7333 – Tourniquet Types in the Pediatric Population

Worksheet author(s): Jen Heng Pek, Nathan P Charlton
Task Force: First Aid
Date Submitted to SAC rep for peer review and approval: 2025-10-26
SAC rep: Therese Djarv

PICOST / Research Question:
Population: Children (less than 18 years of age) with severe, life-threatening external bleeding from an extremity
Intervention: Commercial elastic wrap tourniquet or commercial ratcheting tourniquet
Comparator: Commercial windlass-type tourniquet
Outcomes: Critical – mortality, control of bleeding; Important – blood loss, shock, hypotension, adverse events
Study Designs: Randomized controlled trials (RCTs), non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies), case series (n>20), systematic reviews and guideline publications.
Timeframe: All years and all languages were included if an English abstract was present.

Year of last full review: 2021

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:

We suggest the use of a manufactured windlass tourniquet for the management of life-threatening extremity bleeding in children. (weak recommendation, very low certainty of evidence)

We are unable to recommend for or against other tourniquet types in children due to lack of evidence.

For infants and children with extremities that are too small to allow the snug application of a tourniquet before activating the circumferential tightening mechanism, we recommend the use of direct manual pressure with or without the application of a hemostatic trauma dressing. (Good practice statement)

Technical remarks:
- In both studies included, the Combat Application Tourniquet Generation 7 was the specific brand of windlass rod tourniquet used.
- The included studies evaluated tourniquet use on children from 2 years to 16 years of age with a minimal limb circumference of 13 cm.
- For the purpose of this review, the pediatric age of 18 and younger was chosen by the First Aid and Pediatric Life SupportTask Forces and is the same as used in a previous scoping review by ILCOR.

Databases searched: Cochrane Central Register of Controlled Trials and the Cochrane Database of Systematic Reviews, Embase (Embase.com)
Time Frame: updated from end of last search: 1 January 2020 to 27 September 2025
Date Search Completed: 28 September 2025
Search Results:
Number of articles identified: 40 from Cochrane Central Register of Controlled Trials and the Cochrane Database of Systematic Reviews and 185 from Embase
Number of articles identified as relevant: 4

Summary of Evidence Update:
Since the last search done for the ILCOR systematic reviews (Charlton 2020 235 and Charlton 2021 e14474), one other systematic review,

one guideline and two observational studies were identified.
The systematic review (Starets 2025 116) and guideline (Russell 2023 S2) support the 2021 CoSTR recommendation to use a tourniquet for the management of life-threatening extremity bleeding in children. In addition, there were recommendations to consider pediatric anatomical and physiological differences, and tactical realities (Starets 2025 116), as well as training individuals (Russell 2023 S2).
One observational study (Feeney 2025 162494) reported no mortality and suggested an acceptable safety profile as there were no instances of safety outcomes including acute kidney injury, rhabdomyolysis, nerve injury, compartment syndrome, or amputation. Another observational study (Martino 2025 161955) reported early tourniquet placement, prior to EMS transport arrival, was associated with increased acuity – placement by bystanders and first responders was associated with improved acuity when adjusted for factors such as injury severity and EMS arrival time.

Relevant Guidelines or Systematic Reviews

Organization (if relevant); Author; Year Published	**Guideline or systematic review**	**Topic addressed or PICO(S)T**	**Number of articles identified**	**Key findings**	**Treatment recommendations**
Pediatric Traumatic Hemorrhage Shock Consensus Conference Russell 2023	Guideline	Use of tourniquets in pediatric traumatic hemorrhagic shock	6 – 4 from military, 2 from civilian	Studies showed decreased crystalloid administration, decreased transfusion requirements, and a survival advantage for children treated with tourniquets, particularly when applied before the onset of shock. There were no significant complications from tourniquet use.	In traumatically injured children with exsanguinating extremity hemorrhage, we recommend the use of commercially available tourniquets by individuals with training.
Starets 2025	Systematic review (Full text in Ukrainian, abstract in English)	Use of tourniquets in children of various age groups in prehospital settings	8 articles (evaluated different commercial tourniquet models on simulation models and in clinical scenarios)	Findings indicate tourniquet effectiveness is highly dependent on the child's age, limb circumference and device type.	Findings support the integration of tourniquets into pediatric trauma protocols by accounting for pediatric anatomical and physiological differences, as well as tactical realities. No further details of outcomes in PICOST.

