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Pediatric Life Support: 2025 International Liaison Committee on Resuscitation Consensus on Science With Treatment Recommendations

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Pediatric Life Support: 2025 International Liaison Committee on Resuscitation Consensus on Science With Treatment Recommendations

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ABSTRACT: The International Liaison Committee on Resuscitation conducts continuous review of new peer-reviewed published cardiopulmonary resuscitation science and publishes annual summaries. More comprehensive reviews are published every 5 years. The Pediatric Life Support Task Force chapter of the *2025 International Liaison Committee on Resuscitation Consensus on Science With Treatment Recommendations* addresses all published resuscitation evidence reviewed by International Liaison Committee on Resuscitation Pediatric Life Support Task Force members in the past year, as well as brief summaries of topics reviewed since 2020, to provide a more comprehensive update. In total, 39 questions related to pre-arrest, intra-arrest, and postarrest resuscitation phases of pediatric cardiac arrest are included, including systematic reviews, scoping reviews, and evidence updates. Members of the task force assessed, discussed, and debated the quality of evidence, based on Grading of Recommendations, Assessment, Development, and Evaluation criteria, and their statements include consensus treatment recommendations. Insights into deliberations of the task force are provided in the *Justification and Evidence-to-Decision Framework Highlights* sections. The task force has also listed priority knowledge gaps for further research.

Key Words: AHA Scientific Statements■ cardiac arrest■ cardiopulmonary arrest■ cardiopulmonary resuscitation■ children■ ILCOR ■ pediatrics ■ resuscitation

The International Liaison Committee on Resuscitation (ILCOR) Pediatric Life Support (PLS) Task Force section of the 2025 International Liaison Committee on Resuscitation Consensus on Science With Treatment Recommendations (CoSTR) includes all reviews conducted by the PLS Task Force in the past year. Reviews conducted and published since the 2020 CoSTR are also summarized to provide a single comprehensive reference document for readers. The PLS Task Force work encompasses 39 reviewed PICOST (population, intervention, comparator, outcome, study design, and time frame) reports, including 22 systematic reviews (SysRev). Draft CoSTRs for all topics evaluated with a SysRev in the past year were posted on a rolling basis on the ILCOR website.[1] Each draft CoSTR included the data reviewed and draft treatment recommendations, with public comments accepted for 2 weeks after posting. The task force considered public feedback and provided responses. All CoSTRs are available online.[1]

Although only SysRevs can generate a full CoSTR and new treatment recommendations, many other topics were evaluated with scoping reviews (ScopRevs) or evidence updates (EvUps). Good practice statements, which represent the opinion of task force experts in light of very limited or no direct evidence, can be generated after ScopRevs and occasionally after EvUps in cases where the task force thinks providing guidance is especially important. A separate publication in this issue includes the full details of the evidence evaluation process.[2]

This statement contains the final wording of the treatment recommendations and good practice statements as approved by the ILCOR PLS Task Force, as well as summaries of the key evidence identified, key discussion points, and knowledge gaps. The year that treatment recommendations or good practice statements were generated or last updated by a SysRev is provided in parentheses. In cases where existing treatment recommendations have changed for 2025, the prior recommendations are also presented so the reader can easily see what has changed. Links to the published reviews and full online CoSTRs are provided in the corresponding sections. Evidence-to-decision tables for SysRevs are provided in Appendix A, and the complete EvUp worksheets are provided in Appendix B

Topics are presented using the PICOST format. Where appropriate, the population, context, and concept framework was used.[3] Search strategies were kept deliberately broad to capture all clinical outcomes. The task force then graded available outcomes into critical or important with a preference for outcomes defined in the Pediatric Core Outcome Set for Cardiac Arrest (P-COSCA).[4] To minimize redundancy, the study designs have been removed from the text except in cases where designs included differed from the PLS standard criteria. These standard criteria include randomized controlled trials (RCTs) and nonrandomized studies (nonrandomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Case series were included if they contained ≥5 cases. Unpublished studies (eg, conference abstracts, trial protocols), animal studies, mathematical models, simulation and manikin studies, and algorithm studies with no outcome data were excluded. All languages were included, provided there

was an English abstract. The following topics are addressed in this 2025 PLS Task Force CoSTR:

Periarrest

- Bradycardia with hemodynamic compromise in children (PLS 4030.30, ScopRev 2025)
- Resuscitation of durable mechanical circulatory supported patients with acutely altered perfusion or cardiac arrest (PLS 4190.03, ScopRev 2025)
- Pediatric early warning systems (PLS 4050.02, SysRev 2022)
- Management of pulmonary hypertension (PLS 4160.11, ScopRev 2024, EvUp 2025)

Intra-arrest: Airway, Breathing, Circulation

- Airway, breathing, and circulation (ABC) versus compressions, airway, breathing (CAB): order of ventilation and compression (PLS 4070.02, SysRev 2025)
- Advanced airway interventions in cardiac arrest (PLS 4060.01, SysRev 2024, EvUp 2025)
- Ventilation rate with advanced airway during cardiac arrest (PLS 4120.02, SysRev 2024, EvUp 2025)

Intra-arrest: Defibrillation

- Energy doses for pediatric defibrillation during resuscitation (PLS 4080.12, SysRev 2025)
- Paddle/pad size and placement in infants and children (PLS 4080.17, SysRev 2025)
- Single or stacked shocks for pediatric defibrillation (PLS 4080.19, SysRev 2025)
- Lay rescuer use of automated external defibrillators (AEDs) (PLS 4080.01, SysRev 2022, EvUp 2025)

Intra-arrest: Monitoring

- Pulse check accuracy in pediatrics during resuscitation (PLS 4080.18, SysRev 2025)
- Blood pressure monitoring and targets during pediatric in-hospital cardiac arrest (PLS 4160.08, SysRev 2025)
- Intra-arrest echocardiography (point-of-care cardiac ultrasound) (PLS 4160.05, ScopRev 2020, EvUp 2025)
- Intra-arrest end-tidal CO_2 (PLS 4160.07, ScopRev 2020, EvUp 2025)
- Intra-arrest near-infrared spectroscopy (PLS 4160.09, ScopRev 2020, EvUp 2025)

Intra-arrest: Drugs and Drug Administration

- Vasopressor use during cardiac arrest in children (PLS 4080.21, SysRev 2025)
- Epinephrine administration timing in cardiac arrest (PLS 4090.02, SysRev 2020, EvUp 2025)
- Calcium use during cardiac arrest (PLS 4090.01, SysRev 2023, EvUp 2025)
- Sodium bicarbonate administration in cardiac arrest (PLS 4090.04, EvUp 2020, EvUp 2025)
- Anti-arrhythmic drugs in cardiac arrest with shockable rhythms (PLS 4080.04, SysRev 2018, EvUp 2025)
- Intraosseous (10) versus intravenous (IV) in cardiac arrest (PLS 4080.15, EvUp 2022, EvUp 2025)

Intra-arrest: Special Circumstances

- Cardiopulmonary resuscitation in obese patients (PLS 4080.22, ScopRev 2025)
- In-hospital cardiac arrest (IHCA) due to suspected cardiac shunt/stent obstruction (PLS 4030.25, SysRev 2025)
- Cardiac arrest due to pulmonary embolism (PLS 4160.10, SysRev 2025)
- Pharmacological interventions for the treatment of hyperkalemia in children with cardiac arrest (PLS 4160.17, SysRev 2025)

Intra-arrest: Extracorporeal Cardiopulmonary Resuscitation

- Extracorporeal cardiopulmonary resuscitation (ECPR) in pediatric cardiac patients with single ventricle physiology (PLS 4030.09, 4030.10, SysRev 2025)
- ECPR for cardiac arrest (PLS 4160.02, SysRev 2023, EvUp 2025)

Postresuscitation

- Post-return of spontaneous circulation (ROSC) blood pressure targets (PLS 4190.01, SysRev 2025)
- Prediction of survival with poor neurological outcome after return of circulation (ROC) following pediatric cardiac arrest, combined prognostic SysRev:
  - Blood biomarkers (PLS 4220.01, SysRev 2025)

  - Clinical examination (PLS 4220.02, SysRev 2025)
  - Electrophysiology testing (PLS 4220.03, SysRev 2025)
  - Brain imaging (PLS 4220.04, SysRev 2025)
- Prediction of survival with good neurological out-come after ROC following pediatric cardiac arrest-combined prognostic SysRev:
  - Blood biomarkers (PLS 4220.05, SysRev 2023)
  - Clinical examination (PLS 4220.06, SysRev 2023)
  - Electrophysiology testing (PLS 4220.07, SysRev 2023)
  - Brain imaging (PLS 4220.08, SysRev 2023)
- Effect of prophylactic antiseizure medication or treatment of seizures on outcome of pediatric patients following cardiac arrest (PLS 4210.02, SysRev 2024)
- Post-ROSC oxygenation and ventilation (PLS 4180.01, 4180.02, SysRev 2019, EvUp 2025)

Readers are encouraged to monitor the ILCOR website[5] to provide feedback on planned systematic reviews and to provide comments when additional draft reviews are posted.

PERIARREST

Bradycardia With Hemodynamic Compromise in Children (PLS 4030.30, ScopRev 2025)

Rationale for Review

Bradycardia (heart rate <60 beats per minute) may result from intrinsic heart issues or external factors such as hypoxemia and metabolic disorders. Bradycardia can lead to hemodynamic compromise, cardiopulmonary failure, and potentially pulseless cardiac arrest. Current resuscitation guidelines recommend epinephrine for persistent bradycardia with poor perfusion during CPR[6]; however, there are few data on the natural progression of bradycardia during CPR and the efficacy of epinephrine or other drugs.[7] The ILCOR PLS Task Force prioritized a ScopRev of this topic because of the high prevalence of this presentation in children. The full ScopRev report can be found on the ILCOR website.[8]

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Children (<18 years of age) with bradycardia (defined as heart rate of <60 beats per minute or low for age) with hemodynamic compromise (defined as age-based hypotension, altered mental status [Glasgow Coma Scale <15, nonresponsiveness, or comatose], or other signs of shock [low urine output or elevated lactate], including cardiac arrest) in any setting (in-hospital or out-of-hospital)
- Intervention: Any specific management strategies including but not limited to oxygenation or ventilation, anticholinergic drugs (eg, atropine), inotropes or chronotropes (eg, epinephrine, isoproterenol), electrophysiologic pacing (eg, transcutaneous pacing, temporary cardiac pacing) or CPR
- Comparators: Another specific management strategy including another drug, therapy, placebo, or no drug
- Outcomes: Any clinical outcome
- Time frame: All years to October 6, 2024.

Summary of Evidence

Of the initial 4851 studies identified, 23 were included,[7,9-30] of which 19 described the prevalence and outcomes in children who had cardiac arrest with an initial documented rhythm of bradycardia with poor perfusion and thus did not directly address this PICO question.[10-28] Two papers commented on the impact of atropine for bradycardia with hemodynamic compromise, 1 in patients receiving CPR and 1 in patients who never received CPR.[9,29] Three papers studied the administration of epinephrine during CPR for first documented rhythm of bradycardia with poor perfusion.[7,9,30] Studies on atropine and epinephrine are summarized in Table 1. No studies were identified that assessed administration of oxygen, ventilation, or transcutaneous pacing.

Table 1. Studies Reporting Treatment and Outcomes for Bradycardia With Hemodynamic Compromise

Author, year	Country, design, age	Population	Treatment/exposure	Patients analyzed, (N events)	Total patients with bradycardia and poor perfusion	Outcomes (%)
Atabek, 2002[29]	Turkey, Case series, 2-5 years	Amitraz poisoning	Atropine (given 6-1 0 doses)	14	8	Survival to hospital discharge: 100% with resolution of bradycardia in all patients
Khera, 2019[9]	United States, multicenter retrospective cohort, >30 days and <18 years	CA	CPR	2799 bradycardia initial rhythm with poor perfusion receiving CPR (50% of 5592 total CA cohort)	1930 (69%) maintained pulse 869 (31%) with subsequent pulselessness	Survival to hospital discharge (unadjusted) 70% in those who maintained a pulse versus 30.2% in those with subsequent pulselessness (*P*<0.01) Survival to hospital discharge (adjusted) 57% lower risk of survival with subsequent pulselessness compared with maintained pulse (*P*<0.01) RR, 0.43; 95% Cl, 0.38-0.50; *P<0.00*
			CPR and atropine	854/2799 (30.5%)	519/1930 (26.9%) maintained pulse 335/869 (38.6%) subsequent pulselessness	No outcomes reported for survival to hospital discharge with CPR and atropine
			CPR and epinephrine	1967/2799 (70.3%)	1153/1930 (65.5%) maintained pulse 814/869 (95.2%) subsequent pulselessness	No outcomes reported for survival to hospital discharge with CPR and epinephrine
Holmberg, 2020[7]	United States, multicenter retrospective cohort propensity matched, ≤18 years	CA-bradycardia with poor perfusion	CPR and epinephrine (given within 10 min of CPR) versus CPR and no epinephrine	7056	7056	Survival to hospital discharge with CPR and epinephrine 38% versus no epinephrine 48% (RR, 0.79; 95% Cl, 0.74-0.85; *P*<0.001) Survival to 24 hours: lower for CPR and epinephrine 0.85 (0.81, 0.90) ROSC lower with CPR and epinephrine 0.94 (0.91-0.96) Favorable neurological outcome at discharge lower with CPR and epinephrine 0.76 (0.68-0.84)
O'Halloran, 2024[30]	United States, multicenter retrospective cohort, <19 years	CA-bradycardia	Early "bolus" (epinephrine within first 2 min of CPR) versus no early bolus (no bolus epinephrine or epinephrine >2 min after CPR) 322/452 (71%) CPR and early epinephrine CPR	452 Subanalysis: 186 with invasive ABP assessed during first 10 min CPR 179 received epinephrine and CPR	452 Classified as 68 never pulseless, 53 pulseless and returned to pulse, 65 became pulseless and remained pulseless•	Favorable neurologic outcome at hospital discharge with early epinephrine administration 51% versus 58% (adjusted RR, 0.99; 95% Cl, 0.82-1.18; *P=0.89)* ROSC: 57/68 (84%) never became pulseless 33/53 (62%) became pulseless and then developed bradycardia with a pulse again 28/65 (43%) developed pulselessness and stayed pulseless (*P*=0.001) ROSC (85%) among those patients who never developed pulselessness and received early epinephrine (*P*<0.001)

'On arterial line wave form was described as no pulse or SBP <40 mm Hg for infants (<1 year of age) and <50 mm Hg for children ≥1 year of age.
ABP indicates arterial blood pressure; CA, cardiac arrest; Cl, confidence interval; CPR, cardiopulmonary resuscitation; ROSC, return of spontaneous circulation; and RR, risk ratio.

Task Force Insights

The task force identified numerous gaps in the literature, including absence of studies evaluating bradycardia with hemodynamic compromise in patients not receiving CPR and lack of comparison groups for interventions (eg, CPR versus no CPR) for bradycardia with hemodynamic compromise.

All studies evaluating CPR for bradycardia with hemodynamic compromise were in patients who were already receiving CPR for

presumed cardiac arrest. The task force discussed timing of initiation of CPR for bradycardia for hemodynamic compromise, specifically as most studies were retrospective, and thus the true reason for CPR initiation is unknown.

The task force considered indirect evidence supporting CPR for bradycardia with hemodynamic compromise, specifically studies that show (1) patients receiving CPR for bradycardia with hemodynamic compromise have better survival rates than those receiving CPR for asystole or pulseless electrical activity, and (2) patients receiving CPR for bradycardia with hemodynamic compromise who maintained that rhythm had higher survival rates than those who progressed to pulselessness. There was concern about potential harm associated with delaying initiation of CPR for patients with bradycardia and hemodynamic compromise who are not responsive to oxygenation and ventilation as progression to pulselessness is associated with worse outcomes.

There was insufficient data to support a good practice statement for atropine, epinephrine, or transcutaneous pacing. The scoping review did not identify a sufficient evidence base to support a SysRev.

Treatment Recommendations (2025)

For patients with bradycardia and hemodynamic compromise not responsive to oxygenation and ventilation, consider initiating CPR (good practice statement).

Withdrawn Treatment Recommendations

Based on the lack of any available direct or indirect evidence considered appropriate by the task force for inference, these previous treatment recommendations are all withdrawn.

Epinephrine may be administered to infants and children with bradycardia and poor perfusion that is unresponsive to ventilation and oxygenation (2010, withdrawn 2025).

It is reasonable to administer atropine for bradycardia caused by increased vagal tone or anticholinergic drug toxicity. There is insufficient evidence to support or refute the routine use of atropine for pediatric cardiac arrest (2010, withdrawn 2025).

In selected cases of bradycardia caused by complete heart block or abnormal function of the sinus node, emergency transthoracic pacing may be lifesaving. Pacing is not helpful in children with bradycardia secondary to a postarrest hypoxic/ischemic myocardial insult or respiratory failure. Pacing was not shown to be effective in the treatment of asystole in children (2000, withdrawn 2025).

Resuscitation of Patients Living With Durable Mechanical Circulatory Support With Acutely Altered Perfusion or Cardiac Arrest (PLS 4190.03, ScopRev 2025)

Rationale for Review

This topic was chosen for review because of the increasing prevalence of durable mechanical circulatory supported devices, particularly left ventricular assist devices (LVADs). The optimal approach to identification and resuscitation of patients with acutely impaired perfusion supported by durable mechanical circulatory supported is controversial. The ScopRev was initiated as a nodal review with the Advanced Life Support (ALS) and PLS Task Forces.[31] The full ScopRev report can be found on the ILCOR website.[32]

Population, Concept, Context, Study Design, and Time Frame

- Population: Patients of any age receiving durable mechanical circulatory supported of any kind
- Concept: Acute impaired perfusion resulting in need for acute resuscitation
- Context: In- and out-of-hospital settings
- Study designs: In addition to standard criteria, all case series and reports were included.
- Time frame: Literature search included all years up to May 2024.

Summary of Evidence

Of the 32 studies included,[33-66] 24 were case reports including 2 or fewer patients,[33,36-40,42,45-53,55-58,62-66] 4 were case series including 3 to 10 patients,[34,41,44,60] and 3 were retrospective cohort studies including more than 10 patients.[35,43,59] Thirteen studies described patients who had cardiac arrest and received chest compressions.[34,38,39,41,47,50,51,55,56,58-60,65] In all studies, the durable mechanical circulatory support was a left ventricular or biventricular assist device.

Task Force Insights

The task force identified few data to support recommendations on the optimal approach to resuscitation of mechanical circulatory supported patients who experience acutely impaired perfusion. Most publications identified were case reports or case series. The few

observational cohort studies had limitations including confounding by indication, lack of generalizability, and a high risk of misclassification whereby patients with acutely impaired perfusion are designated as having a cardiac arrest but may not have had a cardiac arrest. No high-quality observational studies or randomized controlled trials were identified.

The task force noted the low risk of device dislodgement from chest compressions identified in the ScopRev. While several observational studies did find a higher risk of poor outcome when chest compressions were administered to patients with acutely impaired perfusion as a result of cardiac arrest compared with no chest compressions, these observational studies were judged to be at high risk for confounding.

The task force also reviewed a scientific statement from the American Heart Association and guidance from the British Societies LVAD Emergency Algorithm Working Group.[67,68] One area of discussion was around the British Societies' recommendation to delay chest compressions in LVAD supported patients for up to 2 minutes while efforts to restart the device are made. The task force felt that these 2 minutes may be unnecessary, and efforts to restart the LVAD device could occur in parallel with chest compressions if multiple rescuers are available.

The ScopRev did not identify sufficient evidence to support a systematic review. The good practice statements generated are the same as those generated by the ALS Task Force.

Treatment Recommendations (2025)

In patients receiving durable mechanical circulatory support who develop acutely impaired perfusion because of cardiac arrest and who are not in the immediate peri-device implantation period, we suggest performing rather than withholding chest compressions (good practice statement). When caring for patients with durable mechanical circulatory support who suffer acutely impaired perfusion as a result of cardiac arrest, we suggest minimizing delays in initiating chest compressions while simultaneously assessing for device-related reversible causes of acutely impaired perfusion (good practice statement).

We suggest rescuers follow an algorithmic approach to concurrently assess and respond to acutely impaired perfusion in patients receiving durable mechanical circulatory support (good practice statement).

Pediatric Early Warning Systems (PLS 4050.02, SysRev 2022)

The utility of pediatric early warning systems was addressed in a SysRev in 2022[69] and details can be found in the 2022 CoSTR summary.[70-72]

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants, children, and adolescents in any inpatient setting
- Intervention: Pediatric early warning system with or without rapid response teams or medical emergency teams
- Comparators: No pediatric early warning system or standard care (without a scoring system)
- Outcomes:
  - Critical: significant clinical deterioration event, including but not limited to unplanned/crash tracheal intubation; unanticipated fluid resuscitation and inotropic/vasopressor use; CPR or extracorporeal membrane oxygenation; death in patients without a do-not-attempt resuscitation order
  - Important: unplanned code events with favorable neurological outcome.
- Time frame: All years to June 26, 2021

Treatment Recommendations (2022)

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

Management of Pulmonary Hypertension (PLS 4160.11, ScopRev 2024, EvUp 2025)

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children with pulmonary hypertension at high risk of pulmonary hypertensive crises with a cardiac arrest in the in-hospital setting including postoperatively.
- Intervention: Specific management strategies, including respiratory management and monitoring to avoid hypoxia and acidosis; use of opioids, sedatives and neuromuscular blocking agents; or pulmonary arterial hypertension-specific targeted therapy Comparators: Standard care without specific strategies for pulmonary hypertensive crisis
- Outcomes: Any clinical outcome
- Time frame: December 1, 2023, to October 17, 2024

Summary of Evidence

The complete EvUp is provided in Appendix B. There is no new published evidence since the ILCOR 2024 ScopRev on this topic, so a SysRev is not warranted.[73,74]

Good Practice Statements (2024)

In children, including neonates, with pulmonary hypertension hospitalized for a clinical worsening event, we propose avoiding factors that may increase pulmonary vascular resistance while treating the aggravating condition to decrease the risk of cardiac arrest. Management strategies include avoiding hypoxia; hypercapnia; acidosis; stressors, such as pain, agitation, dehydration, or fluid overload; anemia; infection; or arrhythmias. Pulmonary hypertension-specific treatments (eg, inhaled nitric oxide, L-arginine, phosphodiesterase inhibitors [eg, milrinone, sildenafil], or endothelin-1 inhibitors [eg, bosentan]) may be considered (good practice statement).[73,74]

In children who develop signs of pulmonary hypertensive crisis, low cardiac output, or right ventricular failure despite optimal medical therapy, extracorporeal membrane oxygenation (ECMO) may be considered before cardiac arrest or for refractory cardiac arrest (ie, ECPR) as a bridge to recovery or as a bridge to the evaluation for organ replacement and transplantation in very select cases (good practice statement).[73,74]

INTRA-ARREST: AIRWAY, BREATHING, AND CIRCULATION

ABC Versus CAB: Order of Ventilation and Compression (PLS 4070.02, SysRev 2025)

Rationale for Review

Because the merits of commencing chest compressions before ventilations are uncertain, we updated the previous SysRev, which was included in the 2019 CoSTR summary.[75,76] Previous SysRevs by ILCOR have found that in simulation studies starting CPR with compressions resulted in faster times to key elements of resuscitation (rescue breaths, chest compressions, completion of first CPR cycle).[77,78] A change from ABC to compression-first and compression-focused CPR has also been associated with a significant increase in rates of bystander CPR and patient survival.[79] Most international adult basic life support (BLS) guidelines now commence CPR with chest compressions before ventilations. Pediatric guidelines vary, with different approaches in various jurisdictions.[80] The SysRev was registered before initiation (Prospective Register of Systematic Reviews [PROSPERO] Registration CRD42024583890) and conducted as a nodal review with the BLS Task Force. The full CoSTR can be found on the ILCOR website.[81]

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

- Population: Adults and children in any setting (in-hospital or out-of-hospital) with cardiac arrest
- Intervention: Commencing CPR with compressions first (30:2)
- Comparators: Commencing CPR with ventilations first (2:30)
- Outcomes:
  - Critical: Survival with favorable neurological outcome at hospital discharge or 30-days; survival at hospital discharge or 30 days; survival with favorable neurological outcome to 1 year; survival to 1 year; event survival; any ROSC
  - Important: Time to commencement of rescue breaths; time to commencement of first compression; time to completion of first CPR cycle; ventilation rate; compression rate; chest compression fraction; minute ventilation
- Study designs: In addition to standard criteria, simulation studies were included if there were insufficient human studies.
- Time frame: September 2019 to June 18, 2024.

Consensus on Science

This updated systematic review identified 1 new pediatric manikin study[82] (published with corrections[83]), in addition to 4 manikin studies[84-87] found in the previous ILCOR reviews.[77,78,88,89] Of the 5 manikin studies, 3 were randomized studies, 1 in adult[85] and 2 in pediatric resuscitation,[82,87] and 2 were observational studies in adult resuscitation.[84,86] No human studies were identified.

The overall certainty of evidence was rated as very low for all outcomes, downgraded for very serious risk of bias and indirectness. A summary of the outcomes of the included studies is shown in Table 2.

Treatment Recommendation (2025)

There is insufficient evidence to support a treatment recommendation regarding the optimal order of commencing CPR in children (ie, ventilation or compressions first).

The task force considers that both an ABC (ventilation followed by compression) and a CAB (compression followed by ventilation) approach are acceptable and that both ventilation and chest compressions are important components of CPR in children (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

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

The majority of the existing evidence (5 manikin studies)[82,84-87] suggests that starting CPR with compressions results in faster times to key elements of resuscitation.

One simulated study in pediatric resuscitation found that starting with compressions delayed the commencement of rescue breaths in cardiac arrest by 6 seconds.[87] This delay may be clinically acceptable. However, alveolar minute ventilation and the number of ventilations delivered in the first minute of resuscitation were higher with the ABC (delivering 5 rescue breaths before commencing chest compressions) sequence.

Indirect evidence from before-and-after out-of-hospital cardiac arrest (OHCA) registry studies in adults, examining changes in dispatcher telephone CPR instructions[79] and implementation of guideline changes,[90,91] suggests that switching from the ABC to CAB approach was associated with increased rates of bystander CPR[79] and improved patient outcomes.[79,90,91] Similar data on in-hospital cardiac arrest show conflicting evidence in patient outcomes.[92,93] One large registry study from Japan demonstrated increased bystander CPR rates in children with bystander-witnessed OHCA after compression-only CPR was introduced.[94] Whether the change in sequence to CAB by some ILCOR member councils has resulted in more infants and children receiving compression-only CPR overall is unknown, although available data continues to support the combination of compressions and breaths is needed for optimal pediatric CPR.[95,96]

The BLS and PLS Task Forces also considered

- The benefits of a single training approach versus separate approaches for adults and children, recognizing regions currently using an ABC approach in children may incur additional short-term costs and resources to implement a CAB approach
- Effective chest compressions generate cumulative coronary perfusion pressure, which falls to near zero when compressions stop,[97] emphasizing the value of approaches where effective chest compressions are commenced promptly and interrupted sparingly.
- Time to first compression is associated with better patient outcomes, including good neurological outcomes in adults.[98]

Table 2. Summative Results of Studies for CAB Versus ABC Systematic Review

Outcomes (importance)	Participants (studies), n	Certainty of evidence (GRADE)	CAB versus ABC	Pvalue
Time to commencement of chest compressions (important)	159 2-person teams (1 crossover pediatric manikin randomized study)[87]	Very low	Mean: 19.3 s ± 2.6 s versus 43.4 s ± 5.0 s	*P*<0.05
	108 2-person teams (1 adult manikin randomized study)[85]	Very low	Mean: 25 s ± 9 s versus 43 s ± 16s	*P*<0.001
	33 6-person teams and 40 single rescuers (2 adult manikin observational studies)[84,86]	Very low	Median: 16.0 s (IOR: 14.0-26.0) versus 42.0 s (IOR: 41.5-59.0)[84] Mean: 15.4 s ± 3.0 s versus 36.0 s ± 4.1 s[86]	*P*<0.001 *P*<0.001
Time to commencement of ventilations (important)	267 2-person teams (2 randomized manikin studies)[85,87]	Very low	Mean: 28.4 s ± 3.1 s versus 22.7 s ± 3.1 s[87] 43 s ± 10 s versus 37 s ± 15 s[85]	*P*<0.05 *P*<0.001
Time to completion of first CPR cycle (30 chest compressions + 2 breaths) (important)	108 2-person teams (1 randomized manikin study)[85]	Very low	Mean: 48 s ± 10 s versus 63 s ± 17 s	*P*<0.001
Ventilation rate (important)	28 2-person teams (1 crossover pediatric randomized manikin study)[82]	Very low	Median ventilations in first minute: 10 (IOR: 8-10) versus 13 (IOR: 12-15)	*P*<0.05
Compression rate (important)	28 2-person teams (1 crossover pediatric randomized manikin study)[82]	Very low	No difference	
	33 6-person teams (1 adult observational study)[84]	Very low	No difference	
Chest compression fraction (important)	28 2-person teams (1 crossover pediatric randomized manikin study)[82]	Very low	66% (IOR: 59-680 versus 57% (IOR: 54-64)	*P*<0.001
	33 6-person teams (1 adult observational study)[84]	Very low	No difference	
Minute alveolar ventilation in first minute (important)	28 2-person teams (1 crossover pediatric randomized manikin study)[82]	Very low	Median: 276 ml (IOR: 140-360) versus 370 ml (IOR: 203-472)	*P*<0.001

ABC indicates airway, breathing, circulation; CAB, compressions, airway, breathing; and GRADE, Grading of Recommendations, Assessment, Development, and Evaluation.

- Bystanders are typically unable to deliver effective ventilations during simulated CPR.[99]
- Due to the public's concerns with mouth-to-mouth ventilations,[100] commencing CPR with airway and ventilations may result in no bystander CPR being provided.
- Delivering the ABC approach leads to more errors in CPR[87]; lay bystanders prefer CAB, and it is easier to learn and retain.[87]
- The delivery of non-mouth-to-mouth ventilation requires the retrieval and preparation of equipment (eg, bag-valve-mask, pocket mask), which, when multiple rescuers are present, can occur during chest compressions.
- The new treatment recommendation in children is about starting CPR and does not mean ventilation should not be provided in resuscitation.
- While the PLS Task Force appreciates that many cardiac arrests in infants and children have a respiratory etiology, the short delay in starting ventilation is unlikely to make a clinically significant difference to outcome, and hypovolemia and shock are common causes as well.
- Further investigation is needed in children. The task forces noted that Utstein-based registry data may be the only source of information to answer this question. Because different councils worldwide have adopted CAB versus ABC, comparative studies of different registries may provide evidence to answer this question.

Knowledge Gaps

No human studies directly evaluating this question in any setting were identified.

Advanced Airway Interventions in Cardiac Arrest (PLS 4060.01, SysRev 2024, EvUp 2025)

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (excluding newborn infants) who had received CPR after out-of-hospital or in-hospital cardiac arrest
- Intervention: Placement of an advanced airway device
- Comparators: Bag-mask ventilation alone or with non-advanced airway interventions (primary); or another advanced airway device (secondary)
- Outcomes: Any clinical outcome
- Time frame: August 15, 2023, to May 22, 2024

Summary of Evidence

A SysRev was last done on this topic for 2024.[73,74] The complete EvUp is provided in Appendix B. No new pediatric studies were identified. There is insufficient evidence to support the conduct of a SysRev.

Treatment Recommendations (2024)

We suggest the use of bag-mask ventilation rather than tracheal intubation or supraglottic airway in the management of children during cardiac arrest in the out-of-hospital setting (weak recommendation, very low-certainty evidence).[73,74]

There is insufficient quality evidence to support any recommendation for or against the use of the bag-mask ventilation compared with tracheal intubation or supraglottic airway for in-hospital cardiac arrest.

