## Appendix A

## Advanced Life Support – 2026 Evidence to Decision Tables

# Table of Contents

# Thrombolytics During Cardiac Arrest (ALS 3203)

## QUESTION

| Should thrombolytics vs. no thrombolytics be used for cardiac arrest in adults or children? | |
|---|---|
| POPULATION: | Adults of children in cardiac arrest |
| INTERVENTION: | Thrombolytics |
| COMPARISON: | No thrombolytics |
| MAIN OUTCOMES: | Survival to hospital discharge; Return of spontaneous circulation (ROSC); Any intracranial hemorrhage; Favourable Neurological Outcome at hospital discharge; |
| SETTING: | Any setting |
| PERSPECTIVE: | Individual Patient |
| BACKGROUND: | Pulmonary embolism and acute coronary syndrome are not uncommon etiologies of cardiac arrest. Thrombolytics are treatment options for these conditions for patients not in cardiac arrest. Some have questioned whether thrombolytics should be added to the routine / standard management algorithm for cardiac arrest. |
| CONFLICT OF INTERESTS: | One member was the lead author on the TROICA trial. |

## ASSESSMENT

### Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | It is estimated that there are over 4 million cardiac arrests that occur per year globally. Acute coronary occlusion (ACS) and pulmonary embolisms (PE) are both common etiologies of cardiac arrest, for which treatment options may include thrombolytic medications. Although the etiology of cardiac arrest is rarely known at the time of treatment, given that ACS and PE are common etiologies, it has been suggested that intra-arrest thrombolysis may be an appropriate empiric treatment option for undifferentiated cardiac arrest. | |

### Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | There have been three randomized clinical trials performed (one pilot trial and two clinical-effectiveness trials), randomizing individuals with cardiac arrest (primarily out-of-hospital cardiac arrest, but a small number of in-hospital cardiac arrest patients) to intra-arrest thrombolytics vs placebo. No trial reported a significant improvement of survival to hospital discharge or survival to hospital discharge with favourable neurological outcome.<br>When examining subgroup analyses, among those with bystander CPR, treatment with thrombolysis (vs. placebo) resulted in a lower proportion with 30-day survival (RR 0.55, 95% CI 0.35, 0.87). Among those with initial shockable rhythms, data was suggestive that | |

| | |
|---|---|
| | thrombolysis (vs. placebo) may lead to worse outcomes (RR 0.80, 95% CI 0.60, 1.06) however this was not statistically significant. |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>● Moderate<br>○ Large<br>○ Varies<br>○ Don't know | The primary risk of thrombolysis is of bleeding complications. Two studies reported bleeding complications, which were consistently numerically higher for those treated with thrombolysis. However, the only bleeding complication that was statistically different between groups was "any intracranial hemorrhage" (RR 6.96, 95% CI 1.59, 30.41). | |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>● Moderate<br>○ High<br>○ No included studies | The research investigating thrombolysis for undifferentiated includes three randomized clinical trials. One trial was judged to have a high risk of bias, however was small and contributed a very small weight to the meta-analysis. Further, the results were not inconsistent with other data. Thus, we have not down-graded the overall certainty of evidence based on this single study. All data are consistent, with no evidence demonstrating a benefit of thrombolysis. However, the confidence intervals of the results are wide, and thus there may still be benefit or harm within these bounds. | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | Previous data indicate that patients prioritize survival with intact neurological function, but also value survival. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | |
|---|---|
| ○ Favors the comparison<br>● Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | The available randomized clinical evidence did not detect a benefit of thrombolysis for undifferentiated out-of-hospital cardiac arrest. Among those with bystander CPR, a harmful effect was detected. Further, thrombolysis resulted in a higher proportion of cases with intracranial hemorrhage. Also worth considering is the task-saturated nature of cardiac arrest resuscitations, and that the deployment of additional interventions may interfere with or worsen the quality of standard resuscitation management. Overall, the balance between desirable and undesirable effects favour not administering thrombolytics. (See Appendix A "Evidence Table" below). |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>● Moderate costs<br>○ Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | Thrombolytics are expensive, often costing over $1000 USD per dose. The drugs typically need to be refrigerated (at 2-8 degrees C), which adds to the expense of storing on ambulances in the out-of-hospital setting. The drugs have a typical shelf-life of 3 years. Overall, the costs and logistical challenges of providing this therapy are not negligible. | |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | There are no studies evaluating the resources required for this intervention. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | |
|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● No included studies | There are no studies which have examined cost-effectiveness. However given the cost of the intervention and lack of evidence of effectiveness, it is unlikely that the intervention would be cost-effective. |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>● Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>○ Don't know | Given there was no benefit seen with thrombolytics, there is no expected impact on equity. If there was a benefit seen, monitoring efforts for inequitable access to this expensive treatment option would have been appropriate. | |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | The available research did not include any assessments of acceptability. However, given that survival with favourable neurological outcomes is a prioritized outcome of patients, and that thrombolytic medications are administered while patients are unconscious, it is likely that the eventual neurological outcome data would govern acceptability. Overall, it is likely that this intervention would be acceptable to patients if it demonstrated effectiveness. | |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | The cost for thrombolytics is not negligible, often costing over $1000 USD per dose. Thrombolytics require refrigerated storage (at 2–8 °C) and need to be reconstituted prior to administration. Overall, thrombolytic use is potentially feasible, but does add to healthcare costs, as well as resulting in additional tasks to perform during cardiac arrest resuscitations. | |

# SUMMARY OF JUDGEMENTS

| JUDGEMENT |
|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | **Trivial** | Small | Moderate | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Trivial | Small | **Moderate** | Large | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | Very low | Low | **Moderate** | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | **Probably favors the comparison** | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | **Moderate costs** | Negligible costs and savings | Moderate savings | Large savings | Varies | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | Probably reduced | **Probably no impact** | Probably increased | Increased | Varies | Don't know |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ● | ○ | ○ | ○ | ○ |

## CONCLUSIONS

**Recommendation**

We recommend against the routine administration of thrombolytics during cardiopulmonary resuscitation for the treatment of cardiac arrest (strong recommendation, moderate certainty of evidence).

**Justification**

· There were three RCT's which examined the benefit of thrombolytics (vs. no thrombolytics) for cardiac arrest. Overall, available data did not demonstrate a benefit of thrombolytics for any clinical outcome, however data indicated a risk of harm due to an increased risk of intracranial bleeding.
· Although studies had specific inclusion criteria (presumed cardiac origin [i.e. no obvious non-cardiac cause], witnessed arrest, or PEA), these categories were still broadly undifferentiated.
· Risk of bias was judged to be low for two large RCT's, and high for a small pilot study. However, we elected not to downgrade the certainty of evidence based on the high risk of bias for the single study, given that: (1) in the meta-analysis the small study had minimal impact on the overall results; (2) results were consistent after removal of the small study; and (3) the results of the small study were consistent with the two larger studies.
· All safety outcomes examining bleeding were suggestive of an increased risk of bleeding from thrombolytic therapy. A single outcome of "any intracranial hemorrhage" showed a statistically significant harm. We classified safety outcomes at a high risk of bias (specifically verification bias), given that all cases were not evaluated for the outcome of interest. For example, patients that died early in the course of treatment did not survive long enough to be evaluated. Even those that survived initial treatment did were not all evaluated for bleeding complications. It is likely that bleeding (even life-threatening bleeding) was missed given that all patients were critically ill and did not all undergo evaluation for bleeding. However, the direction of bias would likely be in underestimating the harms of thrombolytics, and thus a comprehensive evaluation of bleeding would likely only increase the current findings which already suggest a risk of increased bleeding.

## Subgroup considerations

· Although analyses examining subgroups should be considered exploratory and at risk of type I error given multiple comparisons, it is notable that among cases with bystander CPR, thrombolytic therapy (in comparison to no thrombolytic therapy) resulted in an lower proportion of survivors. The subgroup of cases with initial shockable rhythms was also suggestive of harm.

## Implementation considerations

· We considered the resource implications of administering this therapy, which were not negligible. The therapy often costs >$1000 USD, require refrigerated storage, and need to be reconstituted prior to administration.

## Monitoring and evaluation

· Not applicable

## Research priorities

· Our review examined cases of undifferentiated cardiac arrest, which were largely out-of-hospital cardiac arrests
· Future research may be warranted to examine the benefit of thrombolytics among: (1) those with an increased risk of PE; (2) in-hospital cardiac arrest.

**Appendix A: Evidence Table**

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of | Study event rates (%) | | Relative effect (95 | Anticipated absolute effects | |
| | | | | | | | With no thrombolytics | With thrombolytics | | Risk with no | Risk difference with |

| Follow-up | | | | | | evidence | | | % CI) | thrombolytics | thrombolytics |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Survival to hospital discharge** | | | | | | | | | | | |
| 1299 (3 RCTs) | not serious[a] | not serious | not serious | serious[b] | none | ⨁⨁◯◯ Moderate[a,b] | 91/646 (14.1%) | 79/653 (12.1%) | **RR 0.86** (0.65 to 1.14) | 91/646 (14.1%) | **20 fewer per 1,000** (from 49 fewer to 20 more) |
| **Return of spontaneous circulation (ROSC)** | | | | | | | | | | | |
| 1294 (3 RCTs) | not serious[a] | not serious | not serious | serious[b] | none | ⨁⨁◯◯ Moderate[a,b] | 307/643 (47.7%) | 316/651 (48.5%) | **RR 1.04** (0.72 to 1.51) | 307/643 (47.7%) | **19 more per 1,000** (from 134 fewer to 243 more) |
| **Any intracranial hemorrhage** | | | | | | | | | | | |
| 1032 (1 RCT) | serious[c] | not serious | not serious | serious[b] | none | ⨁⨁◯◯ Low[b,c] | 2/514 (0.4%) | 14/518 (2.7%) | **RR 6.95** (1.59 to 30.41) | 2/514 (0.4%) | **22 more per 1,000** (from 2 more to 111 more) |
| **Favourable Neurological Outcome at hospital discharge** | | | | | | | | | | | |
| 1299 (3 RCTs) | not serious[a] | not serious | not serious | serious[b] | none | ⨁⨁◯◯ Moderate[a,b] | 55/653 (8.4%) | 55/646 (8.5%) | **RR 1.00** (0.70 to 1.41) | 55/653 (8.4%) | **0 fewer per 1,000** (from 25 fewer to 35 more) |

**CI:** confidence interval; **RR:** risk ratio

## *Explanations*

a. Risk of bias for Fatovich 2024 was judged to be high, however given the small sample size and low weight on the results, we did not downgrade the overall certainty of evidence based on this single study.
b. Confidence interval are wide, including both clinically important potential benefit and harm.
c. Bleeding outcomes were not consistent across studies. Verification bias was a concern

**References:**


1. Abu-Laban RB, Christenson JM, Innes GD, van Beek CA, Wanger KP, McKnight RD, MacPhail IA, Puskaric J, Sadowski RP, Singer J, Schechter MT and Wood VM. Tissue plasminogen activator in cardiac arrest with pulseless electrical activity. *N Engl J Med*. 2002;346:1522–1528.
2. Bottiger BW, Arntz HR, Chamberlain DA, Bluhmki E, Belmans A, Danays T, Carli PA, Adgey JA, Bode C and Wenzel V; on behalf of the Troica Trial Investigators and the European Resuscitation Council Study Group. Thrombolysis during resuscitation for out-of-hospital cardiac arrest. *N Engl J Med*. 2008;359:2651–2662.
3. Fatovich DM, Dobb GJ and Clugston RA. A pilot randomised trial of thrombolysis in cardiac arrest (the TICA trial). *Resuscitation*. 2004;61:309–313.

# Intramuscular Epinephrine (ALS 3212)

## QUESTION

| SHOULD INTRAMUSCULAR EPINEPHRINE BE USED DURING CARDIAC ARREST IN ADULTS? | |
|---|---|
| **POPULATION:** | Adult patients who suffer a cardiac arrest in any setting. |
| **INTERVENTION:** | Intramuscular (IM) route of epinephrine administration. |
| **COMPARISON:** | IV/IO epinephrine administration. |
| **MAIN OUTCOMES:** | Any clinical outcome. |

## ASSESSMENT

### Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | Survival for cardiac arrest remains poor despite advances in resuscitation. IM epinephrine is a relatively inexpensive intervention that can be delivered by a variety of first responders and enable earlier administration of epinephrine. | This topic was chosen for review because it has never been systematically reviewed by ILCOR. It was prioritized by the ALS Task Force as there is great interest in the topic after a recent publication. This topic was completed using the adolopment process, leveraging a recently published systematic review.[1] |

### Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>● Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | Only one clinical study was identified.[2] The study was single-center study comparing patient outcomes before and after implementation of an early, first-dose IM epinephrine EMS protocol for adult OHCA patients. In both groups epinephrine 1 mg IV or IO was provided every 3–5 min once vascular access was established. The pre-intervention period took place between January 2010 and October 2019. The post-intervention period was between November 2019 and May 2024.<br>5 animal studies were identified.[3-7] The animal studies were heterogenous with regards to methodology and interventions precluding any meaningful synthesis of the results | If the effect of IM epinephrine is similar or attenuated compared to IV/IO epinephrine the desirable effect on clinical important outcomes is likely small. |

### Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Large<br>○ Moderate<br>● Small<br>○Trivial<br>○ Varies<br>○ Don't know | There was no sign of a potential undesirable effect of IM epinephrine in the one clinical study that was identified. | The potential undesirable effects include necrosis and infection at the injection site.<br>Furthermore, it is unclear whether prioritizing IM epinephrine could potentially delay other important interventions. |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | The certainty of evidence was judged very low-certainty (downgraded for risk of bias and imprecision) | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | The importance of survival and neurologically intact survival is generally agreed upon. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>● Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | The one study that was identified[2] showed a clear effect of IM epinephrine, however the study was single-center study comparing patient outcomes before and after implementation of an early, first-dose IM epinephrine EMS, making it at serious risk of confounding. | |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>● Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | IM epinephrine is low-cost in most settings and possibly at a lower cost that IV/IO epinephrine. | |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | No relevant studies were identified. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● No included studies | No cost-effectiveness data were identified. | |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>○Probably no impact<br>●Probably increased<br>○ Increased<br>○ Varies<br>○ Don't know | IM epinephrine is low-cost in most settings and possibly lower cost than IV/IO epinephrine. However, whether IM epinephrine is effective, compared with no epinephrine, is unknown. | |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | No relevant studies were identified. | There is great public interest in the intervention, and it is likely acceptable to stakeholders. |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | IM administration of epinephrine is standard practice for the treatment of anaphylaxis. | |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | **Small** | Moderate | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Large | Moderate | **Small** | Trivial | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | **Probably favors the intervention** | Favors the intervention | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | **Negligible costs and savings** | Moderate savings | Large savings | Varies | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | Probably reduced | Probably no impact | **Probably increased** | Increased | Varies | Don't know |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | **Conditional recommendation against the intervention** | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ● | ○ | ○ | ○ |

## CONCLUSIONS

**Recommendation**

There is insufficient evidence to recommend adding intra-arrest intramuscular epinephrine to standard resuscitation care for cardiac arrest. (weak recommendation, very-low certainty of evidence).

## Justification

- The TF recognized that intramuscular epinephrine is an interesting area of research and has gained increased attention. It is a relatively inexpensive intervention that can be delivered by a variety of first responders and could therefore enable earlier administration of epinephrine. In the management of cardiac arrest, earlier epinephrine is associated with improved clinical outcomes, however these studies are confounded by resuscitation time bias. Additionally, in a secondary analysis of the PARAMEDIC2 study, shorter time to treatment, whether treatment was adrenaline or placebo, was also associated with improved outcome.
- The key historical concern regarding IM epinephrine has been uncertainty regarding its absorption in cardiac arrest. The limited available data suggest that IM epinephrine may be associated with earlier administration, but the clinical effect on outcomes remains uncertain. However, the Task Force felt that it would be premature to recommend the use of IM epinephrine at this stage given that evidence is limited to a single observational study and extrapolation of potential benefit from studies exploring the association between time to drug administration and clinical outcome. The task force highlighted the need for randomized controlled trials to evaluate IM epinephrine in cardiac arrest, with a focus on shortening the time to first dose by administering epinephrine IM compared with IV/IO. The ALS TF considered that some patients receiving CPR may have been in a low flow state and they may be a group that potentially would benefit from early IM epinephrine.
- Only one observational study was identified that evaluated a first-dose intramuscular (IM) epinephrine protocol for adult out-of-hospital cardiac arrest (OHCA) patients, followed by advanced life support and intravenous/intraosseous (IV/IO) epinephrine administration. Consequently, the treatment recommendation does not extend to settings where subsequent advanced life support and IV/IO epinephrine administration are not available. The task force discussed the possibility that IM epinephrine could be useful in such settings, but the evidence is too sparse (no human data comparing IM with IV/IO) to support a recommendation. In addition, the task force discussed whether focus on IM epinephrine could result in delay of standard resuscitation interventions, including IV/IO epinephrine, which could inadvertently cause harm.
- Finally, the taskforce discussed whether the slower absorption of IM epinephrine compared to IV could be beneficial in the early post-resuscitation phase where hypotension is common and associated with poor outcomes, however this remains unknown.
- The relevance of the current topic is unknown for patients with in-hospital cardiac arrest where time to drug administration is shorter due to the high prevalence of pre-existing vascular access and earlier initiation of advanced life support.
- Animal studies were included in the systematic review but the results should be interpreted with caution due to risk of bias and generalizability to humans. In addition, time to drug administration in animals does not reflect the human clinical experience, where epinephrine administration is often delayed compared to animal studies.

**References:**


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2. Palatinus HN, Johnson MA, Wang HE, Hoareau GL, Youngquist ST. Early intramuscular adrenaline administration is associated with improved survival from out-of-hospital cardiac arrest. Resuscitation. 2024;201:110266.
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6. O'Reilly M, Tijssen JA, Lee TF, Ramsie M, Cheung PY, Schmolzer GM. Intramuscular versus intravenous epinephrine administration in a pediatric porcine model of cardiopulmonary resuscitation. Resusc Plus. 2024;20:100769.
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**Intra-Arrest Volume Therapy During Nontraumatic Cardiac Arrest (ALS 3207, part 1)**

# QUESTION

| SHOULD INTRAVASCULAR VOLUME THERAPY BE USED DURING CPR FOR NON-TRAUMATIC CARDIAC ARREST? | |
|---|---|
| **POPULATION:** | Adults with non-traumatic cardiac arrest in any setting. |
| **INTERVENTION:** | Intravascular volume therapy during cardiac arrest. |
| **COMPARISON:** | No intravascular volume therapy or a different intravascular volume therapy during cardiac arrest (a different type, volume, or timing). |
| **MAIN OUTCOMES:** | Any clinical outcome. |

# ASSESSMENT

## Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | Survival from cardiac arrest remains poor despite advances in resuscitation. Optimal fluid management during cardiac arrest is uncertain. | This topic was prioritized given evolving evidence. |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | **Prehospital hypertonic saline with HES**<br>Small RCTs of hypertonic saline plus hydroxyethyl starch (HES) compared to HES alone showed no benefit in survival to hospital admission, survival to hospital discharge, and favorable neurological outcome.[1,2]<br>**Prehospital infusion of cold normal saline**<br>RCTs of prehospital infusion of cold normal saline compared to standard care showed no benefit in return of spontaneous circulation, survival to hospital discharge, favorable neurological outcome, and survival at one year.[3,4] | No randomized trials directly evaluated routine volume therapy versus no volume therapy as a resuscitation strategy. The trials that were identified evaluated specific interventions such as hypertonic saline with hydroxyethyl starch or rapid infusion of ice-cold crystalloids during cardiopulmonary resuscitation.<br>The cold crystalloid trials were designed to induce therapeutic hypothermia rather than for volume resuscitation purposes. The interpretation of these trials was limited by the control group often receiving ambient temperature fluids in addition to ice-cold crystalloids. |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Large<br>○ Moderate<br>○ Small<br>○ Trivial<br>● Varies<br>○ Don't know | **Prehospital hypertonic saline with HES**<br>No adverse events relevant to the PICOST question were reported in these trials.[1,2]<br>**Prehospital infusion of cold normal saline**<br>One RCT reported higher rates of pulmonary edema with prehospital infusion of cold normal saline compared to standard care (62/207 [10%] vs 26/227 [4.5%]; P < 0.05), whereas another RCT reported no difference (7/41 [17%] vs 8/36 [22%]; P = 0.59).[3,4] | Physiological concerns exist that fluid boluses during chest compressions may increase right atrial pressure, impair venous return, and consequently reduce coronary perfusion pressure.<br>Evidence for hypertonic solutions with hydroxyethyl starch has limited relevance as hydroxyethyl starch solutions has been withdrawn from or heavily restricted in most countries because an increased risk of coagulopathy, acute kidney injury, and mortality in multiple large trials of critically ill patients. |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | The certainty of evidence for trials ranged from very low to low across different comparisons and outcomes downgraded for risk of bias, indirectness, and imprecision. The observational studies addressing non-traumatic intra-arrest volume therapy were highly heterogeneous and at serious or critical risk of bias, precluding meaningful meta-analysis. | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | The importance of survival and neurologically intact survival is generally agreed upon. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>● Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | The available evidence does not show any benefit from routine intravascular volume therapy during CPR for non-traumatic cardiac arrest. | Physiological concerns about impaired coronary perfusion with fluid boluses during chest compressions, combined with lack of benefit, suggest the balance probably favors no routine volume therapy in normovolemic patients. |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>● Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | Crystalloid solutions are low-cost in most settings. | |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | No relevant studies were identified. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● No included studies | No cost-effectiveness data were identified. | |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>● Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>○ Don't know | Standard crystalloid solutions are widely available in most prehospital and hospital settings. | |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | No relevant studies were identified. | Most interventions considered are currently used in clinical practice and are likely acceptable to stakeholders. |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | Standard crystalloid solutions are widely available in most prehospital and hospital settings. | |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | **Trivial** | Small | Moderate | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Large | Moderate | Small | Trivial | | **Varies** | Don't know |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | **Probably favors the comparison** | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | **Negligible costs and savings** | Moderate savings | Large savings | Varies | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | Probably reduced | **Probably no impact** | Probably increased | Increased | Varies | Don't know |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

# TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | **Conditional recommendation against the intervention** | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ● | ○ | ○ | ○ |

# CONCLUSIONS

**Recommendation**

We suggest against the routine use of intravascular volume therapy during cardiopulmonary resuscitation in patients with undifferentiated non-traumatic cardiac arrest (weak recommendation, very low-certainty evidence).

We recommend against the use of hydroxyethyl starch solutions during cardiopulmonary resuscitation or after return of spontaneous circulation (strong recommendation, very low-certainty evidence).
If clinical circumstances indicate that the patient was hypovolemic prior to the cardiac arrest, volume therapy may be reasonable (Good Practice Statement).