RCT: none

Nonrandomized Trials, Observational Studies:

Study Acronym; Author; Year Published	**Study Type/Design; Study Size (N)**	**Patient Population**	**Primary Endpoint and Results (include P value; OR or RR; & 95% CI)**	**Summary/Conclusion Comment(s)**

Feeney 2025	Study Type: Retrospective cohort study (N=37 but 51 tourniquets placed, median age 14 years, 72% male)	Inclusion Criteria: Patients less than 18 years with acute traumatic limb injury and tourniquet placed from a level 1 pediatric trauma centre between 2015 and 2022	1° endpoint: 47 placed by first responders to the scene, 4 placed at hospital 12/24 in shock at scene of injury, 7/37 in shock on hospital arrival No in-hospital mortality and no instances of safety outcomes including acute kidney injury, rhabdomyolysis, nerve injury, compartment syndrome, or amputation	There were no instances of mortality or adverse events observed, suggesting an acceptable safety profile of tourniquet use in children. There was no mention on type of tourniquet. Although data on shock was available, it was inadequate to comment on tourniquet application on this outcome.
Martino 2025	Study Type: Retrospective cohort study (N=301, median age 17 years, 86.7% males)	Inclusion Criteria: Patients aged 0-19 years from the National EMS Information Systems database who received tourniquet application either by bystanders or EMS providers from 2017 to 2020	1° endpoint: 187 placed before EMS arrival, 105 placed afterward Acuity at EMS arrival was significantly different (p=0.002) as patients with tourniquet placed before EMS arrival less commonly of critical acuity (18.1% vs 36.3%) Acuity at ED arrival was significantly different (p<0.0001) with lower percentage of patients with tourniquet placed before EMS arrival having critical acuity (21.0% vs 35.2%). The improvement in acuity after tourniquet placement was not significantly different between groups (p=0.22). There was no difference between groups in proportion of patients transported to a trauma centre (before: 38.5% vs after 33.3%, p=0.67)	Tourniquets placement by EMS, bystanders and first responders is effective for pediatric patients in civilian setting. Early tourniquet placement, prior to EMS transport arrival, was associated with increased acuity. Additionally, placement by bystanders and first responders was associated with improved acuity when adjusted for factors such as injury severity and EMS arrival time. There was no mention on type of tourniquet. Although not direct outcomes of PICOST, acuity and transport to a trauma centre can be considered surrogate outcomes for control of bleeding, blood

			Tourniquet placement prior to EMS transport arrival was associated with decrease in initial acuity (OR 0.84, 95% CI 0.76-0.94, p=0.003). Tourniquet placement by bystanders and first responders after transport arrival was associated with improved acuity (OR 1.90, 95% CI 1.06-3.41, p=0.03). Failure of tourniquet placement was associated with decreased odds of improved acuity (OR 0.62, 95% CI 0.44-0.86, p=0.005).	loss, shock and hypotension.

Reviewer Comments:

Two additional observational studies (Feeney 2025 162494 and Martino 2025 161955) were identified in this evidence update. Both studies support the ability of tourniquets to reduce morbidity and mortality in the pediatric population, but neither evaluated the specific type of tourniquet used. Similarly, a systematic review (Starets 2025 116) supported the use of tourniquets in the pediatric population, but also did not specifically mention the type of tourniquet. Together, these articles further support the prior ILCOR recommendation that tourniquets can be used in the management of pediatric patients with life-threatening extremity hemorrhage. However, data regarding the most appropriate tourniquet type in pediatrics is still limited. Therefore, an update of the 2021 systematic review is currently not warranted.

Reference list:

Charlton NP, Swain JM, Brozek JL, et al. Control of severe, life-threatening external bleeding in the out-of-hospital setting: A systematic review. Prehospital Emergency Care. 2021;25:(2),235-267. doi:10.1080/10903127.2020.1743801

Charlton NP, Goolsby CA, Zideman DA, et al. Appropriate tourniquet types in the pediatric population: A systematic review. Cureus. 2021;13(4):e14474. doi:10.7759/cureus.14474

Feeney EV, Harris MR, Furman LM, et al. Pediatric Tourniquet Use: Safe and effective. J Pediatr Surg. 2025;60(10):162494. doi:10.1016/j.jpedsurg.2025.162494