The main goal of CPR is effective ventilation and oxygenation, by whatever means, without compromising the quality of chest compressions. We suggest that clinicians consider transitioning to an advanced airway intervention (supraglottic airway or tracheal intubation) when the team has sufficient expertise, resources, and equipment to enable placement to occur with minimal interruptions to chest compressions or when bag-mask ventilation is not providing adequate oxygenation and ventilation (good practice statement).[73,74]

Ventilation Rate With Advanced Airway During Cardiac Arrest (PLS 4120.02, SysRev 2024, EvUp 2025)

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (excluding newborn infants) with out-of-hospital or in-hospital cardiac arrest (asphyxia! or arrhythmic origin) and an advanced airway
- Intervention: Use of any specific respiratory rate
- Comparators: Compared with ventilation rate of 8 to 10 per minute
- Outcomes: Any clinical outcome
- Time frame: July 18, 2023, to September 30, 2024

Summary of Evidence

The complete EvUp is provided in Appendix B. No new pediatric studies were identified. An updated SysRev is not warranted.

Treatment Recommendations (2024)

There is currently no supporting evidence to make a treatment recommendation on a specific ventilatory rate in pediatric cardiopulmonary resuscitation with an advanced airway.[73,74]

For cardiac arrest that occurs with an advanced airway in place, the use of ventilatory rates >10 breaths per minute may be reasonable. The PLS Task Force suggests using ventilatory rates close to age-appropriate respiratory rates with avoidance of hypoventilation and hyperventilation (good practice statement).[73,74]

INTRA-ARREST: DEFIBRILLATION

Energy Doses for Pediatric Defibrillation During Resuscitation (PLS 4080.12, SysRev 2025)

Rationale for Review

Shockable ventricular arrhythmias-ventricular fibrillation (VF) and pulseless ventricular tachycardia (pVT)-are less frequently recorded in children than in adults but are associated with a higher survival rate than nonshockable rhythms. Early defibrillation is the foundation of treatment, but optimal energy doses for initial and subsequent shocks remain controversial, with notable differences in first shock dose recommendations by ILCOR member councils.[80,101] This SysRev was registered before initiation (PROSPERO Registration CRD42024548898). The full CoSTR is available on the ILCOR website.[102]

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

- Population: Infants and children (excluding newborn infants) in ventricular fibrillation or pulseless ventricular tachycardia during out-of-hospital or in-hospital cardiac arrest
- Intervention: Initial defibrillation dose approximating 2 J/kg (1.5 J/kg-2.5 J/kg)
- Comparators: Initial defibrillation dose of >2.5 J/kg, <1.5 J/kg, or any other specified dose
- Outcomes:
  - Critical: Survival to hospital discharge, ROSC
  - Important: Termination of VF/pVT.
- Study designs: In addition to standard criteria, case series with a minimum of 5 cases were eligible for inclusion.
- Time frame: All years to September 1, 2024

Consensus on Science

Seven studies were included,[103-109] all of which were observational studies and provided very low-certainty evidence (downgraded for imprecision and risk of bias) for the important and critical outcomes described. Key outcomes are summarized in Table 3.

Acknowledging the very low level of certainty, the current available data suggest that outcomes are not significantly better or worse when initial defibrillation doses of <2 J/kg or >2 J/kg are used for children in cardiac arrest with a shockable rhythm, compared with initial doses of approximately 2 J/kg.

Prior Treatment Recommendations (2020)

We suggest the routine use of an initial dose of 2 J/kg to 4 J/kg of monophasic or biphasic defibrillation waveforms for infants or children in VF or pVT cardiac arrest (weak recommendation, very low-quality evidence). There is insufficient evidence on which to base a recommendation for second and subsequent defibrillation doses.[110-112]

Table 3. Summative Results of Studies: Pediatric Defibrillation Dose Systematic Review

Outcomes (importance)	Participants (studies), n	Certainty of evidence (GRADE)	RR (95% CI)	ARD with intervention
Defibrillation dose <2 J/kg (I) compared with defibrillation dose approximating 2 J/kg (C) for defibrillation in children in cardiac arrest				
Termination of VF/pVT (important)	265 (2 nonrandomized studies)[103,105]	Very low	RR, 0.63 (0.14-2.84)	179 fewer per 1000 (from 415 fewer to 888 more)
ROSC (critical)	266 (4 nonrandomized studies)[104,106,108,109]	Very low	RR, 1.06 (0.95-1.18)	51 more per 1000 (from 42 fewer to 152 more)
Survival to hospital discharge (critical)	225 (2 nonrandomized studies)[104,106]	Very low	RR, 1.06 (0.80-1.40)	29 more per 1000 (from 96 fewer to 192 more)
Defibrillation dose >2 J/kg (I) compared with defibrillation dose approximating 2 J/kg (C) for defibrillation in children in cardiac arrest				
Termination of VF/pVT (important)	265 (2 nonrandomized studies)[103,105]	Very low	RR, 0.96 (0.82-1.13)	22 fewer per 1000 (from 99 fewer to 77 more)
ROSC (critical)	596 (6 nonrandomized studies)[104-109]	Very low	RR, 0.95 (0.77-1.17)	29 fewer per 1000 (from 133 fewer to 98 more)
Survival to hospital discharge (critical)	225 (2 nonrandomized studies)[104,106]	Very low	RR, 1.20 (0.38-3.77)	82 more per 1000 (from 253 fewer to 1000 more)

ARD indicates absolute risk difference; C, comparator; CI, confidence interval; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; I, intervention; pVT, pulseless ventricular tachycardia; RR, risk ratio; ROSC, return of spontaneous circulation; and VF, ventricular fibrillation.

Treatment Recommendations (2025)

In the absence of evidence to demonstrate a clear preference for any particular energy dose, we suggest the use of an initial defibrillation dose of 2 J/kg to 4 J/kg for infants or children in VF or pVT cardiac arrest (weak recommendation, very low-certainty evidence).

This review did not investigate the evidence for second and subsequent defibrillation dosages.

Justification and Evidence-to-Decision Framework Highlights

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

Differences remain in the first shock dose recommended by ILCOR member councils, with the European Resuscitation Council and Australian and New Zealand Committee on Resuscitation recommending 4 J/kg for first and all subsequent shocks and the American Heart Association recommending an initial dose of 2 J/kg to 4 J/kg (for ease of teaching, a dose of 2 J/kg is used in algorithms and training materials).[6,113,114] For refractory VF, American Heart Association guidelines recommend increasing defibrillation dose to 4 J/kg, suggesting that subsequent energy doses should be at least 4 J/kg and noting that higher levels may be considered, not to exceed 10 J/kg.

The task force recognized that most studies were conducted in sites where either 2 J/kg or 4 J/kg doses were recommended for initial defibrillation. The variability of dosing was largely attributable to the few energy dose settings on defibrillators. So, although no specific energy dose was found superior, energy selections would generally have been approximating either 2 J/kg or 4 J/kg.

Knowledge Gaps

- Whether there are any specific undesirable effects (eg, myocardial damage) of defibrillation with the different doses studied
- Prehospital and in-hospital studies, ideally comparing existing different dosing strategies with planned subgroup analyses based on patient age and type of shockable rhythm (primary versus secondary) are ethical, necessary, and critically important to help guide clinicians in making these complex decisions. As different resuscitation councils recommend either 2 J/kg or 4 J/kg as an initial defibrillation dose, this may provide an opportunity for an international comparative study.
- Potential adverse effects of higher defibrillation doses when fixed energy doses are provided (eg, through use of AEDs)
- Effect of different defibrillation energy doses on other clinically important outcomes as defined in the P-COSCA set[4]

Paddle/Pad Size and Placement in Infants and Children (PLS 4080.17, SysRev 2025)

Rationale for Review

Definition of proper pad positioning and size to anatomically encompass the heart and ensure good contact is vital in pediatric defibrillation. The PLS Task Force's previous review of defibrillation strategies[115] showed no clear superiority for vector change or double-sequential strategies but reinforced the critical importance of proper pad placement. Since this review, a randomized trial[116]

and retrospective observational study[117] have been published, prompting this SysRev[118] The SysRev was registered before initiation (PROSPERO Registration CRD42024512443) and conducted in partnership with the BLS and ALS Task Forces. The full CoSTR can be found on the ILCOR website and in the BLS section.[119]

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Adults and children in any setting (in-hospital or out-of-hospital) with cardiac arrest and a shockable rhythm at any time during cardiopulmonary resuscitation (CPR)
- Intervention: The use of any specific pad size, orientation, and position
- Comparators: Reference standard pad size, orientation, and position
- Outcomes:
  - Critical: Survival with favorable neurological outcome at hospital discharge or 30-days; survival at hospital discharge or 30 days
  - Important: ROSC; termination of VF; rates of defibrillation
- Time frame: All years to September 22, 2024

Consensus on Science

No pediatric studies were identified that addressed the questions of defibrillator pad or paddle size, orientation, or placement.

Due to the lack of direct evidence in infants and children, the PLS Task Force used the very low-certainty evidence from adult studies, downgraded for indirectness, to inform the treatment recommendations. Details of the adult evidence are available in the BLS CoSTR publication.[120]

Prior Treatment Recommendations (2010)

There is insufficient evidence to alter the current recommendations to use the largest size paddles that fit an infant's or child's chest without touching each other or to recommend one paddle or pad position or type over another.[110,121]

Treatment Recommendations (2025)

For Manufacturers

Manufacturers could consider the standardization of pad size for infants, children, and adults (good practice statement).

Manufacturers of AEDs should standardize pad placement in an anteroposterior position for infants and young children (with 1 pad anteriorly, over the left precordium, and the other pad posteriorly to the heart just inferior to the left scapula) (good practice statement).

Manufacturers should include instructions to ensure adequate contact between the pad and the skin and ensure that their pad position diagrams clearly indicate the ILCOR-recommended pad position (good practice statement).

For AED Users

Follow the AED specific guidance and instructions for pads placement in infants and children (good practice statement).

For Health Care Professionals Trained in Manual Oefibrillation

In infants and children, place pads in an anterior-posterior position (good practice statement).

Vector Change Strategy

We cannot make a recommendation for or against the use of vector change strategy for the treatment of refractory VF or pulseless VT in infants and children.

Justification and Evidence-to-Decision Framework Highlights

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

Due to the lack of direct evidence in infants and children, and the very low certainty of the indirect evidence from adults, the task force was unable to make treatment recommendations for those using AEDs or manual defibrillators. The task force decision to provide a good practice statement suggesting positioning pads in the AP position was based on the indirect evidence in adults that it improves ROSC. However, the task force did recognize the very low certainty of the evidence from this observational study.[122]

In making these recommendations, the PLS Task Force recognized that AP positioning of pads is easier in infants and

children than in adults. Pads may also be used as real-time feedback devices for quality assessment of chest compressions. In these circumstances, pads generally need to be in the AP position. The AP position is not feasible with paddles, which are still used in some low-resource settings.

Knowledge Gaps

- No studies examined the pediatric or in-hospital setting.
- The effectiveness of different pad positions compared with standard positions in any patient population, in the first 3 shocks
- The relative effectiveness of different pad sizes
- The interaction between pad size and pad orientation
- The effectiveness of a vector change strategy in children
- The effectiveness of paddles as compared with pads in children

Single or Stacked Shocks for Pediatric Defibrillation (PLS 4080.19, SysRev 2025)

Rationale for Review

Before 2005, guidelines recommended 3 stacked shocks for shockable rhythms because of low first-shock efficacy with monophasic waveforms and the theoretical reduction in transthoracic impedance after each shock.[123] However, with the advent of biphasic defibrillators, which show high first-shock success and minimal transthoracic impedance reduction, the 2005 guidelines shifted to a single-shock strategy followed by immediate chest compressions.[124,125]

Current ILCOR guidelines, unchanged since 2010, endorse a single-shock approach followed by CPR for pediatric VF or pVT, before reassessing rhythm. EvUps done in 2023 found no new pediatric studies, and adult studies were excluded because of physiological differences between children and adults.[126,127] The PLS Task Force prioritized this SysRev to enable confirmation of current recommendations through a systematic search. The SysRev was registered before initiation (PROSPERO Registration: CRD42024559428) and the full CoSTR is available online.[128]

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (excluding newborn infants) who are in VF or pVT during out-of-hospital or in-hospital cardiac arrest
- Intervention: More than 1 (stacked) shocks for the initial or subsequent defibrillation attempt
- Comparison: A single shock for each defibrillation attempt
- Outcomes: Any clinical outcome
- Time frame: All years to May 15, 2024

Consensus on Science

No studies comparing single versus stacked shock in children with out-of-hospital or in-hospital cardiac arrest with VF or pVT were identified.

Prior Treatment Recommendations (2005, Withdrawn)

A single-shock strategy followed by immediate CPR (beginning with chest compressions) is recommended for children with out-of-hospital or in-hospital VF or pVT.

The prior treatment recommendation of 2005 is unsupported due to the lack of any available direct or indirect evidence. The PLS Task Force therefore withdraws the prior treatment recommendation and replaces it with a good practice statement.

Treatment Recommendations (2025)

In infants and children with out-of-hospital or in-hospital cardiac arrest in VF or pVT, we suggest a single-shock strategy followed by immediate CPR (beginning with chest compressions) (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The 3-shock (stacked) strategy used in pediatric VF or pVT before the 2005 American Heart Association guideline was based on an extrapolation from advanced cardiovascular life support recommendations in adults. The 1-shock strategy has not been directly

studied against a 3-shock strategy in pediatric VF/pVT but the 2005 recommendation[129] that those providing CPR should give a single shock followed immediately by CPR (beginning with chest compressions) rather than the 3 successive ("stacked") shocks in pediatric VF or pVT was based on the evidence that

- First-shock success rate of currently used biphasic defibrillators is up to 90%.[130,131]
- In a 3-shock sequence (stacked) the delay between delivery of the first shock and delivery of the first post-shock compression is up to 37 seconds.[132,133]
- Interruption of chest compressions reduces coronary perfusion pressure.[134]
- If the first shock fails, intervening chest compressions may improve oxygen and substrate delivery to the myocardium, making the subsequent shock more likely to result in defibrillation.
- Data from animal studies document harmful effects from interruptions to chest compressions.[135]

Knowledge Gaps

There are no randomized controlled trials directly comparing 3-shock (stacked) strategy with single biphasic shocks in pediatric defibrillation.

Lay Rescuer Use of AEDs (PLS 4080.01, SysRev 2022, EvUp 2025)

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (excluding newborn infants) with nontraumatic OHCA
- Intervention: Application of or shock delivery from an AED by lay rescuers
- Comparators: Standard care by lay rescuer without AED application
- Outcomes: Any clinical outcome
- Time frame: November 3, 2021, to May 22, 2024

Summary of Evidence

The complete EvUp is provided in Appendix B. A SysRev of this topic was last done for the 2022 CoSTR summary.[70-72] This EvUp identified no new pediatric studies on this subject that would potentially alter the current treatment recommendation. There is insufficient evidence to support the conduct of a SysRev.

Treatment Recommendations (2022)

We suggest the use of an AED by lay rescuers for all children >1 year of age who have nontraumatic OHCA (weak recommendation, very low-certainty evidence).[70-72]

We cannot make a recommendation for or against the use of an AED by lay rescuers for all children <1 year of age with nontraumatic OHCA. [70-72]

INTRA-ARREST: MONITORING

Pulse Check Accuracy in Pediatrics During Resuscitation (PLS 4080.18, SysRev 2025)

Rationale for Review

Guidelines recommend a manual pulse check during rhythm analyses to detect ROSC, with different anatomical sites for different age groups.[136] With the increasing availability of ultrasound and arterial lines, the PLS Task Force prioritized this topic and conducted the first SysRev based on a previous EvUp in 2023.[127] The SysRev was registered before initiation (PROSPERO Registration CRD42024549535). The full CoSTR can be found on the ILCOR website.[138]

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children in any setting (out-of-hospital or in-hospital) with suspected cardiac arrest when assessing whether to start or continue CPR
- Intervention: Any other site for pulse check (eg femoral pulse) OR method (including but not limited to cardiac auscultation, pulse oximetry, ultrasonography, rise in end-tidal CO_2 values above specific thresholds, invasive monitoring)
- Comparators: Pulse check as per current guidelines for health care professionals (brachia! pulse for infants and carotid pulse for children and adolescents)
- Outcomes: Any outcome including but not limited to
  - Accuracy, defined as sensitivity and specificity of detecting a perfusing rhythm
  - Duration of cardiac compression pauses

- Any clinical outcome
- Time frame: All years to April 24, 2024

Consensus on Science

Accuracy

For the critical outcome of accuracy (defined as sensitivity and specificity), this SysRev identified 3 studies with 39 patients and 376 pulse checks, providing very low certainty of evidence.[139-141] All studies had a serious risk of bias. Two studies were further downgraded for imprecision and indirectness. These studies assessed clinicians' ability to accurately palpate a pulse (brachia! or femoral) for children with LVADs or on ECMO, but without cardiac arrest. Sensitivity ranged from 76% to 100%, and specificity 64% to 79%.[139,140] The studies did not directly compare different pulse palpation sites.

Duration of Cardiac Compression Pauses

No studies in infants and children were identified that directly assessed this outcome. One study evaluated the time until a decision was made about whether a pulse was present or not. However, this study was performed in children with LVADs or on ECMO with arterial blood pressure monitoring blinded for the participants.[140] In this study, only 39% (60/153) of the participants decided on the presence of a pulse within 10 seconds. The median duration until any decision was made was 18 seconds, with an accuracy of 85%. Inexperienced participants took longer to make their decisions. This indirect evidence indicates that there is a reasonable concern about prolonged chest compression pauses, especially in inexperienced clinicians. This evidence was gained in a less critical setting with perfused children with warm skin temperature and brisk capillary refill time.

Any Clinical Outcome

No studies in infants and children were identified that assessed any clinical outcome.

Prior Treatment Recommendations (2020)

Palpation of a pulse (or its absence) is not reliable as the sole determinant of cardiac arrest and need for chest compressions. If the victim is unresponsive, and not breathing normally, and there are no signs of life, lay rescuers should begin CPR.[110]

Withdrawn Treatment Recommendation

In infants and children with no signs of life, health care providers should begin CPR unless they can definitely palpate a pulse within 10 seconds.

Treatment Recommendations (2025)

We suggest that the palpation of a pulse (or its absence) is unreliable as the sole determinant of cardiac arrest and the need for chest compressions (weak recommendation, very low certainty on evidence).

In unresponsive children, not breathing normally and without signs of life, lay rescuers and health care professionals should begin CPR (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The complete Evidence-to-decision table is provided in Appendix A

The task force justified including the 2 previously included studies in the SysRev, downgrading those studies for indirectness.[139,140] One additional case series showed good accuracy when ultrasound was performed by trained health care professionals for emergency department resuscitation of children with cardiac arrest during pulse checks.[141] Very experienced clinicians performed the intervention in this case series. The task force concluded that evidence was insufficient to make a treatment recommendation. The duration of pulse checks was not reported in this case series.

The previous treatment recommendation limited the pulse check duration to 10 seconds.[121] However, in 1 study, only 39% (60/153) of the participants decided on the presence of a pulse within 10 seconds.[140] Given the indirect evidence in this SysRev, the task force withdrew the Treatment Recommendation regarding pulse palpation within 10 seconds.

Knowledge Gaps

- No randomized controlled trials were identified comparing ultrasound, arterial blood pressure or different pulse check sites with guideline recommended pulse check sites in children with cardiac arrest.

- The effect of pulse palpation attempts on hands-off time and impact on outcome
- Future studies would benefit from including outcome measures consistent with the P-COSCA recommendations.[4]

Blood Pressure Monitoring and Targets During Pediatric In-Hospital Cardiac Arrest (PLS 4160.08, SysRev 2025)

Rationale for Review

In children who have intra-arterial catheters in place, hemodynamic data may be used to provide information about the quality of chest compressions during cardiac arrest.[142] Since the PLS Task Force ScopRev in 2020,[143] subsequent studies on the topic[144,145] have been published, prompting this SysRev. The SysRev was registered with PROSPERO prior to initiation (Registration CRD42024590080), and the full CoSTR can be found on the ILCOR website.[147]

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children receiving resuscitation after in-hospital cardiac arrest with intra-arterial blood pressure monitoring in place at the time of arrest
- Intervention: A specific blood pressure target during arrest
- Comparators: A different blood pressure target or no blood pressure target
- Outcomes: Critical: ROSC; survival to hospital discharge; survival to hospital discharge with good neurological outcome
- Time frame: All years to July 19, 2024

Consensus on Science

Five observational cohort studies were included.[144,148-151] Three were analyses of the same cohort (Pediatric Intensive Care Quality of CPR study) but examined different subpopulations or different outcomes.[148,150,151]

Diastolic Blood Pressure

For the critically important outcomes of ROSC, survival to hospital discharge, and survival with favorable neurological outcome, we identified 2 observational studies enrolling 577 patients with IHCA and invasive arterial blood pressure monitoring in place at the time of arrest,[144,148] which showed benefit from exposure to diastolic blood pressure (DBP) of ≥25 mm Hg for infants <1 and ≥30 mm Hg for children ≥1 for the first 10 minutes of CPR, when compared with lower DBP A summary of the outcomes of the included studies examining DBP targets is shown in Table 4.

There was no difference in median DBP between subjects with new substantive morbidity after arrest and those without (30.5 mm Hg versus 30.9 mm Hg, P=0.5).[150] This was a subpopulation of the subjects in Berg et al (2018).[148]

Diastolic Blood Pressure: Subgroups

For the critically important outcome of survival to hospital discharge, we identified very low-certainty evidence from a single observational study enrolling children with invasive arterial BP monitoring in place at the time of IHCA, and either medical cardiac disease (n=24) or surgical cardiac disease (n=88).[151] Only patients with surgical cardiac disease had improved survival to hospital discharge (RR, 1.64; 95% CI, 1.06-2.54) from exposure to a DBP of ≥25 mm Hg for infants <1 and ≥30 mm Hg for children ≥1 for the first 10 minutes of CPR when compared with patients with lower DBP.

Table 4. Summative Results of Studies: Pediatric Diastolic BP Targets

Outcomes (importance)	Participants (studies), n	Certainty of evidence (GRADE)	RR (95% CI)	Anticipated absolute effect• (95% CI)	
				Risk with no BP target	Risk with a DBP of 25 mm Hg for infants <1 year and 30 mm Hg for children :2:1 year
Return of spontaneous circulation (critical)	577 (2 nonrandomized studies)[144,148]	Very low	RR, 1.33 (1.12-1.59)	528 per 1000	703 per 1000 (592-840)
Survival to hospital discharge (critical)	577 (2 nonrandomized studies)[144,148]	Very low	RR, 1.55 (1.18-1.91)	407 per 1000	630 per 1000 (480-776)
Survival with favorable neurological outcome (PCPC 1-3 or no change from baseline) (critical)	577 (2 nonrandomized studies)[144,148]	Very low	RR, 1.37 (1.04-1.69)	390 per 1000	535 per 1000 (406-660)
Functional status scale"' increase by 3 or increase by 2 in single domain (in survivors) (critical)	77 (1 nonrandomized study)[150]	Very low	RR, 1.69 (0.83-3.42)	222 per 1000	376 per 1000 (184-760)

'The risk in the intervention group (and its 95% CI) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI). CI indicates confidence interval; DBR diastolic blood pressure; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; PCPC, Pediatric Cerebral Performance Category; and RR, risk ratio.

Systolic Blood Pressure

For the critically important outcomes of survival to hospital discharge and survival with favorable neurological outcome, we identified no difference from exposure to a systolic blood pressure of ≥60 mm Hg for infants <1 and ≥80 mm Hg for children ≥1 for the first 10 minutes of CPR (I) when compared with lower systolic blood pressure.[144,148] A summary of the outcomes of the included studies examining systolic BP targets is shown in Table 5.

There was no difference between the median systolic blood pressure between subjects with new substantive morbidity and those without (76.3 mm Hg versus 63 mm Hg, P=0.2).[150] This was a subpopulation of the subjects in Berg et al (2018).[148]

Presence of Monitoring

A single study[149] examining the effect of clinician-reported use of invasive blood pressure monitoring on CPR quality found no difference in any of the outcomes when compared with no use of invasive blood pressure monitoring.

Prior Treatment Recommendations (2020)

The confidence in effect estimates is so low that the panel decided a recommendation was too speculative.

Treatment Recommendations (2025)

We suggest targeting an intra-arrest diastolic blood pressure of ≥25 mm Hg for infants <1 year and ≥30 mm Hg for children 1 to 18 years of age with invasive blood pressure monitoring in place at the time of cardiac arrest (weak recommendation, very low-certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

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

Measurement of intra-arrest blood pressure is generally available only in high-resource settings, and all studies examined patients with invasive BP monitoring in place at the time of arrest. While this limits the scope of the recommendation, children with invasive BP monitoring may be at higher risk of cardiac arrest, thus making a recommendation valuable.

No randomized controlled trials were identified in the search. We found only very low-certainty evidence from 5 observational trials, all of which were from cohorts in the United States (ICU-RESUSCITATION,[145] Pediatric Intensive Care Quality of CPR study,[148] and Get With The Guidelines-Resuscitation). Other studies[148,150,151] all used the Pediatric Intensive Care Quality of CPR study cohort but with different subpopulations or outcome measures.

The task force noted that in Berg et al (2018), the same population was used to both generate and validate the cutoffs of 25 mm Hg and 30 mm Hg for infants and children, respectively.[148] Berg et al (2023)[144] examined other cutoffs but found 25 mm Hg and 30 mm Hg to be most predictive. We noted that while Berg et al (2018) showed a benefit in functional neurological

outcome (aRR, 1.6; 95% CI, 1.1-2.5), Berg et al (2023) did not (aRR, 1.14; 95% CI, 0.93-1.39). The pooled estimate suggested benefit (aRR, 1.37; 95% CI, 1.04-1.69). Lastly, we noted that certain subgroups were under-represented, including children with heart disease and older children.

Table 5. Summative Results of Studies-Pediatric Systolic BP Targets

Outcomes (importance)	Participants (studies), n	Certainty of evidence (GRADE)	RR (950/oCI)	Anticipated absolute effect* (95% CI)	
				Risk with no BP target	Risk with a SBP of 60 mm Hg for infants <1 and 80 mm Hg for children :2:1
Survival to hospital discharge (critical)	577 (2 nonrandomized studies)[144,148]	Very low	RR, 1.12 (0.95-1.32)	507 per 1000	568 per 1000 (482-670)
Survival with favorable neurological outcome (PCPC 1-3 or no change) (critical)	164 (1 nonrandomized study)[148]	Very low	RR, 1.0 (0.7-1.4)		
Functional status scale increase by 3 or increase by 2 in single domain (in survivors) (critical)	77 (1 nonrandomized study)[150]	Very low	RR, 0.70 (0.40-1.24)	489 per 1000	342 per 1000 (196-606)

'The risk in the intervention group (and its 95%o CI) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI). CI indicates confidence interval; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; PCPC, Pediatric Cerebral Performance Category; RR, risk ratio; and SBP, systolic blood pressure.

Since the evidence is both indirect and imprecise, as described above, the task force limited the recommendation to children with invasive BP monitoring in place at the time of arrest.

Knowledge Gaps

- Randomized trial data comparing the benefits or harms of specific BP targets during arrest
- Use of noninvasive methods to measure BP during arrest
- Whether different blood pressure targets would be more appropriate for older children or adolescents
- The utility of initiating invasive BP monitoring intra-arrest
- Blood pressure targets in children with heart disease
- The importance of diastolic and systolic BP in longer arrests, as studies have focused primarily on BP in the first 10 minutes of CPR
- The effect of mean arterial pressure on outcomes

Intra-arrest Echocardiography (Point-of-Care Cardiac Ultrasound) (PLS 4160.05, ScopRev 2020, EvUp 2025)

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (excluding newborn infants) with cardiac arrest.
- Intervention: The presence of variables (images, cut-off values or trends) during CPR (intra-arrest) that can provide physiologic feedback to guide resuscitation efforts, namely: echocardiography/ point-of-care cardiac ultrasound
- Comparators: The absence of such variables (images, cut-off values or trends)
- Outcomes: Any clinical outcome
- Time frame: July 2020 to June 26, 2024

Summary of Evidence

A ScopRev was done in 2020,[110-112] with an EvUp in 2023[126,127] and for 2025. The 2025 EvUp is included in Appendix B, and neither EvUp since 2020 identified any new pediatric studies on this subject that would inform a treatment recommendation. There is insufficient evidence to support a SysRev,

Good Practice Statement (2025)

The Treatment Recommendation of 2010,[121,153] which was reiterated in 2020,[110-112] has been downgraded to a good practice statement based the lack of evidence.

For children in cardiac arrest, echocardiography may be considered to identify potentially treatable conditions when appropriately skilled personnel are available, but the benefits must be carefully weighed against the known deleterious consequences of interrupting chest compressions (good practice statement).

Intra-arrest End-Tidal Carbon Dioxide (PLS 4160.07, ScopRev 2020, EvUp 2025)

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

- Population: Infants and children (excluding newborn infants) with in-hospital or out-of-hospital cardiac arrest
- Intervention: The presence of variables (images, cut-off values or trends) during CPR (intra-arrest) that
- can provide physiologic feedback to guide resuscitation efforts, namely: end-tidal carbon dioxide ($ETCO_2$)
- Comparators: The absence of such variables (images, cut-off values or trends)
- Outcomes: Any clinical outcome
- Time frame: July 2020 to June 26, 2024

Summary of Evidence

This topic was previously reviewed in a ScopRev for 2020,[110-112] with an EvUp in 2023[126,127] and for 2025, The complete 2025 EvUp is provided in Appendix B. One observational study published in 2022 demonstrated an association between $ETCO_2$ monitoring and ROSC in adolescents.[154] A propensity weighted cohort study[149] concluded that clinician reported use of $ETCO_2$ intra-arrest was not associated with ROSC in children. The ICU-RESUS trial was a large multicenter prospective observational cohort study. A secondary analysis study of ICU-RESUS trial found no association between $ETCO_2$ in first 10 minutes CPR event and survival with favorable neurologic outcome.[155] However, an ancillary study of children in ICU-RESUS trial (CPR-NOVA)[156] found a higher incidence of ROSC and survival to hospital discharge in patients with $ETCO_2$ target >20 mm Hg. It is the first pediatric study to support use of $ETCO_2$ monitoring intra-arrest and defines an intra-arrest $ETCO_2$ target. A SysRev may be justified following future studies assessing this question,

Prior Treatment Recommendation (2020, Unchanged From 2015)

The confidence in effect estimates is so low that the panel decided that a recommendation was too speculative.[157]

Treatment Recommendation (2025)

For children in cardiac arrest monitoring $ETCO_2$ may help achieve quality CPR; however, specified values to guide intra-arrest interventions have not been well established (good practice statement).

Intra-arrest Near-Infrared Spectroscopy (PLS 4160.09, ScopRev 2020, EvUp 2025)

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (excluding newborn infants) with in-hospital or out-of-hospital cardiac arrest
- Intervention: The presence of variables (images, cut-off values or trends) during CPR (intra-arrest) that can provide physiologic feedback to guide resuscitation efforts, namely near infrared spectroscopy
- Comparators: The absence of such variables (images, cut-off values or trends)
- Outcomes: Any clinical outcome
- Time frame: July 2020 to June 26, 2024

Summary of Evidence

This topic was last reviewed in a ScopRev for the 2020 CoSTR. The complete EvUp is provided in Appendix B. We identified 1 additional abstract[158] and a single center observational study by the same authors utilizing data from 3 hospitals in the Pediatric Resuscitation Quality Collaborative.[159] Both studies concluded that higher median cerebral regional oxygen saturation measured with cerebral near infrared spectroscopy during IHCA in children was associated with increased rate of ROSC and survival to hospital discharge. A SysRev is not indicated at this time.