**Justification**

- The systematic review identified no randomized trials that directly evaluated routine volume therapy versus no volume therapy as a resuscitation strategy. The trials that were identified evaluated specific interventions such as hypertonic saline with hydroxyethyl starch or rapid infusion of ice-cold crystalloids during cardiopulmonary resuscitation.
- There are physiological concerns that fluid boluses during chest compressions may increase right atrial pressure, impair venous return, and consequently reduce coronary perfusion pressure.
- Trials evaluating rapid infusion of ice-cold crystalloids were designed to induce therapeutic hypothermia rather than evaluate volume resuscitation. The interpretation of these trials was limited by the control group often receiving ambient temperature fluids in addition to ice-cold crystalloids.
- Hydroxyethyl starch solutions, regardless of their formulation (such as Hespan, HAES-steril, and Voluven), have been withdrawn from or heavily restricted in most countries because of an increased risk of coagulopathy, acute kidney injury, and mortality in multiple large trials of critically ill patients.
- The observational studies were all at serious or critical risk of bias and evaluated highly heterogeneous populations and interventions. These studies generally found no consistent association between volume therapy and outcomes.

**References:**


1. Bender R, Breil M, Heister U, Dahmen A, Hoeft A, Krep H, et al. Hypertonic saline during CPR: Feasibility and safety of a new protocol of fluid management during resuscitation. Resuscitation. 2007;72(1):74-81.
2. Breil M, Krep H, Heister U, Bartsch A, Bender R, Schaefers B, et al. Randomised study of hypertonic saline infusion during resuscitation from out-of-hospital cardiac arrest. Resuscitation. 2012;83(3):347-52.
3. Bernard SA, Smith K, Finn J, Hein C, Grantham H, Bray JE, et al. Induction of Therapeutic Hypothermia During Out-of-Hospital Cardiac Arrest Using a Rapid Infusion of Cold Saline: The RINSE Trial (Rapid Infusion of Cold Normal Saline). Circulation. 2016;134(11):797-805.
4. Debaty G, Maignan M, Savary D, Koch FX, Ruckly S, Durand M, et al. Impact of intra-arrest therapeutic hypothermia in outcomes of prehospital cardiac arrest: a randomized controlled trial. Intensive Care Med. 2014;40(12):1832-42.

**Intravascular Volume Therapy During Traumatic Cardiac Arrest (ALS 3207, part 2)**

# QUESTION

| SHOULD INTRAVASCULAR VOLUME THERAPY BE USED DURING CPR FOR TRAUMATIC CARDIAC ARREST? | |
|---|---|
| **POPULATION:** | Adults with traumatic cardiac arrest in any setting. |
| **INTERVENTION:** | Intravascular volume therapy during cardiac arrest. |
| **COMPARISON:** | No intravascular volume therapy or a different intravascular volume therapy during cardiac arrest (a different type, volume, or timing). |
| **MAIN OUTCOMES:** | Any clinical outcome. |

# ASSESSMENT

## Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | Survival for cardiac arrest remains poor despite advances in resuscitation. Optimal fluid management during cardiac arrest is uncertain. | This topic was prioritized given evolving evidence. |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | **Prehospital blood products**<br>One subgroup analysis within an RCT[1] of prehospital blood products compared to normal saline administration showed no difference in in-hospital mortality or impaired lactate clearance (test for subgroup differences, P = 0.32). | Direct evidence from traumatic cardiac arrest trials was limited to a small subgroup analysis within a study evaluating blood products in patients with hemorrhagic shock. |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large<br>○ Moderate<br>○ Small<br>○ Trivial<br>● Varies<br>○ Don't know | **Prehospital blood products**<br>No adverse events relevant to the PICOST question were reported. | |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | The certainty of evidence was very low, downgraded for risk of bias and imprecision.<br>The observational studies addressing volume therapy for traumatic cardiac arrest were highly heterogeneous and at serious or critical risk of bias, precluding meaningful meta-analysis. | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | The importance of survival and neurologically intact survival is generally agreed upon. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>● Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | The available evidence does not clearly favor any specific volume therapy strategy over another for traumatic cardiac arrest. | Given the distinct pathophysiology of hemorrhagic shock and insufficient direct evidence, no recommendation for specific volume therapies in traumatic cardiac arrest could be made, and practitioners should follow local trauma resuscitation guidelines for managing trauma patients |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>● Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | Crystalloid solutions are low-cost in most settings. | |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | No relevant studies were identified. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● No included studies | No cost-effectiveness data were identified. | |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>● Probably no impact | Standard crystalloid solutions are widely available in most prehospital and hospital settings. | |

| | | |
|---|---|---|
| ○ Probably increased<br>○ Increased<br>○ Varies<br>○ Don't know | | |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | No relevant studies were identified. | Most interventions considered are currently used in clinical practice and are likely acceptable to stakeholders. |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | Standard crystalloid solutions are widely available in most prehospital and hospital settings. | |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | **Trivial** | Small | Moderate | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Large | Moderate | Small | Trivial | | **Varies** | Don't know |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | **Does not favor either the intervention or the comparison** | Probably favors the intervention | Favors the intervention | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | **Negligible costs and savings** | Moderate savings | Large savings | Varies | Don't know |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | Probably reduced | **Probably no impact** | Probably increased | Increased | Varies | Don't know |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

# TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | **Conditional recommendation for either the intervention or the comparison** | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ● | ○ | ○ |

# CONCLUSIONS

## Recommendation

There is insufficient direct evidence to recommend for or against the routine use of specific volume therapies during cardiopulmonary resuscitation in patients with traumatic cardiac arrest.

## Justification

- Direct evidence from traumatic cardiac arrest trials was limited to a subgroup analysis within a study evaluating blood products in patients with hemorrhagic shock
- Given the distinct pathophysiology of hemorrhagic shock and insufficient direct evidence, no recommendation for specific volume therapies in traumatic cardiac arrest could be made, and practitioners should follow local trauma resuscitation guidelines for managing trauma patients
- The routine use of blood products in non-traumatic cardiac arrest remains uncertain and should be limited to the context of clinical trials

**References:**

1. Crombie N, Doughty HA, Bishop JRB, Desai A, Dixon EF, Hancox JM, et al. Resuscitation with blood products in patients with trauma-related haemorrhagic shock receiving prehospital care (RePHILL): a multicentre, open-label, randomised, controlled, phase 3 trial. Lancet Haematol. 2022;9(4):e250-e61.

# Intravascular Volume Therapy After Cardiac Arrest (ALS 3518)

## QUESTION

| SHOULD INTRAVASCULAR VOLUME THERAPY BE USED AFTER RETURN OF SPONTANEOUS CIRCULATION? | |
|---|---|
| **POPULATION:** | Adults with ROSC from cardiac arrest in any setting. |
| **INTERVENTION:** | Intravascular volume therapy after cardiac arrest. |
| **COMPARISON:** | No intravascular volume therapy or a different intravascular volume therapy after cardiac arrest (a different type, volume, or timing). |
| **MAIN OUTCOMES:** | Any clinical outcome. |

## ASSESSMENT

### Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | Survival for cardiac arrest remains poor despite advances in resuscitation. Optimal fluid management after cardiac arrest is uncertain. | This topic was prioritized given evolving evidence. |

### Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | **Prehospital infusion of cold crystalloids:** RCTs of prehospital infusion of cold normal saline compared to standard care showed no benefit in survival to hospital discharge and favorable neurological outcome.[1-8] Subgroup analyses stratified by fluid type showed no significant difference in treatment effect between cold normal saline and Ringer's solution (P = 0.47 for survival; P = 0.61 for favorable neurological outcome).<br>**In-hospital balanced crystalloids vs normal saline**<br>One RCT of in-hospital use of balanced crystalloids compared to normal saline showed no benefit in survival to hospital discharge, survival at 6 months, and favorable neurological outcome.[8]<br>**In-hospital hypertonic saline with HES**<br>One RCT of in-hospital use of hypertonic saline plus hydroxyethyl starch (HES) compared to crystalloids showed no benefit in survival at 1 year.[9] | The cold crystalloid trials were designed to induce therapeutic hypothermia rather than for volume resuscitation purposes. The interpretation of these trials was limited by the control group often receiving ambient temperature fluids in addition to ice-cold crystalloids. |

### Undesirable Effects

| How substantial are the undesirable anticipated effects? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Large<br>○ Moderate<br>○ Small<br>○ Trivial<br>● Varies<br>○ Don't know | **Prehospital infusion of cold crystalloids**<br>One RCT reported higher rates of pulmonary edema (256/631 [41%] vs 184/609 [30%]; P < 0.001) and re-arrest (176/686 [26%] vs 138/671 [21%]; P = 0.008) with prehospital infusion of cold normal saline compared to standard care<br>**In-hospital balanced crystalloids**<br>One RCT reported no difference in development of acute kidney injury (11/27 [41%] vs 7/26 [27%]; P = 0.29) or major adverse kidney events within 30 days (14/27 [52%] vs 7/26 [27%]; P = 0.06).<br>**In-hospital hypertonic saline with HES**<br>No adverse events relevant to the PICOST question were reported in a single trial. | Undesirable effects vary depending on the specific volume therapy strategy.<br>Normal saline causes hyperchloremic acidosis and may be associated with increased risk of acute kidney injury in critically ill patients compared to balanced crystalloids. However, this evidence is not specific to cardiac arrest, and concerns have been raised about the lower tonicity of balanced fluids, which could potentially worsen cerebral edema.<br>Evidence for hypertonic solutions with hydroxyethyl starch has limited relevance as hydroxyethyl starch solutions has been withdrawn from or heavily restricted in most countries because an increased risk of coagulopathy, acute kidney injury, and mortality in multiple large trials of critically ill patients. |
| **Certainty of evidence**<br>What is the overall certainty of the evidence of effects? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | The certainty of evidence for trials ranged from very low to low across different comparisons and outcomes downgraded for risk of bias, indirectness, and imprecision. The observational studies addressing post-arrest volume therapy were highly heterogeneous and at serious or critical risk of bias, precluding meaningful meta-analysis. | |
| **Values**<br>Is there important uncertainty about or variability in how much people value the main outcomes? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | The importance of survival and neurologically intact survival is generally agreed upon. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>● Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | The available evidence does not clearly favor any specific volume therapy strategy over another for post-cardiac arrest care. | |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>● Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | Crystalloid solutions are low-cost in most settings. | |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | No relevant studies were identified. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● No included studies | No cost-effectiveness data were identified. | |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>● Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>○ Don't know | Standard crystalloid solutions are widely available in most prehospital and hospital settings. | |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | No relevant studies were identified. | Most interventions considered are currently used in clinical practice and are likely acceptable to stakeholders. |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | Standard crystalloid solutions are widely available in most prehospital and hospital settings. | |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | **Trivial** | Small | Moderate | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Large | Moderate | Small | Trivial | | **Varies** | Don't know |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | **Does not favor either the intervention or the comparison** | Probably favors the intervention | Favors the intervention | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | **Negligible costs and savings** | Moderate savings | Large savings | Varies | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | Probably reduced | **Probably no impact** | Probably increased | Increased | Varies | Don't know |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | **Conditional recommendation for either the intervention or the comparison** | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ● | ○ | ○ |

## CONCLUSIONS

**Recommendation**

We recommend against the use of hydroxyethyl starch solutions during cardiopulmonary resuscitation or after return of spontaneous circulation (strong recommendation, very low-certainty evidence).

There is insufficient direct evidence to recommend for or against the use of specific volume therapies immediately after return of spontaneous circulation in patients with undifferentiated non-traumatic cardiac arrest.

**Justification**

- Trials evaluating rapid infusion of ice-cold crystalloids were designed to induce therapeutic hypothermia rather than evaluate volume resuscitation. The interpretation of these trials was limited by the control group often receiving ambient temperature fluids in addition to ice-cold crystalloids.
- Only one small trial (Woo et al., 2023) directly compared balanced crystalloids to normal saline in the post-arrest setting. Normal saline causes hyperchloremic acidosis and may be associated with increased risk of acute kidney injury in critically ill patients compared to balanced crystalloids. However, this evidence is not specific to cardiac arrest, and concerns have been raised about the lower tonicity of balanced fluids, which could potentially worsen cerebral edema.
- Hydroxyethyl starch solutions, regardless of their formulation (such as Hespan, HAES-steril, and Voluven), have been withdrawn from or heavily restricted in most countries because of an increased risk of coagulopathy, acute kidney injury, and mortality in multiple large trials of critically ill patients.
- The observational studies were all at serious or critical risk of bias and evaluated highly heterogeneous populations and interventions. These studies generally found no consistent association between volume therapy and outcomes.
- Given the lack of direct evidence comparing different fluid strategies in the post-arrest setting, the task force could not make a recommendation for any specific volume therapy.

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# Video Laryngoscopy vs Direct Laryngoscopy During Cardiac Arrest (ALS 3308)

## QUESTION:

| Video laryngoscopy vs. laryngoscopy without video for endotracheal intubation? | |
|---|---|
| **POPULATION:** | Adults with cardiac arrest in any setting |
| **INTERVENTION:** | Video Laryngoscopy |
| **COMPARISON:** | Laryngoscopy without Video |
| **MAIN OUTCOMES:** | First Pass Success (RCT); Intubation Success (RCT); Time to Intubation; Esophageal Intubation; |
| **SETTING:** | Any (in-hospital or out-of-hospital) |
| **CONFLICT OF INTERESTS:** | none |

## ASSESSMENT

### Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | Advanced airway management is critical in advanced life support for individuals suffering cardiac arrest in order to provide effective ventilation to protect against aspiration of gastric contents. The 2019 ILCOR Consensus on Science and Treatment Recommendations (CoSTR) recommends either supraglottic airway or tracheal intubation when performing advanced airway management in cardiac arrest. Tracheal intubation during cardiac arrest presents unique challenges including challenges related to both patient-factors (e.g. shock, aspiration risk), scene-factors (e.g. intubation in non-intensive care or operating room settings), and resuscitation factors (e.g. ongoing chest compressions complicating laryngoscopic view). These unique challenges increase the risk of adverse effects of tracheal intubation including failed intubation attempts, excess pauses on chest compressions, and complications including esophageal intubation. Identifying the optimal approach to tracheal intubation during cardiac arrest resuscitation is a priority. | The ILCOR Advanced Life Support Task Force identified this question as critical following an evidence update.<br><br>Data from cardiac arrest registries in the United States finds that most patients who suffer cardiac arrest undergo tracheal intubation. |

### Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>● Moderate<br>○ Large | Across 3 RCTs[1-3] (n = 331) and 13 observational studies[4-16] (n ≈ 30,000) of adults undergoing tracheal intubation during cardiac arrest, the use of video laryngoscopy (VL) compared with direct | Given the overall burden of cardiac arrest globally, even modest desirable impacts could be large on the population scale. |

| | | |
|---|---|---|
| ○ Varies<br>○ Don't know | laryngoscopy (DL) was associated with improved procedural outcomes but no demonstrated difference in patient-centered outcomes.<br>For **first-pass tracheal intubation success**, pooled RCT evidence[1-3] (very low certainty, downgraded for risk of bias, inconsistency, indirectness, and imprecision) showed no difference between VL and DL (RR 0.88, 95% CI 0.63–1.22). Observational data generally favored VL, with 8 of 12 studies reporting statistically significant higher success rates with VL.<br>For **overall intubation success**, very low–certainty evidence from 3 RCTs[1-3] showed no difference (RR 1.00, 95% CI 0.90–1.12), while 5 of 6 observational studies favored VL.<br>For **esophageal intubation**, rates were consistently lower with VL (1 RCT[3]: 4.3% vs 0%; pooled observational data: 5.6% vs 1.4%), a clinically meaningful absolute risk reduction (~4%, NNT ≈ 25).<br>No benefit of VL over DL was demonstrated for **ROSC, survival,** or **survival with good neurologic** outcome in any observational study. These outcomes were not reported in any RCT.<br>The potential desirable effects of VL are primarily procedural (improved first-pass and overall success, reduced esophageal intubation, better glottic view, and fewer compression interruptions). These may translate into safer airway management and improved team efficiency, particularly among less experienced operators or in difficult airway conditions. However, since improvements have not been shown to extend to patient-important outcomes (ROSC or survival), the overall magnitude of benefit is judged **moderate**. | |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large<br>○ Moderate<br>● Small<br>○ Trivial<br>○ Varies<br>○ Don't know | Across 3 RCTs and multiple observational studies of adult cardiac arrest, there was no consistent evidence of increased harm with VL compared to DL. Two RCTs[1,3] found no difference in time to intubation between VL and DL and one RCT[3] reported fewer chest-compression interruptions with VL.<br>Observational studies were mixed for time to intubation (some faster with VL), and no study identified higher rates of complications | |

| | | |
|---|---|---|
| | (e.g., esophageal intubation—actually lower with VL, a desirable effect). Undesirable effects specifically attributable to VL (e.g., prolonged attempts, CPR pauses, aspiration) were not consistently observed. | |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | The overall certainty of evidence was assessed separately for randomized trials and for non-randomized studies. The certainty of evidence was judged to be very low across all outcomes assessed in both randomized trials and non-randomized studies, owing to a high risk of bias, unmeasured confounders, incomplete (or no) adjustment for measured potential confounders, and indirectness. | RCT data is limited to small, randomized trials with methodological concerns. All randomized trials were published between 2014 and 2017, when technology and training for video-assisted laryngoscopy was not as advanced. |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>● Possibly important uncertainty or variability<br>○ Probably no important uncertainty or variability<br>○ No important uncertainty or variability | We have not identified any cardiac arrest tracheal intubation studies that specifically addressed how patients valued the different outcomes. | The importance of the outcome of first pass success and overall success is uncertain.<br>The COre Outcome Set for Cardiac Arrest (COSCA) identifies ROSC as an important outcome for efficacy studies.<br>Survival and survival with good neurologic outcome are generally recognized as important by COSCA. |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>● Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | As above, the number and suspected importance of desirable outcomes likely favor the intervention. | |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>○ Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>● Don't know | No studies regarding the cost effectiveness of the intervention were identified. | Studies from the operating theatre have found that video laryngoscopy is cost-effective.<br><br>Resources required likely depends upon training needs, and number of video-capable of laryngoscopes needed (e.g. for hospital settings vs. pre-hopsital settings), and whether a hospital system is currently already using video laryngoscopes. |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | No evidence identified. | The type of video-capable laryngoscope used varied substantially across included studies. |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ No included studies | No studies identified. | Studies from the operating theatre have found that video laryngoscopy is cost-effective. |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>○ Probably no impact<br>○ Probably increased<br>○ Increased<br>● Varies<br>○ Don't know | We did not find any studies regarding the impact of the intervention on health equity. | Although cost effectiveness studies have found video-laryngoscopy to be cost effective in some settings, the initial investment in supplies and training may be high for low resource settings. |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | No studies regarding acceptability identified. | Airway operators with less tracheal intubation experience may find video laryngoscopy to be more acceptable as compared to airway operators with more experience. |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | No studies regarding feasibility were identified. | |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **DESIRABLE EFFECTS** | Trivial | Small | **Moderate** | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Large | Moderate | **Small** | Trivial | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | **Possibly important uncertainty or variability** | Probably no important uncertainty or variability | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | **Probably favors the intervention** | Favors the intervention | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | Negligible costs and savings | Moderate savings | Large savings | Varies | **Don't know** |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | No included studies |
| **EQUITY** | Reduced | Probably reduced | Probably no impact | Probably increased | Increased | **Varies** | Don't know |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | **Conditional recommendation for either the intervention or the comparison** | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ● | ○ | ○ |

## CONCLUSIONS

**Recommendation**

There is insufficient evidence to recommend video laryngoscopy in preference to direct laryngoscopy for tracheal intubation during CPR (weak recommendation, very low–certainty evidence).

To improve tracheal intubation first pass success, overall success, and to reduce rates of inadvertent esophageal intubation, it may be reasonable to perform video laryngoscopy during cardiac resuscitation in settings where this equipment is available and airway operators are well trained in the use of the device. (Good Practice Statement)

## Justification

· This topic was prioritized by the Advanced Life Support Task Force given the expanded use of video laryngoscopy in cardiac arrest and other emergency airway management settings.
· Existing Consensus on Science and Treatment Recommendations for Advanced Airway Management During Adult Cardiac Arrest do not differentiate between video laryngoscopy and direct laryngoscopy.
· Airway management during cardiac arrest is uniquely challenging as a result of ongoing chest compressions, airway contamination, and restricted positioning, which may either enhance or diminish any performance advantages of video laryngoscopy.
· The Advanced Life Support Task Force included both randomized and non-randomized studies, recognizing that existing randomized trials remain few, small, and have numerous methodological flaws while non-randomized data provide important real-world information despite a very high risk of bias.
· Across included studies, there was substantial heterogeneity in video-capable laryngoscopy device type, operator experience, and arrest setting (OHCA vs IHCA), which were considered by the task force in arriving at treatment recommendations.
· In addition to studies of tracheal intubation during cardiopulmonary resuscitation, the Task Force considered indirect evidence comparing video laryngoscopy to direct laryngoscopy among patients not in cardiac arrest in the operating room and in non-elective and emergent tracheal intubations outside of the operating room. The indirect evidence considered generally matched findings from the cardiac arrest population, with a higher rate of first pass success and overall tracheal intubation success. In a Cochrane Review that included six randomized trials comparing video laryngoscopy to direct laryngoscopy in prehospital settings (including two in cardiac arrest populations), there was no benefit of video capable as compared to non-video capable laryngoscopy.
· No data was identified from cardiac arrest populations regarding the cost-effectiveness of video-capable laryngoscopes. Indirect evidence from tracheal intubation in the operating theatre suggest that video-laryngoscopy is cost effective.
· The Task Force noted potential procedural advantages (e.g., higher first-pass success, reduced esophageal intubation) when performing video laryngoscopy although these advantages do not currently translate into improved rates of ROSC, survival, or survival with good neurologic outcomes.
· The recommendation that there is insufficient evidence to recommend an approach to tracheal intubation using a laryngoscope with video capability over a laryngoscope without video capability during cardiac arrest resuscitation was arrived at by consensus of the Advanced Life Support Task Force, based upon mixed data when assessing proximal and procedural outcomes favoring video-capable laryngoscopy and no benefit to either approach when assessing more patient-important outcomes such as survival or survival with favorable neurologic outcome.
· The Task Force considered that in the absence of evidence supporting a different approach to tracheal intubation in the cardiac arrest population as compared to standard practice in non-elective tracheal intubation settings, it would be reasonable for airway operators to procced with their standard approach to laryngoscopy during cardiac arrest resuscitation.

## Subgroup considerations

No specific subgroups were examined.

## Implementation considerations

Implementation in settings where videolaryngoscopes are not already part of clinical practice would require training and monitoring, as well as additional resources to purchase equipment.