Martino AM, Giron A, Schomberg J, et al. Pre-hospital tourniquet use in adolescent and pediatric traumatic hemorrhage: A National Study. J Pediatr Surg. 2025;60(1):161955. doi:10.1016/j.jpedsurg.2024.161955

Russell RT, Esparaz JR, Beckwith MA, et al. Pediatric traumatic hemorrhagic shock consensus conference recommendations. J Trauma Acute Care Surg. 2023;94(1S Suppl 1):S2-S10. doi:10.1097/TA.0000000000003805

Starets OO, Khimenko TM, Vielikova MD, et al. Approaches to providing first aid to children with massive bleeding from the extremities: regulatory framework and world experience. Modern Pediatrics. Ukraine. 2025;4(148):116-127. doi:10.15574/SP.2025.4(148).116127

2026 Evidence Update

FA 7371 – Duration of Cooling for Burns

Worksheet author(s): Jen Heng Pek, Jorien Laermans, Therese Djärv
Task Force: First Aid

PICOST / Research Question:

Population: Adults and children in first aid settings with a thermal burn

Intervention: Active cooling using running water for 20 minutes or more as an immediate first aid intervention

Comparator: Active cooling using running water for any other duration as an immediate first aid intervention

Outcomes: Size of burn, defined as percentage of total body surface area at any reported time point; depth of burn, defined as any degree of deep partial or full thickness burn depth; pain, defined as any measurement of pain or administration of pain relief medications; adverse outcomes, defined as any adverse outcome, including hypothermia; wound healing, defined as time to re-epithelization in days; and complications within 24 hours, defined as organ dysfunction, ICU care, infections (within 7 days), bleeding, and rhabdomyolysis as well as the need for surgical procedures such as skin grafting, fasciotomy, or escharotomy

Study Designs: Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies), case series (n>20), systematic reviews and guideline publications

Timeframe: All years and all languages were included if an English abstract was present.

Year of last full review: 2021

Current ILCOR Consensus on Science and Treatment Recommendation for this PICOST:

We recommend the immediate active cooling of thermal burns using running water as a first aid intervention for adults and children (strong recommendation, very low certainty evidence).

Because no difference in outcomes could be demonstrated with the different cooling durations studied, a specific duration of cooling cannot be recommended.

Young children with thermal burns that are being actively cooled with running water should be monitored for signs and/or symptoms of excessive body cooling (Good Practice Statement).

Databases searched: Ovid MEDLINE(R) and Embase (Embase.com)
Time Frame: updated from end of last search: 1 January 2020 to 15 July 2025
Date Search Completed: 15 July 2025
Search Results:

Number of articles identified: 143 from MEDLINE(R) and 306 from Embase
Number of articles identified as relevant: 6

Summary of Evidence Update:

Since the last search done for the ILCOR systematic review (Djärv 2022 251), one other systematic review, two guidelines and two observational studies were identified.

The systematic review (Griffin 2022 367) and guidelines (Zideman 2021 270 and Ji 2024 tkad061) support the 2021 CoSTR recommendation to immediately use running water to actively cool thermal burns as a first aid intervention for adults and children. Both guidelines recommend cooling with running water for at least 20 minutes, and the systematic review concludes that *'There is considerable evidence to recommend 20 minutes of cool running water within three hours of injury as the fold standard of first aid for thermal burns'*. While this intervention is easily accessible (Griffin 2022 367), the ERC guidelines acknowledge that circumstances surrounding the injury may be challenging and limit its application, therefore urging for any cooling as opposed to no cooling (Zideman 2021 270).

In addition to young children, one observational study (Olawoye 2025 107357) suggested that adults should also be monitored for signs and/or symptoms of excessive body cooling based on the statistical significant finding of lower mortality

if water application was 5 minutes compared to more than 5 minutes, though age was identified as a confounder which was not addressed adequately, thus decreasing the certainty.
Another observational study (Qu 2023 869) reported outcomes of length of stay and hospitalization cost which had no difference when cooling for less than 20 minutes and cooling for 20 minutes or more, were compared to no first aid. However, these were not direct outcomes in the PICOST, thus decreasing the directness.