Good Practice Statement (2025)

The treatment recommendation of 2020[110-112] has been downgraded to a good practice statement based on the lack of evidence.

Monitoring cerebral oxygenation during cardiopulmonary resuscitation is a noninvasive metric that does not require pulsatile signal and may be beneficial to monitor. However, there is no consensus about a cut-off threshold for cerebral oxygenation that can be used to guide or terminate resuscitation during in-hospital cardiac arrest in children (good practice statement).

INTRA-ARREST: DRUGS AND DRUG ADMINISTRATION

Vasopressor Use During Cardiac Arrest in Children (PLS 4080.21, SysRev 2025)

Rationale for Review

Since the SysRev published by the ILCOR PLS Task Force CoSTR in 2020 on timing of epinephrine initial dose and dose interval during CPR in children,[110-112] a systematic review[160] and 3 observational studies[161-163] have been published examining the effects of epinephrine in pediatric cardiac arrest. The PLS Task Force therefore prioritized an updated SysRev, which was registered before initiation (PROSPERO Registration CRD42024596959). The full CoSTR is available on the ILCOR website.[164]

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (<18 years) in cardiac arrest who received chest compression in any setting
- Intervention: Any use of vasopressors (epinephrine, vasopressin, combination of vasopressors)
- Comparators: No vasopressor use
- Outcomes:
  - Critical: Short-term and long-term survival or neurological outcomes.
  - Important: ROSC.
- Time frame: All years to July 16, 2024

Consensus on Science

Two propensity score matched observational studies were identified,[161,163] providing very low- to low-certainty evidence. Both studies were in the out-of-hospital setting and compared outcomes of children who received epinephrine with children who did not.

For favorable neurological outcomes at 1 month, 1 study[163] involving 608 patients found no significant difference when epinephrine was administered compared with no epinephrine (15 more patients with favorable neurological survival at 1 month per 1000 resuscitations; 95% CI, 11 fewer to 92 more).[163]

For favorable neurological outcome at hospital discharge, the second study,[161] involving 1432 patients, found no significant difference when epinephrine was administered compared with no epinephrine (9 more patients with favorable neurological survival at hospital discharge per 1000 resuscitations; 95% CI, 13 fewer to 50 more).

For survival at 1 month, 1 study[163] involving 608 patients found no significant difference when epinephrine was administered compared with no epinephrine (10 more survivors per 1000 resuscitations; 95% CI, 27 fewer to 78 more).

For survival to hospital discharge, 1 study[161] involving 1432 patients found no significant difference when epinephrine was administered compared with no epinephrine (19 more survivor per 1000 resuscitations; 95% CI, 7 fewer to 64 more).

For prehospital ROSC, 2 studies[161,163] involving 2034 patients found a benefit when epinephrine was administered, compared with no epinephrine (63 more patients with ROSC per 1000 resuscitations; 95% CI, 28 more to 145 more).

Prior Treatment Recommendations (2020)

We suggest that the initial dose of epinephrine in pediatric patients with nonshockable IHCA and OHCA be administered as early in the resuscitation as possible (weak recommendation, very low-certainty evidence).

We cannot make a recommendation for the timing of the initial epinephrine dose in shockable pediatric cardiac arrest. The confidence of the effect estimates is so low that we cannot make a recommendation about the optimal interval for subsequent epinephrine doses in pediatric patients with IHCA or OHCA.

Treatment Recommendations (2025)

We suggest the use of epinephrine in pediatric out-of-hospital cardiac arrest (weak recommendation, very low-certainty evidence). There is insufficient evidence to generate a treatment recommendation for the use of epinephrine in pediatric in-hospital cardiac arrest. However, the task force considers the indirect evidence from OHCA to support the administration of epinephrine in pediatric in-hospital cardiac arrest (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

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

The task force acknowledged that the included studies were from settings with advanced emergency medical services. In similar settings, the administration of epinephrine as part of advanced pediatric life support for pediatric OHCA should be continued but also further evaluated.

However, there are very few studies looking at resources required to train, maintain skillsets, and provide the necessary equipment for emergency medical services systems to administer epinephrine in pediatric OHCA.

The task force acknowledged that the ALS Task Force currently recommends the use of epinephrine in adult cardiac arrest. The PLS Task Force did not include indirect evidence from adults because of differences in etiologies of cardiac arrest in children.[161,163,166]

Knowledge Gaps

- The effect of potential undesirable effects of epinephrine. Adverse outcomes from administration of epinephrine have been reported.[162]
- Whether specific subpopulations might potentially benefit (or not) from administration of epinephrine in the prehospital setting.
- Cost-effectiveness and feasibility of the provision of advanced pediatric life support in the prehospital settings (across resource rich and limited emergency medical services systems) to facilitate the administration of epinephrine in pediatric OHCA while ensuring high-quality basic life support.
- Effect of vasopressors during cardiac arrest in the inpatient setting, especially in the context of initial resuscitation of pediatric cardiac arrest patients prior to ECPR.[167,168]

Epinephrine Administration Timing in Cardiac Arrest (PLS 4090.02, SysRev 2020, EvUp 2025)

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (excluding newborn infants) with in-hospital or out-of-hospital cardiac arrest
- Intervention: Administration of the initial dose of epinephrine earlier or later than current guideline recommendations; or administration of epinephrine more or less frequently than every 3 to 5 minutes following the initial dose
- Comparators: Timing of administration of epinephrine in line with current guideline recommendations
- Outcomes: Any clinical outcome
- Time frame: July 2019 to April 25, 2024

Summary of Evidence

The complete EvUp is provided in Appendix B. This topic was last updated by a SysRev for the 2020 CoSTR.[110-112] This EvUp identified 5 new pediatric observational studies on this subject since the last review.[161,168-171] Given the lack of a recommendation for epinephrine dosing intervals, a future SysRev may be warranted. However, no evidence for the time to first dose epinephrine in shockable rhythms was identified and a SysRev for this question is not justified.

Treatment Recommendation (2020)

We suggest the initial dose of epinephrine in pediatric patients with both nonshockable IHCA and OHCA be administered as early in the resuscitation as possible (weak recommendation, very low-certainty evidence).[110-112]

We cannot make a recommendation for the timing of the initial epinephrine dose in shockable pediatric cardiac arrest.

The confidence of the effect estimates is so low that we cannot make a recommendation regarding the optimal epinephrine interval for subsequent epinephrine doses in pediatric patients with IHCA or OHCA.

Calcium Use During Cardiac Arrest (PLS 4090.01, SysRev 2023, EvUp 2025)

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (excluding newborn infants) with in-hospital or out-of-hospital cardiac arrest
- Intervention: Calcium administration
- Comparators: No calcium administration
- Outcomes: Any clinical outcome
- Time frame: November 2019 to October 26, 2024

Summary of Evidence

A SysRev on this topic was published[172] for the 2023 CoSTR summary.[126,127] The 2025 EvUp is provided in Appendix B. We identified 2 additional observational studies in children, both of which found a significantly lower rate of sustained ROSC, lower survival rate to hospital discharge and lower survival to discharge with favorable neurologic outcome associated with use of calcium in arrest.[173,174] There is insufficient evidence to support a new SysRev.

The use of calcium for documented hypocalcemia, hypermagnesemia, or suspected calcium channel blocker overdose was not included in this review. Further evaluation of the use of calcium in these special circumstances is required. The use of calcium in hyperkalemia is reviewed separately.

Treatment Recommendation (2020)

Routine use of calcium for infants and children with cardiopulmonary arrest is not recommended in the absence of hypocalcemia, calcium channel blocker overdose, hypermagnesemia, or hyperkalemia.[110-112]

Sodium Bicarbonate Administration in Cardiac Arrest (PLS 4090.04, EvUp 2020, EvUp 2025)

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (excluding newborn infants) with in-hospital or out-of-hospital cardiac arrest
- Intervention: Use of sodium bicarbonate with a certain dose and timing
- Comparators: No sodium bicarbonate Outcomes: Any clinical outcome
- Time frame: December 1, 2020, to October 21,
- 2024

Summary of Evidence

An EvUp was done for the 2020 CoSTR,[110-112] and the treatment recommendation from 2010 was maintained. The current EvUp identified 2 pediatric studies, 1 a meta-analysis[175] and the other, a secondary analysis of a prospective RCT.[176] Both found sodium bicarbonate administration during pediatric cardiac arrest was associated with a significantly decreased rate of survival to hospital discharge. The complete EvUp is provided in Appendix B. Based on this EvUp, we plan to conduct a systematic review.

Treatment Recommendation (2010)

Routine administration of sodium bicarbonate is not recommended in the management of pediatric cardiac arrest.[110-112,121,153]

Anti-Arrhythmic Drugs in Cardiac Arrest With Shockable Rhythms (PLS 4080.04, SysRev 2018, EvUp 2023, EvUp 2025)

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (excluding newborn infants) with in-hospital or out-of-hospital cardiac arrest and a shockable rhythm at any time during CPR or immediately after ROSC
- Intervention: Administration (IV or IO) of an anti-arrhythmic drug
- Comparators: Administration of another anti-arrhythmic or placebo
- Outcomes: Any clinical outcome
- Time frame: July 5, 2022, to October 1, 2024

Summary of Evidence

This topic was last reviewed with a SysRev in 2018[177-179] and EvUp in 2023.[126,127] The complete EvUp is provided in Appendix B. Our EvUp identified no new pediatric studies on this subject. There is insufficient evidence to support the conduct of a systematic review.

Treatment Recommendation (2018)

We suggest that amiodarone or lidocaine may be used for the treatment of pediatric shock-resistant VF/pVT (weak recommendation, very low-quality evidence).[178,179]

IO Versus IV in Cardiac Arrest (PLS 4080.15, EvUp 2022, EvUp 2025)

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (excluding newborn infants) with in-hospital or out-of-hospital cardiac arrest
- Intervention: Placement of an IO cannula and drug administration through this IO during cardiac arrest
- Comparators: Placement of an IV cannula and drug administration through this IV during cardiac arrest
- Outcomes: Any clinical outcome
- Time frame: December 1, 2021, to May 10, 2024

Summary of Evidence

A SysRev on this topic was last conducted in 2020, and no evidence in children was found at that time so the 2010 recommendation was maintained.[110-112] An EvUp included in the 2022 CoSTR summary[70,72] identified 2 registry studies[180,181] that were not thought sufficient to warrant updating the SysRev and treatment recommendations. The EvUp for 2025 identified no new pediatric studies. The ALS Task Force conducted a SysRev[182] for this PICOST for 2025, but the PLS Task Force agreed that the adult evidence is too indirect to be considered relevant to the infant and child population. The adult evidence may have some relevance to the adolescent population and may be explored by the task force in the future.

Treatment Recommendation (2020, Unchanged From 2010)

lntraosseous cannulation is an acceptable route of vascular access in infants and children with cardiac arrest. It should be considered early in the care of critically ill children whenever venous access is not readily available.[110-112]

INTRA-ARREST: SPECIAL CIRCUMSTANCES

Cardiopulmonary Resuscitation in Obese Patients (ScopRev 2025)

Rationale for Review

This topic was chosen as a ScopRev by the PLS and BLS Task Forces because of the increasing prevalence of obesity worldwide and the specific challenges in providing cardiopulmonary resuscitation to this patient cohort. This topic has not previously been reviewed by ILCOR. The full ScopRev report is available online.[183]

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Adults and children in any setting (in-hospital or out-of-hospital) with cardiac arrest
- Intervention: Cardiopulmonary resuscitation (including mechanical and ECPR) in obese patients (as defined in specific papers)
- Comparators: May have no comparator, comparator of non-obese patients, or comparator of modified CPR for obese patients with standard CPR
- Outcomes:
  - Critical: survival to hospital discharge with good neurological outcome and survival to hospital discharge.
  - Important: ROSC, CPR quality measures (chest
  - compression rate, chest compression depth, ventilation rate, tidal volume, end-tidal CO2), CPR timing (time to commencement of rescue breaths, first compression, first defibrillation if shockable rhythm), CPR techniques (chest compressions, defibrillation, ventilation and airway management, vascular access and medications), health related quality of life and outcomes for those providing CPR (safety, manual handling).
- Time frame: All years to October 1, 2024

Summary of Evidence

Adult evidence is summarized in the BLS CoSTR paper.[120] There were 2 studies of children[184,185] and 1 study in which patient age was not reported.[186] Both pediatric studies[184,185] reported worse neurological outcomes in obese children (compared with normal weight children) at hospital discharge[85] and 12 months.[184]

Survival to hospital discharge was reported in one pediatric study[185] in which survival to hospital discharge was less likely in obese children than normal weight children after cardiac arrest.[185]

The same study showed that obese children had significantly lower chance of ROSC than normal weight children (IHCA).[185]

Task Force Insights

The evidence identified was limited by conflicting results and differences in outcomes measured. The overall results do not suggest a requirement to deviate from standard CPR protocols.

Good Practice Statement (2025)

Standard CPR protocols should be used in obese patients (good practice statement).

Knowledge Gaps

- Few studies of CPR in obese infants, children, and adolescents
- A standardized definition of obese, or population specific definition of obese, for the purpose of resuscitation research
- More robust adjusted analyses of the impact of obesity on CPR outcomes
- The effect of obesity on CPR techniques, CPR quality, and time to and delivery of resuscitation interventions in both adults and children
- Whether the degree of obesity influences CPR performance, outcomes following CPR including health-related quality of life, or inclusion in CPR research
- The effect of patient obesity on those providing CPR (physical exertion, manual handling, fatigue)

IHCA Due to Suspected Cardiac Shunt/Stent Obstruction (PLS 4030.25, SysRev 2025)

Rationale for Review

Aortopulmonary shunts and patent ductus arteriosus stents are important tools for the palliation of patients with congenital heart disease. Current therapies for acute shunt obstruction can include any of the following: (1) increasing the inspired oxygen concentration to maximize alveolar oxygenation; (2) vasoactive agents to maximize shunt perfusion pressure; (3) anticoagulation with heparin to prevent clot propagation; (4) shunt intervention by catheterization or surgery; (5) stabilization with ECPR/ECMO; (6) sternal reopening to relieve shunt compression.[187-192]

The PLS Task Force prioritized this SysRev to define what specific interventions other than standard CPR may improve clinical outcomes in pediatric IHCA due to suspected aortopulmonary shunt/stent obstruction. The SysRev was registered before initiation (PROSPERO Registration CRD42017080475). The full CoSTR can be found on the ILCOR website.[193]

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children in cardiac arrest in the in-hospital setting who have suspected aortopulmonary shunt/stent obstruction
- Intervention: Any intervention (administration of oxygen, vasoactive agents to increase shunt/stent perfusion pressure, ECPR, heparin, sternal opening, catheter-based intervention, surgical intervention) or a combination of these interventions
- Comparison: Standard resuscitation
- Outcomes: Any clinical outcome
- Time frame: Literature search included all years up to June 6, 2024

Consensus on Science

There were 15 articles screened in full text and none met criteria for inclusion.

Treatment Recommendations (2025)

There is insufficient evidence to make a treatment recommendation for infants and children in cardiac arrest in the in-hospital setting who have suspected aortopulmonary shunt/stent obstruction other than standard resuscitation.

Justification and Evidence-to-Decision Framework Highlights

No evidence was identified, and therefore no treatment recommendations other than following standard resuscitation recommendations could be made.

Knowledge Gaps

- There is an absence of RCTs or comparative studies focused on interventions for IHCA due to aortopulmonary shunt or stent obstruction.
- There is an absence of data on the effectiveness of individual interventions (eg, vasoactive agents, heparin) or their combinations in improving clinical outcomes.
- More data are needed on the benefit of using ECPR in patients with specific cardiac anatomies, like those with single ventricle physiology status post shunt or stent. Further research is required to determine its effectiveness and potential risks in these subgroups.
- Data are lacking on survival rates and neurological outcomes following cardiac arrest due to shunt obstruction in pediatric patients.
- More information is needed on the ideal timing and combination of therapies (eg, vasoactive agents, anticoagulation, surgical intervention).

Cardiac Arrest Due to Pulmonary Embolism (PLS 4160.10, SysRev 2025)

Rationale for Review

Pulmonary embolism (PE) is a rare and potentially treatable cause of cardiac arrest in children and adolescents. This question had not previously been examined for children and was prioritized for review by the PLS Task Force. The SysRev was registered before initiation (PROSPERO Registration CRD42024560884). The full CoSTR can be found on the ILCOR website.[194]

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (excluding newborn infants) who are in cardiac arrest due to confirmed or suspected PE in any setting
- Intervention: Any specific alteration in the treatment algorithm (eg, fibrinolysis, embolectomy, thrombectomy, with or without ECPR)
- Comparison: Standard CPR
- Outcomes: Any clinical outcome
- Time frame: All years to May 15, 2024

Consensus on Science

No pediatric studies were identified that directly compared standard cardiac arrest care with any specific alteration in the treatment algorithm due to confirmed or suspected PE.

Two small single-center case series described a total of 10 infants and children where individual or combined interventions (fibrinolysis, embolectomy, thrombectomy, with or without ECPR) were used in addition to standard care for cardiac arrest associated with confirmed or suspected pulmonary embolism.[195,196]

One single institution case series identified PE as the cause of IHCA in 5 (6.3%) of 79 children who received at least 5 minutes of CPR for an IHCA.[195] They were treated with thrombolysis (IV tissue plasminogen activator) in addition to standard CPR; 4 of 5 patients were successfully resuscitated and survived to hospital discharge. Three patients had intact neurological outcome.

A retrospective cohort study of pediatric PE outcomes and risk factors from 2 Canadian pediatric hospitals reported 170 children aged 18 years or younger with massive and submassive pulmonary embolism, 5 of whom suffered cardiac arrest.[196] Patients were treated with a single or combined interventions (embolectomy, thrombolysis, and catheter-directed thrombolysis) with or without ECMO during or after cardiac arrest for PE in addition to the standard cardiac arrest algorithm. Five cases achieved ROSC and 4 survived to hospital discharge.

Treatment Recommendations (2025)

There is insufficient evidence to make a treatment recommendation for or against the use of any specific alteration to the cardiac arrest algorithm for pediatric cardiac arrest due to suspected or confirmed PE.

Justification and Evidence-to-Decision Framework Highlights

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

The task force considered additional data that did not meet the SysRev inclusion criteria. A single-center retrospective study of 33 children with massive and submassive PE reported 4 patients who sustained cardiac arrest. One patient died despite standard cardiac arrest care, while 1 of the 3 who were also treated with one of (or a combination of) systemic fibrinolysis, catheter-

directed fibrinolysis, embolectomy or ECMO survived.[197] In 15 pediatric case reports that did not meet the SysRev inclusion criteria, 4 patients treated using a standard cardiac arrest algorithm did not survive. Seven of the 11 patients treated with alterations to the algorithm (fibrinolysis, embolectomy, ECMO) survived to hospital discharge.

Knowledge Gaps

- Effectiveness of fibrinolysis, embolectomy, thrombectomy with or without ECMO in children who had an in-hospital cardiac arrest due to apparent or confirmed PE

Pharmacological Interventions for the Treatment of Hyperkalemia in Children with Cardiac Arrest (PLS 4160.17, SysRev 2025)

Rationale for Review

Hyperkalemia is a potentially reversible cause of cardiac arrest in both adults and children. Although alternative approaches to advanced life support in patients with hyperkalemia-caused cardiac arrest are recommended by resuscitation councils,[6,113,198,199] this topic has never been formally reviewed by ILCOR. The SysRev was initiated as nodal between ALS and PLS Task Forces.[200] The SysRev was registered before initiation (PROSPERO Registration CRD42023440553). The full CoSTR can be found on the ILCOR website.[201]

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Adults and children with hyperkalemia in any setting (both with or without cardiac arrest)
- Intervention: Acute pharmacological intervention with the aim of mitigating the harmful effect of hyperkalemia or with the aim of lowering potassium values
- Comparators: No intervention, a different intervention (including a different dose), or placebo
- Outcomes:
  - Critical: survival/survival with a favorable neurological outcome (at hospital discharge, 28 days, 30 days,1 month); survival/survival with a favorable neurological outcome at later times (>90 days); health-related quality of life.
  - Important: change in potassium; use of dialysis; electrocardiographic changes/arrythmias; cost-effectiveness
- Time frame: All years to September 9, 2024

Consensus on Science

The evidence in children in summarized here. For the results in adults, see the ALS CoSTR[202] and the SysRev.[200]

Change in Potassium Values (Nonarrest)

Five neonatal studies, 4 interventional and 1 observational, tested insulin and glucose using a weight-based approach.[203-207] Two studies reported decrease in potassium while 2 reported no change. The studies could not be pooled due to differences in methodology.

Four studies in neonates and children (53 patients) compared intravenous β_2-agonists (salbutamol, 4-5 μg/kg) with no treatment for acute hyperkalemia. Meta-analysis showed a mean decrease in potassium of 1.0 mmol (95% CI, 1.5 lower to 0.6 lower) (follow-up range 60 mins).[208-211] Only 1 pediatric study investigated combination therapy of intravenous β_2-agonists and insulin with glucose which showed a reduction in potassium level from a mean (SD) 6.8 mmol (0.6) to 5.0 (1.2) after 45 minutes with the intervention.[212]

Inhaled β_2-agonists (400 μg salbutamol as inhalation) were compared with no treatment for acute hyperkalemia in 3 studies in neonates (51 patients in total), and meta-analysis showed a mean decrease in potassium of 0.9 mmol (95% CI, 1.2 lower to 0.5 lower) in the treatment group (follow-up range 240 mins).[204,207,213]

Outcomes in Cardiac Arrest

Two observational studies investigated the treatment of hyperkalemia during cardiac arrest. Both studies investigated the use of calcium; 1 retrospectively in adult patients[214] and 1 as a secondary analysis of a prospective study (ICU-RESUSCITATION project) in infants and children.[174] The adult study found a lower unadjusted rate of ROSC with the administration of calcium, sodium bicarbonate, or the combination.[214] In the pediatric study, calcium was frequently used during cardiac arrest and was associated with worse outcomes.[174] Both studies were assessed as high risk of bias. No studies were found for the use of sodium bicarbonate for hyperkalemia in cardiac arrest in children.

Treatment Recommendations (2025)

For children in cardiac arrest associated with hyperkalemia, there is insufficient evidence to make a treatment recommendation for or against the use of calcium.

For children in cardiac arrest associated with hyperkalemia, there is insufficient evidence to make a treatment recommendation for or against the use of sodium bicarbonate.

We suggest using intravenous salbutamol or insulin with glucose (or a combination of both) in children with cardiac arrest associated with hyperkalemia with the aim to lower the potassium values during concurrently ongoing high-quality resuscitation efforts (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

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

Based on the current systematic review, there is evidence that treatment with insulin and glucose or inhaled or IV β_2-agonists causes an acute reduction in potassium levels. For all interventions, the reduction in potassium was consistently in the range of 0.7 to 1.2 mmol/L. Whether this acute decrease in potassium translates to an improvement in clinical outcomes is unclear.

The rationale for administering calcium during cardiac arrest caused by hyperkalemia is based on the presumed ability to prevent arrhythmias. Although calcium is widely recognized and used for this indication, the current review did not find any clinical evidence to support this.

After discussion, the PLS Task Force decided not to make any statements about the treatment of children not in cardiac arrest, although some evidence for this group of patients exists and is summarized above.

There is no evidence for the use of bicarbonate to manage hyperkalemia in children. In adults, bicarbonate did not lower potassium values or improve outcomes.

The very low-certainty evidence suggests an association of calcium with worse outcomes but there are critical risks of bias and high uncertainty mainly due to resuscitation time (duration of resuscitative efforts) bias. The rationale for use of calcium for assumed myocardial protective effect is being questioned.

The effects of salbutamol and insulin with glucose on potassium values in cardiac arrest patients have not been studied. However, the task force agreed that the potential benefits of these pharmacological interventions outweigh potential risks, and their use is therefore justified. Inhalational administration of medications is generally not feasible and not recommended during cardiac arrest, supporting the suggestion for intravenous administration of salbutamol in this setting.

Knowledge Gaps

- Optimal strategies for reducing potassium values in children in cardiac arrest associated with hyperkalemia
- Whether any decrease in potassium values (in both intra-arrest and periarrest patients) translates into meaningful patient-centered outcomes such as survival to discharge or survival with favorable neurological outcomes

  The role of calcium, if any, in protecting myocardial cells from hyperkalemia
- Management of children at high risk of hyperkalemia (eg, children with acute or chronic renal failure, tumor lysis syndrome, or others), particularly regarding the preferred treatment, appropriate dosing, and timing of interventions

INTRA-ARREST: ECPR

ECPR in Children With Single Ventricle Physiology (PLS 4030.09, 4030.10, SysRev 2025)

Rationale for Review

The risk of cardiac arrest in a child with single ventricle (SV) physiology is elevated.[215] Conventional CPR may not provide adequate reperfusion in this physiology and low likelihood of ROSC.[216] There is currently no specific recommendation for ECPR that delineates children with SV physiology with IHCA refractory to conventional CPR. A new SysRev was registered before initiation (PROSPERO Registration CRD42023479671). The full CoSTR can be found on the ILCOR website.[217]

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants, children, and adolescents with cardiac arrest following Stage I (Norwood/Hybrid), Stage II (Hemi-Fontan/Bidirectional Glenn) or Stage III (Fontan) palliation for congenital heart disease with SV physiology in the hospital setting
- Intervention: ECPR including ECMO or cardiopulmonary bypass during resuscitation of cardiac arrest
- Comparators: Conventional or manual CPR
- Outcomes: Critical: survival to hospital discharge; survival with favorable neurologic outcome.
- Important: decannulation from ECMO
- Time frame: All years to October 2023

Consensus on Science

Sixteen observational studies were included[218-223] all with very low-certainty evidence. No studies compared children with SV physiology who received ECPR with those receiving conventional or manual CPR. Five studies compared children with SV

physiology who received ECPR with those receiving ECMO without ECPR (ECMO non-ECPR).[220,221,224-226]

An additional 11 studies described ECPR in SV patients, but with no comparator group.[191,218,219,222,223,227-232] Of these, 8 studies were single-center observational cohorts with a total of 318 SV ECPR patients with a survival to hospital discharge rate ranging from 32% to 62%.[218,223,227-232] The remaining 3 studies were registry cohorts from the Extracorporeal Life Support Organization with a total of 805 SV ECPR patients with a survival to hospital discharge rate ranging from 32% to 34%.[191,219,222]

No studies were identified comparing ECPR with conventional or manual CPR.

ECPR Versus ECMO Non-ECPR

For the critical outcome of survival to hospital discharge we identified 3 observational studies[220,221,226] with 91 pediatric SV patients (pooled OR, 0.445; 95% CI, 0.193-1.024) and 2 registry studies[225,231] (OR, 1.09; 95% CI, 0.71-1.71, and OR, 0.665; 95% CI, 0.26-1.72). Collectively these studies found no significant difference in survival to hospital discharge with ECPR compared with ECMO non-ECPR in pediatric SV patients.

For the important outcome of decannulation from ECMO, 1 observational study of 40 pediatric SV patients (OR, 1.75; 95% CI, 0.50-6.09) found no difference in decannulation from ECMO with ECPR compared with ECMO non-ECPR.[232]

Subgroup Analyses

Two observational studies[221,225] in pediatric SV patient status post Stage I Norwood palliation found no difference in survival to hospital discharge with ECPR compared to ECMO non-ECPR (OR, 1.09; 95% CI, 0.71–1.71, and OR, 0.52; 95% CI, 0.10–2.54).

One observational study in pediatric SV patients post Stage Ill Fontan palliation found no difference in survival to hospital discharge with ECPR compared with ECMO non-ECPR (OR, 0.66; 95% CI, 0.26-1.72).[224]

There were no studies identified in SV patients' status post Stage II Hemi-Fontan/Bidirectional Glenn palliation comparing ECPR to ECMO non-ECPR.

Treatment Recommendations (2025)

There is insufficient evidence to make a treatment recommendation for or against the use of ECPR during cardiac arrest in children with single ventricle physiology.

There is insufficient evidence to make a treatment recommendation for or against the use of ECPR compared with ECMO non-ECPR in children with single ventricle physiology.

Justification and Evidence-to-Decision Framework Highlights

There is no published evidence in pediatrics that enables us to compare ECPR with conventional CPR. The available evidence suggests that when comparing ECPR with ECMO non-ECPR in a child with SV physiology the risk of survival to hospital discharge is not statistically different in ECPR compared with ECMO non-ECPR.

Knowledge Gaps

- Comparative prospective studies or randomized trials of ECPR versus conventional or manual CPR
- Few data on survival with neurologic outcome following cardiac arrest with ECPR
- Outcomes of subgroups of SV patients before Stage I, and after Stage I, II and III single ventricle palliation who undergo ECPR
- How the transition from conventional CPR to ECPR alters the quality of resuscitation measures
- How best to provide closed-chest CPR and transition to a sternal opening for ECPR cannulation or how to perform open-chest CPR in the context of cannulating to central ECPR
- Whether oxygenation targets in conventional CPR and at the transition to ECPR in cardiac patients who have cyanotic heart disease should be aligned with baseline pre-arrest blood oxygen saturations
- Whether there is a circuit prime and transfusion management strategy at the time of ECPR that is optimal
- How best to provide early post–cardiac arrest care with ECPR (oxygenation, decarboxylation, perfusion pressure)
- Whether hypothermic temperature control should be delivered with ECPR

ECPR for Cardiac Arrest (PLS 4160.02, SysRev 2023, EvUp 2025)

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (excluding newborn infants) with in-hospital or out-of-hospital cardiac arrest
- Intervention: ECPR, including extracorporeal membrane oxygenation or cardiopulmonary bypass during resuscitation of cardiac arrest
- Comparators: Conventional or manual CPR without ECPR
- Outcomes: Any clinical outcome
- Time frame: June 2022 to October 1, 2024

Summary of Evidence

A SysRev was last conducted on this topic for the 2023 CoSTR summary.[126,127] This EvUp identified 4 systematic reviews,[233-236] 1 narrative review,[237] and 21 other manuscripts[238-257] studying ECPR in the context of pediatric cardiac arrest; the great majority in children with cardiac disease and ICU cardiac arrest. Notably, 2 publications studied noncardiac disease,[239,249] and 2 publications examined pediatric OHCA from the Extracorporeal Life Support Organization registry.[240,251] The complete EvUp is provided in Appendix B. Given the emerging evidence in noncardiac populations with IHCA and OHCA, it may be reasonable to consider a ScopRev in noncardiac populations in the next 2 years.

Treatment Recommendation (2023)

We suggest that ECPR may be considered as an intervention for selected infants and children (eg, pediatric cardiac populations) with IHCA refractory to conventional CPR in settings where resuscitation systems allow ECPR to be well performed and implemented (weak recommendation, very low-certainty evidence).[126,127]

There is insufficient evidence in pediatric OHCA to formulate a treatment recommendation for the use of ECPR.

POSTRESUSCITATION

Blood Pressure Targets Following Return of Circulation After Pediatric Cardiac Arrest (PLS 4190.01, SysRev 2025)

Rationale for Review

Optimal BP targets in infants and children following return of circulation after cardiac arrest are not well defined. New evidence emerged after the ILCOR 2024 SysRev,[73,74] prompting an updated systematic review this year. The SysRev was registered before initiation (PROSPERO Registration CRD42023483865). The full CoSTR can be found on the ILCOR website.[258]

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children in any setting (in-hospital or out-of-hospital cardiac arrest) after ROSC or return of circulation (ROC)
- Intervention: A specific blood pressure target
- Comparators: No blood pressure target or a different blood pressure target
- Outcomes:
  - Critical: survival to hospital discharge; survival with favorable neurological outcome
- Time frame: August 2023 to April 3, 2024

Consensus on Science

Seven nonrandomized observational cohort studies were included, 5 of which were secondary analyses.[259-265] BP target definitions (eg, systolic, mean, and diastolic BP; and >5th, >10th, and >50th centile for age) and time frames for measurement (<20 minutes, 0-6 hours, within 24 hours, and within 0-72 hours) varied across studies. Two studies were excluded as the definition of hypotension could not be ascertained.[266,267] Additional unpublished data was provided by 2 authors,[259,265] which enabled meta-analysis including these studies.