## Monitoring and evaluation

While this topic was not specifically addressed, monitoring first pass success and overall intubation success rates, as well as clinical outcomes, is important to elucidate the benefit of different airway devices.

## Research priorities

· There were no studies directly comparing different types of video-capable laryngoscopes, including no comparisons of hyperangulated vs. standard geometry laryngoscope bladers.
· There were limited studies directly assessing whether the impact of video laryngoscope use was different based upon the experience and skillset of the airway operator.
· The cost effectiveness of a switch to video-capable laryngoscopes is unknown. This is especially true for the pre-hospital setting and in low-resource settings.
· There was no study exploring tracheal intubation adjuncts (e.g. elastic bougie) as they related to video-capable vs. non-video-capable laryngoscopy.
· The training and experience requirements for each tracheal intubation laryngoscopic approach is uncertain.

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## Supplemental Oxygen During CPR (ALS 3305)

# QUESTION

| Can the administration of maximal oxygen concentration improve survival? | |
|---|---|
| **POPULATION:** | Adults with cardiac arrest in any setting |
| **INTERVENTION:** | Administering a maximal oxygen concentration (e.g. 100% by face mask or closed circuit) |
| **COMPARISON:** | No supplemental oxygen (e.g. 21%) or a reduced oxygen concentration (e.g. 40-50%) |
| **MAIN OUTCOMES:** | Survival with favorable neurological/functional outcome at discharge, 30 days, 60 days, 180 days AND/OR 1 year, survival only at discharge, 30 days, 60 days, 180 days AND/OR 1 year, ROSC? |

# ASSESSMENT

## Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | The brain is the most sensitive organ with regards to hypoxia and hypoxic brain injury is the major cause of death in patients with return of spontaneous circulation. The administration of supplemental oxygen appears intuitive. Studies (n = 6) generally find an association between higher $PaO_2$ during arrest and good outcome, but research evidence comparing different oxygen administration strategies is lacking. | All studies (n=6) suggest that a higher $PaO_2$ during CPR is associated with higher ROSC, hospital admission, or functional survival. |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>○ Moderate<br>● Large<br>○ Varies<br>○ Don't know | In a large study on 16,013 out-of-hospital cardiac arrest patients, higher $PaO_2$ is associated with better functional survival (Adjusted ORs for favorable outcome were 2.09 (normoxia) and 5.04 (hyperoxia) vs hypoxia) (Izawa 2022). All six included studies have shown similar associations between higher $PaO_2$ and better outcome. | All the other included studies also showed that a higher $PaO_2$ is correlated to better outcomes (higher rate of ROSC with sustained ROSC, higher hospital admission, higher survival to hospital discharge/1 month, and better functional outcome) |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH VIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Large<br>○ Moderate<br>○ Small<br>● Trivial<br>○ Varies<br>○ Don't know | Hyperoxemia during CPR is rare. | No studies report<br>harm from hyperoxemia during CPR. |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | There are no studies that have compared different amounts of administered oxygen in patients undergoing CPR. In the identified studies all patients received 100% oxygen. The higher oxygen levels in some patients have likely been due to other patient or resuscitation factors such as lung function, etiology or arrest or quality of resuscitation, and not to the administration of oxygen. Therefore, the evidence is indirect and of very low certainty. On the other hand the consistent finding in the identified studies is that a higher $PaO_2$ is associated with better outcomes. | The observational studies addressing $PaO_2$ levels during cardiopulmonary resuscitation were highly heterogeneous and at serious or critical risk of bias, precluding meaningful meta-analysis. |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | The importance of survival and neurologically intact survival is generally agreed upon. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>● Favors the intervention<br>○ Varies<br>○ Don't know | There was no direct evidence favoring the intervention. The available evidence suggests better outcome with higher oxygen levels. No study found worse outcome with high intra-arrest oxygen levels. | Oxygen administration during CPR is **safe and likely beneficial**; monitoring ABG/$PaO_2$ can help optimize outcomes, especially in advanced care settings. |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>● Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | Oxygen is, in general, low-cost. | Resources/costs balance is not reported in the identified studies. |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | No relevant studies were identified. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● No included studies | No cost-effectiveness data were identified. | |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>● Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>○ Don't know | Oxygen is widely available to advanced life support providers in most prehospital and hospital settings. | There are systems in lower-resource settings, in which oxygen is not readily available. The recommendation to provide oxygen during arrest and CPR has been in place for several years however, so this will not be a change. |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | No relevant studies were identified. | Oxygen is currently used during CPR in clinical practice in most healthcare systems, and is likely acceptable to stakeholders. |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | Oxygen is widely available to advanced life support providers in most prehospital and hospital settings. | There are systems in lower-resource settings, in which oxygen is not readily available. The recommendation to provide oxygen during arrest and CPR has been in place for several years however, so this will not be a change. |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | Small | Moderate | **Large** | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Large | Moderate | Small | **Trivial** | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | **Favors the intervention** | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | **Negligible costs and savings** | Moderate savings | Large savings | Varies | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | Probably reduced | **Probably no impact** | Probably increased | Increased | Varies | Don't know |
| **ACCEPTABILITY** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | **Conditional recommendation for the intervention** | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ○ | ● | ○ |

## CONCLUSIONS

**Recommendation**

We suggest using the highest possible inspired oxygen concentration during CPR (weak recommendation, very-low-certainty evidence).

**Justification**

- The quality of evidence quality is very low with only prospective observational or registry studies of critical bias. No study has randomized patients into different levels of supplemental oxygen.
- All patients in the included studies received 100% oxygen. Therefore, the difference in oxygen levels between patients may be related to other things than the use of supplemental oxygen. Across all studies, oxygen administration during CPR appeared to be safe and was associated with improved early outcomes (ROSC, hospital admission, functional survival to hospital discharge/1 month).
- Hyperoxemia during CPR does not appear to be harmful.

**Subgroup considerations**

Oxygen is more likely to be less widely available in the prehospital setting but is available in most systems with ALS capabilities.

**Implementation considerations**

This recommendations has not changed, so the task force did not think implementation would be a challenge.

**Monitoring and evaluation**

Nothing additional was thought to be required.

**Research priorities**

The Task Force discussed that there are unlikely to ever be clinical trials on intra-arrest oxygen supplementation, given the consistency of the observational association between $PaO_2$ and short-term outcomes.

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## Appendix A

## Basic Life Support – 2026 Evidence to Decision Tables

# Table of Contents

# BLS 2001 – Potential Harms to Rescuers

## QUESTION

| Physical Harm to Rescuers | |
|---|---|
| **POPULATION:** | Individuals rescuing adults or children in out-of-hospital or in-hospital cardiac arrest, and/or performing resuscitation |
| **EXPOSURE:** | Responding to children or adults in cardiac arrest and/or performing resuscitation (ventilations, compressions, defibrillation, etc.) out-of-hospital and in-hospital |
| **OUTCOMES:** | Any reported outcome and number of cases of unintentional physical harm (e.g., Infection, morbidity, death, etc.). |
| **STUDY DESIGN:** | Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies), surveys, and case series were eligible for inclusion.<br>Unpublished studies (e.g., conference abstracts, trial protocols), simulation studies, animal studies, studies with an outcome of fatigue or psychological harm, and studies investigating Personal Protective Equipment use were excluded.<br>All relevant publications in any language were included as long as there was an English abstract. |
| **TIME FRAME:** | Literature search updated 01 January 1966 to 06 November 2025 |
| **PERSPECTIVE:** | This is a scoping Review.<br>Included studies had to report potential unintentional harms to the rescuers responding to a cardiac arrest and performing resuscitation (chest compression and mouth-to-mouth ventilation), including the use of a manual defibrillator and automated external defibrillator.<br>Data from defibrillation and cardioversion on patients who are either presumed to be in cardiac arrest but not confirmed, or confirmed not to be in cardiac arrest, were used as indirect evidence.<br>This review excluded the use of personal protective equipment in minimizing infection because this intervention was systematically reviewed in the ILCOR 2020 systematic review. [8]<br>Furthermore, this review excluded fatigue. Although fatigue is significant, the duration and level of discomfort do not meet the definition of harm.<br>This review also excluded psychological harm because the methodology of much of the literature is qualitative or survey-based, and the task force has initiated a specific stand-alone mixed-methods review on this topic. All intentional injuries in responding to a cardiac arrest and providing resuscitation consistent with the First Aid Taskforce definition of harm, and harm sustained during training, were also excluded. |
| **BACKGROUND:** | This topic was chosen for review by the BLS Task Force to update and compare previous literature with the period included in the search strategy for ILCOR 2020 Harm to rescuers from CPR scoping review [18]. The objective of this review is to understand potential unintentional harms to the rescuers responding to a cardiac arrest and performing resuscitation. The act of rescue, such as responding to a cardiac arrest and providing resuscitation in dangerous circumstances, such as aquatic environments or other austere locations, was also considered |
| **CONFLICT OF INTERESTS:** | None recorded |

## ASSESSMENT

| Problem<br>Is the problem a priority? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |

| | | |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | This topic was chosen for review by the Task Force to update and compare previous literature, including the ILCOR 2020 Harm to rescuers from CPR – Summary of a scoping review. [18]<br>There is a potential for unintentional harm to the rescuers responding to a cardiac arrest and performing resuscitation (chest compression, mouth-to-mouth ventilation), and with the use of a manual and automated external defibrillator. Also, the act of rescue, such as responding to a cardiac arrest and providing resuscitation in dangerous circumstances, such as aquatic environments or other austere locations, is a likely possibility.<br>There are two sentinel papers published after the last scoping review that suggested updating the prior scoping review. Rescuer unintentional harm as a result of attempting resuscitation especially in aquatic environments had broadened the scope and clarifies risks of CPR. [14] An additional database publication represents larger frequency data about the risks of CPR. [1]<br>This review is necessary as part of the ILCOR review cycle. The task force feels that the new data the combined data from infectious transmission, rescuer unintentional injury, rescue in dangerous environments, and further data clarifying electrical discharge risk from intentional and unintentional defibrillation studies justifies an update of the scoping review. | |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>● Varies<br>○ Don't know | A total of 20 studies were identified (Data table 1):[1,2,4-7,9-17,19-23] 11 studies investigated intra-arrest harm to rescuers, including nine reporting on the infection transmission[2,4-7,11,13,15,20] and six reporting on defibrillator-related harms[9,16,19,21-23]; one study investigated the potential for harm enroute to the patient[1] and another during the retrieval of an AED[17]; and three studied the reported harms during water rescue.[10,12,14]<br>The studies identified were heterogeneous, which did not support a more specific systematic review.<br>There were 4 case reports [3,6,7,13], 1 case series [11], and 4 [4,5,15,20] related to infection transmission to rescuers during cardiac arrest response.<br>6 studies reported risks associated with electrical exposure, including defibrillation during resuscitation [9,16,21-23].<br>Two studies reported physical risks associated with attempted resuscitation [1,17].<br>Three studies that reported risks associated with water exposure, including resuscitation of a drowning victim [10,12,14]. | |

| | | |
|---|---|---|
| **Undesirable Effects**<br>How substantial are the undesirable anticipated effects? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Trivial<br>● Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | Nine studies examined infection transmission to rescuers during cardiac arrest response, [2,4-7,11,13,15,20] including 7 with calculable infection rates (N=428 exposed rescuers, 110 infections). [2,4,5,7,13,20] Studies encompassed multiple pathogens: COVID-19 (n=3), Severe Fever with Thrombocytopenia Syndrome (SFTS, n=2), SARS-CoV (n=1), Crimean-Congo Hemorrhagic Fever (CCHF, n=1), and Clostridioides difficile contamination (n=1).<br>Six studies reported on potential defibrillator-related harm [9,16,21-23]. Four of these reported on the current leakage through measurement devices placed on the patient's chest during elective cardioversion, one using insulating gloves [9], one with polyethylene medical gloves [16], and two with polyethylene drapes [22,23] . Across all studies, a total of 140 shocks were delivered. Regardless of insulation measures or energy levels (100J, 200J, or 360J), current leakage consistently remained below safe thresholds (5mA), indicating minimal risk of harm.<br>One study investigated potential harm from CPR performed near implantable cardioverter defibrillators (ICD)[19] . This study indicated potential for current leakage above safe thresholds (5mA), indicating risk of harm., which was reduced when chest compressions were performed on the opposite side of the ICD. There was also a single case report [21] of a rescuer performing CPR on a patient with a normally functioning ICD who experienced a shock that left the rescuer with transient paresthesia lasting approximately 60 minutes in fingers, followed by peripheral symptoms (small sensory nerve action potentials) in fingers that persisted for 6 months. There were no other reports of ICD or other defibrillator harm in real-world settings or large trials.<br>Overall, there is a low risk of physical harm to rescuers enroute to patients with OHCA occurring on land. [1] Similarly, there is a low risk of injury when retrieving AEDs from locked glass cabinets. [17]<br>Three studies demonstrated direct evidence of rescue-related fatal drowning from attempted rescue in aquatic environments [10,12,14]. | |
| **Certainty of evidence**<br>What is the overall certainty of the evidence of effects? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |

| | | |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies<br>● n/a | The certainty of evidence was not evaluated as this was a scoping review. | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ●Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>○ Probably no important uncertainty or variability<br>○ No important uncertainty or variability | Across the four basic harm mechanisms, the transmission of infections during resuscitation is important to the population; thus, the importance of uncertainty and variability is heightened. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention Favors the intervention<br>○ Varies<br>● Don't know | Transmission of infection during resuscitation may be similar to that in general medical care; it is unknown if the risk of infection transmission when performing resuscitation outweighs the benefits of resuscitation<br><br>The data suggest there may be risk while attempting rescue of a drowning victim however whether the risk outweighs the benefits is unknown | |

## Resources required

How large are the resource requirements (costs)?"

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>○ Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>● Varies<br>○ Don't know | No additional high costs or resources are required for the interventions. | |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | Further resources may be beneficial in aquatic environments, but the actual cost is variable and uncertain. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● No included studies | no included studies | |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>○ Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>● Don't know | Clearly delineating the harms associated with and the safety measures will increase health equity by broadening the scope of rescuers however there are no studies addressing equity related issues and rescuer harm | |

## Acceptability

Is the intervention acceptable to key stakeholders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>○ Yes<br>● Varies<br>○ Don't know | Performing standard resuscitation is acceptable to the stakeholders.<br>The risk to rescuers is perceived to be low. | |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>○ Yes<br>○ Varies | Interventions to reduce rescuer harm were not identified or tested in this scoping review. | |

| | | |
|---|---|---|
| ● Don't know | | |

## SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | Small | Moderate | Large | | **Varies** | Don't know |
| **UNDESIRABLE EFFECTS** | Trivial | **Small** | Moderate | Large | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | Very low | Low | Moderate | High | | | **N/A** |
| **VALUES** | **Important uncertainty or variability** | Possibly important uncertainty or variability | Probably no important uncertainty or variability | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **Don't know** |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | Negligible costs and savings | Moderate savings | Large savings | **Varies** | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | Probably reduced | Probably no impact | Probably increased | Increased | Varies | **Don't know** |
| **ACCEPTABILITY** | No | Probably no | Probably yes | Yes | | **Varies** | Don't know |
| **FEASIBILITY** | No | Probably no | Probably yes | Yes | | Varies | **Don't know** |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

Not applicable. We have made no recommendation, and we have withdrawn the existing treatment recommendation from 2020.

# CONCLUSIONS

## Recommendation

The treatment recommendation published in 2020 is withdrawn.

Harms to rescuers during cardiac arrest response or resuscitation are rare. However, harms have been reported in specific situations, including water rescue, unsafe AED removal, chest contact during implantable cardioverter defibrillator shock delivery, performing CPR without appropriate PPE, and during transport to a cardiac arrest (good practice statement).

## Justification

Only 20 studies were identified that reported on harms, and these were grouped into transmission of infection, electrical injury during defibrillation, injury occurring while attempting to resuscitate or acquire an AED, and injuries associated with attempted rescue in water.
The task force considered the limited data above suggesting rescue-related risks are rare with the large number of resuscitations performed globally. The current evidence is insufficient to merit a systematic review. However, the evidence does highlight some areas that the task force felt could be included in a good practice statement, particularly given that identified risks are avoidable.

## Subgroup considerations

n/a

## Implementation considerations

Adding information about rescuer harm to resuscitation databases and collection

## Monitoring and evaluation

Implementation data collection about rescuer harm into standard collection forms.

## Research priorities

Hands-on defibrillation and continuous CPR

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# BLS 2031 – Supraglottic Airway Insertion in BLS

## QUESTION

| **Should airway management with a supraglottic airway device during resuscitation by basic life support provider(s) vs. facemask airway management with or without oropharyngeal or nasopharyngeal airway be used for In or out of hospital cardiac arrest managed by BLS providers?** | |
|---|---|
| **POPULATION:** | Adults in any setting (out-of-hospital or in-hospital) in cardiac arrest managed by first responders (example police, firefighter) and/or Emergency Medical Services (EMS) Basic Life Support (BLS) providers |
| **INTERVENTION:** | Airway management with a supraglottic airway device during resuscitation by basic life support provider(s) |
| **COMPARISON:** | Facemask airway management with or without oropharyngeal or nasopharyngeal airway |
| **MAIN OUTCOMES:** | Clinical outcomes identified by the BLS Task Force a priori as: *critical* include survival to hospital discharge with favorable neurological outcome, survival to hospital discharge/30 days; and *important* include survival after hospital discharge/30 days (e.g. 90 days, 180 days, 1 year), return of spontaneous circulation, first pass success, time to successful insertion, CPR quality (compression fraction, successful ventilation, respiratory rate, tidal volume), the need for further airway interventions, regurgitation and aspiration pneumonia. |
| **SETTING:** | out-of-hospital or in-hospital |
| **PERSPECTIVE:** | |
| **BACKGROUND:** | Previous systematic reviews by the ALS task force and by the PLS task force did not address the specific setting of BLS providers independently. SGA are being used by BLS providers in clinical practice. |
| **CONFLICT OF INTERESTS:** | • Nicholas Johnson is a co-investigator for the First Responder Airway and Compression Trial (FACT, NCT05969028), which compares supraglottic airway and mask ventilation among BLS providers.<br>• Guillaume Debaty and Nicolas Segond received funding from the University of Grenoble Alps for a cadaver study that compared supraglottic airway and mask ventilation among BLS providers.<br>• Gavin Perkins received research funding from the National Institute For Health And Social Care Research related to airway management during in-hospital cardiac arrest (AIRWAYS3).<br>• The other authors did not declare any conflicts.<br>• The SAC rep has no COI to disclose on this subject |

## ASSESSMENT

**Problem**

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies | During cardiopulmonary resuscitation (CPR), the main focus is to perform and monitor high quality chest compressions to promote the best possible forward circulation. Providing adequate ventilation during CPR is also a key element of survival. In a recent multicenter observational study, Idris et | |

| | | |
|---|---|---|
| ○ Don't know | al (Idris 2023, 1847) found that during CPR with BVM only, more than 60% of patients had less than 50% effective ventilation. When the 2 ventilations had tidal volume delivery deemed adequate by impedance measures this was independently associated with improved prehospital ROSC and survival and favorable neurological/functional outcome at discharge<br>There is currently no supporting evidence that an advanced airway (i.e. supraglottic airway or tracheal intubation) during CPR improves survival or survival with a favorable neurological/functional outcome after adult cardiac arrest in any setting when compared with bag-mask ventilation (Soar 2025) Current ALS guidelines suggest using either bag-mask ventilation (BMV) or an advanced airway device during CPR. If an advanced airway is used, guidelines suggest a supraglottic airway for adults with out-of-hospital cardiac arrest (OHCA) in settings with a low tracheal intubation success rate. Successfully and consistently performing endotracheal intubation with high first-pass success without complication mandates extensive training and skill maintenance, which is often not feasible for non-professional rescuers and even professional first-responders in some systems.<br>Conventional airway management by BLS providers often employs bag-valve mask (BVM) ventilation. BVM ventilation during CPR is challenging. Data suggest that a large proportion of BVM ventilations do not result in lung inflation (Chang 2019, 174, Idris 2023, 1847). Improper mask seal and air leak around the mask are likely a significant contributor to this difficulty. Patient factors, such as anatomy, facial hair, and emesis, can contribute to improper mask seal and air leak, resulting in inadequate ventilation. Further, multiple providers are often required to achieve adequate mask seal and ventilate during BMV, which may not be possible when personnel are limited. Advanced providers often transition airway from a BVM because of concerns of inadequate ventilation and/or emesis. Supraglottic devices have grown in popularity as tools to facilitate ventilation among advanced providers (Wang 2024, e2427763). Because they seal directly over or in the upper airway, they may improve effective seal, reduce leak which may, in combination improve the quality of ventilation for BLS providers. Improving ventilation at an early stage of CPR could improve outcomes for both OHCA and IHCA (Roth 2015, 1050, Park 2017, 1464, Hart 2020, 688). Learning to use SGA is feasible for individuals without extensive medical training (Bielski 2019, 871, Lemaitre 2019, 61).<br>Moreover, among patients admitted to intensive care units after cardiac arrest, almost 60% will develop early onset pneumonia (Perbet 2011, 1048). While pneumonia after cardiac arrest does not seem to increase mortality or modify neurological prognosis, it increases intensive care unit length of stay up to 4 days on average and hospitalization costs (Pabst 2013, 1514). Nearly 50% of patients suffer emesis | |

| | | |
|---|---|---|
| | during cardiac arrest, and insufflation of the stomach by BVM may contribute to rates of pneumonia after cardiac arrest. By both improving seal and occluding the proximal esophagus, some SGA devices could theoretically reduce the burden of aspiration of gastric contents if placed early in the management of cardiac arrest (Stone 1998, 3).<br>There is a growing body of literature and interest from some BLS providers (e.g. firefighters, lifeguards) to use supraglottic airways (Lefrancois 2002, 77, Lankimaki 2013, 446, Fiala 2017, 104). We aimed to review if the use of SGA compared to BMV with or without oropharyngeal or nasopharyngeal airway for BLS providers during in or out of hospital cardiac arrest is associated with improved outcomes. | |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>● Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | Previous meta-analysis have shown no benefit of supraglottic airway compared to other airway management methods on survival or favorable neurologic outcomes in EMS system. However, SGA was better than intubation or bag-valve-mask ventilation in improving return of spontaneous circulation (Wang 2020, 627). For BLS providers the effect of SGA compared to BVM is likely to be small.<br>In our systematic review, for observational studies, meta-analysis was not possible due to methodological and statistical heterogeneity. For the critical outcome of survival to hospital discharge or 30 days we identified moderate certainty evidence (downgraded for serious risk of bias) from 3 randomized controlled trial (Rumball 2009, 1, Maignan 2015, 113, Fiala 2017, 104) including 628 adult patients with out-of-hospital cardiac arrest managed by BLS-trained emergency medical services personnel demonstrated no significant differences with the use of a supraglottic airway when compared with bag mask ventilation<br>For chest compression fraction and regurgitation, we found a significant effect in favor of SGA, but these outcomes were reported in a few studies with very low certainty of evidence and Very serious risk of bias including a small number of patients. | |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ● Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | In our systematic review, for observational studies, a meta-analysis was not possible due to methodological and statistical heterogeneity. For the 3 RCTs, no significant differences were observed with the use of a supraglottic airway when compared with bag mask ventilation low certainty evidence downgraded for serious risk of bias). We did not identify undesirable anticipated effect related to SGA use. | |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | Across critical outcomes reported in 3RCTs, the certainty of evidence was ranked as very low. | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | Our list of outcomes comprises all outcomes that were included in the Core Outcome Set for Cardiac Arrest, namely survival, survival with favourable neurological outcome. These were outcomes that were prioritised by members of the public, cardiac arrest survivors, researchers and clinicians and are categorised as critical outcomes. For these variables reported in 3RCTs, there was low certainty evidence (downgraded for serious risk of bias) | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>● Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | In our systematic review, for observational studies, meta-analysis was not possible due to methodological and statistical heterogeneity. For the 3 RCTs included, no significant differences was observed with the use of a supraglottic airway when compared with bag mask ventilation. For chest compression fraction and regurgitation, we found a significant effect in favor of SGA but these outcomes were reported in a very limited number of studies with very low certainty of evidence and very serious risk of bias. | |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | Supraglottic devices have grown in popularity as tools to facilitate ventilation among advanced providers (Wang 2024, e2427763). We surmised with a brief look at that literature that learning to use SGA may be feasible for individuals without extensive medical training (Bielski 2019, 871, Lemaitre 2019, 61). | |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | Both SGA and BVM airway management are already used frequently in emergency care for advanced providers. Implementation for BLS providers across EMS system may require a significant amount of training and resources. | |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | **Small** | Moderate | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | **Trivial** | Small | Moderate | Large | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | Very low | **Low** | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |

| BALANCE OF EFFECTS | Favors the comparison | Probably favors the comparison | **Does not favor either the intervention or the comparison** | Probably favors the intervention | Favors the intervention | Varies | Don't know |
|---|---|---|---|---|---|---|---|
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | **Conditional recommendation for either the intervention or the comparison** | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ● | ○ | ○ |

## CONCLUSIONS

### Recommendation

For appropriately trained BLS-trained emergency medical services personnel (ie paramedics, nurses and emergency medical technicians), we suggest providing ventilation with a supraglottic airway or bag-mask with or without oropharyngeal/nasopharyngeal airway (weak recommendation, very low-certainty evidence).