Relevant Guidelines or Systematic Reviews

Organization (if relevant); Author; Year Published	**Guideline or systematic review**	**Topic addressed or PICO(S)T**	**Number of articles identified**	**Key findings**	**Treatment recommendations**
ILCOR Djärv 2022 251	Systematic review	Among adults and children with thermal burn, does active cooling using running water as an immediate first aid intervention for 20 min or more, compared with active cooling using running water for any other duration, change the outcomes of burn size, burn depth, pain, adverse outcome (hypothermia) or complications?	4 articles (cohort studies); 5391 participants (3071 children and 2320 adults)	Children and adult: - No difference in size of burn and skin grafting between burns cooled for 20 minutes or more versus burns cooled less than 20 minutes Children: - Deep dermal depth was seen less among those whose burns were cooled for less than 20 minutes - No difference in wound healing and pain, but 5/29 (14%) developed hypothermia (34-35.9°C) or were visibly cold with shivering Adult: - Deep dermal depth was more common among those whose burns were cooled less than 20 minutes)	The published scientific evidence is inconclusive regarding the optimal duration for cooling of thermal burns with running water as a first aid intervention.
Griffin 2022 367	Systematic review	What effect does the application of cool running	7 articles (3 case-control studies, 3 cohort studies, 1 randomized controlled	Children and adult: - Decreased likelihood of skin grafting	There is considerable evidence to recommend 20 minutes of cool running water within three hours of injury as the gold

		water for 20 minutes within three hours of burn injury have on patient outcomes, and is it more effective than alternative remedies, or no cool running water?	trial); 11383 participants (3661 children and 7722 adults)	- No difference in outpatient visits Children: - Decreased likelihood of hospital admission, acquiring a full thickness burn depth at first dressing change and surgical intervention - Conflicting evidence for hospital length of and time to re-epithelisation Adult: - Reduction in burn depth within 21 days after injury, ICU length of stay and burn wound temperature - No difference for healing time (presumed re-epithelisation), ICU admission and mortality - Cool running water up to 19 min was associated with significant reduction in hospital length of stay but 20 min or greater did not yield significant decrease - Higher pain among patients who received cool running water compared to Burnshield	standard of first aid for thermal burns. Cool running water for 20 minutes as first aid is mostly accessible, simple and can be applied by conscious patients, bystanders and pre-hospital responders. International consensus is required.
ERC Zideman 2021 270	Guideline	Cooling of thermal burns	-	-	Recommendation: "For thermal burns, […] commence immediate cooling of the burn with cold or cool water for 20 minutes." The guideline acknowledges this may be challenging in practice

					in some instances and urges any cooling as opposed to no cooling as circumstances allow.
Chinese Burn Association Tissue Repair of Burns and Trauma Committee, Cross-Straits Medicine Exchange Association of China Ji 2024 tkad061	Guideline	Pre-hospital first aid for thermal burn wounds	-	-	Recommendations: "Start cooling as soon as possible after the burn, and it is recommended to start no later than 3 hours after the injury, with cooling duration of no less than 20 minutes or until the pain in the wound is adequately relieved (highly recommended, high level of evidence). For the mode and temperature of cooling, the use of running water (12-25°C) appropriate for the patient's body temperature is recommended for wounds (moderately recommended, moderate level of evidence)."

RCT: none

Nonrandomized Trials, Observational Studies:

Study Acronym; Author; Year Published	**Study Type/Design; Study Size (N)**	**Patient Population**	**Primary Endpoint and Results (include P value; OR or RR; & 95% CI)**	**Summary/Conclusion Comment(s)**
Qu 2023 869	Study Type: Retrospective cohort study (N=471, hydrothermal burns 42.7%, flame burns 28.2%, contact thermal burns 6.2%, burn impact injury 0.7%)	Inclusion Criteria: (1) Patients aged ≥60 years old; (2) hospitalized in the emergency department from January 2016 to December 2020, including patients who were cured and discharged and died; (3) the first diagnosis of hospitalization was burned, scald, chemical burn, electric burn, hot crush	1° endpoint: 66.3% of patients did not receive any immediate treatment. 12.2% of patients were treated with cold water to irrigate the burn site: - 86.9% had <20 min of irrigating time (10.6% of all patients) - 13.1% had ≥20 min of irrigating time (1.6% of all patients). - *Length of* stay: Compared to no first aid, there was no difference with <20 min cold water irrigation (standardized	The study authors do not discuss or make conclusions about the duration of irrigation with cold running water as first aid. [While the outcomes reported by this study were not that in the PICOST, these may be surrogates for size and depth of burn – larger and deeper likely longer length of stay, hospitalization cost and operation duration. However, this decreases the directness.]