The overall certainty of evidence was rated as very low for all outcomes, downgraded for very serious risk of imprecision, indirectness, inconsistency, and study design. BP cut-offs of systolic BP (5^{th} and 10^{th} percentile) and mean arterial pressure (5^{th}, 10_{th}, and 25^{th} percentiles) for 0 to 6 hours after return of circulation were analyzed for both survival to hospital discharge and survival with favorable neurological outcomes. The results are summarized in Table 6.

Prior Treatment Recommendations (2024)

We suggest in infants and children with return of circulation after an IHCA or OHCA that a systolic BP >10^{th} percentile for age should be targeted (weak recommendation, very low-certainty evidence).[73,74]

Treatment Recommendations (2025)

We suggest in infants and children post return of circulation, following an in-hospital or out-of-hospital cardiac arrest, that a systolic or mean arterial pressure blood pressure >10th percentile for age should be targeted (weak recommendation, very low-certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

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

Measurement of BP is a low-cost intervention and available in nearly all resource settings. However, the Task Force did not review the cost-effectiveness of intermittent, noninvasive BP measurement compared with invasive arterial or continuous BP measurement.

There were no RCTs comparing different treatment approaches or BP targets following cardiac arrest. The available evidence consisted of observational data demonstrating the impact of exposure to different BP thresholds on clinically important outcomes. However, the BP thresholds were chosen either apriori by investigators as a clinically important threshold (eg, ≤5th percentile) or the cut off value was derived statistically from the population data as the most significant inflection point (≤10th percentile). The task force focused on the impact of hypotension on clinical outcomes.

The PLS Task Force considered the exposure overlap of the 2 thresholds of systolic blood pressure <5th centile and <10th centile. It was not statistically possible to perform meta-regression to compare the 2 treatment targets. The consensus was that the higher threshold cut off target (<10th centile) included the population included in the <5th centile group. Acknowledging the low certainty of evidence, the target of >10th centile systolic BP was the more acceptable systolic BP goal and ensured avoidance of the 5th to 10th BP centiles that were associated with worse outcome in the larger study.[259]

Although the effect size from the pooled studies is small, the value of the outcome is high and the potential impact on infants and child survivors globally is therefore large.

Knowledge Gaps

- lnterventional randomized controlled trials comparing benefit or harm of targeting specific BP targets
- Information on impact of prehospital BP measurement or treatment for OHCA
- Whether specific subgroups (eg, medical or cardiac surgical patients) post return of circulation require different BP targets (systolic, mean arterial pressure, or diastolic)
- Data to demonstrate a causal relationship between treatment interventions to achieve higher BP targets and improved outcomes
- The optimal strategy to achieve a BP above the threshold level and any harm associated with these interventions
- Optimal BP targets during extracorporeal life support post-cardiac arrest or when cerebral autoregulation is impaired

Table 6. Summative Results of Studies for Post-arrest BP Targets Review

Outcomes (importance)	Study type, No. participants (n)	Certainty of evidence (GRADE)	aRR (95% CI)	ARD with higher target
Lower target (≤5th centile for age) versus higher target(>5th centile for age) systolic BP within 6 hours post ROC				
Survival to hospital discharge (critical)	Nonrandomized, n=931[200-263]	Very low	1.41; (95% CI, 1.20-1.60)	173 more patients/1000 [95% CI, 84 more patients/1000 to 253 more patients/1000] survived with the intervention
Favorable neurologic outcome at hospital discharge (critical)	Nonrandomized, n= 1371[260,261,265]	Very low	1.30; (95% CI, 1.06-1.60)	132 more patients/1000 [95% CI, 26 more to 264 more patients/1000] survived with favorable neurologic outcome with the intervention
Lower target (≤10th centile for age) versus higher target (>10th centile for age) systolic BP within 6 hours post ROC				
Survival to hospital discharge (critical)	Nonrandomized, n=693[259]	Very Low	1.21; (95% CI, 1.10-1.33); P<0.01	138 more patients/1000 [95% CI, 66 more patients/1000 to 219 more patients/1000] survived with the intervention
Favorable neurologic outcome at hospital discharge (critical)	Nonrandomized, n=1480[259,265]	Low	1.22; (95% CI, 1.10-1.35); P<0.01	116 more patients/1000 [95% CI, 53 more patients/1000 to 185 more patients/1000] survived with favorable neurologic outcome with the intervention
Lower target (≤5th centile for age) versus higher target (>5th centile for age) mean arterial BP within 6 hours post ROC				
Favorable neurologic outcome at hospital discharge (critical)	Nonrandomized, n=787[265]	Low	1.36; (95% CI, 1.18-1.58); *P*<0.01	158 more patients/1000 [95% CI, 79 more patients/1000 to 254 more patients/1000] survived with favorable neurologic outcome with the intervention
Lower target (≤10th centile for age) versus higher target (>10th centile for age) mean arterial BP within 6 hours post ROC				
Favorable neurologic outcome at hospital discharge (critical)	Nonrandomized, n=787[265]	Low	1.21 (95% CI, 1.05-1.32); *P*<0.01	102 more patients/1000 [95% CI, 24 more patients/1000 to 156 more patients/1000] survived with favorable neurologic outcomes with the intervention
Lower target (≤25th centile for age) versus higher target (>25th centile for age) mean arterial BP within 6 hours post ROC				
Favorable neurologic outcome at hospital discharge (critical)	Nonrandomized, n=787[265]	Low	1.29 (95% CI, 0.96-1.74)	150 more patients/1000 [95% CI, 21 fewer patients/1000 to 382 more patients/1000] survived with favorable neurologic outcome with the intervention

ARD indicates absolute risk difference; aRR, adjusted risk reduction; Cl, confidence interval; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; and ROC, return of circulation.

Prediction of Survival With Poor Neurological Outcome After Return of Circulation Following Pediatric Cardiac Arrest-Combined Prognostic SysRev (PLS 4220.01, 4220.02, 4220.03, 4220.04, SysRev 2025)

Rationale for Review

The PLS Task Force undertook a SysRev considering the use of individual prognostic tests including clinical signs, blood biomarkers, brain electrophysiology, and brain imaging to predict poor neurological outcome (PROSPERO Registration CRD42021279221). This is the second part of a SysRev following the original review of individual prognostic tests for predicting good neurological outcome[268] published in the 2023 CoSTR summary.[126,127] The full CoSTRs can be found on the ILCOR website.[269-272]

We defined poor neurological outcome prediction as imprecise when the false positive rate (FPR) was >1%. We defined the evidence as reliable if the FPR was <1% (with upper 95% CIs <10%) and moderately reliable if FPR was <1 % (without a restriction on width of 95% CI). A low FPR rate means that few patients who are predicted to have poor outcome will in fact have a favorable outcome. The task force considered that for prediction of poor outcome, a low FPR (eg, <1%) is more desirable than a high sensitivity. The cut-off of FPR <1% (equivalent to 99% specificity) was chosen as the consequences of false pessimism are substantial and may result in discontinuation of life-sustaining therapy in patients who would have had a good outcome.

Except where noted, all PICOST questions for neuroprognostication used the same population, comparator, outcome, study design, and time frame. The timing of the intervention/diagnostic test was also the same for each. These parameters are therefore listed here once and not repeated in subsequent sections. For all topics, the available evidence had a high risk of bias based on heterogeneity across studies, few studies/patients included, lack of blinding, variation in test assessment and performance, and variability in outcome measurement. Therefore, no meta-analysis was performed, and evidence is considered very low certainty. Overall assessment of test performance was based on visual assessment of forest plots. If only 1 study was available (with small patient sample size), then a suggestion or recommendation could not be made.

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Children (<18 years) who achieve spontaneous or mechanical ROC after resuscitation from IHCA and OHCA.
- Intervention: Index prognostic tests, recorded at one or more of the following time points: <12 hours, 12 to 24 hours, 24 to 48 hours, 48 to 72 hours, 72 hours to 7 days, or 7 to 10 days after cardiac arrest
- Comparators: There was no control group for intervention/exposure. The accuracy of the prognostic index test was assessed by comparing the predicted outcome with the final outcome, which represents the comparator.
- Outcomes:
  - Critical: survival with poor neurological outcome defined as a Pediatric Cerebral Performance Category score of >3, or Vineland Adaptive Behavioral Scale-II <70. Pediatric Cerebral Performance Category score ranges 1 (normal), 2 (mild disability), 3 (moderate disability), 4 (severe disability), 5 (coma), and 6 (brain death)
  - Important: poor neurological outcomes measured with other assessment tools; Pediatric Cerebral Performance Category score >2; change in Pediatric Cerebral Performance Category score >2 from baseline
- Time frame: All years up to August 24, 2024

Blood Biomarkers for the Prediction of Poor Neurological Outcome After ROC Following Pediatric Cardiac Arrest (PLS 4220.01, SysRev 2025)

Intervention: Blood biomarkers, including serum biomarkers either specific to central nervous system damage, eg, neuro-specific enolase (NSE), S100 calcium-binding protein B (S100b), glial fibrillary acidic protein, neurofilament light chain (NfL), or blood markers of inflammation or systemic ischemic reperfusion (eg, blood pH or lactate).

Consensus on Science

Blood biomarker accuracy is summarized in Table 7. Lactate was evaluated in 6 studies.[273-278] Only 2 of the 6 identified an FPR <1 % for poor outcome prediction.[273,278] Persistent acidosis (pH <7.0) had a FPR for poor outcome prediction of 5% to 20% and low sensitivity in 4 studies.[273,276-278] pH and lactate were not reliable prognostic tests.

Three studies reported NSE and S100b in 156 children.[278-280] At 24 hours, S100b predicted a poor neurological outcome with an FPR of 0% (95% CI, 0%-20%) and a sensitivity of 29%-38%.[278-280] Similarly, NSE predicted a poor neurological outcome with a FPR of 0% (95% CI, 0%-20%) and a sensitivity of 19%-26%.[278-280] Myelin basic protein was assessed in 1 study at 24 and 48 hours, predicting poor neurological outcome with low FPR 0% (95% CI, 0%-20%).[280] NSE, S100b and myelin basic protein all fulfilled reliable test criteria but with a wide range of cutoff thresholds in the individual studies.

Only 1 study reported ubiquitin C-terminal hydrolase L1 (UCH-L1), NfL, tubulin associated unit (Tau), and glial fibrillary acidic protein biomarker prediction of poor neurological outcome at 24, 48, and 72 hours.[281] These tests did not reach pre-specified reliability thresholds.

Treatment Recommendations (2025)

We recommend that no single blood-based biomarker be used in isolation to predict poor neurological outcome in children after cardiac arrest (strong recommendation, very low-certainty evidence).

Clinicians should use multiple tests in combination for poor neurological outcome prediction (good practice statement).

Table 7. Blood Biomarker Test for Poor Neurological Outcome Prediction Accuracy

Category	Study count	Patients n=	Threshold and time scale	False positive rate (estimate or range) [95% CI]	Sensitivity
Lactate	1[278]	94	>28.8 mmol/L at <1 hr	<1% [0%-8%]	11%
Lactate	1[273]	61	>2 mmol/L by 48 hr	<1% [0%-11%]	23%
Lactate	4[273,275-277]	780	>2 mmol/L at 6, 12, 24, and 46 hr	14%-84%	32%-94%
Lactate	1[274]	120	>5 mmol/L at 24 hr	11% [5%-19%]	83%
NSE	3[278-280]	152	53.1 µg/L, 56 µg/L, 7 and 132.7 µg/L at <1 hr or 24 hr	0% [0%-20%]	19%-26%
S100b	3[278-280]	156	0.128 µg/L, 2.0 µg/L, and 2.24 µg/L at <1 hr or 24 hr	0% [0%-20%]	29%-38%
MBP	1[280]	43	5.83 µg/L at <1 hr or 24 hr	0% [0%-20%]	4%-12%
UCH-L1, NfL, Tau and GFAP	1[281]	117	Variable *best* thresholds at 24, 46, or 72 hr	4%-5%	12%-61%

GFAP indicates glial fibrillary acidic protein; MBP, myelin basic protein; NfL, neurofilament light chain; NSE, neuron-specific enolase; S100b, S100 calcium binding protein B; Tau, tau protein; and UCH-L1, ubiquitin carboxy-terminal hydrolase L1.

We suggest against using lactate and pH after return of circulation for predicting poor neurological outcome in children after cardiac arrest at any time point (weak recommendation, very low-certainty evidence).

There is insufficient evidence to make a recommendation for or against the use of other blood-based biomarkers (eg, S100 beta, neuron-specific enolase, neurofilament light chain, etc) after return of circulation for predicting poor neurological outcome in children after cardiac arrest at any time point.

Justification and Evidence-to-Decision Framework Highlights

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

Included studies were observational studies and RCTs, but not primarily designed to test prognosis of blood biomarkers.

Lactate and pH were nonspecific markers of hypoxia-ischemia following cardiac arrest. Extreme values (very high lactate, very low pH) have a low FPR in the included studies, but frequent outliers and very low sensitivity were reported.

Four studies identified threshold values across a range of blood-based biomarkers (S100b, NSE, myelin basic protein, UCH-L1, NfL, Tau, and glial fibrillary acidic protein) that are known to represent brain injury and are associated with poor neurological outcome with a low FPR. However, sensitivity was low and the wide range of reported thresholds preclude any accurate description of clinical utility. Furthermore, they are not widely available for clinical use, even though they only require the patient's blood.

No studies reported any assessment of the confounding influence of medication. None of the included studies specifically excluded the presence of residual sedation at the time clinical examination was assessed.

Lack of blinding is a major limitation of biomarker tests, even if the withdrawal of life-sustaining therapy based on test results has not been documented in any of the studies included in our review. No studies included blinding of clinicians to test results and only 1 study had blinded outcome assessment.

Knowledge Gaps

- The prognostic value of potential candidate biomarkers that are more specific for neurological injury (eg, NSE, S100b, NfL, glial fibrillary acidic protein, Tau, UCH-L1)
- Economic cost evaluation and cost-effectiveness of biomarker testing
- Optimal multimodal prognostication, including timing, definitions of testing, accurate outcome timing, and outcome definition
- Wider research and consultation with patients, children, parents, guardians and caregivers, health care professionals, and members of the wider society on understanding survivorship after pediatric cardiac arrest to inform correct definitions and framework of neurological outcome for prediction research

Clinical Examination for the Prediction of Poor Neurological Outcome After Return of Circulation Following Pediatric Cardiac Arrest (PLS 4220.02, SysRev 2025)

Intervention: Clinical examination, including every part of a bedside neurological clinical examination, including pupillary response (assessed using manual light reflex or automated pupillometry), conscious level (eg, Glasgow Coma Scale [GCS] score or Full Outline of Unresponsiveness score), and brainstem reflexes

Consensus on Science

Summary results of clinical examination tests and predictive accuracy are in Table 8.

Absence of the pupillary light reflex prior to 24 hours was not a reliable prognostic test. At 48 and 72 hours after ROC, FPR was less than 1% but 95% confidence intervals were wide.[280,282-287] No studies evaluated information from automated pupillometry.

Table 8. Clinical Examination Test Accuracy for Poor Neurological Outcome Prediction

Test domain	No. of studies	Patients n=	Time scale	False positive rate (estimate or range) [95% CI]	Sensitivity (range) or [95% CII]
Pupil reactivity	7[280,282-286]	312	<1 hr to 24 hr	10%-60%	33%-84%
Pupil reactivity	3[280,282,287]	139	48 hr and 72 hr	<1% [0%-40%]	12%-46%
GCS motor score <4	3[282,297,299]	252	<1 hr and at 4 to 6 hr	50%-83%	86%-94%
GCS<7	1[285]	152	24 hr	69% [41%-89%]	94% [73%-100%]
Motor response	1[282]	27	48 hr	20% [1%-72%]	73% [50%-89%]
Motor response	1[282]	29	72 hr	<1% [0%-28%]	61% [36%-83%]
Pain response	1[288]	41	6 hr to 12 hr	0% [0%-15%]	33% [13%-59%]
Cough or gag response	2[286]	153	24 hr	60% [36%-81%]	65%-68%
Pain response	1[287]	20	72 hr	8% [0%-38%]	75% [35%-97%]

GCS indicates Glasgow Coma Scale.

Total GCS[285] and GCS motor score of less than 4[279,294,296] as assessments of level of consciousness were not predictive of poor neurological outcome. GCS was an unreliable test and motor response was moderately reliable in only 1 study at 72 hours.[282] Presence of other brainstem reflexes (pain, gag reflex, and cough reflex) were infrequently reported and unreliable.[286-288]

Prior Treatment Recommendations (2015)

We suggest that practitioners use multiple variables when attempting to predict outcomes for infants and children after cardiac arrest (weak recommendation, very low-quality evidence).

No previous recommendation regarding use of clinical exam.

Treatment Recommendations (2025)

We recommend that no single clinical examination test be used in isolation to predict poor neurological outcome in children after cardiac arrest (strong recommendation, very low-certainty evidence).

Clinicians should use multiple tests in combination for poor neurological outcome prediction (good practice statement).

The absence of pupil reactivity to light at 48 and 72 hours after ROC may be considered as part of multi-modal testing to predict poor neurological outcome in children after cardiac arrest (good practice statement).

We suggest against using absence of pupil reactivity to light within 24 hours after ROC to predict poor neurological outcome in children after cardiac arrest (weak recommendation, low-certainty evidence).

We suggest against using GCS within 24 hours after ROC to predict poor neurological outcome in children after cardiac arrest (weak recommendation, low-certainty evidence).

There is insufficient evidence to make a recommendation for or against the use of other brainstem or motor response tests to predict poor neurological outcome in children after cardiac arrest at any time point.

Justification and Evidence-to-Decision Framework Highlights

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

For total GCS, GCS motor score and overall motor response, and brain stem tests, only 1 study was available (with small patient sample size) for each test and time point and therefore a suggestion or recommendation could not be made.

For all clinical examination modalities, the inaccuracy of outcome prediction tests may be due to confounding from the effect of sedatives used for delivery of neuroprotective interventions (eg, hypothermic temperature control) or to facilitate ventilation.

No studies reported any assessment of the confounding influence of medication.

No studies included blinding of test results from treating clinicians and only 1 study had blinded outcome assessment (for pupil light reactivity). Lack of blinding is a major limitation of clinical examination tests studies.

The studies inconsistently reported the co-intervention of temperature control on the clinical assessments that will be affected by hypothermia.

Despite its limitations, given the ease of conducting a bedside assessment, the balance between the costs and benefits favors benefits for the functional assessment of pupil light reactivity and coma.

Knowledge Gaps

- Clinical examination for prognostication after cardiac arrest appears promising, but more research is required in infants and children.
- The impact of residual medication or temperature on pupillary light reflex assessment, coma score and motor response in infants and children
- Costs and benefits of the use of automated pupillometry compared with simple pupillary light reflex assessment
- Economic cost and cost-effectiveness of clinical examination for prognostication of poor neurologic outcome
- Optimal approach to prognostication using multimodal approaches, timing, definitions of testing, accurate outcome timing and outcome definition
- We encourage wider research and consultation with patients, children, parents, guardians and caregivers, health care professionals and members of the wider society on understanding survivorship after pediatric cardiac arrest to inform correct definitions and framework of good neurological outcome for prediction research.

Electrophysiology Testing for the Prediction of Poor Neurological Outcome After ROC Following Pediatric Cardiac Arrest (PLS 4220.03, SysRev 2025)

Intervention: Electrophysiology testing, including surface bioelectrical recordings from the central nervous system such as electroencephalogram (EEG) and evoked potentials (EPs) (eg, brainstem auditory evoked potentials, and short-latency somatosensory evoked potentials [SSEPs]). We included studies of the interpretation of raw signals or summary measures derived from processed EEG signals such as amplitude-integrated EEG (aEEG), quantitative EEG (qEEG), or bispectral index.

Consensus on Science

Summary of electrophysiology tests, time scale and prediction accuracy are in Table 9.

Presence of clinical or electrographic seizures in children post-cardiac arrest as a prognostic test was unreliable.[275-277,283,288-297] Presence of status epilepticus at 4 to 72 hours predicted poor neurological outcome at ICU or hospital discharge, with a low FPR of 0%-5% (upper limit of 95% CI ranged 13%-41%)[287,290,295-297] and presence of myoclonic status epilepticus on EEG in '2 studies predicted with a FPR 0% (95% CI, 0%-34%).[288,294] Both were moderately reliable tests.

The absence of a benign continuous EEG background pattern was an inaccurate and unreliable method for predicting poor neurological outcome.[280,283,286-291,293-298]

The presence of an attenuated, isoelectric, or flat EEG after '24 hours had improved prediction accuracy; however, it was imprecise (at the FPR <1% cut off) in more than 50% of included studies.[280,283,286-291,293-298]

Presence of burst suppression, burst attenuation or generalized periodic epileptiform discharges after 24 to 72 hours had a FPR <1% (95% CI upper limit range, 16%-54%) in 3 of 4 studies and was moderately reliable.[287,288,297]

Absence of reactivity,[280,283,286-291,293-298] sleep II architecture or sleep spindles,[283,286] or variability on EEG[294,296] were unreliable tests for poor outcome prediction. A composite score assessing EEG background from a 24-hour monitoring period, obtained from quantitative EEG using the amplitude integrated EEG trace, was assessed in only 1 study and unreliable.[299]

SSEPs, evaluating bilateral absence of N2O waves, reported a FPR 0% (95% CI, 0%-52%) at 24 and 48 hours and 17% at 72 hours.[300] The test was moderately reliable to predict poor neurological outcome, but only assessed in 1 small study.

Table 9. Electrophysiology Tests Accuracy for Poor Neurological Outcome Prediction

Category	Study count (ref)	Patients n=	Time scale	False positive rate (estimate or range) [95% CI]	Sensitivity
Presence of clinical or electrographic seizure	11[275-277,283,288-297]	1308	4 hr-24 hr	0%-20% (3/11 <1% [0%-37%][290,293,294]	2%-38%
Presence of clinical or electrographic seizure	10[275-277,283,288-297]	1053	48 hr-72 hr	0%-42% (3/10 <10%)[275,291,294]	0%-58%
Presence of status epilepticus on EEG	5[287,290,295-297]	299	4 hr-72 hr	0%-5% [95% CI, upper limit 13%-41%]	9%-25%
Presence of myoclonic status epilepticus on EEG	2[288,294]	61	48 hr	0% [95% CI, 0%-34%]	17%-21%
Absence of continuous or normal background EEG*	14[280,283,286-291,293-298]	563	4 hr-72 hr	0%-91% (4/14 studies <10%)	7%-96%
Presence of attenuated, isoelectric or flat EEG background	4[286,290,296,298]	341	<24 hr	10%-90%	51%-100%
Presence of attenuated, isoelectric or flat EEG background	9[280,283,288,289,291,293-295,297,298]	526	24 hr-6 days	0%-71% (all) (7/9<10% [95% CI, upper limit 4%-52%])[283,288,289,291,293,294] (4/9 <1% [95% CI, upper limit 4%-5 2%][283,288,293,294]	17%-100%
Presence of burst suppression, burst attenuation or GPEDS on EEG	7[286,288-290,294,296,297]	395	<24 hr	0%-19% 4/7 <1% [95% CI, upper limit 16%-54%]	9%-30%
Presence of burst suppression, burst attenuation or GPEDS on EEG	4[287,288,297]	98	hours	0%-14% (all) (¾ studies[287,288,297] <1% [95% CI, upper limit 16%-54%])	0%-67%
Absence of reactivity	3[294,296,297]	222	6 hr-72 hr	0%-93%	36%-100%
Absence of sleep II architecture	2[283,286]	123	6 hr-24 hr	20%-43%	84%-92%
Absence of variability	2[294,296]	162	6 hr-48 hr	0%-80%	21%-82%
Quantitative EEG scoring	1[299]	30	24 hr	6% [0%-27%]	33%
Somatosensory evoked potential (SSEPs)†	1[300]	12	24 hr and 48 hr	0% [0%-52%]	100% [29-100]
Somatosensory evoked potential (SSEPs)t	1[300]	12	72 hr	17% [0%-64%]	100% [29-100]

*Defined as normal, continuous and reactive, continuous and unreactive, and nearly continuous by ACNS definitions.[301]

† Absence of N2O waves.

ACNS indicates American Clinical Neurophysiology Society; EEG, electroencephalogram; GPEDS, generalized periodic epileptiform discharges; and SSEP, somatosensory evoked potential.

Prior Treatment Recommendations (2015)

We suggest that the use of EEG within the first 7 days after pediatric cardiac arrest may assist in prognostication (weak recommendation, very low-quality evidence).

Treatment Recommendations (2025)

We recommend that no single electrophysiology test be used in isolation to predict poor neurological outcome in children after cardiac arrest at any time point (strong recommendation, very low-certainty evidence).

Clinicians should use multiple tests in combination for poor neurological outcome prediction (good practice statement).

The presence of status epilepticus between 24 to 72 hours after ROC, presence of burst suppression, burst attenuation or GPEDs between 24 to 72 hours after ROC, all had moderate reliability and may be considered as part of multimodal testing to predict poor neurological outcome in children after cardiac arrest (good practice statement).

We suggest against using the following EEG features for predicting poor neurological outcome: presence of clinical or electrographic seizures; absence of sleep spindle and sleep II architecture on EEG, continuous or normal background EEG, EEG reactivity and EEG variability, at any time point (weak recommendation, very low-certainty evidence).

There was insufficient evidence to make a recommendation for or against the use of presence of attenuated, isoelectric, or flat EEG, absence of N20 response on SSEPs, presence of myoclonic status epilepticus, or quantitative EEG score to predict poor neurological outcome in children after cardiac arrest at any time point.

Justification and Evidence-to-Decision Framework Highlights

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

The available scientific evidence had a high risk of bias based on high heterogeneity across studies, few studies and few patients included, lack of blinding, variation in test assessment and performance, and variability in outcome measurement. Overall assessment of test performance was based on visual assessment of forest plots.

Electrophysiology monitoring may enable reversible events (eg, seizures) to be identified, as well as providing prognostic information. Treatment of seizures may prevent additional secondary injury following a hypoxic-ischemic insult. The role of electrophysiology monitoring was not assessed for this purpose.

The complex interpretation of normality in background EEG patterns in preterm and term infants, and the impact of brain maturation on EEG patterns in infancy and childhood, requires expert neurophysiology input. Studies reported limited information on handling of this area and further refinement of definitions and application of recommendation are required.

SSEPs have high precision in adult studies of neuroprognostication in comatose patients after cardiac arrest.[302] The task force recognizes the lack of available data in children and strongly encourages further multicenter evaluation.

Knowledge Gaps

- Electrophysiology tests for prognostication after cardiac arrest appear promising but more research is required in infants and children.
- More research is required on type of monitoring, intermittent or continuous EEG, use of reduced channel monitoring, quantitative EEG systems, and duration and timing of prognostic assessment.
- Validation needed of ACNS[301] or other international definitions of EEG indices within the pediatric ICU environment for infants and children after cardiac arrest.
- Further work is needed on multimodal prognostication, timing, definitions of testing, accurate outcome timing and definition.
- We encourage wider research and consultation with patients, children, parents, guardians and caregivers, health care professionals and members of the wider society on understanding survivorship after pediatric cardiac arrest to inform correct definitions and framework of good neurological outcome for prediction research.

Brain Imaging for the Prediction of Poor Neurological Outcome After Return of Circulation Following Pediatric Cardiac Arrest (PLS 4220.04, SysRev 2025)

Intervention: Neuroimaging modalities. These modalities include head computed tomography (CT) and brain magnetic resonance imaging (MRI).

Consensus on Science

Head CT reported absence of gray-white matter differentiation or reversal sign at 24 hours was a moderately reliable test for poor neurological outcome prediction.[297,303] All other CT reported tests (presence of effacement of sulci or basal cisterns, presence of CT lesions, oedema, or intracranial hemorrhage) were unreliable for poor neurological outcome prediction.[280,297,303]

MRI apparent diffusion coefficient threshold $<650 \times 10^{-6}$ mm^2/s in $\geq 10\%$ of brain volume (indicating high ischemic burden), at a median of 4 days after ROC, predicted poor neurological outcome with FPR 0% to 6% (95% CI, 1%-21%) and sensitivity of 49% to 52%.[289,291,304] One study reached threshold for moderate reliability.[304]

Any region of abnormality on restricted diffusion, or individual regions of diffusion restriction did not meet our threshold for reliability.[287,291,304-306]

Table 10 summarizes results from CT and MRI imaging.

Treatment Recommendations (2025)

We recommend no single imaging test be used alone to predict poor neurological outcome in children after cardiac arrest at any time point (strong recommendation, very low-certainty evidence).

Clinicians should use multiple tests in combination for poor neurological outcome prediction (good practice statement).

An abnormal MRI showing high ischemic burden on apparent diffusion coefficient mapping at 72 hours and beyond after ROC or CT scan showing loss of gray-white matter differentiation within 24 hours after ROC may be considered as part of multimodal testing to predict poor neurological outcome in children after cardiac arrest (good practice statement).

Table 10. Brain Imaging for the Prediction of Poor Neurological Outcome

Category	Study count	Patients n=	Time scale	False positive rate (estimate or range) [95% CII]	Sensitivity
Head CT absence of GWM differentiation	2[297,303]	142	24 hr	0%-36%	20%-30%
Head CT presence of reversal sign	1[303]	78	24 hr	0% [0%-12%]	65%
Head CT presence of effacement of sulci or basal cisterns	2[297,303]	142	24 hr	0-7 [95% CI, upper limit 0%-30%]	27%-68%
Head CT presence of CT lesions, oedema, or intracranial hemorrhage	3[200,297,303]	173	24 hr	7%-17%	11%-68%
Magnetic resonance imaging (MRI) ADC threshold $<650x10^{-6}$ mm 2/s in ≥10% of brain volume	3[289,291,304]	250	4-7 days	0%-6% [1%-21%]	49%-52%
Magnetic resonance imaging (MRI) ADC threshold for high ischemic burden	1[304]	90	4-7 days	<1% [0%-21%]	80% [44%-97%]
Magnetic resonance imaging (MRI) Any region of abnormality on restricted diffusion	2[287,291]	97	4-7 days	12%-58%	98%-100%
Magnetic resonance imaging (MRI)-14 individual regions of the brain on DWI, T1, T2 weighted imaging	3[287,305,306]	67	4-7 days	0%-33% [95% CI, upper limit 23%-60%]	0%-57%

ADC indicates apparent diffusion coefficient; CT, computed tomography; DWI, diffusion-weighted imaging; GWM, gray-white matter; and MRI, magnetic resonance imaging.

Justification and Evidence-to-Decision Framework Highlights

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

The available scientific evidence had a high risk of bias based on high heterogeneity across studies, few studies and few patients included, lack of blinding, variation in test assessment and performance, and variability in outcome measurement. Overall assessment of test performance was based on visual assessment of forest plots.

The low FPR (high specificity) for abnormal MRI on global assessment for predicting poor neurological outcome reduces the chance of false pessimism if an abnormal MRI predicts a poor neurological outcome. FPR <1 % was only recorded for 1 study for global assessment of brain injury. Low FPR was identified during regional brain assessment, however in only a few cases, and with wide confidence limits on the point estimate.

The sensitivity of abnormal MRI or CT to predict a poor neurological outcome is moderate to high, but up to 40% may be falsely categorized and a falsely pessimistic prediction made.

The precision of MRI and CT is affected by the timing of the investigation and is at risk of pseudonormalization. The definition of a presence diffusion-weighted imaging or cut off values for apparent diffusion coefficient level on MRI, or gray-to-white matter ratio on CT was inconsistent in the included studies.

MRI and CT are both expensive tests and require specialist equipment, training, interpretation and most often, patient transport to obtain the information. This may be prohibitive in physiologically unstable patients, or some health care settings.