For appropriately trained volunteer community BLS responders or dispatched first responders (e.g., firefighters, police, lifeguards), we support the use of a supraglottic airway or bag-mask with or without oropharyngeal/nasopharyngeal airway to provide ventilation (Good practice statement).

We support a competency-based training program with regular retraining for both bag-mask ventilation and airway insertion (good practice statement).

### Justification

Most published studies were in basic life support trained emergency medical technicians, with two studies in nurses untrained to perform endotracheal intubation. There were no studies in other basic life support providers (volunteer or first responders). According to Utstein definition, a volunteer community responder is someone alerted to the scene, first responders are non-EMS dispatched to the scene (eg, fire, police) and EMS responders have the ability to transport the patient to hospital.
The existing body of published literature is generally very low-quality evidence. The three RCTs report no difference in patient outcomes between a BVM and SGA, whereas the observational results were more varied. Indirect evidence from feasibility and implementation studies indicates that the use of supraglottic airway devices (i-gels) by firefighters is safe and can be introduced with appropriate training.(Lankimaki 2013, 446, Boland 2015, 96, Haske 2019, 167, Andresen 2023, 100480). Data from simulation and cadaver studies involving first responders (including lifeguards, mountain rescue teams, and volunteer responders) suggest that the use of various supraglottic airway devices is feasible (Adelborg 2014, 343), may improve ventilation success rates with appropriate training (Segond 2022, 1) and shows no significant differences in usability compared to advanced life support providers (Nørkjær 2020, 73).
Several observational studies were at significant risk of bias as the use of supraglottic airway was at the discretion of EMS with no adjustment for confounders (Stone 1998, 3, Sos-Kanto study group 2009, 490, Hasegawa 2013, 257, Lin 2014, 27, Roth 2015, 1050, Park 2017, 1464, Jinno 2019, 2479, Kim 2020, 21, Jung 2022, Song 2023, 24,

Tang 2024, 703). There was also considerable heterogeneity among the studies, limiting the conclusions. Meta-analysis was not possible in observational studies due to this methodological and statistical heterogeneity. Moreover, in several observational studies, BVM was used prior to SGA (Stone 1998, 3, Sos-Kanto study group 2009, 490, Hasegawa 2013, 257, Lin 2014, 27, Maignan 2015, 113, Roth 2015, 1050, Park 2017, 1464, Kim 2020, 21, Jung 2022, Song 2023, 24, Tang 2024, 703); thus the quality of ventilation before-and-after the switch and the timing of the switch in the intervention limits the interpretation of the results.
The included observational studies are a risk of resuscitation time bias (i.e. SGA are more likely to be used in longer resuscitations and most likely all resuscitations were initially managed with BVM for an unspecified time interval). No study used methods to adjust for this bias in either their multivariable models or propensity analysis (Andersen 2018, 79).
There are insufficient data to express a preference for a particular supraglottic airway device over BVM. Due to the limited evidence, we pooled data from different supraglottic airway devices; however, the performance of individual supraglottic airway devices may vary. However, three observational studies not included have reported higher rates of successful placement with i-gels compared to laryngeal tubes (Andersen 2017, 494, Smida 2023, Smida 2024, 193).
Due to the study design and limited data, we were unable to assess the differences between any of our a priori subgroup considerations (patient gender, basic life support providers (first rescuers, emergency medical technician, other healthcare professional, OHCA vs. IHCA, SGA type).
In this systematic review, face masks were always associated with a self-inflating bag attached to a face mask via a shutter valve (bag-valve mask). Face masks alone were not assessed.
Only one observational study (Roth 2015, 1050) assessed ventilation quality during resuscitation using BVM, with or without the use of a supraglottic airway. As a result, the quality of ventilation delivered by either technique remains uncertain and is likely to vary across providers and devices. Effective BVM is difficult to perform well (Gerber 2021, 252, Idris 2023, 1847), and may require multiple personnel and depend on provider training and skill. The optimal bag-mask technique and the use of airway adjuncts (such as oropharyngeal or nasopharyngeal airways) could not be specifically evaluated. SGAs may be preferred as it provides a more secure seal than BVM ventilation and require fewer hands once the airway is secure. The limited evidence, with very serious risk of bias from observational studies, suggests that SGA may mitigate the risk of regurgitation during CPR.
They are limited evidence from one RCT (low certainty, moderate risk of bias) and one observational study (low certainty serious risk of bias) that SGA may increase hands-on time during CPR.

## Subgroup considerations

All the a priori subgroup considerations.
- patient gender
- basic life support providers (first rescuers, emergency medical technician, other healthcare professional)
- OHCA vs. IHCA
- Supraglottic device reported by type (example igel, laryngeal mask)

There is insufficient evidence to explore any of these subgroups.

## Implementation considerations

Supraglottic devices have grown in popularity as tools to facilitate ventilation among advanced providers (Wang 2024, e2427763). Learning to use SGA is feasible for individuals without extensive medical training (Bielski 2019, 871, Lemaitre 2019, 61).
Both SGA and BVM airway management are already used frequently in emergency care for advanced providers. Implementation for BLS providers across EMS system may require a significant amount of training and resources.

## Monitoring and evaluation

not applicable

## Research priorities

There was a lack of RCTs comparing the SGA devices.
There was a lack of studies assessing critical outcomes such as favorable neurologic outcome.
Adverse effects were not consistently reported, limiting the analysis on several important outcomes, such as regurgitation and aspiration. No study adjusted for the resuscitation time bias.
Ventilation success was poorly defined and evaluated in trials.
Measures of ventilation quality with either strategy are missing.
Studies were confounded by the presence or absence of multiple levels of paramedic competency in airway management. It is difficult to assess the effect of intervention across a multi-tiered response to cardiac arrest using observational data.

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# BLS 2401 – Ventilation Parameters During Adult CPR

## QUESTION

| **Should ventilation with a lower tidal volume vs. ventilation with a higher tidal volume be used for adults and children receiving assisted ventilation during cardiac arrest.?** | |
|---|---|
| **POPULATION:** | adults and children receiving assisted ventilation during cardiac arrest. |
| **INTERVENTION:** | ventilation with a lower tidal volume |
| **COMPARISON:** | ventilation with a higher tidal volume |
| **MAIN OUTCOMES:** | Neurologically-intact survival; Survival to hospital discharge; ROSC; pH; |
| **SETTING:** | In-Hospital or out-of-hospital cardiac arrest |

## ASSESSMENT

**Problem**

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | Cardiac arrest (CA) results in immediate tissue hypoxia and acidemia leading to irreversible damage if not temporized. Critical to survival is early and optimal delivery of cardiopulmonary resuscitation, including quality chest compressions, early defibrillation, and effective ventilation. While ventilation is a key component of CPR, evidence to guide practice is limited.<br>Prior to return of spontaneous circulation, animal studies indicate an early, dynamic deterioration of oxygen and acid-base status following CA.(Chang et al., 2019; Chang & Idris, 2017) Notably, evidence from both animal and human studies indicate that variation in ventilation during CA resuscitation can markedly affect outcome, but the optimal parameters have not been clearly defined.(Ashoor et al., 2017; Aufderheide et al., 2004; Yannopoulos et al., 2006) Early studies documented adverse hemodynamic consequences related to hyperventilation, while more recent research highlights potentially ineffective ventilation in a substantial proportion of patients.(Aufderheide et al., 2004; Aufderheide & Lurie, 2004; Bhandari et al., 2022; Chang et al., 2019; Lesimple et al., 2022; Van Den Daele et al., 2021) Both hypo- and hyperventilation have be associated with worse outcome, though results are mixed and best practices are not well-defined.(Aufderheide et al., 2004; Aufderheide & Lurie, 2004; Chang et al., 2019; Wang et al., 2022) Further, there is growing recognition that respiratory complications are common after CA and contribute substantially to morbidity and mortality.(Johnson et al., 2018) Over half of resuscitated CA patients develop the acute respiratory distress syndrome (ARDS), a severe form of lung injury; these patients are less likely to survive and recover neurologically.(Johnson et | |

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|---|---|---|
| | al., 2019; Shih et al., 2022) Ventilation with large, injurious tidal volumes and high pressures are key risk factors for ARDS in hospitalized patients, however one study demonstrated that small ventilation bags during SCA were unexpectedly associated with lower odds of sustained ROSC in an observational study, highlighting an urgent need to evaluate optimal ventilation bag size and tidal volume during CA.(ARDSnet Investigators, 2000; Fuller et al., 2013; Serpa Neto et al., 2012; Snyder et al., 2023) Two recent studies demonstrated that lung inflation, as determined by changes in thoracic impedance, occurs infrequently during CPR, and that lack of lung inflation is associated with worse outcome.(Chang et al., 2019; Idris et al., 2023) Two pediatric studies have demonstrated that hyperventilation is common during CPR, especially when an advanced airway is in place. (Donoghue et al., 2020; McInnes et al., 2011) Optimal ventilation rates, volumes, and inspiratory times applied during CPR, balancing systemic hemodynamics and oxygen delivery, have not been clearly defined. | |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>● Moderate<br>○ Large<br>○ Varies<br>○ Don't know | The anticipated benefits of various ventilation strategies during cardiac arrest are supported by low- to very low-quality evidence, with findings varying in magnitude depending on the specific strategy and outcome. The overall anticipated desirable effect is moderate.<br><br>Higher ventilation rates appear to show potentially substantial desirable effects for critical and important outcomes such as survival with favorable neurological outcomes, survival to discharge, and ROSC. For the critical outcome of survival with favorable neurological outcomes, low-quality evidence (OR 8.39, 95% CI 3.43–20.5) suggests a large effect, indicating the possibility of meaningful benefit. Similarly, for survival to discharge, very low-quality evidence (OR 8.15, 95% CI 4.24–15.6) suggests a sizable benefit without significant statistical heterogeneity, but clinical heterogeneity. For ROSC, very low-quality evidence shows a moderate but meaningful effect (OR 3.40, 95% CI 2.4–4.6). While these findings suggest notable clinical benefits, limitations in study design, particularly the reliance on non-RCT data, introduce significant uncertainty, and the overall quality of the evidence necessitates cautious interpretation. Statistical heterogeneity was low to moderate ($I^2$ 0-30%) for these studies across all outcomes, but significant clinical heterogeneity was noted in populations and approaches to measurement.<br><br>Higher tidal volumes show no consistent evidence of substantial desirable effects. For survival with favorable neurological | |

| | | |
|---|---|---|
| | outcomes, very low-quality evidence (OR 1.55, 95% CI 1.06–2.26) suggests a small potential benefit, but the magnitude of the effect is modest. For survival to discharge and ROSC, there is no clear evidence of benefit (OR 1.26, 95% CI 0.94–1.69; OR 1.13, 95% CI 0.95–1.36, respectively), with very low-quality evidence downgrading confidence in these findings. The lack of significant desirable effects, combined with conflicting findings in small RCTs and observational studies, suggests that higher tidal volumes are unlikely to produce large favorable effects in clinical outcomes. Statistical heterogeneity varied across outcomes and significant clinical heterogeneity was noted in populations, approaches to delivery of different tidal volumes, and measurement.<br><br>The achievement of ventilation-induced impedance changes in ≥50% of chest compression pauses appears to have substantial anticipated desirable effects. For survival with favorable neurological outcomes, low-quality evidence (OR 4.45, 95% CI 2.99–6.63) suggests a meaningful benefit. Similarly, for survival to discharge, low-quality evidence (OR 3.50, 95% CI 2.54–4.81) indicates a moderate to large benefit. For ROSC, very low-quality evidence (OR 2.02, 95% CI 1.69–2.7) suggests more modest, yet still favorable, effects. These desirable effects highlight the potential positive impacts of ensuring effective ventilation as detected through impedance changes, although the low quality of evidence warrants careful consideration. Statistical heterogeneity was low (I2 0%) for these studies across all outcomes.<br><br>The magnitude of the desirable effects varies across ventilation strategies. Higher ventilation rates show potentially substantial benefits across critical and important outcomes, though the evidence quality is low. The anticipated benefits of higher tidal volumes are likely small, if present at all, given the lack of consistent findings. Ventilation-induced impedance changes in ≥50% of chest compression pauses appear to show moderate to large effects on critical and important outcomes, presenting them as a potentially desirable ventilation strategy. Overall, while the anticipated desirable effects across these strategies are promising, the limitations in the evidence base reduce confidence in their magnitude and call for further research to clarify their potential benefits. | |
| **Undesirable Effects**<br>How substantial are the undesirable anticipated effects? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |

| | | |
|---|---|---|
| ○ Trivial<br>● Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | The undesirable effects of various ventilation strategies during cardiac arrest are primarily tied to risks of hyperventilation, hypoventilation, and excessive tidal volumes, which can impair gas exchange, lung injury, barotrauma, decrease coronary perfusion pressure, and reduce venous return. Higher ventilation rates may lead to hyperventilation-induced hypocapnia, causing cerebral vasoconstriction and worsened neurological outcomes, while hypoventilation (<10 breaths per minute) has been associated with lower ROSC and survival rates. Larger tidal volumes increase the risk of excessive intrathoracic pressure, potentially reducing cardiac output or causing barotrauma, although existing evidence is inconsistent and of very low quality. Furthermore, inadequate synchronization of ventilation-induced impedance changes with chest compressions may exacerbate acid-base disturbances or impair hemodynamic stability. Despite physiological plausibility of harm from these strategies, the evidence remains weak and inconsistent, necessitating further research to better establish the magnitude of undesirable effects. In our systematic review, we did not identify specific undesirable effects with any particular ventilation strategy other than the differences in outcomes reported, but these were not collected systematically in most ofthe existing studies. | |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | Across critical and important outcomes, the certainty of evidence was ranked as very low. | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or | Our list of outcomes comprises outcomes that were included in the ILCOR Core Outcome Set for Cardiac Arrest, survival with favourable neurological outcome, survival, and ROSC. These were outcomes that were prioritised by members of the public, cardiac arrest survivors, researchers and clinicians and are categorised as critical outcomes. | |

| | | |
|---|---|---|
| variability | | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>● Varies<br>○ Don't know | The balance of effects between desirable and undesirable outcomes is variable according to outcome and specific intervention. Higher ventilation rates appear to offer benefits for critical outcomes such as survival with favorable neurological outcomes, survival to discharge, and ROSC, as evidenced by low- to very low-quality studies reporting large effect sizes. For tidal volumes, desirable effects are modest at best, with limited evidence of benefit for survival or ROSC. Ventilation-induced impedance changes in ≥50% of chest compression pauses demonstrate favorable effects across survival and ROSC outcomes. Overall, while some interventions (e.g., higher ventilation rates and impedance-driven strategies) show promise for improving outcomes, the low quality of evidence combined with unknown risks of harm leaves uncertainty about whether they consistently outweigh the undesirable effects compared to the comparison strategies. Robust randomized trials are needed to better define the balance of effects and guide clinical decision-making. | |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>● Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | All of the interventions studied represent variations in standard care or could easily be implemented without significant cost other than training and education. | |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>● Low<br>○ Moderate<br>○ High<br>○ No included studies | Since no additional equipment or devices are needed, the costs are unlikely to be excessive. While some additional training may be required, this would result in only low cost. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>● Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ No included studies | The interventions likely are low cost as the ventilation strategies proposed rely on existing equipment and techniques commonly used during resuscitation, such as bag-valve devices, mechanical ventilators, and advanced airways. There are no significant additional costs associated with implementing higher ventilation rates or impedance-driven ventilation adjustments, as these interventions primarily involve optimizing techniques within the current standard of care. However, the benefit of the intervention is not clear. While improving survival rates and achieving favorable neurological outcomes can lead to reduced long-term healthcare costs associated with prolonged hospital stays or rehabilitation, it is unclear whether the intervention would confer these benefits. | |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>○ Probably no impact<br>○ Probably increased<br>○ Increased<br>● Varies<br>○ Don't know | There may be variable effects on equity depending on the specific intervention and population. Data from other disease states, such as ARDS, indicate that women routinely receive tidal volumes that are inappropriate for their body size. Whether this applies in cardiac arrest is unknown. | |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | The intervention is probably acceptable to key stakeholders as most of these ventilation strategies are already being implemented in practice at times. While concerns about risks such as hyperventilation or high tidal volumes exist, the fact that these approaches are already part of resuscitation practices suggests general acceptability, especially if supported by clearer evidence and guidelines. | |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | These interventions are feasible to implement as it builds on existing practices and uses readily available equipment commonly found in resuscitation settings, such as bag-valve masks, advanced airways, and mechanical ventilators. The recommendation to monitor ventilation rate and adequacy, while avoiding both hyperventilation and hypoventilation, is achievable in most systems, especially those equipped with basic airway adjuncts or feedback tools. Advanced monitors such as | |

| | | |
|---|---|---|
| | flow or spirometry-based devices can further enhance adherence in facilities with access to these technologies. Tidal volume recommendations are also feasible to implement, with tools like mechanical ventilators and clinical judgment helping guide appropriate tidal volume delivery based on predicted body weight. Although some additional training may be required to optimize technique or reinforce guidelines, the overall intervention remains practical and can be incorporated into current workflows with minimal disruption. | |

## SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | Small | **Moderate** | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Trivial | **Small** | Moderate | Large | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | **Varies** | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | **Negligible costs and savings** | Moderate savings | Large savings | Varies | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | **Low** | Moderate | High | | | No included studies |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | **Does not favor either the intervention or the comparison** | Probably favors the intervention | Favors the intervention | Varies | No included studies |
| **EQUITY** | Reduced | Probably reduced | Probably no impact | Probably increased | Increased | **Varies** | Don't know |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

# TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | **Conditional recommendation for either the intervention or the comparison** | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ● | ○ | ○ |

# CONCLUSIONS

## Recommendation

We suggest delivering 2 ventilations for every 30 compressions or 10 ventilations per minute (1 ventilation every 6 seconds) for continuous compressions in adults with cardiac arrest with or without an advanced airway (weak recommendation, very low–certainty evidence).

When manual ventilation is being provided, it is reasonable to deliver enough volume to produce visible chest rise (good practice statement).

When tidal volume can be measured, we suggest delivering a tidal volume of 400 to 600 mL (or 6–10 mL/kg of ideal or predicted body weight) in adults with cardiac arrest (weak recommendation, very low–certainty evidence).

It is reasonable to ensure effective ventilation and avoid both hyperventilation and hypoventilation (good practice statement).

## Justification

This topic was prioritized by the Basic Life Support (BLS), Advanced Life Support (ALS), and Pediatric Life Support (PLS) Task Forces based on recent observational studies (Chang et al., 2019; Idris et al., 2023) and small randomized trials suggesting associations between ventilation parameters and outcomes. However, the evidence is marked by substantial heterogeneity in study design, populations, ventilation delivery methods (manual vs. mechanical ventilation), and interventions. Older studies documented harm associated with hyperventilation during cardiac arrest (Aufderheide et al., 2004), while more recent data highlight common occurrences of hypoventilation and its association with poor outcomes, particularly in the absence of advanced airways (Chang et al., 2019; Idris et al., 2023).

The evidence base includes limited randomized trials (e.g., Prause et al., 2023; Langhelle et al., 2000; Shin et al., 2024), which are small, single-center, and underpowered. Larger multicenter randomized trials are urgently needed to confirm findings and establish definitive guidance for ventilation rate, tidal volume, and monitoring strategies. Given the clinical heterogeneity among studies, the Task Forces agreed that meta-analysis was not feasible. Further observational studies indicate favorable associations with ventilation rates >10 breaths per minute, but these findings are limited by high risk of bias and unclear mechanisms.

Most studies informing these recommendations included patients treated by advanced healthcare providers, including paramedics, nurses, and physicians. While interventions such as monitoring ventilation rate and delivering breaths to achieve chest rise have evidence supporting their use, the overall quality of evidence remains low to very low due to methodological concerns, significant heterogeneity in study designs, and indirectness in assessing key outcomes. Many of the studies reviewed were observational, with significant risks of bias. The variability in reported metrics, such as ventilation rates and tidal volumes, further limits the generalizability of findings and complicates the interpretation of results.