		injury, or low-temperature scald; and (4) medical records were complete.	regression coefficient = -0.001, p=0.972), ≥20 min cold water irrigation (standardized regression coefficient = -0.027, p=0.386), and other first aid (standardized regression coefficient =-0.034, p=0.313). - *Hospitalization costs*: Compared to no first aid, there was no difference with cold water with 20 min cold water irrigation (standardized regression coefficient = -0.001, p=0.963), ≥20 min cold water irrigation (standardized regression coefficient = -0.012, p=0.552), and other first aid (standardized regression coefficient =0.003, p=0.891). - *Total operation duration*: data not reported	
Olawoye 2025 107357	<u>Study Type:</u> Prospective cohort study (N=335, flame 60%, scald 33.1%)	<u>Inclusion Criteria:</u> All burn injury patients admitted for inpatient care were included. The admission criteria included burn injury greater than or equal to 15 % total body surface area (TBSA), burn injuries in extremes of age, burn in special areas, as well as burn injuries requiring burn wound excision and grafting.	<u>1° endpoint:</u> 143 patients (53.2%) received cool water over the burn wound as first aid: 58.3% for 5 min, 13.7% for 10 min, 5.8% for 20 min, 0.7% for more than 20 min (in 21.6% water was used just to extinguish the flames). There was a statistically significant association between the duration of water application and the rate of wound infection (lower infection rates if water was applied for 5 min compared to more than 5 min; p=0.023) and mortality (lower mortality if water was applied for 5 min; p=0.001).	The authors state that, in the Nigerian context where burn extents are larger than in developed countries, water application of no more than 5 minutes will be more beneficial to maximize cooling effect of water while reducing hypothermia and its systemic effects. However, the study data show that the median age of patients receiving 5 min of cool water is 6 years, whereas the age in the other groups lies significantly higher (10 min: 21 years, 20 min: 19 years, only to extinguish flame: 35 years). There is thus a high risk of confounding that has not been addressed

				adequately, decreasing the certainty in the results of this study.

Reviewer Comments:

Although the optimal duration of cooling with running water was inconclusive in the 2022 ILCOR systematic review (Djärv 2022 251), two guidelines (Zideman 2021 270 and Ji 2024 tkad061) recommended at least 20 minutes of cooling with running water for first aid, and another systematic review (Griffin 2022 367) concluded that '*There is considerable evidence to recommend 20 minutes of cool running water within three hours of injury as the fold standard of first aid for thermal burns*'.

Of the two new observational studies, one did not discuss the duration of cold running water as first aid (and did not provide any data on one of the outcomes of interest, i.e. total operation duration; Qu 2023 869), and the other was limited to the Nigerian context and at high risk of residual confounding (Olawoye 2025 107357), making its findings insufficiently trustworthy.

Therefore, an update of the 2022 systematic review is currently not warranted.

Reference list:

Djärv T, Douma M, Palmieri T, et al. Duration of cooling with water for thermal burns as a first aid intervention: A systematic review. Burns. 2022;48(2):251-262. doi:10.1016/j.burns.2021.10.007

Griffin B, Cabilan CJ, Ayoub B, et al. The effect of 20 minutes of cool running water first aid within three hours of thermal burn injury on patient outcomes: A systematic review and meta-analysis. *Australas Emerg Care*. 2022;25(4):367-376. doi:10.1016/j.auec.2022.05.004

Ji S, Xiao S, Xia Z; Chinese Burn Association Tissue Repair of Burns and Trauma Committee, Cross-Straits Medicine Exchange Association of China. Consensus on the treatment of second-degree burn wounds (2024 edition). *Burns Trauma*. 2024;12:tkad061. Published 2024 Jan 30. doi:10.1093/burnst/tkad061

Olawoye OA, Isamah CP, Ademola SA, et al. Effect of prehospital topical application of water and other agents on outcome in burn injured patients: A prospective study. *Burns*. 2025;51(2):107357. doi:10.1016/j.burns.2024.107357

Qu Y, Liu T, Chai J, Hu F, Duan H, Chi Y. Epidemiological and Clinical Characteristics of 471 Elderly Burn Patients in China: A Burn Center-based Study. *J Burn Care Res*. 2023;44(4):869-879. doi:10.1093/jbcr/irac190

Zideman DA, Singletary EM, Borra V, et al. European Resuscitation Council Guidelines 2021: First aid. *Resuscitation*. 2021;161:270-290. doi:10.1016/j.resuscitation.2021.02.013