Task Force Knowledge Gaps

- Neuroimaging for prognostication after cardiac arrest appears promising, but more research is required in infants and children.
- Standardization of definitions and assessment of optimal thresholds for gray-to-white matter ratio calculation on CT, and diffusion-weighted imaging, apparent diffusion coefficient thresholds on MRI
- The optimal timing for prognostication using CT and MRI after cardiac arrest
- The role of assessing regional areas of the brain for predicting outcome, or the use of magnetic resonance spectroscopy
- Economic cost evaluation and cost-effectiveness studies on the use of CT and MRI for prognostication

A summary of the treatment recommendation and good practice statements is illustrated in the Figure.

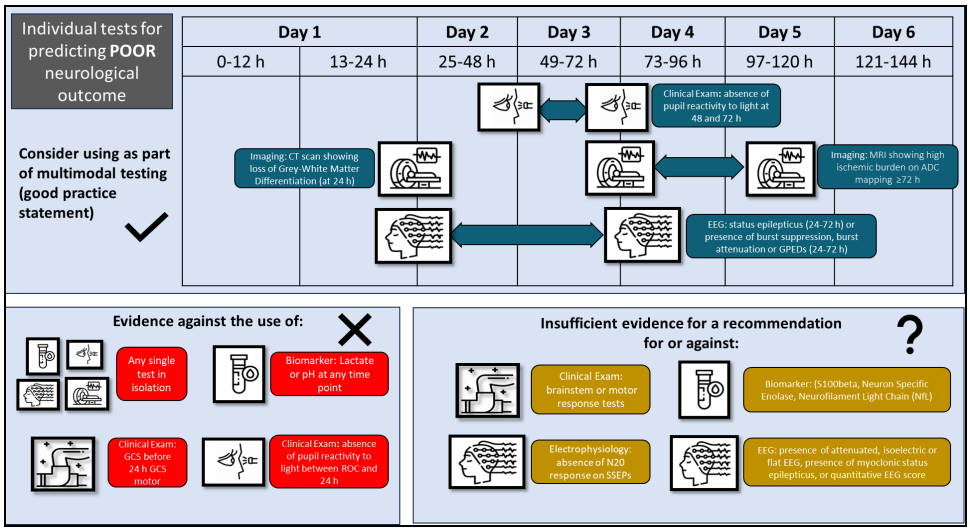

Figure. Summary of treatment recommendations and good practice statement for poor outcome prediction after pediatric cardiac arrest.

Prediction of Survival With Good Neurological Outcome After Return of Circulation Following Pediatric Cardiac Arrest-Combined Prognostic SysRev (PLS 4220.05, 4220.06, 4220.07, 4220.08, SysRev 2023)

The PLS Task Force conducted a SysRev of prognostication of favorable neurologic outcome in 2023.[268] Details of this CoSTR can be found in the 2023 CoSTR summary.[126,127]

Population, Intervention, Comparator, Outcome, and Time Frame (for All Neuroprognostication)

- Population: Children (<18 years of age) who achieve a return of circulation (ROC, which includes ROSC or mechanical circulation) after resuscitation from IHCA and OHCA, from any cause
  - Studies that included newborn infants or patients in hypoxic coma from causes without a cardiac arrest (eg, respiratory arrest, toxidromes, drowning, hanging) were excluded, except when a subpopulation of cardiac arrest patients could be evaluated separately.
- Intervention: Index prognostic tests, recorded at one or more of the following time points: <12 hours, 12 hours to <24 hours, 24 hours to <48 hours, 48 hours to <72 hours, 72 hours to <7 days, or 7 days to 10 days after cardiac arrest
- Comparator: There was no control group for intervention/exposure. The accuracy of the prognostic index test was assessed by comparing the predicted outcome with the final outcome, which represents the comparator.
- Outcome:
  - Critical: prediction of survival with good neurological outcome (defined as a Pediatric Cerebral Performance Category score of 1, 2, or 3 or Vineland Adaptive Behavioral Scale-II ≥70) at the pediatric intensive care unit or hospital discharge, 1 month or later
- Time frame: January 1, 2010, to December 31, 2022

Treatment Recommendations (2023)

All evaluated tests were used in combination with other tests by clinicians in these studies. Although the predictive accuracy of tests was evaluated individually, we recommend that no single test should be used in isolation for prediction of good neurological outcome (good practice statement).

We suggest using pupillary light reflex within 12 hours after ROC for predicting good neurological outcome in children after cardiac arrest (weak recommendation, very low-certainty evidence).

We cannot make a recommendation for or against using total GCS, GCS motor score, or motor response after ROC for predicting good neurological outcome in children after cardiac arrest.

We cannot make a recommendation for or against the use of other brainstem tests after ROC for predicting good neurological outcome in children after cardiac arrest. We suggest using a normal plasma lactate value (<2 mmol/L) up to 12 hours following ROC for predicting good neurological outcome of children after cardiac arrest (weak recommendation, very low-certainty evidence).

We cannot make a recommendation for or against using time-to-lactate clearance within 48 hours following ROC for predicting good neurological outcome.

We suggest against using pH following ROC for predicting good neurological outcome after cardiac arrest (weak recommendation, very low-certainty evidence).

We cannot make a recommendation for or against the use of blood neurobiomarkers (eg, S1 00b, NSE) after ROC for predicting good neurological outcome in children after cardiac arrest.

We suggest using EEG within 6 to 72 hours after ROC for predicting good neurological outcome in children after cardiac arrest (weak recommendation, low-certainty evidence).

We suggest using the following EEG features after ROC for predicting good neurological outcome: presence of sleep spindle and sleep II architecture at 12 to 24 hours, or continuous or normal background EEG between 1 and 72 hours, or EEG reactivity between 6 to 24 hours (weak recommendation, very low-certainty evidence).

We suggest against using the following EEG features after ROC to predict good neurological outcome: absence of clinical or electrographic seizures; absence of status epilepticus; absence of myoclonic epilepsy; absence of burst suppression, burst attenuation, or generalized periodic epileptiform discharges; or absence of attenuated, isoelectric, or flat EEG (weak recommendation, very low-certainty evidence).

We cannot make a recommendation for or against the use of the presence or absence of N20 response SSEPs after ROC for predicting good neurological outcome.

We cannot make a recommendation for or against the use of EEG variability or EEG voltage or quantitative EEG score for predicting good neurological outcomes.

We suggest against using normal CT imaging at 24 to 48 hours from ROC for predicting good neurological outcome (weak recommendation, very low-certainty evidence).

We suggest using normal MRI between 72 hours and 2 weeks after ROC for predicting good neurological outcome (weak recommendation, low-certainty evidence).

We cannot make a recommendation for or against the use of transcranial Doppler ultrasound for predicting good neurological outcome.

Effect of Prophylactic Antiseizure Medication or Treatment of Seizures on Outcome of Children Following Cardiac Arrest (PLS 4210.02: SysRev 2024 CoSTR Summary)

Administration of prophylactic anti-seizure medication to prevent seizures or treatment of seizures was addressed in a SysRev in 2024, and details can be found in the 2024 CoSTR summary.[73,74]

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Adults or children in any setting (IHCA or OHCA) with ROC
- Intervention: One strategy for prophylactic anti-seizure medication OR seizure treatment
- Comparators: Another strategy or no prophylactic anti-seizure medication OR seizure treatment
- Outcomes:
  - Critical: survival; survival with favorable neurological outcome
- Time frame: All years up to September 11, 2023

Treatment Recommendations (2024)

We suggest against the routine use of prophylactic anti-seizure medication in children post-cardiac arrest (good practice statement).

We suggest the treatment of seizures in children post-cardiac arrest (good practice statement).

Post-ROSC Oxygenation and Ventilation (PLS 4180.01 and PLS 4180.02, SysRev 2019, EvUp 2025)

Population, Intervention, Comparator, Outcome, and Time Frame

- Population: Infants and children (excluding newborn infants) who achieve ROC after out-of-hospital or in-hospital cardiac arrest
- Intervention: A ventilation and oxygenation strategy targeting a specific oxygen saturation as measured by a pulse oximeter (SpO_2), PaO_2, or $PaCO_2$
- Comparators: Treatment without specific targets or with an alternate target to the intervention
- Outcomes: Any clinical outcome
- Time frame: July 1, 2019, to June 20, 2024

Summary of Evidence

Our EvUp identified 4 new observational pediatric studies[307-310] on this topic. One study[309] found an association between hypoxemia and hypercapnia and the critical outcomes of favorable neurologic outcome and survival to hospital discharge, while the other studies found no overall association. In 1 study,[307] increased cumulative $PaCO_2$ exposure was associated with lower survival to hospital discharge among infants. An updated SysRev is warranted.

Treatment Recommendation (2020)

We suggest that rescuers measure Pao_2 after ROSC and target a value appropriate to the specific patient condition. In the absence of specific patient data, we suggest rescuers target normoxemia after ROSC (weak recommendation, very low-quality evidence).[110-112]

Given the availability of continuous pulse oximetry, targeting an oxygen saturation of 94% to 99% may be a reasonable alternative to measuring PaO_2 for titrating oxygen when feasible to achieve normoxia (based on expert opinion).[110-112]

We suggest that rescuers measure $PaCO_2$ after ROSC and target normocapnia (weak recommendation, very low-certainty evidence).[110-112]

Consider adjustments to the target $PaCO_2$ for specific patient populations where normocapnia may not be desirable (eg, chronic lung disease with chronic hypercapnia, congenital heart disease with single-ventricle physiology, increased intracranial pressure with impending herniation) (good practice statement).[110-112]

PLS Task Force PICOSTs Not Reviewed by SysRev or ScopRev (2021 to 2025)

A list of topics not reviewed with a SysRev of ScopRev since 2020 is provided in Table 11. In cases where an EvUp was conducted since 2020 this is indicated. Several topics reviewed by other ILCOR task forces have included children in their search, in some cases generating statements that include children. A list of these topics and the year they were last reviewed, and by which task force, is provided in Appendix C.

Topics retired in 2025 are listed in Table 12.

Table 11. Topics Not Reviewed With a SysRev of ScopRev Since 2020

PLS 4030.01	Adenosine use in SVT during resuscitation (EvUp 2023)
PLS 4030.04	Cardiogenic shock and inotropes
PLS 4030.08	Drugs for unstable tachycardia (SVT or wide complex)
PLS 4030.19	Prearrest care of pediatric dilated cardiomyopathy or myocarditis (EvUp 2024)
PLS 4030.31	Pre-arrest IV/10 bolus vasopressor (epinephrine)
PLS 4050.03	Pediatric METs and RRTs (EvUp 2022)
PLS 4070.01	FIO_2 titrated to oxygenation during cardiac arrest (EvUp 2023)
PLS 4070.04	Timing of intubation for IHCA
PLS 4080.02	Adhesive pads versus paddles for defibrillation
PLS 4080.06	Chest compression depth
PLS 4080.07	Chest compression only CPR versus conventional CPR (EvUp 2022)
PLS 4080.08	CPR feedback device
PLS 4080.1	Chest compression rate
PLS 4080.11	Effect of chest compression pause duration
PLS 4080.13	Heads up CPR
PLS 4080.14	Interposed abdominal compression CPR
PLS 4080.16	One hand versus 2 hand compressions (and circumferential)
PLS 4080.2	Synced/nonsynced shock for ventricular tachycardia
PLS 4080.23	Chest compression recoil
PLS 4080.24	Chest compression-to-ventilation ratios
PLS 4080.25	Tidal volumes (chest rise)
PLS 4100.01	Family presence during resuscitation
PLS 4120.01	Ventilation rate in pediatric respiratory arrest with a perfusing rhythm present (EvUp 2024)
PLS 4150.01	Methods of calculating pediatric drug doses for cardiac arrest

PLS 4160.01	Channelopathy and consideration of etiology of arrest
PLS 4160.06	Intracardiac arrest monitoring clinical prognostic factors for cardiac arrest in infants and children
PLS 4160.12	Resuscitation of the pediatric patient with a single ventricle, post Stage I repair (EvUp 2023)
PLS 4160.13	Resuscitation of the pediatric patient with hemi-Fontan/ bidirectional Glenn circulation (EvUp 2023)
PLS 4160.14	Resuscitation of the pediatric patient with single-ventricle, status-post Stage III/Fontan/total cavopulmonary connection/anastomosis (EvUp 2023)
PLS 4160.16	Point of care ultrasound for identification of reversible **causes**
PLS 4190.02	Post-ROSC inotrope approach
PLS 4210.01	Monitor kidney function and urine output as dialysis may be required
PLS 4210.03	Post-ROSC targeted temperature management (EvUp 2022)
PLS 4210.06	Follow-up clinics to improve survivorship
PLS 4221.01	Multimodal prognostic model for neuroprognostication

CPR indicates cardiopulmonary resuscitation; IHCA, in-hospital cardiac arrest; IO, intraosseous; IV, intravenous; MET, medical emergency team; ROSC, return of spontaneous circulation; RRT, rapid response team; and SVT, supraventricular tachycardia.

Table 12. PLS Task Force PICOSTs Retired 2025

PLS 4010.01	Atropine use for emergency intubation
PLS 4010.02	Formulas for ETT size
PLS 4020.01	Negative pressure ventilation in congenital heart disease patients
PLS 4020.02	Optimal ventilation strategy for Fontan or hemi-Fontan/ bidirectional Glenn physiology in periarrest state
PLS 4020.03	Ventilation target for infants with congenital heart disease preoperatively
PLS 4030.05	Corticosteroids for septic shock
PLS 4030.06	Diagnostic tests for shock
PLS 4030.07	Distributive shock and inotropes
PLS 4030.12	Etomidate and septic shock
PLS 4030.13	Fluid resuscitation in septic shock
PLS 4030.14	Graded volume resuscitation for traumatic shock
PLS 4030.15	Timing of Intubation for shock
PLS 4030.16	Low cardiac output stage post-congenital heart disease surgery blood pressure management
PLS 4030.17	Medical treatment of excessive QP:QS circulation in neonatal congenital heart disease
PLS 4030.18	Postoperative care of child with pulmonary hypertension
PLS 4030.24	Shock vasoconstrictors
PLS 4030.26	Treatment of high-risk myocarditis patients
PLS 4030.27	Type of fluid for septic shock
PLS 4030.28	Volume of fluid for septic shock
PLS 4030.32	Cardioversion for SVT
PLS 4050.01	Cervical spine management
PLS 4080.05	Chest compression only CPR for intubated neonates outside of delivery room
PLS 4090.03	ET versus IV drugs
PLS 4110.01	Cricoid pressure for kids
PLS 4110.02	Cuffed versus uncuffed ETTs
PLS 4110.03	Verification of airway placement
PLS 4160.04	Infants and children in cardiac arrest with sepsis

ET indicates endotracheal; ETT, endotracheal tube; IV, intravenous; and SVT, supraventricular tachycardia.

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Disclosures

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*Modest

†Significant

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This table represents the relationships of reviewers that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all reviewers are required to complete and submit A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest

†Significant

REFERENCES

1. International Liaison Committee on Resuscitation. ILCOR CoSTR website. Accessed February 20, 2025. https: /costr.ilcor.org
2. Morley PT, Berg KM, Billi JE, Nolan JP, Montgomery WH, Atkins DL, Bray JE, Carlson JN, de Caen AR, Djii.rv T, et al. Methodology and conflict of interest management: 2025 International Liaison Committee on Resuscitation Consensus on Science With Treatment Recommendations. *Circulation.* 2025;152(suppl 1):S23-S33. doi: 10.1161/CIR.0000000000001366
3. Peters MDJ, Marnie C, Tricco AC, Pollock D, Munn Z, Alexander L, Mcinerney P, Godfrey CM, Khalil H. Updated methodological guidance for the conduct of scoping reviews. *JBI Evid Implement.* 2021;19:3-10. doi: 10.1097/XEB.0000000000000277
   Topjian AA, Scholefield BR, Pinto NP, Fink EL, Buysse CMP, Haywood K, Maconochie I, Nadkarni VM, de Caen A, Escalante-Kanashiro R, et al. P-COSCA (Pediatric Core Outcome Set for Cardiac Arrest) in Chil dren: An Advisory Statement From the mittee on Resuscitation. *Resuscitation.* 10.1016/j.resuscitation.2021.01.023
4. Topjian AA, Scholefield BR, Pinto NP, Fink EL, Buysse CMP, Haywood K, Maconochie I, Nadkarni VM, de Caen A, Escalante-Kanashiro R, 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;162:351–364. doi: 10.1016/j.resuscitation.2021.01.023
5. International Liaison Committee on Resuscitation. ILCOR website. Accessed February 19, 2025. https://www.ilcor.org/home
6. Topjian AA, Raymond TT, Atkins D, Chan M, Duff JP, Joyner BL Jr., Lasa JJ, Lavonas EJ, Levy A, Mahgoub M, et al; on behalf of the Pediatric Basic and Advanced Life Support Collaborators. Part 4: Pediatric Basic and Advanced Life Support: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation.* 2020;1 42:S469-S523. doi: 10.1161/Cl R.0000000000000901
7. Holmberg MJ, Ross CE, Yankama T, Roberts JS, Andersen LW; American Heart Association's Get With The Guidelines®-Resuscitation Investigators. Epinephrine in children receiving cardiopulmonary resuscitation for bradycardia with poor perfusion. *Resuscitation.* 2020;149:180-190. doi: 10.1016/j.resuscitation.2019.12.032
8. Topjian A, Scholefield BR, Gray J, Ashworth J, Kienzle M, Ross C, O'halloran A, Gray S, Morrison LJ, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. *Bradycardia with haemodynamic compromise - a scoping review: Consensus on Science with Treatment Recommendations* [Internet] Brussels, Belgium, International Liaison Committee on Resuscitation (ILCOR) Pediatric Life Support Task Force. Accessed January 20, 2025. https://costr.ilcor.org/document/bradycardia-with-haemodynamic-compromise-in-children-pls-4030-30-tf-scr. 2025
9. Khera R, Tang Y, Girotra S, Nadkarni VM, Link MS, Raymond TT, Guerguerian AM, Berg RA, Chan PS; American Heart Association's Get With the Guidelines-Resuscitation Investigators. Pulselessness after Initiation of Cardiopulmonary Resuscitation for Bradycardia in Hospitalized Children: Prevalence, Predictors of Survival, and Implications for Hospital Profiling. *Circulation.* 2019;140:370-378. doi: 10.1161/CIRCULATIONAHA.118.039048
10. AI-Eyadhy A, Almazyad M, Hasan G, Alkhudhayri N, Alsaeed AF, Habib M, Alhaboob AAN, Alayed M, Alsehibani Y, Alsohime F, et al. Outcomes of Cardiopulmonary Resuscitation in the Pediatric Intensive Care of a Tertiary Center. *J Pediatr Intensive Care.* 2021;12:303-311. doi: 10.1055/s-0041-1733855
11. Bae G, Eun SH, Yoon SH,Kim HJ, Kim HR, Kim MK, Lee HN, Chung HS, Koo C. Mortality after cardiac arrest in children less than 2 years: relevant factors. *Pediatr Res.* 2024;95:200-204. doi: 10.1038/s41390-023-02764-2
12. Donoghue A, Berg RA, Hazinski MF, Praestgaard AH, Roberts K, Nadkarni VM; American Heart Association National Registry of CPR Investigators. Cardiopulmonary resuscitation for bradycardia with poor perfusion versus pulseless cardiac arrest. *Pediatrics.* 2009;124:1541-1548. doi: 10.1542/peds.2009-0727
13. Ganesan RG, Das S, Parameswara N, Biswal N, Pabhu A Survival after in-hospital cardiac arrest among paediatric patients-A descriptive study. *J Clin Diagn Res.*2018;12:SC04-SC09. doi: 10.7860/ JCDR/2018/32395.11175
14. Handley SC, Passarella M, Raymond TT, Lorch SA, Ades A, Foglia EE. Epidemiology and outcomes of infants after cardiopulmonary resuscitation in the neonatal or pediatric intensive care unit from a national registry. *Resuscitation.* 2021;1 65:1 4-22. doi: 10.1016/j.resuscitation.2021.05.029
15. Haque A, Rizvi A, Sano S. Outcome of in-hospital pediatric cardiopulmonary arrest from a single center in Pakistan. *Indian J Pediatr;* 2011;78:1356-1360. doi: 10.1007/s 12098-011-0439-4
16. Kienzle MF, Morgan RW, Faerber JA, Graham K, Katcoff H, Landis WP, Topjian AA, Kilbaugh TJ, Nadkarni VM, Berg RA, et al. The effect of epinephrine dosing intervals on outcomes from pediatric in-hospital cardiac arrest *Am J Respir Crit Care Med.* 2021;204:977-985. doi: 10.1164/rccm.202012-44370C
17. Lasa JJ, Alali A, Minard CG, Parekh D, Kully S, Gaies M, Raymond TT, Guerguerian AM, Atkins D, Foglia E, et al; on behalf of the American Heart Association's Get With the Guidelines-Resuscitation Investigators. Cardiopulmonary Resuscitation in the Pediatric Cardiac Catheterization Laboratory: A Report from the American Heart Association's Get with the Guidelines-Resuscitation Registry·. *Pediatr Crit Care Med.* 2019;20:1040-1047. doi: 10.1097/PCC.0000000000002038
18. Meert K, Telford R, Holubkov R, Slomine BS, Christensen JR, Berger J, Ofori-Amanfo G, Newth CJL, Dean JM, Moler FW. Paediatric in-hospital cardiac arrest: Factors associated with survival and neurobehavioural outcome one year later. *Resuscitation.* 2018;124:96-105. doi: 10.1016/j.resuscitation.2018.01.013
19. Morgan RW, Landis WP, Marquez A, Graham K, Roberts AL, Lauridsen KG, Wolfe HA, Nadkarni VM, Topjian AA, Berg RA, et al. Hemodynamic effects of chest compression interruptions during pediatric in-hospital cardiopulmonary resuscitation. *Resuscitation.* 2019;139:1-8. doi: 10.1016/j.resuscitation.2019.03.032
20. Morgan RW, Reeder RW, Ahmed T, Bell MJ, Berger JT, Bishop R, Bochkoris M, Burns C,Carcillo JA, Carpenter TC, et al. Outcomes and characteristics of cardiac arrest in children with pulmonary hypertension: A secondary analysis of the ICU-RESUS clinical trial. *Resuscitation.* 2023;190:109897. doi: 10.1016/j.resuscitation.2023.109897
21. Rathore V, Bansal A, Singhi SC, Singhi P, Muralidharan J. Survival and neurological outcome following in-hospital paediatric cardiopulmonary resuscitation in North India. *Paediatr Int Child Health.* 2016;36:141-147. doi: 10.1179/2046905515Y.0000000016
22. Reis AG, Nadkarni V, Perondi MB, Grisi S, Berg RA. A prospective investigation into the epidemiology of in-hospital pediatric cardiopulmonary resuscitation using the international Utstein reporting style. *Pediatrics.* 2002;109:200-209. doi: 10.1542/peds.109.2.200

23. Shimoda-Sakano TM, Paiva EF, Schvartsman C, Reis AG. Factors associated with survival and neurologic outcome after in-hospital cardiac arrest in children: A cohort study. *Resusc Plus.* 2023;13:100354. doi: 10.1016/j.resplu.2022.100354
24. Skellett S, Orzechowska I, Thomas K, Fortune PM. The landscape of paediatric in-hospital cardiac arrest in the United Kingdom National Cardiac Arrest Audit. *Resuscitation.* 2020;155:165-171. doi: 10.1016/j.resuscitation.2020.07.026
25. Zeng J, Qian S, Zheng M, Wang Y, Zhou G, Wang H. The epidemiology and resuscitation effects of cardiopulmonary arrest among hospitalized children and adolescents in Beijing: An observational study. *Resuscitation.* 2013;84:1685-1690. doi: 10.1016/j.resuscitation.2013.08.007
26. Zinna SS, Morgan RW, Reeder RW, Ahmed T, Bell MJ, Bishop R, Bochkoris M, Burns C, Carcillo JA, Carpenter TC, et al. Chest compressions for pediatric organized rhythms: A hemodynamic and outcomes analysis. *Resuscitation.* 2024;194:110068. doi: 10.1016/j.resuscitation.2023.110068
27. Ding X, Liu G, Qian S, Zeng J, Wang Y, Chu J, Chen 0, Chen J, Duan Y, Jin D, et al. Epidemiology of Cardiopulmonary Arrest and Outcome of Resuscitation in PICU Across China: A Prospective Multicenter Cohort Study. *Front Pediatr.* 2022;10:811819. doi: 10.3389/fped.2022.811819
28. Holmberg MJ, Wiberg S, Ross CE, Kleinman M, Hoeyer-Nielsen AK, Donnino MW, Andersen LW. Trends in Survival After Pediatric In-Hospital Cardiac Arrest in the United States. *Circulation.* 2019;140:1398-1408. doi: 10.1161/CIRCULATIONAHA.119.041667
29. Atabek ME, Aydin K, Erkul **I.** Different clinical features of amitraz poisoning in children. *Hum Exp Toxicol.* 2002;21:13-16. doi: 10.1191/09603271 02ht207oa
30. O'Halloran AJ, Reeder RW, Berg RA, Ahmed T, Bell MJ, Bishop R, Bochkoris M, Burns C, Carcillo JA, Carpenter TC, et al. Early bolus epinephrine administration during pediatric cardiopulmonary resuscitation for bradycardia with poor perfusion: an ICU-resuscitation study. *Crit Care.* 2024;28:242. doi: 10.1186/s 13054-024-05018-7
31. Moskowitz A, Pocock H, Lagina A, Ng KC, Scholefield BR, Zelop CM, Bray J, Rossano J, Johnson NJ, Dunning J, et al; on behalf of the ILCOR Advanced Life Support, Basical Life Support, and Pediatric Life Support Task Forces. Resuscitation of patients with durable mechanical circulatory support with acutely altered perfusion or cardiac arrest: A scoping review. *Resuscitation.* 2024;203:110389. doi: 10.1016/j.resuscitation.2024.110389
32. Moskowitz A, Pocock H, Lagina A, Chong-Ng K, Scholefield BR, Zelop C, Bray J, Rossano J, Johnson NJ, Dunning J, et al. *Resuscitation of Patients with Durable Mechanical Circulatory Support with Acutely Altered Perfusion or Cardiac Arrest: A Scoping Review - Consensus on Science with Treatment Recommendations* [Internet] Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Adult, Basic and Pediatric Life Support Task Force. Accessed February 19, 2025. https://costr.ilcor.org/document/resuscitation-of-durable-mechanical-circulatory-supported-patients-with-acutely-altered-perfusion-or-cardiac-arrest-als-scr. 2025.
33. Akin S, Ince C, Struijs A, Caliskan K. Case Report: Early Identification of Subclinical Cardiac Tamponade in a Patient With a Left Ventricular Assist Device by the Use of Sublingual Microcirculatory Imaging: A New Diagnostic Imaging Tool? *Front Cardiovasc Med.* 2022;9:818063. doi: 10.3389/fcvm.2022.818063
34. Andersen M, Videbaek R, Boesgaard S, Sander K, Hansen PB, Gustafsson F. Incidence of ventricular arrhythmias in patients on long-term support with a continuous-flow assist device (HeartMate II). *J Heart Lung Transplant.* 2009;28:733-735. doi: 10.1016/j.healun.2009.03.011
35. Barssoum K, Patel H, Rai D, Kumar A, Hassib M, Othman HF, Thakkar S, El Karyoni A, Idemudia 0, Ibrahim F, et al. Outcomes of Cardiac Arrest and Cardiopulmonary Resuscitation in Patients With Left Ventricular Assist Device; an Insight From a National Inpatient Sample. *Heart Lung Circ.* 2022;31:246-254. doi: 10.101 6/j.hlc.2021.05.096
36. Bouchez S, De Somer F, Herek I, Van Belleghem Y, De Pauw M, Stroobandt R. Shock-refractory ventricular fibrillation in a patient implanted with a left ventricular assist device. *Resuscitation.* 2016;107:e1-e2. doi: 10.1016/j.resuscitation.2016.06.034
37. Brenyo A, Joshi N, Aktas M. Successful therapeutic hypothermia for cardiac arrest in a patient with a left ventricular assist device. *Resuscitation.* 2011;82:e19. doi: 10.1016/j.resuscitation.2011.07.035
38. Cubillo El, Weis RA, Ramakrishna H. Emergent reconnection of a transected left ventricular assist device driveline. *J Emerg Med.* 2014;47:546-551. doi: 10.1016/j.jemermed.2014.07.028
39. Doita T, Kawamura T, Inoue K, Kawamura A, Kashiyama N, Matsuura R, Saito T, Yoshioka D, Toda K, Miyagawa S. Sudden severe left ventricular assist device inflow cannula obstruction caused by huge thrombus after closure of mechanical aortic valve: case report. *J Artif Organs.* 2022;25:364-367. doi: 10.1007/s10047-022-01332-5
40. Duff JP, Decaen A, Guerra GG, Lequier L, Buchholz H. Diagnosis and management of circulatory arrest in pediatric ventricular assist device patients: presentation of two cases and suggested guidelines. *Resuscitation.* 2013;84:702-705. doi: 10.1016/j.resuscitation.2012.09.032
41. Esangbedo ID, Yu P. Chest Compressions in Pediatric Patients With Continuous-Flow Ventricular Assist Devices: Case Series and Proposed Algorithm. *Front Pediatr.* 2022;10:883320. doi: 10.3389/fped.2022.883320
42. Eyituoyo HO, Aben RN, Arinze NC, Vu DP, James EA. Ventricular Fibrillation 7 Years After Left Ventricular Assist Device Implantation. *Am J Case Rep.* 2020;21:e923711. doi: 10.12659/AJCR.923711
43. Garg S, Ayers CR, Fitzsimmons C, Meyer D, Peltz M, Bethea B, Cornwell W, Araj F, Thibodeau J, Drazner MH. In-hospital cardiopulmonary arrests in patients with left ventricular assist devices. *J Card Fail.* 2014;20:899-904. doi: 10.1016/j.cardfail.2014.10.007
44. Godishala A, Nassif ME, Raymer DS, Hartupee J, Ewald GA, Larue SJ, Vader J M. A Case Series of Acute Myocardial Infarction in Left Ventricular Assist Device-Supported Patients. *ASAIO J.* 2017;63:e 18-e24. doi: 10.1097/MAT.0000000000000401
45. Haglund NA, Schlendorf K, Keebler **M,** Gupta C, Maltais S, Ely EW, Lenihan D. Is a palpable pulse always restored during cardiopulmonary resuscitation in a patient with a left ventricular assist device? *Am J Med Sci.* 201 4;347:322-327. doi: 10.1097/MAJ.0000000000000219
46. Harper R, Ludwig J, Morcos **M,** Morris S. Myocardial Irritation from a Left Ventricular Assist Device Resulting in Refractory Ventricular Tachycardia. *J Emerg Med.* 2019;56:87-93. doi: 10.1016/j.jemermed.2018.09.013
47. Iwashita Y, Ito A, Sasaki K, Suzuki K, Fujioka M, Maruyama K, Imai H. Cardiopulmonary resuscitation of a cardiac arrest patient with left ventricular assist device in an out-of-hospital setting: A case report. *Medicine (Baltim).* 2020;99:e18658. doi: 10.1097/MD.0000000000018658
48. Mulukutla V, Lam W, Simpson L, Mathuria N. Successful catheter ablation of hemodynamically significant ventricular tachycardia in a patient with biventricular assist device support. *Hear/Rhythm Case* Rep.201 5;1:209-212. doi: 10.1016/j.hrcr.2015.02.015
49. Oates CP, Towheed A, Hadadi CA. Refractory hypoxemia from intracardiac shunting following ventricular tachycardia ablation in a patient with a left ventricular assist device. *Hear/Rhythm Case Rep.* 2022;8:760-764. doi: 10.1016/j.hrcr.2022.08.008
50. Ornato JP, Louka A, Grodman SW, Ferguson JD. How to determine whether to perform chest compressions on an unconscious patient with an implanted left ventricular assist device. *Resuscitation.* 2018;1 29:e12-e13. doi: 10.1016/j.resuscitation.2018.05.024
51. Plymen C, Pettit SJ, Tsui S, Lewis C. Right ventricular failure due to late embolic RV infarction during continuous flow LVAD support. *BMJ Case Rep.* 2015;2015:bcr2015212174. doi: 10.1136/bcr-2015-212174
52. Pokrajac N, Cantwell LM, Murray J M, Dykes JC. Characteristics and Outcomes of Pediatric Patients With a Ventricular Assist Device Presenting to the Emergency Department. *Pediatr Emerg Care.* 2022;38:e924-e928. doi: 10.1097/PEC.0000000000002493
53. Ratman K, Bietka A, Kalinowski ME, Herdyriska-W&s MM, Przybytowski P, Zembala MO. Permanent cardiac arrest in a patient with a left ventricular assist device support. *Kardiol Pol.* 2022;80:709-710. doi: 10.33963/KP.a2022.0115
54. Retherford L,Miller S, Takayama H,Sladen R. 1222: Resuscitation of a 46 Year Old Woman With Heartmate **II** LVAD:Two Resuscitations, Two Outcomes. *Crit Care Med.* 2012;40:1-328. doi: 10.1097/01.ccm.0000425434.69410.a9
55. Rottenberg EM. eComment. The thoracic configuration of patients with left ventricular assist devices likely determines whether cardiopulmonary resuscitation using sternal compressions is both safe and effective. *Interact Cardiovasc Thorac Surg.* 201 4;19:289. doi: 10.1093/icvts/ivu 199
56. Saito S, Toda K, Miyagawa S, Yoshikawa Y, Hata H, Yoshioka D, Kainuma S, Yoshida S, Sawa Y. Therapeutic hypothermia after global cerebral ischemia due to left ventricular assist device malfunction. *J Artif Organs.* 2019;22:246-248. doi: 10.1007/s10047-019-01099-2
57. Sande Mathias I, Burkhoff D, Bhimaraj A. Cardiac Tamponade With a Transaortic Percutaneous Left Ventricular Assist Device: When Alarms Caused No Alarm. *JACC* Case *Rep.* 2023;19:101936. doi: 10.1016/j.jaccas.2023.101936