For ventilation rate, the recommendation of 2 ventilations for every 30 compressions or delivering 10–20 breaths per minute during continuous compressions aligns with clinical practice and physiological reasoning. Evidence from observational studies and small randomized trials highlights the harms associated with both hypoventilation (<10 breaths per minute) and hyperventilation (>20 breaths per minute), emphasizing the importance of maintaining ventilation within this optimal range. Studies demonstrate associations

between unfavorable outcomes and hypoventilation in patients without advanced airways, while older evidence suggests harm from hyperventilation due to hypocapnia-induced cerebral vasoconstriction and decreased coronary perfusion pressure. However, the thresholds for hyper- and hypoventilation remain imprecise, as individual patient needs may vary.

For tidal volume, the recommendation to deliver 6–10 mL/kg of predicted body weight (or 400–500 mL when predicted body weight is unknown) is physiologically sound and seeks to minimize harm while maintaining adequate gas exchange. Excessive tidal volumes risk increasing intrathoracic pressure, which can impair venous return and lead to barotrauma. While evidence regarding tidal volume is limited and inconsistent, findings from small randomized trials and observational studies highlight the need to avoid extremes that could cause barotrauma or ineffective ventilation. The absence of high-quality comparative trials underscores the importance of adhering to reasonable tidal volume ranges based on physiologic principles.

The recommendation to deliver tidal volume to achieve visible chest rise is a pragmatic approach in settings where ventilation monitoring is unavailable. However, advanced tools like flow monitors or spirometers are not universally accessible, and factors such as technique variability among providers may impact ventilation quality. Monitoring ventilation adequacy and avoiding both hypoventilation and hyperventilation remains a cornerstone of these recommendations. While precise techniques and tools for optimal monitoring remain undefined, physiological reasoning and existing evidence suggest significant benefits in maintaining ventilation parameters within an acceptable range. Advanced tools may improve monitoring accuracy but are not required for implementing these recommendations in most settings.

Ultimately, these recommendations are presented as Good Practice Statements given the limitations with current evidence, which largely is observational, uncertainty, and clinical heterogeneity in the included studies. Future high-quality trials are necessary to address uncertainties, reduce variation in practice, and strengthen the evidence base for ventilation during resuscitation.

## Subgroup considerations

The following subgroup analyses could be performed, if sufficient data is available:

- patient gender
- patient age group
- patient race/ethnic background
- likely cause/etiology (presumed or confirmed) and/or initial cardiac rhythm
- Pediatrics
- Airway device: basic life support airway, supraglottic device, tracheal intubation

There is insufficient evidence to explore any of these subgroups.

## Implementation considerations

Implementing these ventilation recommendations is feasible but requires attention to training, resources, and integration into existing protocols. Regular provider education is critical to ensure proficiency in delivering recommended ventilation rates, achieving chest rise, and avoiding extremes like hyperventilation or hypoventilation, especially when using manual bag-valve devices. While advanced monitoring tools like capnography or spirometry can enhance accuracy, visible chest rise serves as a practical alternative in resource-limited settings. Tailoring ventilation strategies to patient-specific factors and using quality assurance initiatives can help refine implementation, optimize resuscitation practices, and improve patient outcomes.

## Monitoring and evaluation

Monitoring and evaluating implementation can be achieved through regular data collection on key ventilation parameters, such as rate, tidal volume, visible chest rise, and adherence to guidelines during resuscitations. Use of feedback devices, such as capnography or real-time audiovisual systems, can provide immediate insights into performance and identify areas for improvement. Post-event debriefings and quality assurance reviews can analyze outcomes, assess provider adherence, and highlight training needs. Ongoing audits and incorporating findings into training programs will ensure continuous improvement and alignment with best practices.

## Research priorities

Several key gaps in the evidence base for optimal ventilation strategies during cardiac arrest highlight the need for future research. First, there are no adequately powered randomized controlled trials (RCTs) to detect differences in neurologically-intact survival, which should be prioritized given its critical importance. Research is also needed to refine thresholds for "higher" and "lower" ventilation rates across diverse patient populations, including adults vs. children and in-hospital vs. out-of-hospital cardiac arrests, as ventilation requirements may vary by context. Similarly, the ideal tidal volume remains unclear, despite concerns about smaller tidal volumes potentially avoiding barotrauma and elevated intrathoracic pressure; inconsistent findings from recent studies (e.g., Snyder et al., 2023) highlight the importance of addressing this question.

Ventilation practices for pediatric cardiac arrest are notably underexplored compared to adults, and future studies should aim to bridge this gap. Additionally, there is minimal evidence comparing ventilation strategies (e.g., rate, tidal volume, adequacy) in patients with advanced airways versus basic airway techniques, such as bag-mask ventilation or 30:2 CPR without airway insertion. Mechanistic understanding is limited, with blood gases often reported only after ROSC, leaving gaps in understanding physiologic changes during ventilation. Finally, research should explore whether ventilation practices and outcomes differ based on patient-specific factors such as etiology of arrest, initial rhythm, or other prognostic variables to better inform tailored approaches to resuscitation. Filling these gaps would greatly enhance the evidence base for ventilation strategies during cardiac arrest and improve patient care.

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# BLS 2404 – Bag Size for Manual Ventilation During Adult CPR

## QUESTION

| **In adults with in-hospital or out-of-hospital cardiac arrest receiving manual ventilation during CPR, does use of a smaller manual resuscitation bag compared with a standard-size bag reduce delivered tidal volume and improve resuscitation outcomes?** | |
|---|---|
| **POPULATION:** | Adults with in-hospital or out-of-hospital cardiac arrest receiving manual ventilation during CPR |
| **INTERVENTION:** | Use of a smaller manual resuscitation bag than standard size (i.e. using pediatric bag for adult patients) for the patient to limit delivered tidal volume |
| **COMPARISON:** | Use of a standard/larger bag (i.e. approximately 1500ml) |
| **MAIN OUTCOMES:** | ***Critical***: Favourable neurological survival (as measured by cerebral performance category or modified Rankin Score) at discharge or 30-days and at any time interval after 30-days. ***Important***: Survival to discharge or 30 days, Survival to hospital admission, Survival to any time interval after discharge or 30 days survival, Return of spontaneous circulation (ROSC) ***Other:*** Delivered tidal volume, ventilation rate, barotrauma |
| **SETTING:** | In-Hospital or out-of-hospital cardiac arrest |

## ASSESSMENT

**Problem**

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | Effective ventilation during cardiopulmonary resuscitation (CPR) is essential to optimize oxygen delivery and carbon dioxide removal while minimizing the risk of harm from excessive ventilation. Hyperventilation during CPR has been associated with increased intrathoracic pressure, reduced venous return, decreased coronary and cerebral perfusion, and lower rates of ROSC and survival.<br><br>In current practice, standard adult manual resuscitation bags have a nominal volume of approximately 1.5 liters. Even with partial compression, these bags can easily deliver tidal volumes that exceed guideline recommendations, particularly when used by providers under high-stress conditions such as cardiac arrest.<br><br>Studies in both simulation and clinical environments have demonstrated that providers frequently deliver excessive tidal volumes when using standard-sized bags. The use of a smaller-volume manual resuscitation bag (e.g., pediatric-sized bag of 0.5–1.0 L) for adults or larger pediatric patients has been proposed as a simple, low-cost strategy to limit excessive tidal volume delivery during CPR. This strategy may reduce the risk of hyperventilation-related hemodynamic compromise and lung | |

| | | |
|---|---|---|
| | injury while maintaining adequate oxygenation and ventilation. However, evidence directly linking smaller bag use during CPR to improved patient outcomes—such as ROSC, survival to discharge, or favorable neurological outcome—remains limited and mixed. One recent study demonstrated that small adult ventilation were associated with lower odds of ROSC.<br><br>Given the central role of ventilation quality in CPR and the ease of implementation of a bag size intervention, this review will evaluate the impact of using a smaller manual resuscitation bag compared to standard-sized bags on both clinical outcomes (ROSC, survival, neurological outcome) and process measures (delivered tidal volume, ventilation rate) in adults with in-hospital or out-of-hospital cardiac arrest. | |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>● Moderate<br>○ Large<br>○ Varies<br>○ Don't know | The anticipated benefits of using a smaller-volume manual resuscitation bag during adult cardiopulmonary resuscitation are supported by very low- to low-certainty evidence, from a single before–after clinical study and two simulation studies. These studies demonstrate that when providers switch from standard adult to smaller- volume bags, delivered tidal volumes are consistently lower and ventilation delivery more closely aligns with guideline recommendations.<br>The magnitude of these changes varies by setting and provider experience but is observed across simulation and physiologic clinical studies.<br>Evidence linking these time-dependent improvements in ventilation delivery to patient-centered outcomes is limited and derived from one observational study with substantial confounding. As a result, anticipated desirable effects are driven by improvements in ventilation parameters over time rather than demonstrated effects on survival or neurological outcomes. The overall magnitude of anticipated benefit was judged to be small to moderate, with low confidence due to indirectness and heterogeneity. | |

## Undesirable Effect

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>● Moderate<br>○ Large<br>○ Varies<br>○ Don't know | The potential undesirable effects of using a smaller manual resuscitation bag during adult CPR relate hypoventilation, inadequate minute ventilation, and impaired gas exchange if ventilation is delivered inconsistently. In theory, use of smaller bags could result in insufficient tidal volumes if not paired with appropriate ventilation rates or technique, potentially leading to hypercapnia or worsening acidosis during resuscitation. However, these effects were not observed in the included simulation or physiologic studies, where ventilation | |

| | | |
|---|---|---|
| | parameters generally remained within guideline-recommended ranges.<br>Concerns regarding lung injury or barotrauma are more commonly associated with larger tidal volumes and excessive intrathoracic pressures rather than smaller bags. No included studies systematically assessed barotrauma or other ventilation-related harms attributable to smaller bag use, and no signal of harm was identified.<br>Overall, while there is physiological plausibility for undesirable effects related to inappropriate ventilation delivery, available evidence does not demonstrate important harms associated with smaller manual resuscitation bags. | |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | Across all outcomes, the certainty of evidence was ranked as very low. Evidence was derived from one observational clinical study and two simulation studies; no randomized clinical trials evaluating ventilation bag size during adult cardiac arrest were identified. In the observational cohort study, use of a smaller-volume bag was associated with significantly lower rates of favorable neurological outcome (5% vs 7%, adjusted odds ratio [AOR]=0.65, 95%CI: 0.43 to 0.99) and survival to hospital admission (35% vs 42%, AOR= 0.73, 95%CI: 0.60 to 0.90) and numerically lower survival to discharge (9% vs 12%, AOR=0.79, 95%CI: 0.57 to 1.09). These findings are impacted by substantial confounding, indirectness, and imprecision inherent to non-randomized designs, resulted in serious downgrading for risk of bias and inconsistency. Simulation studies demonstrated indirect and inconsistent results. Both simulation studies showed a higher proportion of ventilations with lower than guideline recommended delivered tidal volume with smaller bags and a higher proportion of ventilations with higher than guideline recommended delivered tidal volume with larger bags. | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>○ Probably no important uncertainty or variability<br>● No important uncertainty or variability | Our list of outcomes comprises outcomes that were included in the ILCOR Core Outcome Set for Cardiac Arrest, survival with favorable neurological outcome, survival, and ROSC. These were outcomes that were prioritized by members of the public, cardiac arrest survivors, researchers and clinicians and are categorized as critical outcomes. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>●Varies<br>○ Don't know | The balance of desirable and undesirable effects varies, and the number of studies were small. That patient outcomes worsened in the only clinical study and tidal volumes were more likely to be under guideline recommendation in simulation with the smaller volume bag favors use of the standard bag. However, both simulation studies showed a higher proportion of participants exceeding the upper limit of guideline recommendations for tidal volume. However, the later could be addressed in education and training. | |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>● Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | Adult (standard) and pediatric ventilation bags are currently used in resuscitation. The treatment recommendation does not change current practice and does not impact resources. Although using one bag size for all resuscitation would require less future equipment cost. | |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>● Low<br>○ Moderate<br>○ High<br>○ No included studies | Since no additional equipment or devices are needed, the costs are unlikely to be excessive. While some additional training may be required, this would result in only low cost. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>● Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ No included studies | The intervention is likely low cost, as it uses manual resuscitation bags that are already widely available and requires minimal additional training. However, its cost-effectiveness is uncertain, as evidence demonstrating improvements in survival or neurological outcomes is limited, making it unclear whether physiologic benefits translate into reduced healthcare utilization or long-term costs | |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>● Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>○ Don't know | There is likely no impact as both sizes of manual resuscitation bags are currently used. | |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | The intervention is probably acceptable to key stakeholders, as both sizes of manual resuscitation bags are already routinely used during CPR. | |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | The intervention is feasible to implement, as it builds on existing resuscitation practices and uses equipment that is already widely available, including manual resuscitation bags and standard airway adjuncts. Adoption of smaller bags for adult CPR would require minimal workflow changes and limited additional training, primarily focused on reinforcing ventilation targets and technique. Overall, the intervention can be readily incorporated into current resuscitation workflows with minimal disruption. | |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | Small | **Moderate** | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Trivial | Small | **Moderate** | Large | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | **Very low** | **Low** | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | Probably no important uncertainty or variability | **No important uncertainty or variability** | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | **Varies** | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | **Negligible costs and savings** | Moderate savings | Large savings | Varies | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | **Low** | Moderate | High | | | No included studies |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | **Does not favor either the intervention or the comparison** | Probably favors the intervention | Favors the intervention | Varies | No included studies |
| **EQUITY** | Reduced | Probably reduced | **Probably no impact** | Probably increased | Increased | Varies | Don't know |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | **Conditional recommendation against the intervention** | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ● | ○ | ○ | ○ |

## CONCLUSIONS

**Recommendation**

We suggest the use of a standard adult size bag (maximum volume 1500–1600 mL) for manual ventilation of adults during cardiopulmonary resuscitation (weak recommendation, very low–certainty evidence).

## Justification

The recommendation is driven by limited observational evidence suggesting harm. Simulation and physiologic studies consistently demonstrate that smaller- volume manual resuscitation bags are associated with more guideline-consistent ventilation delivery, supporting biologic plausibility given known harms of excessive ventilation during CPR. However, evidence evaluating patient-centered outcomes remains limited and subject to high risk of bias.

The only available clinical observational study reported an association between smaller bag use and worse survival-related outcomes. These findings were judged to be of very low certainty due to serious risk of bias, residual confounding, imprecision, and indirectness, including differences in airway management, provider behavior, and resuscitation context. No randomized clinical trials have evaluated the effect of bag volume on survival or neurological outcomes during adult cardiac arrest, although one additional clinical study has been completed and is awaiting publication.

Given the very low certainty of evidence for critical outcomes and substantial uncertainty regarding the balance of benefits and harms, the Task Force judged that the balance of effects does not clearly favor a change in practice at this time, supporting a weak recommendation for continued use of a standard adult manual resuscitation bag.

## Subgroup considerations

The following subgroup analyses could be performed, if sufficient data is available:

- patient gender
- patient age group
- patient race/ethnic background
- likely cause/etiology (presumed or confirmed) and/or initial cardiac rhythm
- Pediatrics
- Airway device: basic life support airway, supraglottic device, tracheal intubation

There is insufficient evidence to explore any of these subgroups.

## Implementation considerations

Implementing these ventilation recommendations is feasible but requires attention to training, resources, and integration into existing protocols. Regular provider education is critical to ensure proficiency in delivering recommended ventilation rates, achieving chest rise, and avoiding extremes like hyperventilation or hypoventilation, especially when using manual bag-valve devices. While advanced monitoring tools like capnography or spirometry can enhance accuracy, visible chest rise serves as a practical alternative in resource-limited settings. Tailoring ventilation strategies to patient-specific factors and using quality assurance initiatives can help refine implementation, optimize resuscitation practices, and improve patient outcomes.

## Monitoring and evaluation

Monitoring and evaluating implementation can be achieved through regular data collection on key ventilation parameters, such as rate, tidal volume, visible chest rise, and adherence to guidelines during resuscitations. Use of feedback devices, such as capnography or real-time audiovisual systems, can provide immediate insights into performance and identify areas for improvement. Post-event debriefings and quality assurance reviews can analyze outcomes, assess provider adherence, and highlight training needs. Ongoing audits and incorporating findings into training programs will ensure continuous improvement and alignment with best practices.

## Research priorities

Randomized clinical trials comparing smaller versus standard-size bags during adult CPR with patient-centered outcomes (survival and favorable neurological outcome) are needed. Studies should also evaluate safety outcomes such as barotrauma and hypoventilation, and assess how effects vary by airway strategy, arrest setting, and rescuer experience. Implementation research should examine feasibility, acceptability, training requirements, and the impact of pairing bag choice with real-time feedback (capnography, ventilation monitors) to optimize ventilation delivery.

**References:**


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2. Riyapan S, Hirunwidchayarat P, Ruangsomboon O, Chaisirin W, Limsuwat C, Surabenjawong U, M onsomboon A, Prapruetkit N, Chakorn T. Comparison between pediatric-sized and adult-sized bag-valve-mask ventilation for achieving appropriate tidal volume in simulated adult out-of-hospital cardiac arrest in a moving ambulance. *J Med Assoc Thai*. 2021;104:1404–1410. doi: 10.35755/jmedassocthai.2021.09.10408
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## BLS 2501 – Compression Rate, Depth, and Recoil for Adult, Child, and Infant CPR

# QUESTION

| | |
|---|---|
| **POPULATION:** | Adults, children and infants (excluding newborns) in any setting (in-hospital or out-of-hospital) with cardiac arrest |
| **INTERVENTION:** | Alternative chest compression rate, depth or chest wall recoil during cardiopulmonary resuscitation (CPR) |
| **COMPARISON:** | Standard chest compression rate, depth or chest wall recoil during cardiopulmonary resuscitation (CPR) |
| **MAIN OUTCOMES:** | Any clinical outcome for adults, children and infants (excluding newborns) – including survival with favourable neurological outcome (critical), survival to hospital discharge or 30 days (critical), return of spontaneous circulation (ROSC) (important); any physiological outcome – including blood pressure, end-tidal $CO_2$<br><br>(including clinical outcomes as defined in the Pediatric Core Outcome Set for Cardiac Arrest for children [1]). |
| **SETTING:** | All settings |
| **PERSPECTIVE:** | This was a scoping Review<br><br>Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion.<br><br>Included studies had to report on only one chest compression component or two or more components or the interaction between two or more components. Included studies must have reported *a comparison* between two or more chest compression rates and/or chest compression depths and/or measures of chest wall recoil and/or measures of chest wall leaning.<br><br>Manikin studies and animal studies were excluded. Grey literature and social media and non-peer reviewed studies, unpublished studies, conference abstracts and trial protocols were excluded |
| **BACKGROUND:** | The three main components of chest compression – rate, depth and recoil – were reviewed as separate systematic reviews in the 2015 ILCOR CoSTR [2,3]. The BLS Task Force subsequently decided to revisit this topic in 2019/2020 as a scoping review. The prior systematic search strategies were broadened to identify an evidence map evaluating the impact of these chest compression components i.e. rate, depth and recoil on outcomes individually and in interaction with each other [4].<br><br>However, the task force had not reviewed the topic since then. Three separate search strategies from the 2019/2020 Scoping Review (for each of depth, rate and recoil) have been updated / harmonized into one single search strategy. This corrects some minor discrepancies between the previous searches and has helped us to better identify studies which report on the interaction between two or more chest compression components. |
| **CONFLICT OF INTERESTS:** | None recorded |

# ASSESSMENT

## Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | Early, high-quality chest compressions are considered a vital part of the response to cardiac arrest. There are **existing** ILCOR recommendations (2015) for chest compression depth, rate and recoil for both adults and children, albeit these are based on low or very-low certainty evidence.<br>Prior treatment recommendations in adults (2015):<br><br>*We recommend a manual chest compression rate of 100 to 120/min (strong recommendation, very-low certainty evidence).*<br><br>*We recommend a chest compression depth of approximately 5 cm (2 in) (strong recommendation, low certainty evidence) while avoiding excessive chest compression depths (greater than 6 cm [greater than 2.4 in an average adult) during manual CPR (weak recommendation, low-certainty evidence).*<br><br>*We suggest that rescuers performing manual CPR avoid leaning on the chest between compressions to allow full chest wall recoil (weak recommendation, very low-certainty evidence).*<br><br>Prior treatment recommendations in children (2015):<br><br>*We suggest that rescuers compress the chests of infants by at least one third the anterior-posterior dimension, or approximately 1½ inches (4 cm). We suggest that rescuers compress the child's chest by at least one third of the anterior-posterior dimension, or approximately 2 inches (5 cm) (weak recommendation, very-low-quality evidence).* | |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>● Varies | **CHEST COMPRESSION RATE – ADULTS**<br><br>**Favourable neurological survival at discharge or 30-days:** one RCT and three observational studies<br>**Survival to hospital discharge / 30-days / one month:** one RCT and nine observational studies | There was a lack of consistency about which rate or depth range was the optimum. |

| | | |
|---|---|---|
| ○ Don't know | **Survival to ED or hospital admission / similar:** two observational studies<br>**ROSC:** one RCT and nine observational studies<br>**Physiological outcomes:** five observational studies<br>**Other:** one observational study (first shock success in VF)<br><br>**CHEST COMPRESSION RATE – INFANTS AND CHILDREN**<br><br>**Favourable neurological survival at discharge or 30-days:** one observational study<br>**Survival to hospital discharge / 30-days / one month:** three observational studies<br>**Survival to 24hrs:** one observational study<br>**ROSC:** two observational studies<br>**Physiological outcomes:** five observational studies<br><br>**CHEST COMPRESSION DEPTH – ADULTS**<br><br>**Favourable neurological survival at discharge or 30-days:** one observational study<br>**Survival to hospital discharge / 30-days / one month:** five observational studies<br>**Survival to ED or hospital admission / similar:** one RCT and three observational studies<br>**ROSC:** five observational studies<br>**Physiological outcomes:** three observational studies<br>**Other:** two observational studies (first shock success in VF; CPR-induced injuries)<br><br>**CHEST COMPRESSION DEPTH – INFANTS AND CHILDREN**<br><br>**Favourable neurological survival at discharge or 30-days:** two observational studies<br>**Survival to hospital discharge / 30-days / one month:** three observational studies<br>**Survival to 24hrs:** two observational studies<br>**ROSC:** three observational studies<br>**Physiological outcomes:** three observational studies<br><br>**INTERACTIONS – ADULTS**<br><br>**Favourable neurological survival at discharge or 30-days:** four observational studies<br>**Survival to hospital discharge / 30-days / one month:** four observational studies<br>**Survival to 24hrs:** one observational study<br>**ROSC:** three observational studies | |

| | | |
|---|---|---|
| | **Physiological outcomes:** two observational studies<br><br>**INTERACTIONS – INFANTS AND CHILDREN**<br>**Physiological outcomes:** one observational study<br><br>Full details and references are in the main scoping review summary and tables. | |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | One paper reported that deeper chest compressions were associated with more CPR-related injuries. The rate of injuries in the <50mm and 50-60mm mean depth groups were similar (28% vs 27%) and higher in the >60mm depth group (49%) [5] | Sternal and rib fractures were the most commonly reported injuries. There were low numbers of other injuries including myocardial and lung injury. Rate of CPR injury over time did not affect survival<br><br>Single paper, relatively low numbers |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | Most evidence on chest compression depth and rate came from observational studies, and results varied.<br>There was no available evidence about recoil/leaning.<br>Evidence in the adult population was mainly in OHCA patients<br>Evidence in the infant and child population was mainly in IHCA patients<br>Where RCT evidence was available it was not the chest compression components that were the main variable being studied for their effect on the outcome(s) of interest | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | As this was a scoping review a range of clinical and physiological outcomes were considered. This did include multiple observational studies in both adults and infants/children examining the critical outcomes of survival with favourable neurological outcome and survival to 30 days / one month / hospital discharge, which researchers, patients and their families have deemed of great importance / value [1, 6]. | |

## Balance of effects

| Does the balance between desirable and undesirable effects favor the intervention or the comparison? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Favors the comparison<br>○ Probably favors the comparison<br>● Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | Evidence varied, and there was no clear evidence to change current recommendations | |

## Resources required

How large are the resource requirements (costs)?"