58. Schweiger M, Vierecke J, Stiegler P, Prenner G, Tscheliessnigg KH, Wasler A. Prehospital care of left ventricular assist device patients by emergency medical services. *Prehosp Emerg Care.* 2012;16:560-563. doi: 10.3109/10903127.2012.702192
59. Senman B, Pierce J, KittipibuI V, Barnes S, Whitacre M, Katz J N. Safety of Chest Compressions in Patients With aDurable Left Ventricular Assist Device. *JACC Heart Fail.* 2024;12:1928-1930. doi: 10.101 6/j.jchf.2024.03.004
60. Shinar Z, Bellezzo J, Stahovich M, Cheskes S, Chillcott S, Dembitsky W. Chest compressions may be safe in arresting patients with left ventricular assist devices (LVADs). *Resuscitation.* 201 4;85:702-704. doi: 10.1016/j.resuscitation.2014.01.003
61. Theeuwes C, Frost M, Vierecke J. (813) Prolonged Cardiopulmonary Resuscitation with Lucas Device in a Patient with Left Ventricular Assist Device. *J Heart Lung Transplant* 2023;42:S356. doi: 10.101 6/j.healun.2023.02.826
62. Thiele J, Matusch D, Reifferscheid F. Reanimation unter besonderen Umstanden: Kreislaufstillstand bei implantiertem Linksherzassist-Device (LVAD). *NOTARZT* 2018;34:188-191. doi: 10.1055/a-0581-8645
63. Victor S, Hayanga JWA, Bozek JS, Wendel J, Lagazzi LF, Hayanga HK. Cardiac Tamponade Causing Predominant Left Atrial and Ventricular Compression After Left Ventricular Assist Device Placement. *Am J* Case *Rep.* 2022;23:e938115. doi: 10.12659/ AJCR.938115
64. Wilson W, Goldraich L, Parry D, Cusimano R, Rao V, Horlick E. Cardiac arrest secondary to sudden LVAD failure in the setting of aortic valve fusion successfully managed with emergent transcatheter aortic valve replacement. *Int J Cardiol.* 201 4;1 71:e40-e41. doi: 10.1016/j.ijcard.2013.11.117
65. Yuzefpolskaya M, Uriel N, Flannery M, Yip N, Mody K, Cagliostro B, Takayama H, Naka Y, Jorde UP, Goswami S, et al. Advanced cardiovascular life support algorithm for the management of the hospitalized unresponsive patient on continuous flow left ventricular assist device support outside the intensive care unit. *Eur Heart J Acute Cardiovasc Care.* 2016;5:522-526. doi: 10.1177/2048872615574107
66. Ziegler LA, Pousatis S, Kaczorowski DJ, Madathil RJ. Emergency Splicing of Transected Ventricular Assist Device Driveline. *Ann Thorac Surg.* 2021;111:e329-e331. doi: 10.1016/j.athoracsur.2020.07.073
67. Peberdy MA, Gluck JA, Ornato JP, Bermudez CA, Griffin RE, Kasirajan V, Kerber RE, Lewis EF, Link MS, Miller C, et al; on behalf of the American Heart Association Emergency Cardiovascular Care Committee; Council on Cardiopulmonary, Critical Care, Perioperative, and Resuscitation; Council on Cardiovascular Diseases in the Young; Council on Cardiovascular Surgery and Anesthesia; Council on Cardiovascular and Stroke Nursing; and Council on Clinical Cardiology. Cardiopulmonary Resuscitation in Adults and Children With Mechanical Circulatory Support: A Scientific Statement From the American Heart Association. *Circulation.* 2017;135:e1115-e1134. doi: 10.11 61/Cl R.0000000000000504
68. Akhtar W, Baston VR, Berman M, Bhagra S, Chue C, Deakin CD, Dalzell JR, Dunning J, Dunning J, Gardner RS, et al. British societies guideline on the management of emergencies in implantable left ventricular assist device recipients in transplant centres. *Intensive Care Med.* 2024;50:493-501. doi: 10.1007/s00134-024-07382-y
69. Chong SL, Goh MSL, Ong GY, Acworth J, Sultana R, Yao SHW, Ng KC; International Liaison Committee on Resuscitation (ILCOR) and ILCOR Pediatric Life Support Task Force. Do paediatric early warning systems reduce mortality and critical deterioration events among children? A systematic review and meta-analysis. *Resusc Plus.* 2022;11:100262. doi: 10.1016/j.resplu.2022.100262
70. Wyckoff MH, Greif R, Morley PT, Ng KC, Olasveengen TM, Singletary EM, Soar J, Cheng A, Drennan IR, Liley HG, et al. 2022 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations: Summary From the Basic Life Support; Advanced Life Support; Pediatric Life Support; Neonatal Life Support; Education, Implementation, and Teams; and First Aid Task Forces. Res*uscitation.* 2022;181:208-288. doi: 10.101 6/j.resuscitation.2022.10.005
71. Wyckoff MH, Greif R, Morley PT, Ng KC, Olasveengen TM, Singletary EM, Soar J, Cheng A, Drennan IR, Liley HG, et al; on behalf of the Collaborators. 2022 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations: Summary From the Basic Life Support; Advanced Life Support; Pediatric Life Support; Neonatal Life Support; Education, Implementation, and Teams; and First Aid Task Forces. *Circulation.* 2022;1 46:e483-e557. doi: 10.11 61/Cl R.0000000000001095
72. Wyckoff MH, Greif R, Morley PT, Ng KC, Olasveengen TM, Singletary EM, Soar J, Cheng A, Drennan IR, Liley HG, et al. 2022 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations: Summary From the Basic Life Support; Advanced Life Support; Pediatric Life Support; Neonatal Life Support; Education, Implementation, and Teams; and First Aid Task Forces. *Pediatrics.* 2023;151:e2022060463. doi: 1 0.1542/peds.2022-060463
73. Greif R, Bray JE, Djarv T, Drennan IR, Liley HG, Ng KC, Cheng A, Douma MJ, Scholefield BR, Smyth M, 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;1 50:e580-e687.doi: 10.1161/Cl R.0000000000001 288
74. Greif R, Bray JE, Djarv T, Drennan IR, Liley HG, Ng KC, Cheng A, Douma MJ, Scholefield BR, Smyth M, 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. *Resuscitation.* 2024;205:110414. doi: 10.1016/j.resuscitation.2024.110414
75. Soar J, Maconochie I, Wyckoff MH, Olasveengen TM, Singletary EM, Greif R, Aickin R, Bhanji F, Donnino MW, Mancini ME, et al. 2019 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Resuscitation.* 2019;145:95-150. doi: 10.1016/j.resuscitation.2019.10.016
76. Soar J, Maconochie I, Wyckoff MH, Olasveengen TM, Singletary EM, Greif R, Aickin R, Bhanji F, Donnino MW, Mancini ME, et al. 2019 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.* 2019;140:e826-e880. doi: 10.11 61/Cl R.0000000000000734
77. Olasveengen TM, Mancini ME, Perkins GD, Avis S, Brooks S, Castren M, Chung SP, Considine J, Couper K, Escalante R, et al; on behalf of the Adult Basic Life Support Collaborators. Adult Basic Life Support: International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Resuscitation.* 2020;1 56:A35-A79. doi: 10.1016/j.resuscitation.2020.09.010
78. Olasveengen TM, Mancini ME, Perkins GD, Avis S, Brooks S, Castren M, Chung SP, Considine J, Couper K, Escalante R, et al; on behalf of the Adult Basic Life Support Collaborators. Adult Basic Life Support: 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Circulation.* 2020;142:S41-S91. doi: 10.1161/CIR.0000000000000892
79. Bray JE, Deasy C, Walsh J, Bacon A, Currell A, Smith K. Changing EMS dispatcher CPR instructions to 400 compressions before mouth-to-mouth improved bystander CPR rates. *Resuscitation.* 2011;82:1393-1398. doi: 10.1016/j.resuscitation.2011.06.018
80. Shepard LN, Nadkarni VM, Ng KC, Scholefield BR, Ong GY. ILCOR pediatric life support recommendations translation to constituent council guidelines: An emphasis on similarities and differences. *Resuscitation.* 2024;201:110247. doi: 10.1016/j.resuscitation.2024.110247
81. Bray J, Dassanayake V, Considine J, Scholefield B, Schexnayder S, Olasveengen TM; on behalf of the International Liaison Committee on Resuscitation Basic Life Support Task Force and Pediatric Life Support Task Force. Starting CPR (ABC vs. CAB) for Cardiac Arrest in Adults and Children Consensus on Science with Treatment Recommendations. Accessed August 19, 2025. https://costr.ilcor.org/document/starting-cpr-abc-vs-cab-pls-4070-02-tf-sr
82. Suppan L, Jampen L, Siebert JN, Zund S, Stuby L, Ozainne F. Impact of Two Resuscitation Sequences on Alveolar Ventilation during the First Minute of Simulated Pediatric Cardiac Arrest: Randomized Cross-Over Trial. *Healthcare (Basel).* 2022;10:2451. doi: 10.3390/healthcare10122451
83. Suppan L, Jampen L, Siebert JN, Zund S, Stuby L, Ozainne F. Correction: Suppan *el al.* Impact of Two Resuscitation Sequences on Alveolar Ventilation during the First Minute of Simulated Pediatric Cardiac Arrest: Randomized Cross-Over Trial. Healthcare 2022, 10, 2451. *Healthcare (Basel).* 2023;11:1 799. doi: 10.3390/healthcare11121799
84. Kobayashi M, Fujiwara A, Morita H, Nishimoto Y, Mishima T, Nitta M, Hayashi T, Hatta T, Hayashi Y, Hachisuka E, et al. A manikin-based observational study on cardiopulmonary resuscitation skills at the Osaka Senri medical rally. *Resuscitation.* 2008;78:333-339. doi: 10.1016/j.resuscitation.2008.03.230
85. Marsch S, Tschan F, Semmer NK, Zobrist R, Hunziker PR, Hunziker S. ABC versus CAB for cardiopulmonary resuscitation: a prospective, randomized simulator-based trial. *Swiss Med Wkly.* 2013;143:w13856. doi: 10.441 4/ smw.201 3.13856
86. Sekiguchi H, Kondo Y, Kukita I. Verification of changes in the time taken to initiate chest compressions according to modified basic life support guidelines. *Am J*

Emerg Med. 2013;31:1248-1250. doi: 10.1016/j.ajem.2013.02.047
87. Lubrano R, Cecchetti C, Bellelli E, Gentile I, Loayza Levano H, Orsini F, Bertazzoni G, Messi G, Rugolotto S, Pirozzi N, et al. Comparison of times of intervention during pediatric CPR maneuvers using ABC and CAB sequences: A randomized trial. *Resuscitation.* 2012;83:1 473-1 477. doi: 10.1016/j.resuscitation.2012.04.011
88. Travers AH, Perkins GD, Berg RA, Castren M, Considine J, Escalante R, Gazmuri RJ, Koster RW, Lim SH, Nation KJ, et al; on behalf of the Basic Life Support Chapter Collaborators. Part 3: Adult Basic Life Support and Automated External Defibrillation: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Circulation.* 2015;132:S51-S83. doi: 10.11 61/Cl R.0000000000000272
89. Perkins GD, Travers AH, Berg RA, Castren M, Considine J, Escalante R, Gazmuri RJ, Koster RW, Lim SH, Nation KJ, et al; on behalf of the Basic Life Support Chapter Collaborators. Part 3: Adult basic life support and automated external defibrillation: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation.* 2015;95:e43-e69. doi: 10.1016/j.resuscitation.2015.07.041
90. Pasupula DK, Bhat A, Siddappa Malleshappa SK, Munir MB, Barakat A, Jain S, Wang NC, Saba S, Bhonsale A. Impact of Change in 2010 American Heart Association Cardiopulmonary Resuscitation Guidelines on Survival After Out-of-Hospital Cardiac Arrest in the United States. *Circ Arrhythm Electrophysiol.* 2020;13:e007843. doi: 10.1161/CIRCEP.119.007843
91. Garza AG, Gratton MC, Salomone JA, Lindholm D, McElroy J, Archer R. Improved patient survival using a modified resuscitation protocol for out-of-hospital cardiac arrest. *Circulation.* 2009;119:2597-2605. doi: 10.1161/CIRCULATIONAHA.108.815621
92. Mallikethi-Reddy S, Briasoulis A, Akintoye E, Jagadeesh K, Brook RD, Rubenfire M, Afonso L, Grines CL. Incidence and Survival After In-Hospital Cardiopulmonary Resuscitation in Nonelderly Adults: US Experience, 2007 to 2012. *Circ Cardiovasc Oual Outcomes.* 2017;10:e003194. doi: 10.11 61/Cl RCOUTCOM ES.116.003194
93. Wang CH, Huang CH, Chang WT, Tsai MS, Yu PH, Wu YW, Chen WJ. Outcomes of adults with in-hospital cardiac arrest after implementation of the 2010 resuscitation guidelines. *Int J Cardiol.* 2017;249:21 4-219. doi: 10.101 6/j.ijcard.2017.09.008
94. Goto Y, Funada A, Maeda T, Goto Y. Temporal trends in neurologically intact survival after paediatric bystander-witnessed out-of-hospital cardiac arrest: A nationwide population-based observational study. *Resusc Plus.* 2021;6:100104. doi: 10.1016/j.resplu.2021.100104
95. Nairn MY, Griffis HM, Berg RA, Bradley RN, Burke RV, Markenson D, McNally BF, Nadkarni VM, Song L, Vellano K, et al. Compression-Only Versus Rescue-Breathing Cardiopulmonary Resuscitation After Pediatric Out-of-Hospital Cardiac Arrest. *J Am Coll Cardiol.* 2021;78:1042-1052. doi: 10.1016/j.jacc.2021.06.042
96. Zhang X, Zhang W, Wang C, Tao W, Dou 0, Yang Y. Chest-compression-only versus conventional cardiopulmonary resuscitation by bystanders for children with out-of-hospital cardiac arrest: A systematic review and meta-analysis. *Resuscitation.* 2019;134:81-90. doi: 10.1016/j.resuscitation.2018.10.032
97. Nassar BS, Kerber R. Improving CPR performance. *Chest.* 2017;152:1061-1069. doi: 10.1016/j.chest.2017.04.178
98. Goh JL, Pek PP, Fook-Chong SMC, Ho AFW, Siddiqui FJ, Leong BS-H, Mao DRH, Ng W, Tiah L, Chia MY-C, et al; on behalf of the PAROS Clinical Research Network. Impact of time-to-compression on out-of-hospital cardiac arrest survival outcomes: A national registry study. *Resuscitation.* 2023;190:109917. doi: 10.1016/j.resuscitation.2023.109917
99. Beard M, Swain A, Dunning A, Baine J, Burrowes C. How effectively can young people perform dispatcher-instructed cardiopulmonary resuscitation without training? *Resuscitation.* 2015;90:138-142. doi: 10.1016/j.resuscitation.2015.02.035
100. Bray JE, Smith K, Case R, Cartledge S, Straney L, Finn J. Public cardiopulmonary resuscitation training rates and awareness of hands-only cardiopulmonary resuscitation: a cross-sectional survey of Victorians. *Emerg Med Australas.* 2017;29:1 58-164. doi: 10.1111 / 1742-6723.12720
101. Ong GY, Kurosawa H, lkeyama T, Park JD, Katanyuwong P, Reyes OCF, Wu ET, Hon KLE, Maconochie IK, Shepard LN, et al. Comparison of paediatric basic life support guidelines endorsed by member councils of Resuscitation Council of Asia. *Resusc Plus.* 2023;16:100506. doi: 10.1016/j.resplu.2023.100506
102. Acworth J, del Castillo J, Tiwari LK, Atkins D, de Caen A, Scholefield BR, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. *Energy doses for pediatric defibrillation during resuscitation - Paediatric Consensus on Science with Treatment Recommendations [Internet]* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Paediatric Advanced Life Support Task Force. Accessed January 20, 2025. https://costr.ilcor.org/document/energy-doses-for-pediatric-defibrillation-during- resuscitation-pls-4080-12-tf-sr. 2025
103. Gutgesell HP, Tacker WA, Geddes LA, Davis S, Lie JT, McNamara DG. Energy dose for ventricular defibrillation of children. *Pediatrics.* 1976;58:898-901.
104. Hoyme DB, Zhou Y, Girotra S, Haskell SE, Samson RA, Meaney P, Berg M, Nadkarni VM, Berg RA, Hazinski MF, et al. Improved survival to hospital discharge in pediatric in-hospital cardiac arrest using 2 Joules/kilogram as first defibrillation dose for initial pulseless ventricular arrhythmia. *Resuscitation.* 2020;1 53:88-96. doi: 10.1016/j.resuscitation.2020.05.048
105. Meaney PA, Nadkarni VM, Atkins DL, Berg MD, Samson RA, Hazinski MF, Berg RA; American Heart Association National Registry of Cardiopulmonary Resuscitation Investigators. Effect of defibrillation energy dose during in-hospital pediatric cardiac arrest. *Pediatrics.2011;*127:e16-e23. doi: 10.1542/peds.2010-1617
106. Rodriguez-Nunez A, Lopez-Herce J, del Castillo J, Bellon JM; Iberian-American Paediatric Cardiac Arrest Study Network RIBEPCI. Shockable rhythms and defibrillation during in-hospital pediatric cardiac arrest. *Resuscitation.* 2014;85:387-391. doi: 10.1016/j.resuscitation.2013.11.015
107. Rodriguez-Nunez A, Lopez-Herce J, Garda C, Dominguez P, Carrillo A, Bellon JM; Spanish Study Group of Cardiopulmonary Arrest in Children. Pediatric defibrillation after cardiac arrest: initial response and outcome. *CritCare.* 2006;10:R113. doi: 10.1186/cc5005
108. Tibballs J, Carter B, Kiraly NJ, Ragg P, Clifford M. External and internal biphasic direct current shock doses for pediatric ventricular fibrillation and pulseless ventricular tachycardia. *Pediatr Crit Care Med.* 2011;12:1 4-20. doi: 10.1097/PCC.Ob013e3181dbb4fc
109. Tibballs J, Kinney S. A prospective study of outcome of in-patient paediatric cardiopulmonary arrest. *Resuscitation.* 2006;71:310-318. doi: 10.1016/j.resuscitation.2006.05.009
110. Maconochie IK, Aickin R, Hazinski MF, Atkins DL, Bingham R, Couto TB, Guerguerian AM, Nadkarni VM, Ng KC, Nuthall GA, et al; on behalf of the Pediatric Life Support Collaborators. Pediatric Life Support: 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency CardiovascularCare Science WithTreatment Recommendations.*Resuscitation.* 2020;156:A 120-A155. doi: 10.1016/j.resuscitation.2020.09.013
111. Maconochie IK, Aickin R, Hazinski MF, Atkins DL, Bingham R, Couto T B, Guerguerian AM, Nadkarni VM, Ng KC, Nuthall GA, et al. Pediatric Life Support 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Pediatrics.* 2021;147:e2020038505B. doi: 10.1542/peds.2020-038505B
112. Maconochie IK, Aickin R, Hazinski MF, Atkins DL, Bingham R, Couto TB, Guerguerian AM, Nadkarni VM, Ng KC, Nuthall GA, et al; on behalf of the Pediatric Life Support Collaborators. Pediatric Life Support: 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations.*Circulation.* 2020;142:S140-S184. doi: 10.1161 /CIR.0000000000000894
113. Van de Voorde P, Turner NM, Djakow J, de Lucas N, Martinez-Mejias A, Biarent D, Bingham R, Brissaud 0, Hoffmann F, Johannesdottir GB, et al. European Resuscitation Council Guidelines 2021: Paediatric Life Support. *Resuscitation.* 2021;161:327-387. doi: 10.1016/j.resuscitation.2021.02.015
114. ANZCOR. Guideline 12.2 - Paediatric Advanced Life Support (PALS). Accessed August 17, 2025. https://www.anzcor.org/home/paediatric-advanced-Iife-support/guideline-12-2paediatric-advanced-life-support-pals/
115. Maconochie IK, Aickin R, Hazinski MF, Atkins DL, Bingham R, Couto TB, Guerguerian A-M, Nadkarni VM, Ng K-C, Nuthall GA, et al; on behalf of the Pediatric Life Support Collaborators. Pediatric life support: 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Circulation.* 2020;142(suppl 1):S140-S184. doi: 10.1161/CIR.0000000000000894
116. Cheskes S, Verbeek PR, Drennan IR,McLeod SL, Turner L,Pinto R, Feldman M, Davis M, Vaillancourt C, Morrison LJ, et al. Defibrillation Strategies for Refractory Ventricular Fibrillation. *N Engl J Med* 2022;387:1947-1956. doi: 10.1056/NEJMoa2207304
117. Steinberg MF,OlsenJA,Persse D,Souders CM, Wik L.Efficacy of defibrillator pads placement during ventricular arrhythmias, a before and after analysis. *Resuscitation.* 2022;174:1 6-19. doi: 10.101 6/j.resuscitation.2022.03.004
118. Ristagno G, Semeraro F, Raffay V, Stirparo G, Lulic I, Deakin C, Drennan IR, Del Castillo J, Acworth J, Morley PT, et al. Pad size, orientation, and placement for defibrillation during basic life support: a systematic review. *Resusc Plus.* 2025;25:101030. doi: 10.1016/j.resplu.2025.101030

119. Lopez-Herce J, del Casillo J, Ristagno G, Raffay V, Semeraro F, Deakin C, Drennan I, Acworth J, Morley PT, Perkins D, et al. *Pad positions and size in Adults and Children Consensus on Science with Treatment Recommendations {Internet]* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Pediatric Life Support Task Force. Accessed January 20, 2025. https://costr.ilcor.org/document/paddle-pad-size-and-placement-in-infants-and-chiIdren-pls-4080-17-updated-systematic-review. 2025.
120. Bray JE, Smyth MA, Perkins GD, Cash RE, Chung SR Considine J, Dainty KN, Dassanayake V, Debaty G, Dewan M, et al. Adult basic life support: 2025 International Liaison Committee on Resuscitation Consensus on Science With Treatment Recommendations. *Circulation.* 2025;152(suppl 1):SXXX-SXXX. doi: 10.1161 /CIR.0000000000001364
121. Kleinman ME, de Caen AR, Chameides L, Atkins DL, Berg RA, Berg MD, Bhanji F, Biarent D, Bingham R, Coovadia AH, et al; on behalf of the Pediatric Basic and Advanced Life Support Chapter Collaborators. Part 10: pediatric basic and advanced life support: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Circulation.* 2010;122:S466-S515. doi: 10.1161/Cl RCULATIONAHA 110.971093
122. Ristagno G, Raffay V, Semeraro F, Deakin C, Drennan I, Acworth J, Morley PT, Perkins D, Smyth M, Olasveengen TM, et al. Pad positions and size in adults and children: Consensus on Science With Treatment Recommendations. Accessed February 26, 2025. https://costr.ilcor.org/ document/pad-paddle-size-and-placement-in-adults-bls-and-als-sr-bls-2601. 2024.
123. AHA Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Part 4: the automated external defibrillator: key link in the chain of survival. The American Heart Association in Collaboration with the International Liaison Committee on Resuscitation. *Circulation.* 2000;102(Suppl 1):160-176. doi: 10.11 61/circ.102.suppl_1.1-60
124. ILCOR. 2005 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Part 6: Paediatric basic and advanced life support. *Resuscitation.* 2005;67:271-291. doi: 10.1016/j.resuscitation.2005.09.020
125. ILCOR. The International Liaison Committee on Resuscitation (ILCOR) consensus on science with treatment recommendations for pediatric and neonatal patients: pediatric basic and advanced life support. *Pediatrics.* 2006;117:e955-e977. doi: 10.1542/peds.2006-0206
126. Berg KM, Bray JE, Ng KC, Liley HG, Greif R, Carlson J N, Morley PT, Drennan IR, Smyth M, Scholefield BR, et al; on behalf of the Collaborators. 2023 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.* 2023;148:e187-e280. doi: 10.1161/CIR.0000000000001179
127. Berg KM, Bray JE, Ng KC, Liley HG, Greif R, Carlson J N, Morley PT, Drennan IR, Smyth M, Scholefield BR, et al; on behalf of the Collaborators. 2023 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. *Resuscitation.* 2024;195:109992. doi: 10.1016/j.resuscitation.2023.109992
128. Tiwari LK, del Castillo J, Acworth J, Gupta P, Scholefield BR, de Caen A, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. *Single or stacked shocks for pediatric defibrillation - Paediatric Consensus on Science with Treatment Recommendations {Internet]* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Paediatric Advanced Life Support Task Force. Accessed January 20, 2025. https://costr.ilcor.org/document/single-or-stacked-shocks-for-pediatric-defibrillation-pls-4080-19-tf-sr.2025.
129. International Liaison Committee on R. 2005 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Part 3: defibrillation. *Resuscitation.* 2005;67:203-211. doi: 10.1016/j.resuscitation.2005.09.017
130. Bain AC, Swerdlow CD, Love CJ, Ellenbogen KA, Deering TF, Brewer JE, Augostini RS, Tchou PJ. Multicenter study of principles-based waveforms for external defibrillation. *Ann Emerg Med* 2001;37:5-12. doi: 10.1067/mem.2001.111690
131. Poole JE, White RD, Kanz KG, Hengstenberg F, Jarrard GT, Robinson JC, Santana V, McKenas DK, Rich N, Rosas S, et al. Low-energy impedance-compensating biphasic waveforms terminate ventricular fibrillation at high rates in victims of out-of-hospital cardiac arrest. LIFE Investigators. *J Cardiovasc Electrophysiol.* 1997;8:1373-1385. doi: 10.1111 /j.1540-8167.1997.tbO 1034.x
132. AHA 2005 American Heart Association (AHA) guidelines for cardiopulmonary resuscitation (CPR) and emergency cardiovascular care (ECC) of pediatric and neonatal patients: pediatric basic life support. *Pediatrics.* 2006;117:e989-1004. doi: 10.1542/peds.2006-0219
133. Yu T, Weil MH, Tang W, Sun S, Klouche K, Povoas H, Bisera J. Adverse outcomes of interrupted precordial compression during automated defibrillation. *Circulation.* 2002;106:368-372. doi: 10.11 61/01.cir.0000021429.22005.2e
134. Swenson RD, Weaver WD, Niskanen RA, Martin J, Dahlberg S. Hemodynamics in humans during conventional and experimental methods of cardiopulmonary resuscitation. *Circulation.* 1988;78:630-639. doi: 10.1161/01.cir.78.3.630
135. Niemann JT, Cairns CB, Sharma J, Lewis RJ. Treatment of prolonged ventricular fibrillation. Immediate countershock versus high-dose epinephrine and CPR preceding countershock. *Circulation.* 1992;85:281-287. doi: 10.1161/01.cir.85.1.281
136. Phillips B, Zideman D, Garcia-Castrillo L, Felix M, Shwarz-Schwierin V; European Resuscitation Council. European Resuscitation Council Guidelines 2000 for Advanced Paediatric Life Support: A statement from Paediatric Life Support Working Group and approved by the Executive Committee of the European Resuscitation Coucil. *Resuscitation.* 2001;48:231-234. doi: 10.1016/s0300-9572(00)00381-6
137. Deleted in proof.
138. Katzenschlager S, Scholefield BR, de Caen A, Acworth J, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. *Pulse check accuracy in pediatrics during resuscitation - Pediatric Consensus on Science with Treatment Recommendations {Internet]* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Pediatric Advanced Life Support Task Force. Accessed January 20, 2025. https://costr.ilcor.org/document/pulse-check-accuracy-in-pediatrics-during-resuscitation-pls-4080-18-tf-sr.2025.
139. Tibballs J, Russell P. Reliability of pulse palpation by healthcare personnel to diagnose paediatric cardiac arrest. *Resuscitation.* 2009;80:61-64. doi: 10.1016/j.resuscitation.2008.10.002
140. Tibballs J, Weeranatna C. The influence of time on the accuracy of healthcare personnel to diagnose paediatric cardiac arrest by pulse palpation. *Resuscitation.* 2010;81:671-675. doi: 10.1016/j.resuscitation.2010.01.030
141. Tsung JW, Blaivas M. Feasibility of correlating the pulse check with focused point-of-care echocardiography during pediatric cardiac arrest: a case series. *Resuscitation.* 2008;77:264-269. doi: 10.1016/j.resuscitation.2007.12.015
142. Berg RA, Nadkarni VM, Clark AE, Moler F, Meert K, Harrison RE, Newth CJ, Sutton RM, Wessel DL, Berger JT, et al; on behalf of the Eunice Kennedy Shriver National Institute of Child Health and Human Development Collaborative Pediatric Critical Care Research Network. Incidence and Outcomes of Cardiopulmonary Resuscitation in PICUs. *Crit Care Med* 2016;44:798-808. doi: 10.1097/CCM.0000000000001484
143. Kool M, Atkins DL, Van de Voorde P, Maconochie IK, Scholefield BR, Aickin R, Hazinski MF, Bingham R, Bittencourt Couto T, Guerguerian A-M, et al. Focused echocardiography, end-tidal carbon dioxide, arterial blood pressure or near-infrared spectroscopy monitoring during paediatric cardiopulmonary resuscitation: a scoping review. *Resusc Plus.* 2021;6:100109. doi: 10.1016/j.resplu.2021.100109
144. Berg RA, Morgan RW, Reeder RW, Ahmed T, Bell MJ, Bishop R, Bochkoris M, Burns C, Carcillo JA, Carpenter TC, et al. Diastolic Blood Pressure Threshold During Pediatric Cardiopulmonary Resuscitation and Survival Outcomes: A Multicenter Validation Study. *Crit Care Med.* 2023;51:91-102. doi: 10.1097/CCM.0000000000005715
145. Sutton RM, Wolfe HA, Reeder RW, Ahmed T, Bishop R, Bochkoris M, Burns C, Diddle JW, Federman M, Fernandez R, et al; on behalf of the ICU-RESUS and Eunice Kennedy Shriver National Institute of Child Health. Effect of Physiologic Point-of-Care Cardiopulmonary Resuscitation Training on Survival With Favorable Neurologic Outcome in Cardiac Arrest in Pediatric ICUs: A Randomized Clinical Trial. *JAMA.* 2022;327:934-945. doi: 10.1001 /jama.2022.1738
146. Deleted in proof.
147. Gray J, Christoff A, Nuthall G, Morrison LJ, Sahai A, Frazier M, Loeb D, Carlisle MA, Scholefield BR, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. *Measuring invasive blood pressure during pediatric in-hospital cardiac arrest: Consensus on Science with Treatment Recommendations [Internet]* Brussels, Belgium, International Liaison Committee on Resuscitation (ILCOR) Pediatric Life Support Task Force International Liaison Committee on Resuscitation.