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>○ Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>● Don't know | Training materials and equipment already exist to measure chest compression depth / rate – costs to amend/reprogram these would likely be small<br>There is likely to be significant research cost to design suitable trial(s)<br>to determine optimum values for chest compression components. | |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | This was not evaluated. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● No included studies | This was not examined. | |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>○ Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>● Don't know | not applicable | |

## Acceptability

Is the intervention acceptable to key stakeholders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>○ Yes<br>○ Varies<br>● Don't know | Not applicable | |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>○ Yes<br>○ Varies<br>● Don't know | Not applicable<br><br>Unlikely that future changes in recommendations for optimum values would be too difficult to measure and implement | |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | Small | Moderate | Large | | **Varies** | Don't know |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **UNDESIRABLE EFFECTS** | **Trivial** | Small | Moderate | Large | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | **Does not favor either the intervention or the comparison** | Probably favors the intervention | Favors the intervention | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | Negligible costs and savings | Moderate savings | Large savings | Varies | **Don't know** |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | Probably reduced | Probably no impact | Probably increased | Increased | Varies | **Don't know** |
| **ACCEPTABILITY** | No | Probably no | Probably yes | Yes | | Varies | **Don't know** |
| **FEASIBILITY** | No | Probably no | Probably yes | Yes | | Varies | **Don't know** |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

Not applicable. We have made no recommendation.
Based on the results of this scoping review and the a priori decision of the Paediatric Life Support Taskforce to use adult data as indirect evidence for compression rate the PLS TF have prepared a Good Practice Statement in the interim until the 2015 systematic reviews and CoSTR can be updated.

The target for *manual chest compression rate may be 100 to 120/min for infants and children in cardiac arrest (Good Practice Statement).*

## CONCLUSIONS

**Recommendation**

We recommend a manual chest compression rate of 100 to 120/min (strong recommendation, very low–certainty evidence).

We recommend a chest compression depth of approximately 5 cm (2 inches) (strong recommendation, low-certainty evidence) while avoiding excessive chest compression depths (>6 cm [>2.4 inches] in an average adult) during manual CPR (weak recommendation, low-certainty evidence).

We suggest that rescuers performing manual CPR avoid leaning on the chest between compressions to allow full chest wall recoil (weak recommendation, very low–certainty evidence).

We suggest that rescuers compress the chests of infants by at least one third the anteroposterior dimension, or approximately 1½ inches (4 cm). We suggest that rescuers compress the child's chest by at least one third of the anteroposterior dimension, or approximately 2 inches (5 cm) (weak recommendation, very low–quality evidence).

The target for manual chest compression rate may be 100 to 120/min for infants and children in cardiac arrest (good practice statement).

## Justification

This scoping review demonstrated that most studies focused on a single chest compression component, and several studies suggest the presence of confounding interactions that should prompt caution when evaluating any chest compression component in isolation.

Most studies are observational – where we identified randomized trials, the chest compression components were not the variables primarily being investigated.

Most adult studies identified in this review were focused on out-of-hospital cardiac arrest. Studies in infants and children, however, were predominantly from in-hospital studies.

Studies are heterogeneous and making direct comparisons between studies is difficult. There is a lack of consistency in results between studies.

Early paediatric clinical studies that shaped existing chest compression guidance relied on single-sensor CPR quality monitors, which may have overestimated compression depth because measurements could be influenced by non-rigid surfaces and patient movement during compressions [7, 8]. In contrast, more recent observational studies using advanced dual-sensor (anterior and posterior) feedback devices have found that recommended paediatric compression depth targets are seldom achieved in clinical settings, especially for infants [9-11]. These dual-sensor systems measure the displacement between two sensors rather than overall movement of the device and patient, reducing artifact from surface compliance and motion.

## Subgroup considerations

Not applicable

## Implementation considerations

There have been no changes to existing recommendations

## Monitoring and evaluation

N/A – no changes to existing recommendation

## Research priorities

There is a paucity of studies in infants and children.

There is a lack of evidence from studies in infants and children about which chest compression depths to perform based on the weight or size of the patient.

Further clinical studies employing dual-sensor technology that correlate compression metrics with P-COSCA outcomes [1] are needed to better define optimal targets for compression depth, rate, and recoil in infants and children.

There is a lack of evidence about the effect of leaning and recoil on clinical outcomes.

There is a lack of randomized trials or high-quality evidence related to chest compression components on critical and important clinical outcomes, particularly considering the interaction between these components.

In this review we excluded papers reporting continuous data about chest compression rate and depth, and the association with clinical and physiological outcomes. We can therefore make no comment about the best combination of chest compression rate and depth during CPR.

# REFERENCES


1. Topjian AA, Scholefield BR, Pinto NP, Fink EL, Buysse CMP, Haywood K, et al. P-COSCA (Pediatric Core Outcome Set for Cardiac Arrest) in Children: An Advisory Statement From the International Liaison Committee on Resuscitation. Circulation. 2020;142:e246-e61.
2. Perkins GD, Travers AH, Berg RA, Castrén M, Considine J, Escalante R, et al. 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:e43-69.
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# BLS 2211 – Rhythm Analysis During Compressions

## QUESTION

| Should analysis of cardiac rhythm during chest compressions vs. standard care (analysis of cardiac rhythm during pauses in chest compressions) be used for adults and children with cardiac arrest? | |
|---|---|
| **POPULATION:** | Adults in any setting (out of hospital or in hospital) with cardiac arrest |
| **INTERVENTION:** | Analysis of cardiac rhythm during chest compressions |
| **COMPARISON:** | Standard care - analysis of cardiac rhythm during pauses in chest compressions |
| **MAIN OUTCOMES:** | Survival to hospital discharge with good neurological outcome and survival to hospital discharge / 30 days were ranked as critical outcomes<br>Return of spontaneous circulation (ROSC) was ranked as an important outcome<br>CPR quality metrics such as chest compression fraction, pauses in compressions, compressions per minute etc. were included as important outcomes |
| **SETTING:** | Any setting (in-hospital or out-of-hospital) |
| **PERSPECTIVE:** | Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. Unpublished studies (e.g., conference abstracts, trial protocols) are excluded.<br>All years and all languages were included as long as there was an English abstract; unpublished studies (e.g., conference abstracts, trial protocols) were excluded.<br>Literature search updated to Sept 23, 2019 to October 10th 2024 |
| **BACKGROUND:** | High quality CPR with few pauses in chest compressions is emphasized in current Guidelines and CPR teaching practices.<br>Rhythm analysis and pulse checks cause pauses in chest compressions, and artifact-filtering algorithms for analysis of electrocardiographic rhythm during CPR has been proposed as a measure to reduce pauses in chest compressions. |
| **CONFLICT OF INTERESTS:** | None |

## ASSESSMENT

### Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | High quality CPR with few pauses in chest compressions is emphasized in current Guidelines and CPR teaching practices. Rhythm analysis and pulse checks cause pauses in chest compressions, and artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR has been proposed as a measure to reduce pauses in chest compressions. Chest compressions are the sole source of forward blood flow during cardiac arrest in the BLS setting and there is general consensus that measures to decrease pauses are important. | Excessive pauses in chest compressions are commonly reported, and are regarded as a high priority problem. |

### Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>○ Varies<br>● Don't know | This systematic review update identified 711 studies, with 87 duplicates removed. After title and abstract screening (624 studies), 12 underwent full-text review, of which 10 were excluded (5 conference abstracts, 5 incorrect outcomes). Ultimately, 2 observational studies (Derkenne 2024, de Graaf 2021) met eligibility criteria, both focusing on software-based cardiac rhythm analysis during CPR in OHCA patients.<br>Survival to hospital discharge with good neurological outcome and survival to hospital discharge<br>For the critical outcomes of survival to hospital discharge with good neurological outcome and survival to hospital discharge/30 days, we identified very low certainty evidence (downgraded for serious risk of bias and inconsistency) from one observational study (Derkenne 2024). In this study, 570 OHCA patients were treated with either the Analyse While Compressing (AWC) algorithm (n=285, 2021-22) or a conventional defibrillation algorithm (n=285, 2017). Both groups received BLS care from firefighter teams using ERC 2015 guidelines and the DEFIGARD Touch 7 AED. The AWC algorithm allowed real-time rhythm analysis during chest compressions, triggering an earlier rhythm check if VF was detected. In the control group, rhythm checks occurred at fixed two-minute intervals. There was no significant difference in survival to hospital discharge between groups (adjusted hazard ratio: 0.96 [95% CI, 0.78–1.18], p=0.49). However, in a subgroup of OHCA in public locations with call-to-AED time <12.5 min, survival was higher with AWC (adjusted hazard ratio: 0.83 [95% CI, 0.73–0.93]).<br>Return of Spontaneous Circulation<br>For the important outcome of ROSC we identified no studies.<br>CPR Quality Metrics<br>For the important outcome of CPR quality metrics, we identified very low certainty evidence (downgraded for serious risk of bias) from two observational studies (De Graaf 2021; Derkenne 2024).<br>In the observational study by De Graaf (2021), 783 OHCA patients were treated with AEDs using either the cprINSIGHT algorithm (Stryker LIFEPAK CR2, 2018–2019) or conventional AEDs (Stryker LIFEPAK 1000, 2016–2017). The cprINSIGHT algorithm allowed real-time rhythm analysis during chest compressions by using transthoracic impedance filtering to classify rhythms as shockable, non-shockable, or inconclusive. If shockable, the AED pre-charged and delivered the shock at the end of the two-minute cycle, whereas a non-shockable rhythm resulted in uninterrupted CPR. The intervention group had a higher chest compression fraction (CCF) (86% [IQR 79–92] vs. 80% [IQR 73–86], p < 0.001) and shorter pre-shock pause (8s [IQR 7–11] vs. 22s [IQR 20–24], p < 0.001) and peri-shock pause (12s [IQR 10–16] vs. 25s [IQR 22–29], p < 0.001).<br>In the observational study by Derkenne (2024), 570 OHCA patients were treated using either the Analyse While Compressing (AWC) algorithm (n=285, 2021–2022) or a conventional defibrillation algorithm (n=285, 2017). The primary outcome of CCF was significantly higher in the intervention group (77% [72–80] vs. 72% [67–76], p < 0.001). Several secondary CPR metrics were improved in the intervention group, including increased prompt CCF during CPR phases, reduced hands-off times (pre-shock, peri-shock, and post-shock), shorter analysis and CPR phase durations, and improved shock delivery timing in cases of | |

| | | |
|---|---|---|
| | ventricular fibrillation storm. There was no significant difference in chest compression rate between groups. Differences were noted in the time spent in shockable, organized, and asystolic rhythms. | |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large<br>○ Moderate<br>○ Small<br>○ Trivial<br>○ Varies<br>● Don't know | Both the de Graaf paper and the Clement Derkenne paper did not seem to show any undesirable effects of the Intervention.<br>They both confirmed that their algorithms performed at high Sensitivity and Specificity. | Direct undesirable effects are unlikely, but adding any new technology to the resuscitation setting always has the unintended potential to further increase the complexity, thereby potentially reducing CPR quality. |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | Both the de Graaf paper and the Derkenne papers are Observational studies downgraded from Low Certainty to Very Low Certainty of Evidence because of serious risk of bias. (Using the ROBINS-I tool) | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important un certainty or variability<br>○ Probably no important uncertainty or variability<br>●No important uncertainty or variability | Chest compressions are the sole source of forward blood flow during cardiac arrest in the BLS setting – and there is general consensus that measures to decrease pauses are important. Excessive pauses in chest compressions are commonly reported, and are regarded as a high priority problem. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● Don't know | Data for critical outcomes is lacking<br>Data for CPR quality metrics looks promising<br>But we do not have trials giving us high certainty of evidence<br>No obvious undesirable effects of the Intervention identified<br>However not enough data about this topic available to be able to make an opinion. | |

## Resources required

How large are the resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>● Moderate costs<br>○ Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | Artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR are new technology that needs to be integrated in defibrillator software, the exact cost of this software upgrade is not known. While some defibrillator manufacturers already provide this technology in their products as a supplement to rhythm analysis during pauses, upgrading defibrillators that currently do not have this technology is likely to need significant investment in equipment as well as training resources. | |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | General requirements for education and training when implementing new elements in CPR algorithms is well recognized, but as EMS systems have pre-existing programs for regular training and re-training, the additional cost of each element or change is rarely studied. As development of new defibrillators might include several upgrades, the exact costs of the addition of filtering algorithms are not known. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>Does not ○favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● No included studies | As the science evaluating artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR is limited, any benefit to patient outcomes remains to be determined. | |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>● Probably reduced<br>○ Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>○ Don't know | As this is new technology to be integrated into expensive medical equipment, it is likely that access to this technology would be dependent on available resources within health care systems. Health equity would likely decrease. | |

## Acceptability

Is the intervention acceptable to key stakeholders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○Yes<br>○ Varies<br>○ Don't know | There is broad agreement that minimizing pauses in chest compressions is a priority in CPR monitoring and training. If the technology was actually shown to reduce compression pauses it is likely to be acceptable to stakeholders. | |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | The de Graaf and Derkenne papers would collectively suggest artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR is feasible to implement. | |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | Small | Moderate | Large | | Varies | **Don't know** |
| **UNDESIRABLE EFFECTS** | Large | Moderate | Small | Trivial | | Varies | **Don't know** |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | Probably no important uncertainty or variability | **No important uncertainty or variability** | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **Don't know** |
| **RESOURCES REQUIRED** | Large costs | **Moderate costs** | Negligible costs and savings | Moderate savings | Large savings | Varies | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | **Probably reduced** | Probably no impact | Probably increased | Increased | Varies | Don't know |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | **Yes** | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | **Conditional recommendation against the intervention** | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ● | ○ | ○ | ○ |

## CONCLUSIONS

### Recommendation

We suggest the usefulness of artifact-filtering algorithms for analysis of electrocardiographic rhythm during CPR be assessed in clinical trials or research initiatives (Good Practice Statement)

### Justification

In making a recommendation against routine use, we placed priority on avoiding the costs of introducing a new technology where the effectiveness or harm on patient outcomes remains to be determined.
This being highlighted by the absence of randomised controlled trials or observational studies with adequate comparisons. Furthermore, consideration was given on avoiding the costs of introducing a new technology where the effectiveness or harm on patient outcomes remained to be determined. It was however noted that no signal of harm was evident.
Therefore it was felt that artifact filtering algorithms could not be recommended for routine analysis or inferring of electrocardiographic rhythm during CPR. As a result the Treatment Recommendations have been replaced with a Good Practice Statement suggesting that the usefulness of artifact-filtering algorithms for analysis of electrocardiographic rhythm during CPR be assessed in clinical trials or research initiatives.

In making a recommendation for further research; the task force is acknowledging a) there is thus far insufficient evidence to support a decision for or against routine use, b) further research has potential for reducing uncertainty about the effects and c) further research is thought to be of good value for the anticipated costs.
The task force also acknowledges that some EMS systems may already have implemented artifact-filtering algorithms for analysis of electrocardiographic rhythm during CPR, and as such wish to strongly encourage such systems to report on their experiences to build the evidence base regarding the use of these technologies in clinical practice.

### Subgroup considerations

## Implementation considerations

Artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR is new technology that needs to be integrated in defibrillator software, the exact cost of this software upgrade is not known. While some defibrillator manufacturers already provide this technology in their products as a supplement to rhythm analysis during pauses, upgrading defibrillators that currently do not have this technology is likely to need significant investment in equipment as well as training resources. Furthermore, as development of new defibrillators might include several upgrades, the exact cost of the addition of filtering algorithms is not known.

## Monitoring and evaluation

In addition to demonstrating benefit for this new technology related to patient outcomes, studies should also monitor and report quality of CPR.

**References:**


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# BLS 2606-ALS 3105 – Anticipatory Charging of the Defibrillator

## QUESTION

| | |
|---|---|
| **POPULATION:** | Adults and children with cardiac arrest in any setting |
| **INTERVENTION:** | Charging the defibrillator prior to rhythm analysis |
| **COMPARISON:** | Charging the defibrillator after rhythm analysis |
| **MAIN OUTCOMES:** | Survival to hospital discharge, 30 days or greater than 30 days with good neurological outcome, and survival to hospital discharge 30 days or greater than 30 days were ranked as critical outcomes. Return of spontaneous circulation (ROSC) and event survival was ranked as an important outcome. Other outcomes considered were defibrillation success, pre-shock pause, hands-off time, post-shock pause, peri-shock pause, compression-fraction, hands-on time and provider safety (inadvertent shocks). |
| **SETTING:** | All settings |
| **PERSPECTIVE:** | |
| **BACKGROUND:** | This nodal review, conducted by the Basic Life Support (BLS) and Advanced Life Support (ALS) Taskforces, is the first systematic review on anticipatory charging undertaken by the International Liaison Committee on Resuscitation (ILCOR). A previous scoping review performed by the ALS Task Force in 2019 concluded that "anticipatory manual defibrillator charging appears to be feasible in the clinical setting, although its impact on clinical outcomes is uncertain."[1] That review identified only one clinical study addressing anticipatory charging in in-hospital cardiac arrests, alongside three manikin-based simulation studies. |
| **CONFLICT OF INTERESTS:** | Ziad Nehme: Intellectual |

## ASSESSMENT

### Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | Pauses in chest compressions during cardiac arrest are associated with poorer outcomes, including shock success and patient survival.[2-4] Pauses for rhythm interpretation and defibrillation are the most significant source of interruptions in chest compressions.[5] To eliminate pauses during resuscitation, some health services and emergency medical services (EMS) have adopted a method of rhythm analysis that involves pre-charging the defibrillator in anticipation of rhythm analysis and defibrillation. The approach, known as anticipatory charging, differs to current practices where chest compressions are paused for both rhythm analysis and charging (known here as standard charging) or paused only for rhythm analysis before recommencing chest compressions during charging (the charging method described in the 2010 ERC/AHA guidelines).[6, 7] | |

### Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Trivial<br>● Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | **Favourable neurological survival at discharge or 30-days**<br>For the critical outcome of favourable neurological survival at discharge or 30-days, we identified very low certainty evidence (downgraded for risk of bias and indirectness) from one cohort study.[8] In a retrospective study of 737 OHCA, patients receiving a bundled intervention consisting of anticipatory charging were associated with higher risk-adjusted odds of neurologically intact survival at discharge (CPC 1 or 2) compared with patients not treated with the bundle (AOR 2.3, 95% CI: 1.3, 4.0).[8]<br><br>**Survival to hospital discharge or 30-day survival**<br>For the critical outcome of survival to hospital discharge or 30-day survival, we identified very low certainty evidence (downgraded for risk of bias, indirectness and imprecision) from three cohort studies.[9-11] In a before-and-after study of 178 adult OHCA patients, anticipatory charging was not associated with improved survival to hospital discharge compared with a combination of standard charging and the ERC 2010 charging method (absolute difference = 4.6%, 95% CI: -9.7%, 18.9%).[10] Conversely, two studies from Victoria, Australia, conducted over the same time period, including one involving 10600 adult OHCA (excludes EMS witnessed patients)[11] and another including 1981 EMS witnessed OHCA,[9] found that the introduction of a bundle of care, including anticipatory charging, was associated with improved survival to hospital discharge compared with standard charging using semi-automatic defibrillation (AOR 1.33, 95% CI 1.11, 1.58 and AOR 1.37, 95% CI: 1.00, 1.88, respectively).<br><br>**Return of spontaneous circulation (ROSC) and event survival**<br>For the important outcome of return of spontaneous circulation, we identified very low certainty evidence (downgraded for risk of bias, indirectness and imprecision) from four cohort studies.[8-11] A before-and-after study of 178 adult OHCA patients found that anticipatory charging was not associated with improved ROSC compared with a combination of standard charging and the ERC 2010 charging method (absolute difference = –1.0%, 95% CI: –16.0%, 14.0%).[10] Another retrospective study of 10600 adult OHCA found that the introduction of a bundle of care, including anticipatory charging, was associated with improved ROSC (AOR 1.13, 95% CI: 1.01, 1.27) and event survival (AOR 1.21, 95% CI: 1.07, 1.36) compared with standard charging using semi-automatic defibrillation.[11] Another study from the same region/period,[9] involving 1981 EMS witnessed OHCA, found that the introduction of the same bundle of care was not associated with improved ROSC (AOR 0.85, 95% CI: 0.67, 1.10) or event survival (AOR: 1.03, 95% CI: 0.80, 1.32) compared with standard charging using semi-automatic | |

| | | |
|---|---|---|
| | defibrillation. In another retrospective study of 737 OHCA, patients receiving a bundle of care, including anticipatory charging, achieved higher ROSC (absolute difference = 13.7%, 95% CI: 6.8% to 20.6%), but not event survival (absolute difference = 2.3%, 95% CI: –4.7% to 9.3%), compared to patients not treated with the bundle.[8]<br><br>CPR quality<br>For the outcome of CPR quality, we identified very low certainty evidence (downgraded for risk of bias, indirectness and imprecision) from three cohort studies.[10-12]<br>• Pre-shock pause: Three studies reported on this outcome. One study identified a reduction in preshock pauses with anticipatory charging compared with the standard charging.[10] Another cohort study identified that a bundle of care including anticipatory charging was associated with a reduction in pre-shock pauses compared to the standard charging using semi-automatic defibrillation.[11] A study of in-hospital cardiac arrest found that anticipatory charging did not reduce pre-shock pauses compared with the ERC 2010 charging method, although a combination of anticipatory charging and the ERC 2010 method was associated with lower pre-shock pauses compared to the standard charging.[10]<br>• Post-shock pause: Two studies reported on this outcome. One study found that anticipatory charging reduced post-shock pauses compared to standard charging.[10] Two studies found no difference in post-shock pauses between the anticipatory and ERC2010 charging method.[10, 12]<br>• Peri-shock pause: One study reported on this outcome and found that anticipatory charging reduced peri-shock pauses compared to standard charging, but increased peri-shock pauses compared to the ERC2010 charging method.[10]<br>• Chest compression rate and depth: Two studies reported effects on chest compression rate and depth. One study found that a bundle of care including anticipatory charging increased compression depth compared to standard charging using semi-automatic defibrillation,[11] while another identified that both the anticipatory and ERC2010 charging methods were associated with higher compression rates compared to standard charging.[12]<br>• Chest compression fraction: One study reported on chest compression fraction and found that anticipatory charging increased hands-on chest time compared with standard charging.[10] | |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ● Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | The effects of anticipatory charging on clinically important outcomes were inconclusive. Although no study reported harm with the use of anticipatory charging, the majority of studies found no association with neurologically intact survival and survival to hospital discharge/30-days. For the outcome of provider safety, we identified very low certainty evidence (downgraded for risk of bias) from one cohort study.[12] The retrospective study of 225 in-hospital cardiac arrests showed that anticipatory charging was associated with similar rates of inadvertent shock administration compared with standard defibrillation (1.5%, 95% CI: –1.4% to 4.4%) and compared with defibrillation using the ERC2010 method (absolute difference = 1.5%, 95% CI: –1.4%, 4.4%). This study is too small to inform the safety profile of anticipatory charging.[12] | In theory, charging the defibrillator before rhythm analysis introduces a small but real risk of inappropriate shock delivery—either because the rhythm is misinterpreted under pressure or because the operator reflexively discharges the defibrillator once the device is ready. Existing studies suggest these events are uncommon, but most data come from one small observational study.[12] There is also minimal evidence describing near-misses, human-factor errors, or unintended workflow consequences introduced by early charging. As a result, although anticipatory charging appears operationally safe, the actual risk of inadvertent shock or provider exposure is still poorly quantified. The small risk of a rescuer receiving an inadvertent shock may be minimised even further if all rescuers wear gloves. [13] |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | The certainty of evidence for all outcomes was very low, downgraded for risk of bias and indirectness. The effects of anticipatory charging on clinically important outcomes were also inconclusive. Those that reported positive associations with clinical outcomes involved bundles of care consisting of anticipatory charging and other major modifications to resuscitation.[8, 9, 11] These studies are limited by indirectness. The sample size in most clinical studies lacked the power to demonstrate clinically meaningful improvements in patient outcomes from modest reductions in CPR interruptions.[10, 12] | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>● Possibly important uncertainty or variability<br>○ Probably no important uncertainty or variability<br>○ No important uncertainty or variability | Only one study was identified that provided adjusted estimates of the intervention effect for favourable neurological survival at discharge. In that retrospective study, patients receiving a bundled intervention consisting of precharging of the defibrillator during chest compressions were associated with higher risk-adjusted odds of neurologically intact survival at discharge (CPC 1 or 2) compared with patients not treated with the bundle (AOR 2.3, 95% CI: 1.3, 4.0).[7] No studies examined quality of life outcomes or longer-term patient outcomes. Neither study compared anticipatory charging to the ERC/AHA 2010 charging methods. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>● Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | We did not find any evidence that anticipatory charging was superior to existing methods described in the 2010 ERC/AHA guidelines for patient outcomes. It was also unclear if anticipatory charging improves CPR quality compared to the ERC/AHA 2010 method. Studies that reported positive associations with clinical outcomes involved bundles of care consisting of anticipatory charging and other major modifications to resuscitation compared with standard defibrillation.[3, 5, 7] These studies may be limited by indirectness. | |

## Resources required

How large are the resource requirements (costs)?"

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>● Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | The Task Force balanced the importance of reducing interruptions to CPR with the likely cost and resource implications associated with training health care professionals and teams in the use of anticipatory charging. Unlike the standard approach, anticipatory charging likely involves greater training and resource burden to ensure teams are able to adequately implement safe defibrillation practices in high-performing environments. However, the cost associated with using anticipatory charging is unlikely to be different from existing methods of hands-on charging described in 2010 ERC/AHA guidelines.[17, 18] | |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | There were no economic evaluations of the two treatment strategies. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>● Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ No included studies | Anticipatory charging is likely to be as cost-effective as other methods of charging with chest compressions, such as those described in the 2010 ERC/AHA guidelines.[17, 18] | |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>● Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>○ Don't know | It is unlikely that anticipatory charging would enhance equitable access to resuscitation. | |

## Acceptability

Is the intervention acceptable to key stakeholders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | There has already been widespread adoption of anticipatory charging and other methods of charging during CPR. Charging of the defibrillator during ongoing chest compressions was first introduced by the AHA in 2005. | |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes | The Task Force balanced the importance of reducing interruptions to CPR with the likely cost and resource implications associated with training health care professionals and teams in the use of anticipatory charging. | |

| | | |
|---|---|---|
| ○ Varies<br>○ Don't know | Unlike the standard approach, anticipatory charging likely involves greater training and resource burden to ensure teams are able to adequately implement safe defibrillation practices in high-performing environments. The use of mnemonics such as COACHED (Compressions continue, Oxygen away, All else clear, Charging, Hands off, Evaluate rhythm, Defibrillate or Disarm) are commonly used in practice but are often incorrectly applied.[9] Health care systems should consider the initial and ongoing training requirements of anticipatory charging. | |

## SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | **Small** | Moderate | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | **Trivial** | Small | Moderate | Large | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | **Possibly important uncertainty or variability** | Probably no important uncertainty or variability | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | **Probably favors the intervention** | Favors the intervention | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | **Negligible costs and savings** | Moderate savings | Large savings | Varies | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | **Does not favor either the intervention or the comparison** | Probably favors the intervention | Favors the intervention | Varies | No included studies |
| **EQUITY** | Reduced | Probably reduced | **Probably no impact** | Probably increased | Increased | Varies | Don't know |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| ○ | ○ | the intervention or the comparison<br>● | ○ | ○ |

# CONCLUSIONS

## Recommendation

We suggest charging a manual defibrillator during chest compressions, either before or after rhythm analysis (weak recommendation, very low certainty evidence). Both approaches require appropriate training to ensure safe and effective delivery (good practice statement).

## Justification

- We identified 11 studies, including 6 simulation studies and 5 cohort studies. The majority of included studies compared anticipatory charging to standard charging (e.g. pausing compressions for rhythm analysis and charging). Simulation studies suggest that anticipatory charging is feasible and can significantly reduce the duration of interruptions to chest compressions, compared with standard charging. Conversely, differences between anticipatory charging and the ERC/AHA 2010 charging method were inconsistent, with some studies reporting shorter hands-off chest delays with anticipatory charging,[10, 11] while others reported longer delays.[2, 12]
- The effects of anticipatory charging on clinically important outcomes were also inconclusive. Those that reported positive associations with clinical outcomes involved bundles of care consisting of anticipatory charging and other major modifications to resuscitation.[3, 5, 7] These studies are limited by indirectness. The sample size in most clinical studies lacked the power to demonstrate clinically meaningful improvements in patient outcomes from modest reductions in CPR interruptions.[2, 6]
- The majority of studies describing anticipatory charging involve manual defibrillation. Although it is generally not possible to undertake anticipatory charging using an AED, there are some simulation studies that explore the use of CPR filtering technology embedded into AEDs that allow pre-emptive charging and rhythm analysis during chest compressions. While the uptake of this technology in clinical environments is not widespread, the BLS Task Force has undertaken a separate review of the efficacy of rhythm analysis during chest compressions in another CoSTR.[19] It is too soon to recommend the use of these technologies in clinical practice.
- Anticipatory charging is often introduced into practice as part of a bundle of practices designed to reduce hands-off chest time. These bundles are often referred to as high-performance CPR, team-focused CPR or minimally interrupted cardiac resuscitation.[3, 5, 7] The Task Force discussed the risk of indirectness with the inclusion of these studies, however, also acknowledged that there is unlikely to be further clinical studies exploring anticipatory charging as an isolated intervention. Their inclusion in this review has resulted in increased clinical heterogeneity between the included papers, and the effects of anticipatory charging reported in these studies should be interpreted with caution.
- Evidence on the safety profile of anticipatory charging remains limited. In theory, charging the defibrillator before rhythm analysis introduces a small but real risk of inappropriate shock delivery—either because the rhythm is misinterpreted under pressure or because the operator reflexively discharges the defibrillator once the device is ready. Existing studies suggest these events are uncommon, although most data come from one small observational study and may be too small to determine the real-world incidence inadvertent shocks.[6] There is also minimal evidence describing near-misses, human-factor errors, or unintended workflow consequences introduced by early charging. As a result, although anticipatory charging appears operationally safe, the actual risk of inadvertent shock or provider exposure is still poorly quantified. The small risk of a rescuer receiving an inadvertent shock may be minimised even further if all rescuers wear gloves.[20]

## Subgroup considerations

## Implementation considerations

The Task Force balanced the importance of reducing interruptions to CPR with the likely cost and resource implications associated with training health care professionals and teams in the use of anticipatory charging. Unlike the standard approach, anticipatory charging likely involves greater training and resource burden to ensure teams are able to adequately implement safe defibrillation practices in high-performing environments.

## Research priorities

1. Although anticipatory charging reduces interruptions in CPR, robust evidence linking it to improved patient outcomes are still lacking.
2. Evidence is limited in how often anticipatory charging leads to adverse events (e.g. near-misses, incorrect shock delivery, or increased provider exposure to electrical risk).
3. While anticipatory charging can reduce peri-shock pauses, its real-world effect on hands-off time across different teams, systems, and levels of provider training remains poorly quantified.
4. The optimal method of charging and rhythm analysis remains unclear, and further comparisons are required between anticipatory charging and the ERC/AHA 2010 method.
5. Further studies are required to examine the impact of anticipatory charging on inappropriate shocks for asystole and pulseless electrical activity.

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**Appendix A**

**Pediatric Life Support – 2026 Evidence to Decision Tables**

# Table of Contents

# Ventilation Parameters During Cardiac Arrest in Children (PLS 4120.02, 4080.28)

## QUESTION

| Should specific ventilation parameters (eg lower rate vs. ventilation with a higher rate) be used for children receiving assisted ventilation during cardiac arrest? | |
|---|---|
| **POPULATION:** | Children receiving assisted ventilation during cardiac arrest |
| **INTERVENTION:** | Ventilation with a specific tidal volume, respiratory rate, inspiratory time, or positive end-expiratory pressure |
| **COMPARISON:** | Ventilation with a specific tidal volume, respiratory rate, inspiratory time, or positive end-expiratory pressure |
| **MAIN OUTCOMES:** | Any clinical outcome, including but not limited to return of spontaneous circulation (ROSC), survival and survival with favorable neurologic outcome at discharge, 30 days or longer, duration of mechanical ventilation, oxygenation, blood gas parameters, progression to ARDS, barotrauma, ICU and hospital length of stay, with a preference for outcomes listed in the ILCOR COSCA(7) or P-COSCA |
| **SETTING:** | Any setting (in or out of hospital) |
| **CONFLICT OF INTERESTS:** | no conflicts of interest |

## ASSESSMENT

**Problem**

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | Ventilation delivery during pediatric cardiac arrest is a core component of high-quality CPR, yet optimal ventilation parameters remain uncertain. Existing evidence shows wide variability in actual ventilation practice and suggests that ventilation parameters—including rate, tidal volume, and interaction with airway strategy—may influence hemodynamics, gas exchange, ROSC, and survival. Multiple recent observational studies in adults demonstrate associations between ventilation parameters and outcomes, and the most recent pediatric in-hospital and out-of-hospital studies (Sutton 2019; Stanton 2025)[1, 2] report that higher delivered ventilation rates are associated with improved ROSC and survival outcomes, although certainty is very low. Despite this, no pediatric randomized trials exist, no comparative evidence informs tidal volume, inspiratory time, or PEEP during CPR, and practice variation remains substantial. | Effective ventilation is essential in pediatric cardiac arrest given the predominance of respiratory etiologies. Suboptimal ventilation (both hypo- and hyperventilation) has been linked in prior research to hypotension, impaired gas exchange, and reduced survival, underscoring the relevance of this question for improving CPR quality. The lack of clear evidence-based targets for key ventilation parameters creates uncertainty in clinical practice and highlights the need for evidence synthesis.<br>Given the clinical importance, observed practice variability, and emerging but incomplete data, the Task Force agreed this is a high-priority area for evaluation. |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>○ Varies<br>● Don't know | Observational pediatric data (IHCA and OHCA) suggest that higher ventilation rates, within or slightly previous pediatric guideline ranges, are associated with higher odds of ROSC and survival with good neurological outcome (Sutton 2019; Stanton 2025). Adult observational studies and small RCTs also suggest that avoiding marked hypoventilation may improve gas exchange, hemodynamics, and survival. However, all pediatric data are observational, sample sizes are small, and estimates are imprecise, so the magnitude of benefit is very uncertain. | |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large<br>○ Moderate<br>○ Small<br>○ Trivial<br>○ Varies<br>● Don't know | Hyperventilation during CPR can decrease coronary and cerebral perfusion, lower arterial pressure, increase intrathoracic pressure, and potentially cause dynamic hyperinflation and barotrauma. These harms are well described physiologically and in adult experimental/observational work, but there are limited pediatric data directly quantifying these adverse effects. The Good Practice Statement emphasizes measuring ventilation rate and adequacy of tidal volume delivery and avoiding hypoventilation. Overall, the potential for physiologic harm is recognized but its magnitude remains uncertain. | |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | The pediatric evidence consists of two observational studies (one IHCA, one OHCA) evaluating ventilation rate during CPR, both at serious risk of bias, with indirectness (restricted settings, advanced airway, specific monitoring) and imprecision due to small sample sizes. Adult data come from heterogeneous observational studies and small RCTs with similar concerns about risk of bias, inconsistency, and indirectness for pediatric practice. No pediatric comparative trials address tidal volume, inspiratory time, or PEEP. The TF therefore rated overall certainty as very low. | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | The main outcomes—ROSC, survival, and survival with favorable neurological outcome—are universally regarded as critically important by patients, families, and clinicians. These outcomes align with P-COSCA core outcomes and existing ILCOR priorities. There may be some variation in the relative importance placed on survival with significant disability versus death, but this is unlikely to materially affect decisions about ventilation parameters during CPR. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>● Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | Physiologic reasoning and available pediatric data suggest that avoiding hypoventilation is beneficial. Observational pediatric studies show associations between higher delivered ventilation rates and improved ROSC and survival. Given very low certainty evidence and lack of evidence to define an upper limit for ventilation rate, the Task Force issued 2 Good Practice Statements focused on reasonable ventilation rate targets by age, ensuring measurement of ventilation rate and adequacy of tidal volume delivery, and avoiding hypoventilation. | |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>● Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | Delivering ventilation to achieve reasonable ventilation rate targets in children with an advanced airway relies primarily on provider technique and training, not additional consumables. Measuring ventilation rate and adequacy of tidal volume delivery (e.g., waveform capnography, ventilator measures and impedance) may require equipment that is not universally available, particularly in low-resource systems, but these tools are already in use in many pediatric resuscitation settings. Overall, resource implications are modest compared with other critical care interventions. | |

## Certainty of evidence of required resources

| What is the certainty of the evidence of resource requirements (costs)? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | In well-resourced systems, implementing the suggested ventilation rates and monitoring may be straightforward and could improve the quality of CPR. In low-resource settings where advanced airways and capnography are not consistently available, strict emphasis on monitored ventilation parameters could widen perceived gaps between guideline recommendations and what is feasible, potentially impacting equity. However, the Good Practice Statement focuses on avoiding obvious hypoventilation rather than mandating specific technology, which may mitigate inequity. The overall impact on equity is therefore uncertain. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● No included studies | No studies were identified that directly evaluate the cost-effectiveness of specific ventilation parameters during pediatric cardiac arrest. Delivering ventilation to achieve reasonable ventilation rate targets with an advanced airway does not require additional consumables and can generally be implemented with existing equipment and personnel. Measuring ventilation adequacy (e.g., capnography or ventilator parameters or impedance measures) may add cost in systems where such tools are not already available, but these technologies are commonly used in many resuscitation settings and serve broader purposes beyond ventilation rate guidance. Because no formal economic evaluations exist and resource implications vary widely across settings, the overall cost-effectiveness of the intervention is uncertain. | |

## Equity

What would be the impact on health equity?

| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>○ Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>● Don't know | In well-resourced systems, implementing the suggested ventilation rates and monitoring may be straightforward and could improve the quality of CPR. In low-resource settings where advanced airways and capnography are not consistently available, strict emphasis on monitored ventilation parameters could widen perceived gaps between guideline recommendations and what is feasible, potentially impacting equity. However, the Good | |

| | | |
|---|---|---|
| | Practice Statement focuses on avoiding obvious hypoventilation rather than mandating specific technology, which may mitigate inequity. The overall impact on equity is therefore uncertain. | |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | The recommended ventilation rate targets are consistent with current pediatric resuscitation guidelines and with current practice in many systems. It is unlikely to conflict with patient or family values and is generally supported by clinicians who recognize the risks of both under- and over-ventilation during CPR. Emphasis on monitoring and avoiding extremes aligns with quality-improvement initiatives and is therefore likely acceptable to resuscitation teams and guideline developers. | |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | Achieving reasonable ventilation rate targets in children with an advanced airway is feasible with appropriate training, team coordination, and the use of simple timing aids (e.g., metronomes or ventilator settings). Many systems already track ventilation performance using waveform capnography, ventilator readouts, or other monitoring tools, which can facilitate measurement of ventilation rate and adequacy of tidal volume delivery. However, consistent implementation may be challenging in crowded or low-resource environments, or where providers are unfamiliar with age-based ventilation targets or lack access to real-time measures. Overall, the Task Force judged the Good Practice Statements to be feasible to implement across most resuscitation settings, while acknowledging variability in resources and practice. | |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | Small | Moderate | Large | | Varies | **Don't know** |
| **UNDESIRABLE EFFECTS** | Large | Moderate | Small | Trivial | | Varies | **Don't know** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | **Probably favors the intervention** | Favors the intervention | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | **Negligible costs and savings** | Moderate savings | Large savings | Varies | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | Probably reduced | Probably no impact | Probably increased | Increased | Varies | **Don't know** |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

# TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | **Conditional recommendation for the intervention** | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ○ | ● | ○ |

# CONCLUSIONS

## Good Practice Statements

For children in cardiac arrest with an advanced airway, it is reasonable to target a ventilation rate consistent with age-related physiological normal values (good practice statement).

It is reasonable to measure ventilation rate and adequacy of tidal volume delivery and avoid hypoventilation (Good Practice Statement).

There is currently no evidence to make a treatment recommendation on the upper limit for ventilation rate, tidal volume delivery, inspiratory time or positive end-expiratory pressure during cardiac arrest in children.

## Justification

- This topic was prioritized by the BLS, ALS, and PLS Task Forces as a nodal review based on multiple recent observational studies9, 10 demonstrating association between ventilation parameters and outcomes as well as several small randomized trials.
- Ventilation during cardiac arrest encompasses multiple components including rate, volume, and monitoring, as well as airway devices, feedback, and integration with chest compressions.
- The previous ILCOR systematic review on pediatric ventilation rates performed in 202415 did not identify any pediatric comparative studies evaluating specific ventilation rates, and therefore no direct pediatric evidence was available to guide rate recommendations.
- The Task Force discussed that this systematic review differed from earlier work in that it was now possible to include two pediatric observational studies6, 7, providing the first comparative pediatric data evaluating ventilation rate during cardiac arrest. In the prior review, these data could only be considered indirect, and treatment recommendations were based largely on adult evidence and physiologic rationale. Despite the addition of these studies, the Task Force noted that the certainty of evidence remains very low, derived exclusively from pediatric in-hospital settings with an advanced airway and capnography in place.
- The Task Force further discussed that the ventilation rates associated with improved outcomes in Sutton 20196 were inferred from spline-based analyses rather than from prespecified, randomized comparisons. The cubic spline analysis suggested stable survival between 25 and 35 breaths/min for children older than 1 year of age and between 30 to 50 breaths/min for children younger than 1 year old, the actual ventilation rates delivered in practice were frequently even higher, and the study design did not allow determination of a causal or optimal target for ventilation rates.
- While this analysis provides helpful physiologic and observational context, it remains exploratory and should not be interpreted as defining an optimal ventilation threshold. However, when considered together with the more recent out-of-hospital evidence7, which similarly observed higher mean ventilation rates among children who achieved ROSC albeit the breaths per minute rate were much lower, the Task Force supports the overall conclusion that higher—rather than lower—ventilation rates were associated with improved outcomes in the available pediatric data, although certainty remains very low.
- Because of these limitations, the PLS Task Force agreed that the evidence remained too indirect to establish an optimal ventilation rate in children, and that no comparative pediatric data exist to inform ventilation rate in out-of-hospital arrest or in non-intubated patients. No pediatric studies have evaluated optimal tidal volume delivery or PEEP during CPR.
- The use of the adult algorithm measuring ventilation using ETCO2 waveform capnography needs validation in pediatric patients. The study by Stanton 20257 suggested it
was feasible to use, however ventilation rates observed in the study fall well below rates associated with the best outcomes.

## Subgroup considerations

**Age groups (infants vs. older children):**
Pediatric ventilation physiology varies substantially by age. Infants have higher baseline metabolic and minute ventilation requirements, lower functional residual capacity, and are more sensitive to hypoventilation. Sutton et al. stratified ventilation thresholds by age (<1 year vs >1 year), and both age groups showed an association between higher delivered ventilation rates and improved outcomes..

**Etiology of arrest (respiratory vs. cardiac):**
Children with respiratory etiologies (e.g., asphyxia, drowning, bronchiolitis) may benefit more from avoiding hypoventilation, whereas children with primary cardiac etiologies may be more susceptible to the hemodynamic consequences of hyperventilation. Neither available pediatric study provides data stratified by etiology, so the Task Force could not make etiology-specific recommendations.

**Setting (IHCA vs. OHCA):**
IHCA (Sutton 2019) and OHCA (Stanton 2025) studies both show directionally similar associations between higher delivered ventilation rates and better outcomes, but absolute ventilation performance and monitoring capabilities

differ across settings. OHCA care may be subject to more variability in provider experience and competence in airway management, limiting generalizability across settings.

**Airway strategy (ETT vs. SGA vs. BMV):**

The pediatric evidence informing the recommendation is limited to patients with *advanced airways* (almost entirely ETT or SGA). No comparative data exist for bag-mask ventilation or for comparing airway strategies. Therefore, the TF cannot assume similar ventilation dynamics or benefits in non-intubated patients.