Accessed January 20, 2025. https://costr.ilcor.org/document/measuring-invasive-blood-pressure-during-pediatric-in-hospi!al-card iac-arrest-pIs-4160-08-tf-sr.2025.

148. Berg RA, Sutton RM, Reeder RW, Berger JT, Newth CJ, Carcillo JA, McQuillen PS, Meert KL, Yates AR, Harrison RE, et al; on behalf of the Eunice Kennedy Shriver National Institute of Child Health and Human Development Collaborative Pediatric Critical Care Research Network(CPCCRN) PICqCPR (Pediatric Intensive Care Quality of Cardio-Pulmonary Resuscitation) Investigators. Association Between Diastolic Blood Pressure During Pediatric In-Hospital Cardiopulmonary Resuscitation and Survival. *Circulation.* 2018;137:1784-1795. doi: 10.1161/CIRCULATIONAHA.117.032270
149. Kienzle MF, Morgan RW, Alvey JS, Reeder R, Berg RA, Nadkarni V, Topjian AA, Lasa JJ, Raymond TT, Sutton RM; on behalf of the American Heart Association's Get With The Guidelines®-Resuscitation Investigators. Clinician-reported physiologic monitoring of cardiopulmonary resuscitation quality during pediatric in-hospital cardiac arrest: A propensity-weighted cohort study. *Resuscitation.* 2023;188:109807. doi: 10.1016/j.resuscitation.2023.109807
150. Wolfe HA, Sutton RM, Reeder RW, Meert KL, Pollack MM, Yates AR, Berger JT, Newth CJ, Carcillo JA, McQuillen PS, et al; on behalf of the Eunice Kennedy Shriver National Institute of Child Health. Functional outcomes among survivors of pediatric in-hospital cardiac arrest are associated with baseline neurologic and functional status, but not with diastolic blood pressure during CPR. *Resuscitation.* 2019;1 43:57-65. doi: 10.1016/j.resuscitation.2019.08.006
151. Yates AR, Sutton RM, Reeder RW, Meert KL, Berger JT, Fernandez R, Wessel D, Newth CJ, Carcillo JA, McQuillen PS, et al; on behalf of the Eunice Kennedy Shriver National Institute of Child Health and Human Development Collaborative Pediatric Critical Care Research Network. Survival and Cardiopulmonary Resuscitation Hemodynamics Following Cardiac Arrest in Children With Surgical Compared to Medical Heart Disease. *Pediatr Crit Care Med.* 2019;20:1126-1136. doi: 10.1097/PCC.0000000000002088
152. Pollack MM, Holubkov R, Glass P, Dean JM, Meert KL, Zimmerman J, Anand KJ, Carcillo J, Newth CJ, Harrison R, et al; on behalf of the Eunice Kennedy Shriver National Institute of Child Health and Human Development Collaborative Pediatric Critical Care Research Network. Functional Status Scale: new pediatric outcome measure. *Pediatrics.* 2009;124:e18-e28. doi: 10.1542/peds.2008-1987
153. de Caen AR, Kleinman ME, Chameides L, Atkins DL, Berg RA, Berg MD, Bhanji F, Biarent D, Bingham R, Coovadia AH, et al; on behalf of the Paediatric Basic and Advanced Life Support Chapter Collaborators.Part 10: Paediatric basic and advanced life support: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation.201* 0;81:e213-e259. doi: 10.1016/j.resuscitation.2010.08.028
154. Sorcher JL, Hunt EA, Shaffner DH, O'Brien CE, Jeffers JM, Jones SI, Newton H, Duval-Arnould J. Association of end-tidal carbon dioxide levels during cardiopulmonary resuscitation with survival in a large paediatric cohort. *Resuscitation.* 2022;1 70:316-323. doi: 10.1016/j.resuscitation.2021.10.029
155. Yates AR, Nairn MY, Reeder RW, Ahmed T, Banks RK, Bell MJ, Berg RA, Bishop R, Bochkoris M, Burns C, et al. Early Cardiac Arrest Hemodynamics, End-Tidal Co2, and Outcome in Pediatric Extracorporeal Cardiopulmonary Resuscitation: Secondary Analysis of the ICU-RESUScitation Project Dataset (201 6-2021). *Pediatr Crit Care Med.* 2023;25:312-322. doi: 10.1097/pcc.0000000000003423
156. Morgan RW, Reeder RW, Bender D, Cooper KK, Friess SH, Graham K, Meert KL, Mourani PM, Murray R, Nadkarni VM, et al; on behalf of the ICU-RESUS and Eunice Kennedy Shriver National Institute of Child Health and Human Development Collaborative Pediatric Critical Care Research Network (CPCCRN) Investigator Groups. Associations Between End-Tidal Carbon Dioxide During Pediatric Cardiopulmonary Resuscitation, Cardiopulmonary Resuscitation Quality, and Survival. *Circulation.* 2024;149:367-378. doi: 10.1161 /CIRCULATIONAHA.123.066659
157. Maconochie IK, de Caen AR, Aickin R, Atkins DL, Biarent D, Guerguerian AM, Kleinman ME, Kloeck DA, Meaney PA, Nadkarni VM, et al; on behalf of the Pediatric Basic Life Support and Pediatric Advanced Life Support Chapter Collaborators. Part 6: Pediatric basic life support and pediatric advanced life support: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation.* 2015;95:e 147-e168. doi: 10.1016/j.resuscitation.2015.07.044
158. Esangbedo I, Rajapreyar P, Kirschen M, Niles D, Je S, Topjian AA, Nadkarni VM, Raymond TT. Abstract 304: Cerebral near-infrared spectroscopy during pediatric in-hospital cardiac arrest: a multicenter, observational study. 2022;146(suppl 1):A304. doi: 10.1161/circ.146.suppl_1.304
159. Raymond TT, Esangbedo ID, Rajapreyar P, Je S, Zhang X, Griffis HM, Wakeham MK, Petersen TL, Kirschen MP, Topjian AA, et al; on behalf of the Pediatric Resuscitation Quality (pediRES-Q) Collaborative Investigators. Cerebral Oximetry During Pediatric In-Hospital Cardiac Arrest: A Multicenter Study of Survival and Neurologic Outcome. *Crit Care Med.* 2024;52:775-785. doi: 10.1097/CCM.0000000000006186
160. Ohshimo S, Wang CH, Couto TB, Bingham R, Mok YH, Kleinman M, Aickin R, Ziegler C, DeCaen A, Atkins DL, et al; on behalf of the International Liaison Committee on Resuscitation (ILCOR) Pediatric Task Force. Pediatric timing of epinephrine doses: A systematic review. *Resuscitation.* 2021;1 60:106-117. doi: 10.1016/j.resuscitation.2021.01.015
161. Amoako J, Komukai S, lzawa J, Callaway CW, Okubo M. Evaluation of Use of Epinephrine and Time to First Dose and Outcomes in Pediatric Patients With Out-of-Hospital Cardiac Arrest. *JAMA Netw Open.* 2023;6:e235187. doi: 10.1001/jamanetworkopen.2023.5187
162. Eriksson CO, Bahr N, Meckler G, Hansen M, Walker-Stevenson G, Idris A, Aufderheide TP, Daya MR, Fink EL, Jui J, et al; on behalf of the Child Safety Initiative-Emergency Medical Services for Children. Adverse Safety Events in Emergency Medical Services Care of Children With Out-of-Hospital Cardiac Arrest. *JAMA Netw Open.* 2024;7:e2351535. doi: 10.1001 /jamanetworkopen.2023.51535
163. Matsuyama T, Komukai S, lzawa J, Gibo K, Okubo M, Kiyohara K, Kiguchi T, Iwami T, Ohta B, Kitamura T. Pre-Hospital Administration of Epinephrine in Pediatric Patients With Out-of-Hospital Cardiac Arrest. *J Am Coll Cardiol.* 2020;75:194-204. doi: 10.1016/j.jacc.2019.10.052
164. Kurosawa H, Ong G, Raymond T, Acworth J, Atkins D, Scholefield BR, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. *Vasopressor use during cardiac arrest in children-Paediatric Consensus on Science with Treatment Recommendations [Internet}* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Paediatric Advanced Life Support Task Force. Accessed January 20, 2025. https://costr.ilcor.org/document/vasopressor-use-during-cardiac-arrest-in-children-pls-4080-21-tf-sr-updated.2025.
165. Deleted in proof.
166. Perkins GD, Ji C, Deakin CD, Quinn T, Nolan JP, Scomparin C, Regan S, Long J, Slowther A, Pocock H, et al; on behalf of the PARAMEDIC2 Collaborators. A Randomized Trial of Epinephrine in Out-of-Hospital Cardiac Arrest. *N Engl J Med.* 2018;379:711-721. doi: 10.1056/NEJMoa1806842
167. Lasa JJ, Jain P, Raymond TT, Minard CG, Topjian A, Nadkarni V, Gaies M, Bembea M, Checchia PA, Shekerdemian LS, et al. Extracorporeal Cardiopulmonary Resuscitation in the Pediatric Cardiac Population: In Search of a Standard of Care. *Pediatr Crit Care Med.* 2018;19:125-130. doi: 10.1097/PCC.0000000000001388
168. Ortmann LA, Reeder RW, Raymond TT, Brunetti MA, Himebauch A, Bhakta R, Kempka J, di Bari S, Lasa JJ. Epinephrine dosing strategies during pediatric extracorporeal cardiopulmonary resuscitation reveal novel impacts on survival: A multicenter study utilizing time-stamped epinephrine dosing records. *Resuscitation.* 2023;188:109855. doi: 10.1016/j.resuscitation.2023.109855
169. Best K, Wyckoff MH, Huang R, Sandford E, Ali N. Pulseless electrical activity and asystolic cardiac arrest in infants: identifying factors that influence outcomes. *J Perinatal.* 2022;42:574-579. doi: 10.1038/s41372-022-01349-x
170. Kienzle MF, Morgan RW, Reeder RW, Ahmed T, Berg RA, Bishop R, Bochkoris M, Carcillo JA, Carpenter TC, Cooper KK, et al; on behalf of the Oxy-PICU Investigators of the Pediatric Critical Care Society Study Group. Epinephrine Dosing Intervals Are Associated With Pediatric In-Hospital Cardiac Arrest Outcomes: A Multicenter Study. *Crit Care Med.* 2024;52:1344-1355. doi: 10.1097/CCM.0000000000006334
171. Recher M, Canon V, Lockhart M, Lafrance M, Hubert H, Leteurtre S. High dose of epinephrine does not improve survival of children with out-of-hospital cardiac arrest: Results from the French National Cardiac Arrest Registry. *Front Pediatr* 2022;10:978742. doi: 10.3389/fped.2022.978742
172. Hsu CH, Couper K, Nix T, Drennan I, Reynolds J, Kleinman M, Berg KM; on behalf of the Advanced Life Support and Paediatric Life Support Task Forces at the International Liaison Committee on Resuscitation (ILCOR). Calcium during cardiac arrest: A systematic review. *Resusc Plus.* 2023;1 4:100379. doi: 10.1016/j.resplu.2023.100379
173. Dhillon GS, Kleinman ME, Staffa SJ, Teele SA, Thiagarajan RR; American Heart Association's Get With The Guidelines - Resuscitation (GWTG-R) Investigators. Calcium Administration During Cardiopulmonary Resuscitation for In-Hospital Cardiac Arrest in Children With Heart Disease Is Associated With Worse Survival-A Report From the American Heart Association's Get With The Guidelines-Resuscitation (GWTG-R) Registry. *Pediatr Crit Care Med.* 2022;23:860-871. doi: 10.1097/PCC.0000000000003040
174. Cashen K, Sutton RM, Reeder RW, Ahmed T, Bell MJ, Berg RA, Burns C, Carcillo JA, Carpenter TC, Michael Dean J, et al; on behalf of the Eunice Kennedy Shriver National Institute of Child Health and Human Development Collaborative Pediatric Critical Care Research Network (CPCCRN) and National Heart Lung and Blood Institute ICU-RESUScitation Project Investigators. Calcium use during paediatric in-hospital cardiac arrest is associated with worse outcomes. *Resuscitation.* 2023;185:109673. doi: 10.1016/j.resuscitation.2022.109673
175. Chang CY, Wu PH, Hsiao CT, Chang CP, Chen YC, Wu KH. Sodium bicarbonate administration during in-hospital pediatric cardiac arrest: a systematic review and meta-analysis. *Resuscitation.* 2021;162:188-197. doi: 10.1016/j.resuscitation.2021.02.035
176. Cashen K, Reeder RW, Ahmed T, Bell MJ, Berg RA, Burns C, Carcillo JA, Carpenter TC, Dean J M, Diddle JW, et al; on behalf of the Eunice Kennedy Shriver National Institute of Child Health and Human Development Collaborative Pediatric Critical Care Research Network (CPCCRN) and National Heart Lung and Blood Institute ICU-

RESUScitation Project Investigators. Sodium Bicarbonate Use During Pediatric Cardiopulmonary Resuscitation: A Secondary Analysis of the ICU-RESUScitation Project Trial. *Pediatr Crit Care Med.* 2022;23:784-792. doi: 10.1097/PCC.0000000000003045

177. Ali MU, Fitzpatrick-Lewis D, Kenny M, Raina P, Atkins DL, Soar J, Nolan J, Ristagno G, Sherifali D. Effectiveness of antiarrhythmic drugs for shockable cardiac arrest: A systematic review. *Resuscitation.* 2018;132:63-72. doi: 10.1016/j.resuscitation.2018.08.025
178. Soar J, Donnino MW, Maconochie I, Aickin R, Atkins DL, Andersen LW, Berg KM, Bingham R, Bottiger BW, Callaway CW, et al; on behalf of the ILCOR Collaborators. 2018 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations Summary. *Resuscitation.* 2018;133:194-206. doi: 10.1016/j.resuscitation.2018.10,017
179. Soar J, Donnino MW, Maconochie I, Aickin R, Atkins DL, Andersen LW, Berg KM, Bingham R, Bottiger BW, Callaway CW, et al; on behalf of the ILCOR Collaborators. 2018 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations Summary. *Circulation.* 2018;138:e714-e730. doi: 10.1161/CIR.0000000000000611
180. Besserer F, Kawano T, Dirk J, Meckler G, Tijssen JA, DeCaen A, Scheuermeyer F, Beno S, Christenson J, Grunau B; on behalf of the Canadian Resuscitation Outcomes Consortium. The association of intraosseous vascular access and survival among pediatric patients with out-of-hospital cardiac arrest. *Resuscitation.* 2021;167:49-57. doi: 10.1016/j.resuscitation.2021.08.005
181. Recher M, Baert V, Escutnaire J, Bastard O Le, Javaudin F, Hubert H, Leteurtre S. lntraosseous or Peripheral IV Access in Pediatric Cardiac Arrest? Results From the French National Cardiac Arrest Registry. *Pediatr Crit Care Med.* 2021;22:286-296. doi: 10.1097/PCC.0000000000002659
182. Couper K, Andersen LW, Drennan IR, Grunau BE, Kudenchuk PJ, Lall R, Lavonas EJ, Perkins GD, Vallentin MF, Granfeldt A, et al. *Intravenous and intraosseous drug administration for Cardiac Arrest in Adults. Consensus on Science with Treatment Recommendations [Internet]* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Advanced Life Support Task Force. Accessed January 20, 2025. https://costr.ilcor.org/ document/io-v-iv-drugs-als-2046-tf-sr.2024.
183. Considine J, Couper K, Greif R, Ong GY, Smyth MA, Ng KC, Kidd T, Mariero Olasveengen T, Bray J. Cardiopulmonary resuscitation in obese patients: A scoping review. *Resusc Plus.* 2024;20:100820. doi: 10.1016/j.resplu.2024.100820
184. Meert KL, Telford R, Holubkov R, Slomine BS, Christensen JR, Dean J M, Moler FW; on behalf of the Therapeutic Hypothermia after Pediatric Cardiac Arrest (THAPCA) Trial Investigators. Pediatric Out-of-Hospital Cardiac Arrest Characteristics and Their Association With Survival and Neurobehavioral Outcome. *Pediatr Crit Care Med.* 2016;1 7:e543-e550. doi: 10.1097/PCC.0000000000000969
185. Srinivasan V, Nadkarni VM, Helfaer MA, Carey SM, Berg RA; on behalf of the American Heart Association National Registry of Cardiopulmonary Resuscitation Investigators. Childhood obesity and survival after in-hospital pediatric cardiopulmonary resuscitation. *Pediatrics.* 2010;125:e481-e488. doi: 10.1542/peds.2009-1324
186. Kosmopoulos M, Kalra R,Alexy T, Gaisendrees C, Jaeger D, Chahine J, Voicu S, Tsangaris A, Gutierrez AB, Elliott A, et al. The impact of BMI on arrest characteristics and survival of patients with out-of-hospital cardiac arrest treated with extracorporeal cardiopulmonary resuscitation. *Resuscitation.* 2023;188: 109842. doi: 10.1016/j.resuscitation.2023.109842
187. Bonnet M, Petit J, Lambert V, Brenot P, Riou JY, Angel CY, Belli E, Baruteau AE. Catheter-based interventions for modified Blalock-Taussig shunt obstruction: a 20-year experience. *Pediatr Cardiol.* 2015;36:835-841. doi: 10.1007/s00246-014-1086-0
188. Guzzetta NA, Foster GS, Mruthinti N, Kilgore PD, Miller BE, Kanter KR. In-hospital shunt occlusion in infants undergoing a modified blalock-taussig shunt. *Ann Thorac Surg.* 2013;96:176-182. doi: 10.1016/j.athoracsur.2013.03.026
189. Krasemann T, Tzifa A, Rosenthal E, Qureshi SA Stenting of modified and classical Blalock-Taussig shunts--lessons learned from *seven* consecutive cases. *Cardiol Young.* 2011;21:430-435. doi: 10.1017/S1047951111000254
190. MacMillan M, Jones TK, Lupinetti FM, Johnston TA Balloon angioplasty for Blalock-Taussig shunt failure in the early postoperative period. *Catheter Cardiovasc lnterv.* 2005;66:585-589. doi: 10.1002/ccd.20438
191. Marino BS, Tabbutt S, Maclaren G, Hazinski MF, Adatia I, Atkins DL, Checchia PA, DeCaen A, Fink EL, Hoffman GM, et al; on behalf of the American Heart Association Congenital Cardiac Defects Committee of the Council on Cardiovascular Disease in the Young; Council on Clinical Cardiology; Council on Cardiovascular and Stroke Nursing; Council on Cardiovascular Surgery and Anesthesia; and Emergency Cardiovascular Care Committee. Cardiopulmonary Resuscitation in Infants and Children With Cardiac Disease: A Scientific Statement From the American Heart Association. *Circulation.* 2018;137:e691-e782. doi: 10.1161/CIR.0000000000000524
192. Moszura T, Ostrowska K, Dryzek P, Moll J, Sysa A Thrombolysis and stent implantation in a child with an acute occlusion of the modified Blalock-Taussig shunt--a case report. *Kardiol Pol.* 2004;60:354-356.
193. Raymond TT, Guerguerian AM, Acworth J, Scholefield BR, Atkins DL, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. */HCA due to Suspected Cardiac Shunt/Stent Obstruction Consensus on Science with Treatment Recommendations [Internet]* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Pediatric Life Support Task Force. Accessed January 20, 2025. https:// costr.ilcor.org/document/pls-4030-25-ihca-due-to-suspected-cardiac-shunt-stent-obstruction-pls-4030-25-pls-tf-sr2025.
194. Tiwari L, Scholefield BR, Kleinman M, Nadkarni V, Wang SG, Ross C, de Caen A, Acworth J, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. *Reversible causes of pediatric cardiac arrest - Pulmonary Embolism - Paediatric Consensus on Science with Treatment Recommendations [Internet]* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Paediatric Advanced Life Support Task Force. Accessed January 20, 2025. https:// costr.ilcor.org/document/reversible-causes-of-pediatric-cardiac-arrest-pulmonary-embolus-pls-41 60-10. 2025.
195. Morgan RW, Stinson HR, Wolfe H, Lindell RB, Topjian AA, Nadkarni VM, Sutton RM, Berg RA, Kilbaugh TJ. Pediatric In-Hospital Cardiac Arrest Secondary to Acute Pulmonary Embolism. *Crit Care Med.* 2018;46:e229-e234. doi: 10.1097/CCM.0000000000002921
196. Pelland-Marcotte MC, Tucker C, Klaassen A, Avila ML, Amid A, Amiri N, Williams S, Halton J, Brandao LR Outcomes and risk factors of massive and submassive pulmonary embolism in children: a retrospective cohort study. *Lancet Haematol.* 2019;6:e 144-e1 53. doi: 10.1016/S2352-3026(18)30224-2
197. Ross CE, Shih JA, Kleinman ME, Donnino MW. Pediatric Massive and Submassive Pulmonary Embolism: A Single-Center Experience. *Hosp Pediatr.* 2020;10:272-276. doi: 10.1542/hpeds.2019-0290
198. Lott C, Truhlar A, Alfonzo A, Barelli A, Gonzalez-Salvado V, Hinkelbein J, Nolan JP, Paal P, Perkins GD, Thies KC, et al; on behalf of the ERC Special Circumstances Writing Group Collaborators. European Resuscitation Council Guidelines 2021: Cardiac arrest in special circumstances. *Resuscitation.* 2021;161:1 52-219. doi: 10.1016/j.resuscitation.2021.02.011
199. Panchal AR, Bartos JA, Cabanas JG, Donnino MW, Drennan IR, Hirsch KG, Kudenchuk PJ, Kurz MC, Lavonas EJ, Morley PT, et al; on behalf of the Adult Basic and Advanced Life Support Writing Group. Part 3: Adult Basic and Advanced Life Support: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation.* 2020;142:S366-S468. doi: 10.11 61/Cl R0000000000000916
200. Jessen MK, Andersen LW, Djakow J, Chong NK, Stankovic N, Staehr C, Vammen L, Petersen AH, Johannsen CM, Eggertsen MA, et al. Pharmacological interventions for the acute treatment of hyperkalaemia: a systematic review and meta-analysis. *Resuscitation.* 2025;208:110489. doi: 10.1016/j.resuscitation.2025.110489
201. Djakow J, Ng KC, Raymond TT, Atkins DL, Acworth J, Scholefield BR, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. *Pharmacological Interventions for the Treatment of Hyperkalaemia in Paediatric Patients with Cardiac arrest - Paediatric Consensus on Science and Treatment Recommendations {internet]* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Paediatric Advanced Life Support Task Force. Accessed January 20, 2025. https://costr.ilcor.org/document/pharmacological-interventions-for-the-treatment-of-hyperkalaemia-in-paediatric-patients-with-cardiac-arrest-pls-4160-17-tfsr.2025.
202. Granfeldt A, Holmberg M, Andersen LW, Ng KC, Djakow J; on behalf of the Advanced Life Support and Pediatric Life Support Task Forces. Pharmacological Interventions for the Acute Treatment of Hyperkalemia: a systematic review. Accessed January 20, 2025. https://costr.ilcor.org/ document/pharmacological-interventions-for-the-acute-treatment-of-hyperkalemia-als-3403-tf-sr.2024.
203. Lui K, Thungappa U, Nair A, John E. Treatment with hypertonic dextrose and insulin in severe hyperkalaemia of immature infants. *Acta Paediatr.* 1992;81:213-216. doi: 10.1111 /j.1651-2227.1992.tb12206.x
204. Mu SC, Hung HY, Hsu CH, Kao HA, Ho MY, Huang FY. Salbutamol in the treatment of neonatal hyperkalemia. *Clin Neonatal.* 1997;4:9-12.
205. Hu PS, Su BH, Peng CT, Tsai CH. Glucose and insulin infusion versus kayexalate for the early treatment of non-oliguric hyperkalemia in very-low-birth-weight infants. *Acta Paediatr Taiwan.* 1999;40:314-318.
206. Hung KC, Su BH, Lin TW, Peng CT, Tsai CH. Glucose-insulin infusion for the early treatment of non-oliguric hyperkalemia in extremely-low-birth-weight infants. *Acta Paediatr Taiwan.* 2001;42:282-286.
207. Saw HP, Chiu CD, Chiu YP, Ji HR, Chen JY. Nebulized salbutamol diminish the blood glucose fluctuation in the treatment of non-oliguric hyperkalemia of premature infants. *J Chin Med Assoc.* 2019;82:55-59. doi: 10.1016/j.jcma.2018.04.002
208. Murdoch IA, Dos Anjos R, Haycock GB. Treatment of hyperkalaemia with intravenous salbutamol. *Arch Dis Child.* 1991;66:527-528. doi: 10.1136/adc.66.4.527
209. McClure RJ, Prasad VK, Brocklebank JT. Treatment of hyperkalaemia using intravenous and nebulised salbutamol. *Arch Dis Child.* 1994;70:126-1 28. doi: 10.1136/adc.70.2.126
210. Noyan A, Anarat A, Pirti M, Yurdakul Z. Treatment of hyperkalemia in children with intravenous salbutamol. *Acta Paediatr Jpn.* 1995;37:355-357. doi: 10.1111/j.1442-200x.1995.tb03329.x
211. Kemper MJ, Harps E, Hellwege HH, Muller-Wiefel DE Effective treatment of acute hyperkalaemia in childhood by short-term infusion of salbutamol. *Eur J Pediatr.* 1996;155:495-497. doi: 10.1007/BF01955188
212. Arias-Reyes JA, Matos-Martinez M, Velasquez-Jones L, Dubey-Ortega LA [Correction of hyperkalemia with intravenous salbutamol in children with chronic renal insufficiency]. *Bo/ Med Hosp Infant Mex.* 1989;46:603-606.
213. Singh BS, Sadiq HF, Noguchi A, Keenan WJ. Efficacy of albuterol inhalation in treatment of hyperkalemia in premature neonates. *J Pediatr.* 2002;141:16-20. doi: 10.1067/mpd.2002.125229
214. Wang CH, Huang CH, Chang WT, Tsai MS, Yu PH, Wu YW, Hung KY, Chen WJ. The effects of calcium and sodium bicarbonate on severe hyperkalaemia during cardiopulmonary

resuscitation: a retrospective cohort study of adult in-hospital cardiac arrest. *Resuscitation.* 2016;98:105-111. doi: 10.1016/j.resuscitation.2015.09.384
215. Allen J, Cooper DS, Klugman D, Raymond TT, Wooton S, Garza J, Clarke-Myers K, Anderson J, Pasquali SK, Absi M, et al; on behalf of the PC4 CAP Collaborators. Preventing Cardiac Arrest in the Pediatric Cardiac Intensive Care Unit Through Multicenter Collaboration. *JAMA Pediatr.* 2022;176:1027-1036. doi: 10.1001/jamapediatrics.2022.2238
216. Wolf MJ, Kanter KR, Kirshbom PM, Kogan BE, Wagoner SF. Extracorporeal cardiopulmonary resuscitation for pediatric cardiac patients. *Ann Thorac Surg.* 2012;94:874-9; discussion 879. doi: 10.1016/j.athoracsur.2012.04.040
217. Raymond TT, Guerguerian AM, Lasa J, Dhillon G, Moga M, Scholefield BR, Acworth J, Atkins DL, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. *ECPR in Pediatric Cardiac Patients with Single Ventricle Physiology Consensus on Science with Treatment Recommendations {Internet]* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Pediatric Life Support Task Force. Accessed January 20, 2025. https://costr.ilcor.org/document/ ecpr-in-pediatric-cardiac-patients-with-single-ventricle-physiology-pls-4030-09-and-4030-10-tf-sr 2025.
218. Alsoufi B, Awan A, Manlhiot C, AI-Halees Z, Al-Ahmadi M, McCrindle BW, Alwadai A Does single ventricle physiology affect survival of children requiring extracorporeal membrane oxygenation support following cardiac surgery? *World J Pediatr Congenit Heart Surg.* 2014;5:7-15. doi: 10.1177/21 501351135 07292
219. Chan T, Thiagarajan RR, Frank D, Bratton SL. Survival after extra-corporeal cardiopulmonary resuscitation in infants and children with heart disease. *J Thorac Cardiovasc Surg.* 2008;136:984-992. doi: 10.1016/j.jtcvs.2008.03.007
220. Chrysostomou C, Morell VO, Kuch BA, O'Malley E, Munoz R, Wearden PD. Short- and intermediate-term survival after extracorporeal membrane oxygenation in children with cardiac disease. *J Thorac Cardiovasc Surg.* 2013;146:317-325. doi: 10.1016/j.jtcvs.2012.11.014
221. Hoskote A, Bohn D, Gruenwald C, Edgell D, Cai S, Adatia I, Van Arsdell G. Extracorporeal life support after staged palliation of a functional single ventricle: subsequent morbidity and survival. *J Thorac Cardiovasc Surg.* 2006;131:1114-1121. doi: 10.1016/j.jtcvs.2005.11.035
222. Jolley M, Thiagarajan RR, Barrett CS, Salvin JW, Cooper DS, Rycus PT, Teele SA Extracorporeal membrane oxygenation in patients undergoing superior cavopulmonary anastomosis. *J Thorac Cardiovasc Surg.* 2014;148:1512-1518. doi: 10.1016/j.jtcvs.2014.04.028
223. Kane DA, Thiagarajan RR, Wypij D, Scheurer MA, Fynn-Thompson F, Emani S, del Nido PJ, Betit P, Laussen PC. Rapid-response extracorporeal membrane oxygenation to support cardiopulmonary resuscitation in children with cardiac disease. *Circulation.* 2010;122:S241-S248. doi: 10.1161/CIRCULATIONAHA.109.928390
224. Polimenakos AC, Wojtyla P, Smith PJ, Rizzo V, Nater M, El Zein CF, llbawi MN. Post-cardiotomy extracorporeal cardiopulmonary resuscitation in neonates with complex single ventricle: analysis of outcomes. *Eur J Cardiothorac Surg.* 2011;40:1396-1 405; discussion 1405. doi: 10.1016/j.ejcts.2011.01.087
225. Rood KL, Teele SA, Barrett CS, Salvin JW, Rycus PT, Fynn-Thompson F, Laussen PC, Thiagarajan RR Extracorporeal membrane oxygenation support after the Fontan operation.*J Thorac Cardiovasc* Surg.2011;1 42:504-510. doi: 10.1016/j.jtcvs.2010.11.050
226. Sperotto F, Saengsin K, Danehy A, Godsay M, Geisser DL, Rivkin M, Amigoni A, Thiagarajan RR, Kheir JN. Modeling severe functional impairment or death following ECPR in pediatric cardiac patients: Planning for an interventional trial. *Resuscitation.* 2021;167:12-21. doi: 10.1016/j.resuscitation.2021.07.041
227. McMullan DM, Thiagarajan RR, Smith KM, Rycus PT, Brogan TV. Extracorporeal cardiopulmonary resuscitation outcomes in term and premature neonates·. *Pediatr Crit Care Med.* 201 4;15:e9-e16. doi: 10.1097/PCC.Ob013e3182a553f3
228. Melvan JN, Davis J, Heard M, Trivedi JR, Wolf M, Kanter KR, Deshpande SR, Alsoufi B. Factors Associated With Survival Following Extracorporeal Cardiopulmonary Resuscitation in Children. *World J Pediatr Congenit Heart Surg.* 2020;11:265-274. doi: 10.1177/2150135120902102
229. Philip J, Burgman C, Arikan A, Bavare A, Price J, Adachi I, Shekerdemian L. 493: Etiology is crucial in survival in extra corporeal life support in cardiopulmonary resuscitation. *Crit Care Med.* 2013;41:A 120. doi: 10.1097/01.ccm.0000439636.87283.3b
230. Polimenakos AC, Rizzo V, EI-Zein CF, llbawi MN. Post-cardiotomy Rescue Extracorporeal Cardiopulmonary Resuscitation in Neonates with Single Ventricle After Intractable Cardiac Arrest: Attrition After Hospital Discharge and Predictors of Outcome. *Pediatr Cardiol.* 2017;38:314-323. doi: 10.1007/s00246-016-1515-3
231. Sherwin ED, Gauvreau K, Scheurer MA, Rycus PT, Salvin JW, Almodovar MC, Fynn-Thompson F, Thiagarajan RR. Extracorporeal membrane oxygenation after stage 1 palliation for hypoplastic left heart syndrome. *J Thorac CardiovascSurg.* 2012;144:1337-1343. doi: 10.1016/j.jtcvs.2012.03.035
232. Stephens EH, Shakoor A, Jacobs SE, Okochi S, Zenilman AL, Middlesworth W, Kalfa D, Chai PJ, Chaves DV, Bacha E, et al. Characterization of Extracorporeal Membrane Oxygenation Support for Single Ventricle Patients. *World J Pediatr Congenit Heart Surg.* 2020;11:183-191. doi: 10.11 77/2150135119894294
233. Andre MC, Vuille-Dit-Bille RN, Berset A, Hammer J. Rewarming Young Children After Drowning-Associated Hypothermia and Out-of-Hospital Cardiac Arrest: Analysis Using the CAse REport Guideline. *Pediatr Crit Care Med.* 2023;24:e417-e424. doi: 10.1097/PCC.0000000000003254
234. Maier S, Rosner L, Saemann L, Sogl J, Beyersdorf F, Trummer G, Czerny M, Benk C. Extracorporeal Membrane Oxygenation in Intoxication and Overdoses: A Systematic Review. *Thorac Cardiovasc Surg.* 2024;72:288-295. doi: 10.1055/s-0043-1764160
235. Sperotto F, Daverio M, Amigoni A, Gregori D, Dorste A, Allan C, Thiagarajan RR. Trends in In-Hospital Cardiac Arrest and Mortality Among Children With Cardiac Disease in the Intensive Care Unit: A Systematic Review and Meta-analysis. *JAMA Netw Open.* 2023;6:e22561 78. doi: 10.1001 /jamanetworkopen.2022.56178
236. Sperotto F, Daverio M, Amigoni A, Gregori D, Dorste A, Kobayashi RL, Thiagarajan RR, Maschietto N, Alexander PM. Extracorporeal Cardiopulmonary Resuscitation Use Among Children With Cardiac Disease in the ICU: A Meta-Analysis and Meta-Regression of Data Through March 2024. *Pediatr Crit Care Med.* 2024;25:e4 10-e417. doi: 10.1097/pcc.0000000000003594
237. Sperotto F, Gearhart A, Hoskote A, Alexander PMA, Barreto JA, Habel V, Valencia E, Thiagarajan RR. Cardiac arrest and cardiopulmonary resuscitation in pediatric patients with cardiac disease: a narrative review. *Eur J Pediatr* 2023;182:4289-4308. doi: 10.1007/s00431-023-05055-4
238. Bakos M, Braovac D, Barie H, Belina D, Zeljko D, Dilber D, Novak M, Matic T Extracorporeal membrane oxygenation in children: An update of a single tertiary center 11-Year experience from Croatia. *Perfusion.* 2023;38:1002-1011. doi: 10.1177/02676591221093204
239. Beni CE,Rice-Townsend SE,Esangbedo ID,Jancelewicz T,Vogel AM,Newton C, Boomer L, Rothstein DH. Outcome of Extracorporeal Cardiopulmonary Resuscitation in Pediatric Patients Without Congenital Cardiac Disease: Extracorporeal Life Support Organization Registry Study. *Pediatr Crit Care Med.* 2023;24:927-936. doi: 10.1097/pcc.0000000000003322
240. Bilodeau KS, Gray KE, McMullan DM. Extracorporeal cardiopulmonary resuscitation outcomes for children with out-of-hospital and emergency department cardiac arrest. *Am J Em.erg Med.* 2024;81:35-39. doi: 10.1016/j.ajem.2024.03.035
241. Brunetti MA, Gaynor JW, Zhang W, Banerjee M, Domnina YA, Gaies M. Hospital variation in postoperative cardiac extracorporeal membrane oxygenation use and relationship to postoperative mortality. *Cardiol Young.* 2024;34:2543-2550. doi: 10.1017/s 1047951124026568
242. Choi YH, Jhang WK, Park SJ, Choi HJ, Oh MS, Kwon JE, Kim BJ, Shin JA, Lee IK, Park JD, et al. Pediatric Extracorporeal Membrane Oxygenation in Korea: A Multicenter Retrospective Study on Utilization and Outcomes Spanning Over a Decade. *J Korean Med Sci.* 2024;39:e33. doi: 10.3346/jkms.2024.39.e33
243. Gottschalk U, Kbhne M, Holst T, Huners I, von Stumm M, Muller G, Stark V, van Ruth V, Kozlik-Feldmann R, Singer D, et al. Outcomes of extracorporeal membrane oxygenation and cardiopulmonary bypass in children after drowning-related resuscitation. *Perfusion.* 2023;38:109-114. doi: 10.1177/02676591211041229
244. Gutierrez-Soriano L, Becerra Zapata E, Maya Trujillo N, Franco Gruntorad GA, Hurtado Pena P. ECPR for prolonged Pediatric Cardiac Arrest, an outcome without major neurological compromise. *J Extra Corpor Technol.* 2023;55:197-200. doi: 10.1051/ject/2023019
245. Han P, Rasmussen L, Su F, Dacre M, Knight L, Berg M, Tawfik D, Haileselassie B. High Variability in the Duration of Chest Compression Interruption is Associated With Poor Outcomes in Pediatric Extracorporeal Cardiopulmonary Resuscitation. *Pediatr Crit Care Med.* 2024;25:452-460. doi: 10.1097/pcc.0000000000003461
246. Joye R, Cousin VL, Wacker J, Hoskote A, Gebistorf F, Tonna JE, Rycus PT, Thiagarajan RR, Polito A Death by Neurologic Criteria in Children Undergoing Extracorporeal Cardiopulmonary Resuscitation: Retrospective Extracorporeal Life Support Organization Registry Study, 2017-2021. *Pediatr Crit Care Med.* 2024;25:e 1 49-e1 57. doi: 10.1097/PCC.0000000000003406
247. Kaku N, Matsuoka W, Ide K, Totoki T, Hirai K, Mizuguchi S, Higashi K, Tetsuhara K, Nagata H, Nakagawa S, et al. Survival trends of extracorporeal membrane oxygenation support for pediatric emergency patients in regional and metropolitan areas in Japan. *Pediatr Neonatal.* 2024;66:55-59. doi: 10.1016/j.pedneo.2024.04.005
248. Kamsheh AM, Edelson JB, Faerber J, Mondal A, Ouarshie W, Edwards JJ, Lin KY, O'Connor MJ, Wittlieb-Weber C, Maeda K, et al. Mechanical Circulatory Support in Pediatric Myocarditis: Support Strategies and Outcomes in a Nationally Representative Cohort. *JHLT Open.* 2024;3:100026. doi: 10.1016/j.jhlto.2023.100026
249. Loaec M, Himebauch AS, Reeder R, Alvey JS, Race JA, Su L, Lasa JJ, Slavis JC, Raymond TT, Coleman R, et al; on behalf of the American Heart Association's (AHA) Get With The Guidelines-Resuscitation (GWTG-R) Investigators. Outcomes of Extracorporeal Cardiopulmonary Resuscitation for In-Hospital Cardiac Arrest Among Children With Noncardiac Illness Categories. *Crit Care Med.* 2024;52:551-562. doi: 10.1097/CCM.0000000000006153
250. Mowrer MC, Lima L, Nair R, Li X, Sandhu H, Bridges B, Barbaro RP, Bhar S, Nkwantabisa R, Ghafoor S, et al. Pediatric Hematology and Oncology Patients on Extracorporeal Membrane Oxygenation: Outcomes in a Multicenter, Retrospective Cohort 2009-2021. *Pediatr Crit Care Med.* 2024;25:1026-1034. doi: 10.1097/PCC.0000000000003584
251. Olson TL, Kilcoyne HW, Morales-Demori R, Rycus P, Barbaro RP, Alexander PMA, Anders MM. Extracorporeal cardiopulmonary resuscitation for pediatric out-of-hospital cardiac arrest: A review of the Extracorporeal Life Support Organization Registry. *Resuscitation.* 2024;203:110380. doi: 10.1016/j.resuscitation.2024.110380
252. Remy T, Jegard J, Chenouard A, Maminirina P, Liet JM, Couec ML, Joram N, Bourgoin P. Characteristics and outcomes of children and young adults with sickle cell disease supported with extracorporeal membrane oxygenation (ECMO): An updated analysis of the ELSO registry. *Artif Organs.* 2024;49:508-515. doi: 10.1111 /aor.14880

253. Schwartz JM, Ng DK, Roem J, Padmanabhan N, Romero D, Joe J, Campbell C, Sigal GB, Wohlstadter J N, Everett AD, et al. Higher levels of brain injury biomarker tau are associated with unfavorable outcomes in patients supported with ECMO following cardiac arrest. *Resusc Plus.* 2024;18:100609. doi: 10.1016/j.resplu.2024.100609
254. Turner AD, Streb MM, Ouyang A, Leonard SS, Hall TA, Bosworth CC, Williams CN, Guerriero RM, Hartman ME, Said AS, et al. Long-Term Neurobehavioral and Functional Outcomes of Pediatric Extracorporeal Membrane Oxygenation Survivors. *ASAIO J.* 2024;70:409-416. doi: 10.1097/ MAT.0000000000002135
255. Varrica A, Cotza M, Rito ML, Satriano A, Carboni G, Saracino A, Reali M, Hafdhullah M, Ranucci M, Giamberti A Post cardiotomy extracorporeal membrane oxygenation in pediatric patients: Results and neurodevelopmental outcomes. *Artif Organs.* 2024;48:1525-1535. doi: 10.1111/aor.14842
256. Yoo BA, Yoo S, Choi ES, Kwon BS, Park CS, Yun TJ, Kim DH. Extracorporeal Cardiopulmonary Resuscitation in Infants: Outcomes and Predictors of Mortality. *J Chest Surg.* 2023;56:162-170. doi: 10.5090/jcs.22.138
257. Zhao WT, He WL, Yang LJ, Lin R. Outcomes in pediatric extracorporeal cardiopulmonary resuscitation: A single-center retrospective study from 2007 to 2022 in China. *Am J Em.erg Med.* 2024;83:25-31. doi: 10.1016/j.ajem.2024.06.034
258. Nuthall G, Christoff A, Morrison LJ, Acworth J, Scholefield BR, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. *Blood pressure targets following re/um of circulation after cardiac arrest: Consensus on Science with Treatment Recommendations [Internet]* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Advanced Life Support Task Force. Accessed January 20, 2025. https://costr.ilcor.org/document/blood-pressure-targets-following-return-of-circulation-after-pediatric-cardiac-arrest-pls-4190-01-tf-sr.2025.
259. Gardner MM, Hehir DA, Reeder RW, Ahmed T, Bell MJ, Berg RA, Bishop R, Bochkoris M, Burns C, Carcillo JA, et al. Identification of post-cardiac arrest blood pressure thresholds associated with outcomes in children: an ICU-Resuscitation study. *Crit Care.* 2023;27:388. doi: 10.1186/s 13054-023-04662-9
260. 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 :1 43-149. doi: 10.1097/pcc.0000000000002119
261. Topjian AA, French B, Sutton RM, Conlon T, Nadkarni VM, Moler FW, Dean J M, Berg RA Early postresuscitation hypotension is associated with increased mortality following pediatric cardiac arrest *Crit Care Med* 2014;42:1518-1523. doi: 10.1097/CCM.0000000000000216
262. Topjian AA, Sutton RM, Reeder RW, Telford R, Meer! KL, Yates AR, Morgan RW, Berger JT, Newth CJ, Carcillo JA, et al; on behalf of the Eunice Kennedy Shriver National Institute of Child Health and Human Development Collaborative Pediatric Critical Care Research Network (CPCCRN) Investigators. The association of immediate post cardiac arrest diastolic hypertension and survival following pediatric cardiac arrest *Resuscitation.* 2019;141:88-95. doi: 10.1016/j.resuscitation.2019.05.033
263. Topjian AA, Telford R, Holubkov R, Nadkarni VM, Berg RA, Dean J M, Moler FW; on behalf of the Therapeutic Hypothermia After Pediatric Cardiac Arrest (THAPCA) Trial Investigators. Association of Early Postresuscitation Hypotension With Survival to Discharge After Targeted Temperature Management for Pediatric Out-of-Hospital Cardiac Arrest: Secondary Analysis of a Randomized Clinical Trial.*JAMA Pediatr.* 2018;172:143-153. doi: 10.1001/jamapediatrics.2017.4043
264. Topjian AA, Telford R, Holubkov R, Nadkarni VM, Berg RA, Dean J M, Moler FW; on behalf of the Therapeutic Hypothermia after Pediatric Cardiac Arrest (THAPCA) Trial Investigators. The association of early post-resuscitation hypotension with discharge survival following targeted temperature management for pediatric in-hospital cardiac arrest. *Resuscitation.* 2019;141:24-34. doi: 10.1016/j.resuscitation.2019.05.032
265. Ushpol A, Je S, Niles D, Majmudar T, Kirschen M, Del Castillo J, Buysse C, Topjian A, Nadkarni V, Gangadharan S; PediRES-0 investigators. Association of blood pressure with neurologic outcome at hospital discharge after pediatric cardiac arrest resuscitation. *Resuscitation.* 2024;194:110066. doi: 10.1016/j.resuscitation.2023.110066
266. Lin Y-R, Li C-J, Wu T-K, Chang Y-J, Lai S-C, Liu T-A, Hsiao M-H, Chou C-C, Chang C-F. Post-resuscitative clinical features in the first hour after achieving sustained ROSC predict the duration of survival in children with non-traumatic out-of-hospital cardiac arrest *Resuscitation.* 2010;81:41 0-417. doi: 10.1016/j.resuscitation.2010.01.006
267. Lin YR, Wu HR Chen WL, Wu KH, Teng TH, Yang MC, Chou CC, Chang CF, Li CJ. Predictors of survival and neurologic outcomes in children with traumatic out-of-hospital cardiac arrest during the early postresuscitative period. *J Trauma Acute Care Surg.* 2013;75:439-447. doi: 10.1097/TAObO 13e31829e2543
268. Scholefield BR, Tijssen J, Ganesan SL, Kool M, Couto TB, Topjian A, Atkins DL, Acworth J, McDevitt W, Laughlin S, et al. Prediction of good neurological outcome after return of circulation following paediatric cardiac arrest: a systematic review and meta-analysis. *Resuscitation.* 2024;207:110483. doi: 10.1016/j.resuscitation.2024.110483
269. Scholefield BR, Tijssen J, Ganesan S, Topjian A, Bittencourt Couto T, Atkins DL, Acworth J, Guerguerian AM, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. *Biomarkers for the prediction of survival with poor neurological outcome after return of circulation following pediatric cardiac arrest Consensus on Science with Treatment Recommendations [internet]* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Pediatric Life Support Task Force. Accessed January 20, 2025. https://costr.ilcor.org/documenV blood-biomarkers-for-the-prediction-of-poor-neurological-outcome-after-return-of-circulation-foIlowing-pediatric-cardiac-arrest-pls-4220-01 -tf-sr.2025.
270. Scholefield BR, Tijssen J, Ganesan S, Topjian A, Bittencourt Couto T, Atkins DL, Acworth J, Guerguerian AM, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. *Clinical examination for the prediction of survival with poor neurological outcome after return of circulation following pediatric cardiac arrest Consensus on Science with Treatment Recommendations [internet]* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Pediatric Life Support Task Force. Accessed January 20, 2025. https://costr.ilcor.org/ document/clinical-examination-for-the-prediction-of-poor-neurological-outcome-after-return-of-circulation-following-pediatric-cardiac-arrest-pls-4220-02-tf-sr.2025.
271. Scholefield BR, Tijssen J, Ganesan S, Topjian A, Bittencourt Couto T, Atkins DL, Acworth J, Guerguerian AM, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. *Electrophysiology testing for the prediction of survival with poor neurological outcome after return of circulation following pediatric cardiac arrest Consensus on Science with Treatment Recommendations [internet]* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Pediatric Life Support Task Force. Accessed January 20, 2025. https://costr.ilcor.org/ documenVelectrophysiology-testing-for-the-prediction-of-poor-neurologi-cal-outcome-after-return-of-circulation-following-pediatric-cardiac-arrest-pls-4220-03.2025.
272. Scholefield BR, Tijssen J, Ganesan S, Topjian A, Bittencourt Couto T, Atkins DL, Acworth J, Guerguerian AM, on behalf of the International Liaison Committee on Resuscitation Pediatric Life Support Task Force. *Brain Imaging for the prediction of survival with poor neurological outcome after return of circulation following pediatric cardiac arrest Consensus on Science with Treatment Recommendations [internet]* Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Pediatric Life Support Task Force. Accessed January 20, 2025. https://costr.ilcor.org/ document/brain-imaging-for-the-prediction-of-poor-neurological-out-come-after-return-of-circulation-following-pediatric-cardiac-arrest-pls-4220-04-tf-sr.2025.
273. De La Liana RA, Le Marsney R, Gibbons K, Anderson B, Haisz E, Johnson K, Black A, Venugopal P, Mattke AC. Merging two hospitals: the effects on pediatric extracorporeal cardiopulmonary resuscitation outcomes. *J Pediatr Intensive Care.* 2021;10:202-209. doi: 10.1055/s-0040-1715853
274. Lopez-Herce J, del Castillo J, Matamoros M, Canadas S, Rodriguez-Calvo A, Cecchetti C, Rodriguez-Nunez A, Carrillo A; on behalf of the Iberoamerican Pediatric Cardiac Arrest Study Network RIBEPCI. Post return of spontaneous circulation factors associated with mortality in pediatric in-hospital cardiac arrest: a prospective multicenter multinational observational study. *CritCare.* 2014;18:607. doi: 10.1186/s13054-014-0607-9
275. Meert KL, Guerguerian AM, Barbaro R, Slomine BS, Christensen JR, Berger J, Topjian A, Bembea M, Tabbutt S, Fink EL, et al; on behalf of the Therapeutic Hypothermia After Pediatric Cardiac Arrest (THAPCA) Trial Investigators. Extracorporeal Cardiopulmonary Resuscitation: One-Year Survival and Neurobehavioral Outcome among Infants and Children with In-Hospital Cardiac Arresr. *Crit Care Med* 2019;47:393-402. doi: 10.1097/CCM.0000000000003545
276. Moler FW, Silverstein FS, Holubkov R, Slomine BS, Christensen JR, Nadkarni VM, Meert KL, Browning B, Pemberton VL, Page K, et al; on behalf of the THAPCA Trial Investigators. Therapeutic Hypothermia after In-Hospital Cardiac Arrest in Children. *N Engl J Med.* 2017;376:318-329. doi: 10.1056/NEJMoa1610493
277. Moler FW, Silverstein FS, Holubkov R, Slomine BS, Christensen JR, Nadkarni VM, Meer! KL, Clark AE, Browning B, Pemberton VL, et al; on behalf of the THAPCA Trial Investigators. Therapeutic hypothermia after out-of-hospital cardiac arrest in children. *N Engl J Med* 2015;372:1898-1908. doi: 10.1056/NEJMoa1411480
278. Kramer R Miera 0, Berger F, Schmitt K. Prognostic value of serum biomarkers of cerebral injury in classifying neurological outcome after paediatric resuscitation. *Resuscitation.* 2018;122:113-120. doi: 10.1016/j.resuscitation.2017.09.01 2
279. Bangshoj J, Liebetrau B, Wiberg S, Gjedsted J, Kjaergaard J, Hassager C, Wanscher M. The Value of the Biomarkers Neuron-Specific Enolase and S100 Calcium-Binding Protein for Prediction of Mortality in Children Resuscitated After Cardiac Arrest *Pediatr Cardiol.* 2022;43:1659-1665. doi: 10.1007/s00246-022-02899-9
280. Fink EL, Berger RR Clark RSB, Watson RS, Angus DC, Richichi R, Panigrahy A, Callaway CW, Bell MJ, Kochanek PM. Serum biomarkers of brain injury to classify outcome after pediatric Cardiac Arrest'. *Crit Care Med* 201 4;42:664-674. doi: 10.1097/01.ccm.0000435668.53188.80
281. Fink EL, Kochanek PM, Panigrahy A, Beers SR, Berger RR Bayir H, Pineda J, Newth C, Topjian AA, Press CA, et al; on behalf of the Personalizing Outcomes After Child Cardiac Arrest (POCCA) Investigators. Association of Blood-Based Brain Injury Biomarker Concentrations with Outcomes after Pediatric Cardiac Arrest *JAMA Netw Open.* 2022;5:e2230518. doi: 10.1001/jamanetworkopen.2022.30518
282. Abend NS, Topjian AA, Kessler SK, Gutierrez-Colina AM, Berg RA, Nadkarni V, Dlugos DJ, Clancy RR, lchord RN. Outcome prediction by motor and pupillary responses in children treated with therapeutic hypothermia after cardiac arrest *Pediatr Crit Care Med* 2012;13:32-38. doi: 10.1097/PCC.Ob013e3182196a7b
283. Ducharme-Crevier L, Press CA, Kurz J E, Mills MG, Goldstein J L, Wainwright MS. Early presence of sleep spindles on electroencephalography is associated with good outcome after pediatric cardiac arrest. *Pediatr Crit Care Med* 2017;18:452-460. doi: 10.1097/PCC.0000000000001137
284. Lin JJ, Hsu MH, Hsia SH, Lin YJ, Wang HS, Kuo HC, Chiang MC, Chan OW, Lee EP, Lin KL; on behalf of the iCNS Group. Epileptiform Discharge and Electrographic Seizures during the Hypothermia Phase as Predictors of Rewarming Seizures in Children after Resuscitation. *J Clin Med.* 2020;9:2151. doi: 10.3390/jcm9072151
285. Nishisaki A, Sullivan J 3rd, Steger B, Bayer CR, Dlugos D, Lin R, lchord R, Helfaer MA, Nadkarni V. Retrospective analysis of the prognostic value of electroencephalography patterns obtained in pediatric in-hospital cardiac arrest survivors during three years. *Pediatr Crit Care Med.* 2007;8:10-17. doi: 10.1097/01.pcc.0000256621.63135.4b
286. Topjian AA, Zhang B, Xiao R, Fung FW, Berg RA, Graham K, Abend NS. Multimodal monitoring including early EEG improves stratification of brain injury severity after pediatric cardiac arrest. *Resuscitation.* 2021;167:282-288. doi: 10.1016/j.resuscitation.2021.06.020
287. Oualha M, Gatterre P, Boddaert N, Dupic L, De Saint Blanquat L, Hubert P, Lesage F, Desguerre I. Early diffusion-weighted magnetic resonance imaging in children after cardiac arrest may provide valuable prognostic information on clinical outcome. *Intensive Care* Med.2013;39: 1306-1312. doi: 10.1007/s00134-013-2930-z
288. Brooks GA, Park JT. Clinical and Electroencephalographic Correlates in Pediatric Cardiac Arrest: Experience at a Tertiary Care Center. *Neuropediatrics.* 2018;49:324-329.

doi: 10.1055/s-0038-1657757
289. Bach AM, Kirschen MP, Fung FW, Abend NS, Ampah S, Mondal A, Huh JW, Chen SL, Yuan I, Graham K, et al. Association of EEG Background With Diffusion-Weighted Magnetic Resonance Neuroimaging and Short-Term Outcomes After Pediatric Cardiac Arrest. *Neurology.* 2024;102:e209134. doi: 10.1212/WNL.0000000000209134
290. Fung FW, Topjian AA, Xiao R, Abend NS. Early EEG Features for Outcome Prediction After Cardiac Arrest in Children. *J Clin Neurophysiol.* 2019;36:349-357. doi: 10.1097/WNP.0000000000000591
291. Kirschen MP, Licht DJ, Faerber J, Mondal A, Graham K, Wnters M, Balu R, Diaz-Arrastia R, Berg RA, Topjian A, et al. Association of MRI brain injury with outcome after pediatric out-of-hospital cardiac arrest. *Neurology.* 2021;96:e719-e731. doi: 10.1212/WNL.0000000000011217
292. Lin JJ, Lin YJ, Hsia SH, Kuo HC, Wang HS, Hsu MH, Chiang MC, Lin CY, Lin KL. Early Clinical Predictors of Neurological Outcome in Children With Asphyxia! Out-of-Hospital Cardiac Arrest Treated With Therapeutic Hypothermia. *Front Pediatr.* 2019;7:534. doi: 10.3389/fped.2019.00534
293. Mazzio EL, Topjian AA, Reeder RW, Sutton RM, Morgan RW, Berg RA, Nadkarni VM, Wolfe HA, Graham K, Nairn MY, et al; on behalf of the ICU-RESUS Eunice Kennedy Shriver National Institute of Child Health. Association of EEG characteristics with outcomes following pediatric ICU cardiac arrest: a secondary analysis of the ICU-RESUScitation trial. *Resuscitation.* 2024;201:110271. doi: 10.1016/j.resuscitation.2024.110271
294. Ostendorf AP, Hartman ME, Friess SH. Early electroencephalographic findings correlate with neurologic outcome in children following cardiac arrest. *Pediatr Crit Care Med.* 2016;17:667-676. doi: 10.1097/PCC.0000000000000791
295. Smith AE, Ganninger AP, Mian AY, Friess SH, Guerriero RM, Guilliams KP. Magnetic resonance imaging adds prognostic value to EEG after pediatric cardiac arrest. *Resuscitation.* 2022;1 73:91-100. doi: 10.1016/j.resuscitation.2022.02.Q17
296. Topjian AA, Sanchez SM, Shults J, Berg RA, Dlugos DJ, Abend NS. Early Electroencephalographic Background Features Predict Outcomes in Children Resuscitated from Cardiac Arrest. *Pediatr Crit Care Med.* 2016;17:547-557.doi: 10.1097/PCC.0000000000000740
297. Yang D, Ryoo E, Kim HJ. Combination of early EEG, brain CT, and ammonia level is useful to predict neurologic outcome in children resuscitated from cardiac arrest. *Front Pediatr.* 2019;7:223. doi: 10.3389/fped.2019.00223
298. Kessler SK, Topjian AA, Gutierrez-Colina AM, lchord RN, Donnelly M, Nadkarni VM, Berg RA, Dlugos DJ, Clancy RR, Abend NS. Short-term outcome prediction by electroencephalographic features in children treated with therapeutic hypothermia after cardiac arrest. *Neurocrit Care.* 2011;14:37-43. doi: 10.1007/s12028-010-9450-2
299. Bourgoin P, Barrault V, Joram N, Leclair Visonneau L, Toulgoat F, Anthoine E, Loron G, Chenouard A The prognostic value of early amplitude-integrated electroencephalography monitoring after pediatric cardiac arrest. *Pediatr Crit Care Med.* 2020;21:248-255.
300. McDevitt WM, Rowberry TA, Davies P, Bill PR, Notghi LM, Morris KP, Scholefield BR. The Prognostic Value of Somatosensory Evoked Potentials in Children After Cardiac Arrest: The SEPIA Study. *J Clin Neurophysiol.* 2021;38:30-35. doi: 10.1097/wnp.0000000000000649
301. Hirsch LJ, Fong MWK, Leitinger M, LaRoche SM, Beniczky S, Abend NS, Lee JW, Wusthoff CJ, Hahn CD, Westover MB, et al. American Clinical Neurophysiology Society's Standardized Critical Care EEG Terminology: 2021 Version. *J Clin Neurophysiol.* 2021;38:1-29. doi: 10.1097/WNP.0000000000000806
302. Sandroni C, D'Arrigo S, Cacciola S, Hoedemaekers CWE, Kamps MJA, Oddo M, Taccone FS, Di Rocco A, Meijer FJA, Westhall E, et al. Prediction of poor neurological outcome in comatose survivors of cardiac arrest: a systematic review. *Intensive Care Med.* 2020;46:1803-1851. doi: 10.1007/s00134-020-06198-w
303. Starling RM, Shekdar K, Licht D, Nadkarni VM, Berg RA, Topjian AA. Early head CT findings are associated with outcomes after pediatric out-of-hospital cardiac arrest. *Pediatr Crit Care Med.* 2015;16:542-548. doi: 10.1097/PCC.0000000000000404
304. Yacoub M, Birchansky B, Mlynash M, Berg M, Knight L, Hirsch KG, Su F; Revive Initiative at Stanford Children's Health. The prognostic value of quantitative diffusion-weighted MRI after pediatric cardiopulmonary arrest. *Resuscitation.* 2019;135:103-109. doi: 10.1016/j.resuscitation.2018.11.003
305. Fink EL, Panigrahy A, Clark RSB, Fitz CR, Landsittel D, Kochanek PM, Zuccoli G. Regional brain injury on conventional and diffusion weighted MRI is associated with outcome after pediatric cardiac arrest. *Neurocrit Care.* 2013;19:31-40. doi: 10.1007/s12028-012-9706-0
306. Fink EL, Wisnowski J, Clark R, Berger RP, Fabio A, Furtado A, Narayan S, Angus DC, Watson RS, Wang C, et al. Brain MR imaging and spectroscopy for outcome prognostication after pediatric cardiac arrest. *Resuscitation.* 2020;157:185-194. doi: 10.1016/j.resuscitation.2020.06.033
307. Albrecht M, de Jonge RCJ, Del Castillo J, Christoff A, De Hoag M, Je S, Nadkarni VM, Niles DE, Tegg 0, Wellnitz K, et al; on behalf of the pediRES-O Collaborative Investigators. Association of cumulative oxygen and carbon dioxide levels with neurologic outcome after pediatric cardiac arrest resuscitation: a multicenter cohort study. *Resusc Plus.* 2024;20:100804. doi: 10.1016/j.resplu.2024.100804
308. Barreto JA, Weiss NS, Nielsen KR, Farris R, Roberts JS. Hyperoxia after pediatric cardiac arrest: Association with survival and neurological outcomes. *Resuscitation.* 2022;171:8-14. doi: 10.1016/j.resuscitation.2021.12.003
309. Frazier AH, Topjian AA, Reeder RW, Morgan RW, Fink EL, Franzon D, Graham K, Harding ML, Mourani PM, Nadkarni VM, et al. Association of Pediatric Postcardiac Arrest Ventilation and Oxygenation with Survival Outcomes. *Ann Am Thorac Soc.* 2024;21:895-906. doi: 10.1513/AnnalsATS.202311-9480C
310. Holton C, Lee BR, Escobar H, Benton T, Bauer P. Admission Pa o2 and Mortality Among PICU Patients and Select Diagnostic Subgroups. *Pediatr Crit Care Med.* 2023;24:e362-e371. doi: 10.1097/PCC.0000000000003247