**Monitoring availability:**

Both pediatric studies derived ventilation rates from post-hoc analysis of continuous physiologic waveforms, using quantitative capnography to identify ventilations in both the in-hospital study (Sutton et al.) and the out-of-hospital study (Stanton et al.). In Sutton et al., thoracic impedance–based respiratory plethysmography was used only as a supporting signal to identify periods of active chest compressions and pause time, not to count ventilations. Systems without continuous waveform capture may exhibit greater variability in delivered ventilation rates, limiting the generalizability of these associations.

**Comorbidities / pre-arrest physiology:**

Children with chronic lung disease (e.g., prematurity complications, neuromuscular weakness) may have different optimal ventilation parameters, but no study provided subgroup analyses by comorbidity.

## Implementation considerations

Implementing reasonable ventilation rate targets for children with an advanced airway during CPR requires attention to training, team coordination, and monitoring. Achieving consistent ventilation delivery can be challenging in high-stress resuscitation environments, particularly where multiple providers rotate through airway or ventilation roles. Systems that already use waveform capnography or ventilator-based monitoring may find implementation straightforward, as these tools provide real-time feedback on ventilation rate and adequacy of tidal volume delivery. In settings without continuous monitoring, simple aids such as metronomes, timed verbal cues, or structured role assignment may help avoid hypoventilation.

Because the evidence informing this recommendation was derived entirely from children with advanced airways and real-time ventilation monitoring, implementation may be more variable where supraglottic airways or bag-mask ventilation are used. Additional emphasis on training in pediatric airway management, ventilation timing, and minimizing excessive ventilation pressures is important in these contexts.

EMS systems and hospitals should consider incorporating ventilation rate targets into pediatric resuscitation checklists, cognitive aids, and debriefing tools. Integration of ventilation monitoring into quality-improvement programs (e.g., defibrillator downloads, capnography review) may support consistent performance. As equipment availability and staffing vary across settings, flexibility is needed to adapt implementation strategies to local resources. The recommendation does not mandate new technology and can be operationalized with existing equipment, but systems lacking ventilation feedback tools may benefit from investing in low-cost solutions to support correct ventilation delivery.

## Monitoring and evaluation

Monitoring ventilation quality during pediatric CPR is essential to support delivery of reasonable ventilation rate targets and to avoid hypoventilation. Systems should track ventilation rate and adequacy using available monitoring tools, such as waveform capnography, ventilator-derived respiratory rates, or impedance-based measurements. When real-time monitoring tools are unavailable, post-event review of resuscitation records, monitor/defibrillator downloads, or capnography waveforms can provide valuable information on achieved ventilation performance.

Key indicators for monitoring include:

- Delivered ventilation rate (breaths per minute), ideally captured continuously
- Variability in ventilation rate across the resuscitation
- Availability and use of ventilation monitoring tools (e.g., capnography)
- Airway strategy used and its influence on ventilation performance
- Team adherence to assigned ventilation roles during resuscitation
- Post-event debrief data, including ventilation trends in relation to hemodynamics and $EtCO_2$

Programs with established CPR quality-improvement systems may incorporate these indicators into routine case reviews, debriefings, and performance dashboards. Pediatric-specific feedback, focused team training,

and tracking of improvement over time can help reinforce correct ventilation delivery. As new evidence emerges, ongoing evaluation of clinical outcomes—especially ROSC, survival, and neurological outcome on discharge—will be important to assess the impact of ventilation practices and guide future refinements of recommendations.

## Research priorities

On the basis of the identified knowledge gaps, the Task Force highlighted the following research priorities:

1. Define optimal ventilation rate targets in pediatric cardiac arrest.
    - Conduct prospective observational studies and randomized or cluster-randomized trials comparing different ventilation rate ranges in infants and children, both in-hospital and out-of-hospital.
    - Include both advanced airway and non-intubated patients (bag-mask ventilation, supraglottic airway) and report core outcomes (ROSC, survival, neurological outcome at hospital discharge).
2. Evaluate the delivery of tidal volume, inspiratory pressure, and PEEP during pediatric CPR.
    - Perform physiologic and clinical studies that compare different tidal volume delivery and PEEP strategies, including minute ventilation targets, and examine their effects on oxygenation, hemodynamics, lung injury, and longer-term outcomes.
    - Integrate continuous monitoring (e.g., capnography, airway pressure, blood gases, thoracic impedence) to understand mechanisms.
3. Characterize the physiologic consequences of hypo- and hyperventilation.
    - Undertake detailed physiologic studies (clinical and, where necessary, translational) to describe how different ventilation patterns during CPR affect $PaCO_2$, $PaO_2$, pH, cerebral perfusion, coronary perfusion, and blood pressure in children.
    - Link these physiologic changes to short- and long-term clinical outcomes.
    - Develop etiology-specific ventilation strategies.
4. Design studies that stratify or randomize patients according to arrest etiology (e.g., primary respiratory failure, cardiac etiology, drowning, pulmonary injury) to determine whether optimal ventilation targets differ by cause.
    - Explore whether etiology-specific protocols improve outcomes compared with a uniform ventilation strategy.

Clarify the interaction between airway strategy and optimal ventilation parameters.5. Compare ventilation performance and outcomes across airway approaches (bag-mask ventilation, supraglottic airway, endotracheal intubation) using standardized measurement of rate, volume delivery, and pressures.

- Determine whether recommended ventilation targets should differ according to airway type, and evaluate the role of feedback technologies across these strategies.
- Conduct adequately powered pediatric trials and high-quality prospective studies.

6. Prioritize large, multicenter pediatric studies—including randomized or pragmatic trials—of ventilation strategies during cardiac arrest with neurologically-intact survival as a primary outcome.
    - Embed ventilation monitoring and feedback into cardiac arrest registries and quality-improvement programs to support learning health-system approaches and enable future trials.

## References

1. Stanton K, Mershad A, Kadish C, Murphy A, Lowe R, Ania I, et al. Ventilation Rates and Capnography in Pediatric Out-of-Hospital Cardiac Arrest with Advanced Airways. Prehosp Emerg Care. 2025;29(8):1072–7.
2. Sutton RM, Reeder RW, Landis WP, Meert KL, Yates AR, Morgan RW, et al. Ventilation Rates and Pediatric In-Hospital Cardiac Arrest Survival Outcomes. Crit Care Med. 2019;47(11):1627–36.

# Intramuscular Epinephrine During Cardiac Arrest in Children (PLS 4090.05)

## QUESTION

| Should IM epinephrine vs. IV or IO or be used for cardiac arrest? (PLS 4090.05) | |
|---|---|
| **POPULATION:** | Children in cardiac arrest in any setting |
| **INTERVENTION:** | Intramuscular (IM) route of epinephrine administration |
| **COMPARISON:** | IV/IO administration |
| **MAIN OUTCOMES:** | Patient outcomes – ROSC (important), survival and survival with favorable neurologic outcome at any time point (critical).<br>Process outcomes - administration of epinephrine, time to epinephrine, and accuracy of dosing |
| **SETTING:** | all settings |
| **CONFLICT OF INTERESTS:** | Janice Tijssen published previous studies on intramuscular epinephrine and is funded for a trial on IM Epinephrine. |

## ASSESSMENT

### Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | Studying new interventions for cardiac arrest is essential because it is a common and life-threatening emergency with persistently poor survival and neurological outcomes, and only through developing, testing, and refining innovative strategies can we meaningfully improve the chances of saving lives. | |

### Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>● Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | In the management of cardiac arrest, earlier epinephrine is associated with improved clinical outcomes. Meanwhile, administration of epinephrine by IV and IO routes has its challenges. IM epinephrine may be a more efficient route of administration of epinephrine. However, response to early epinephrine likely will be associated with etiology of arrest, duration of arrest, comorbidities, quality of CPR, etc. From a population perspective, the impact may be small. | |

### Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Large<br>○ Moderate<br>○ Small<br>○ Trivial<br>○ Varies<br>● Don't know | IM epinephrine safety has been demonstrated through millions of administrations in the setting of anaphylaxis. The doses used in adult OHCA are approximately 10 times greater and may pose a greater risk of necrosis. The risk of local infection is likely no greater than with an autoinjector for anaphylaxis- which is exceedingly rare. There are no safety studies of IM epinephrine in cardiac arrest. There is a potential for harm by detracting from standard of care, and by having 2 different concentrations of epinephrine for one clinical condition (1:1000 for IM epinephrine and 1:10,000 for IV/IO epinephrine). | |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | There are no pediatric studies of IM epinephrine in cardiac arrest. | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>○ Probably no important uncertainty or variability<br>● No important uncertainty or variability | There is no pediatric evidence, but if there were outcomes to measure, there would be no uncertainty about the value of P-COSCA outcomes. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● Don't know | There is no pediatric evidence. | |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | There is no evidence, but IM epinephrine is an acceptable therapy in anaphylaxis. | |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | There are no dosing studies of IM epinephrine in cardiac arrest, but pediatric epinephrine dosing is based on weight and thus cannot be prepared until a patient's weight is known. Currently, there are no commercially available prefilled syringes of 1:1000 epinephrine concentration (for greater than 0.3mg in an autoinjector). In a simulation study, the time required to prepare a syringe of 1:1000 epinephrine was equivalent to the time required to insert an IV or IO. However, the stability, sterility, and potency of pre-filled plastic epinephrine syringes have not been evaluated for durations of > 3 months. Thus, for pediatric dosing of 1:1000 epinephrine for cardiac arrest, there are feasibility concerns. | |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **DESIRABLE EFFECTS** | Trivial | **Small** | Moderate | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Large | Moderate | Small | Trivial | | Varies | **Don't know** |
| **CERTAINTY OF EVIDENCE** | Very low | Low | Moderate | High | | | **No included studies** |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | Probably no important uncertainty or variability | **No important uncertainty or variability** | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **Don't know** |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

## CONCLUSIONS

### Recommendation

There is insufficient pediatric evidence to recommend adding intra-arrest intramuscular (IM) epinephrine to standard resuscitation care for cardiac arrest in children.

### Justification

The TF recognized that intramuscular epinephrine is an interesting area of research. In the management of cardiac arrest, earlier epinephrine is associated with improved clinical outcomes. Meanwhile, administration of epinephrine by IV and IO routes has its challenges. IM epinephrine may be a more efficient route of administration of epinephrine but it may also lead to suboptimal effects. Adult and animal studies were included in the SR for comprehensiveness but the results these should be interpreted with caution. The task force explicitly refrained from using adult-derived indirect evidence for many paediatric recommendations because of fundamental differences in arrest aetiology. Animal studies often fail to integrate standard of care post-arrest therapies and do not report neurological outcomes. In addition, time to drug administration in animals does not reflect the human clinical experience, where epinephrine administration is often delayed compared to animal studies.

### Subgroup considerations

No subgroup data available

### Implementation considerations

There are no dosing studies of IM epinephrine in cardiac arrest, but pediatric epinephrine dosing is based on weight and thus cannot be prepared until a patient's weight is known. Currently, there are no commercially available prefilled syringes of 1:1000 epinephrine concentration (for greater than 0.3mg in an autoinjector). In a simulation study, the time required to prepare a syringe of 1:1000 epinephrine was equivalent to the time required to insert an IV or IO. However, the stability, sterility, and potency of pre-filled plastic epinephrine syringes has not been evaluated for durations of > 3 months. Thus, for pediatric dosing of 1:1000 epinephrine for cardiac arrest, there are feasibility concerns.

## Monitoring and evaluation

## Research priorities

There are no pediatric studies evaluating intramuscular epinephrine in cardiac arrest. The TF suggests that there is sufficient biological plausibility and equipoise for this therapy to warrant human pediatric trials. Future studies should evaluate IM epinephrine compared to no epinephrine (e.g., in low resourced settings), in addition to IM epinephrine compared to IV/IO epinephrine, in children with cardiac arrest.

There are no dosing studies of IM epinephrine in cardiac arrest. Future studies should evaluate the pharmacokinetic profile of IM epinephrine in cardiac arrest to inform dosing.

There are no safety studies of IM epinephrine in cardiac arrest. There is a potential for harm by detracting from standard of care, and by having 2 different concentrations of epinephrine for one clinical condition (1mg/ml [1:1000] for IM epinephrine vs 0.1mg/ml [1:10,000] for IV/IO epinephrine).

**References:**


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6. Mauch J, Ringer SK, Spielmann N, Weiss M. Intravenous versus intramuscular epinephrine administration during cardiopulmonary resuscitation - a pilot study in piglets. *Paediatr Anaesth*. 2013;23:906–912. doi: 10.1111/pan.12149
7. Redding JS, Asuncion JS, Pearson JW. Effective routes of drug administration during cardiac arrest. *Anesth Analg*. 1967;46:253–258.
8. O'Reilly M, Tijssen JA, Lee TF, Ramsie M, Cheung PY, Schmolzer GM. Intramuscular versus intravenous epinephrine administration in a pediatric porcine model of cardiopulmonary resuscitation. *Resusc Plus*. 2024;20:100769. doi: 10.1016/j.resplu.2024.100769

# Vasopressor Use During Cardiac Arrest in Children (PLS 4080.21)

## QUESTION

| Should Vasopressor vs No vasopressor be used for children during cardiac arrest? | |
|---|---|
| **POPULATION:** | Infants and children (excluding newborns) in cardiac arrest who received chest compressions in any setting |
| **INTERVENTION:** | Any use of vasopressors (epinephrine, vasopressin, or combination of vasopressors) |
| **COMPARISON:** | No vasopressor use |
| **MAIN OUTCOMES:** | Critical clinical outcomes, including short-term survival and neurological outcomes (e.g., hospital discharge, 28 days, 30 days, and 1 month), and long-term survival and neurological outcomes (e.g., 3 months, 6 months, and 1 year) as per Pediatric Core Outcome Set for Cardiac Arrest |
| **SETTING:** | Any setting (in-hospital or out-of-hospital) |
| **PERSPECTIVE:** | |
| **BACKGROUND:** | Despite being a cornerstone of advanced life support protocols in children, the efficacy of vasopressors in improving survival and neurological outcomes is unclear. |
| **CONFLICT OF INTERESTS:** | None |

## ASSESSMENT

### Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | Administration of epinephrine in paediatric cardiac arrest has been traditionally taught as a fundamental part of advanced life support despite a lack of evidence that it improves patient-centered outcomes such as long-term neurological outcomes. | |

### Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>○ Moderate<br>● Large<br>○ Varies<br>○ Don't know | The search strategy identified 954 unique records, of which 21 were selected for full-text review. Of these, 5 satisfied all inclusion and exclusion criteria.<br>Two papers were pre-hospital retrospective, propensity-score matched cohort studies (Amoako 2023[1], Matsuyama 2020[2]). The two studies provided low certainty of evidence for the critical outcomes (downgraded for serious risk of bias and serious indirectness) and very low certainty of evidence for the important outcomes (downgraded for serious risk of bias, very serious inconsistency, and serious | A randomized trial of epinephrine in out-of-hospital cardiac arrest in adults highlighted the lack of overall improvement in neurologically intact survival in the epinephrine group. |

| | | |
|---|---|---|
| | indirectness). The remaining three observational studies (Banerjee 2020, Rodríguez-Núñez 2006, Dieckmann 1995)[3-5] did not adjust for epinephrine administration in their analyses and therefore excluded from the meta-analysis. No RCTs were identified.<br><br>While survival to hospital discharge is highly desirable, further studies are needed to evaluate long term neurological outcomes of pre-hospital administration of epinephrine for paediatric out-of-hospital cardiac arrest. These patient-centered clinical outcomes should be studied. | |

| Certainty assessment | | | | | | | № of patients | | Effect | |
|---|---|---|---|---|---|---|---|---|---|---|
| № of studies | Study design | Risk of bias | Inconsistency | Indirectness | Imprecision | Other considerations | Vasopressor use (epinephrine) | no vasopressor (no epinephrine) | Adjusted Risk Ratio (95% CI) | Risk difference (95% CI) |
| **Favorable neurological outcome at 1-month** | | | | | | | | | | |
| 1 | non-randomised studies<br>Matsuyama, 2020[20] | serious[a] | not serious | serious[c,d] | not serious | none | 11/304 (3.6%) | 8/304 (2.6%) | **1.56**<br>(0.61 to 3.96) | **15 more per 1,000**<br>(from 11 fewer to 92 more) |
| **Favorable neurological outcome at hospital discharge** | | | | | | | | | | |
| 1 | non-randomised studies<br>Amoako, 2023[21] | serious[b] | not serious | serious[c] | not serious | none | 32/713 (4.5%) | 27/713 (3.8%) | **1.23**<br>(0.67 to 2.25) | **9 more per 1,000**<br>(from 13 fewer to 50 more) |
| **1 month survival** | | | | | | | | | | |
| 1 | non-randomised studies<br>Matsuyama, 2020[20] | serious[b] | not serious | serious[c,d] | not serious | none | 31/304 (10.2%) | 24/304 (7.9%) | **1.13**<br>(0.67 to 1.93) | **10 more per 1,000**<br>(from 27 fewer to 78 more) |
| **Survival to Hospital Discharge** | | | | | | | | | | |
| 1 | non-randomised studies<br>Amoako, 2023[21] | serious[b] | not serious | serious[c] | not serious | none | 45/713 (6.3%) | 36/713 (5.0%) | **1.38**<br>(0.87 to 2.19) | **19 more per 1,000**<br>(from 7 fewer to 64 more) |
| **Pre-hospital ROSC** | | | | | | | | | | |
| 2 | non-randomised studies<br>Matsuyama, 2020[20]; Amoako, 2023[21] | serious[b] | very serious[b] | serious[c] | not serious | none | 157/1017 (15.4%) | 97/1017 (9.5%) | **1.64**<br>(1.26 to 2.13) | **63 more per 1,000**<br>(from 28 more to 145 more) |

**CI:** confidence interval; **RR:** risk ratio

a. Due to missing data

b. Difference in study population (age)

c. Not a direct comparison

d. The population is limited to children greater than 8 years old

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>● Varies<br>○ Don't know | While there are no direct undesirable anticipated effects that were reported in the included studies, the resources that may be needed for additional equipment, training and maintenance of skillsets of EMS personnel to enable the administration of adrenaline/epinephrine in paediatric out-of-hospital cardiac arrests may be substantial.<br><br>These advanced interventions should be evaluated against other priorities of healthcare systems in committing significant resources to implement pre-hospital administration of adrenaline/epinephrine in paediatric cardiac arrest, especially in resource-limited settings.<br><br>The 2 studies included for meta-analysis were from advanced EMS systems that could provide pre-hospital advanced paediatric life support. | There are some potential drawbacks in epinephrine administration in an out-of-hospital setting. A recent cohort study highlighted that among pediatric out-of-hospital cardiac arrest treated by emergency medical service in the United States, there was at least one severe adverse safety event (eg, failure to give an indicated medication, |

| | | |
|---|---|---|
| | | 10-fold medication overdose) occurred in 610/1019 (60%) patients, and 310/1019 (30%) patients had 2 or more adverse events. The only factor associated with severe adverse safety events was young age.<br><br>A randomized trial of epinephrine in out-of-hospital cardiac arrest in adults demonstrated that administration of epinephrine increased 30-day survival rates, although a larger proportion of patients in the epinephrine group were more significantly neurologically impaired. |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>● Low<br>○ Moderate<br>○ High<br>○ No included studies | Based on the 2 propensity-score matched studies included for meta-analysis, the use of epinephrine in the out-of-hospital setting did demonstrate an improved ROSC rate (Amoako 2023, Matsuyama 2020) and survival to hospital discharge in only 1 study (Amoako 2023).<br><br>However, there were significant limitations in the studies. While both retrospective studies were propensity score matched and statistical adjustments were made to account for potential confounders in both studies, the cohorts that received epinephrine pre-hospital versus those who did not within the same EMS systems could still be inherently different. | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>○ Probably no important uncertainty or | There is no uncertainty or variability in using mortality (survival to hospital discharge) as a valued clinical outcome. However, patient-centered clinical outcomes such as long-term neurological function were not evaluated. | For existing systems that have EMS can provide advanced paediatric life support for paediatric out-of-hospital cardiac arrest, longitudinal evaluation of the outcomes of administration of adrenaline/epinephrine |

| | | |
|---|---|---|
| variability<br>● No important uncertainty or variability | | to improve patient-centred clinical outcomes such as long-term neurological outcomes are needed. |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>● Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | The evidence is supportive of the administration of epinephrine in paediatric out-of-hospital cardiac arrest to significantly improve ROSC rates and probably short-term mortality outcomes.<br>In any healthcare system that has advanced EMS life support teams that are trained and have the necessary resources to administer epinephrine for paediatric cardiac arrest patients in the out-of-hospital setting, these would likely result in similar clinical outcomes.<br><br>Future specific research will need to focus on the prospective evaluation of mature EMS systems that are already able to provide advanced life support to paediatric cardiac arrest patients in the pre-hospital setting to evaluate patient-centric clinical outcomes, especially long-term neurological outcomes, with the use of the administration of adrenaline/epinephrine. | Our task force reaffirms that in mature EMS systems that can provide advanced paediatric life support, the administration of epinephrine in paediatric out-of-hospital cardiac arrests is still recommended.<br><br>The cost-effectiveness of healthcare systems committing significant resources to train and maintain skillsets in developing EMS systems or in resource-limited settings, so that EMS personnel may be able to obtain vascular access for the administration of epinephrine in the pre-hospital setting, is still unknown. |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>○ Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>● Varies<br>○ Don't know | There is a paucity of studies looking at resources required to train, maintain skillsets, and provide the necessary equipment and drugs needed for EMS systems to administer epinephrine in paediatric out-of-hospital cardiac arrests.<br>There are no studies looking at the health economic impact and benefits of EMS to be able to deliver vasopressors in paediatric out-of-hospital cardiac arrests in resource-rich healthcare systems, but also in resource-limited countries.<br>However, the resources needed are likely to be substantial in developing EMS systems while probably not significant in mature EMS systems that currently provide advanced paediatric life support. | The advocacy to administer adrenaline/epinephrine in pediatric out-of-hospital cardiac arrests should consider additional trainin g and resources in different healthcare settings to provide these advanced life support measures. |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | It is of note that these 2 propensity-score matched studies were from healthcare settings with advanced EMS systems.<br>There were no studies identified that evaluated the resources required to train, maintain skillsets, and provide the necessary equipment and drugs needed for EMS systems to administer epinephrine in paediatric out-of-hospital cardiac arrests. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>● Varies<br>○ No included studies | There were no studies identified that evaluated the cost-effectiveness of EMS systems having EMS personnel sufficiently trained and resources allocated to enable the provision of advanced paediatric life support to administer epinephrine in the out-of-hospital setting versus not having one is unknown. | |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>○ Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>● Don't know | There were no studies identified that looked directly at the health-economic impact and benefits of EMS to be able to deliver vasopressors in paediatric out-of-hospital cardiac arrests in all settings, including in resource-limited countries.<br><br>Further studies should look not only at resource-rich healthcare institutions but also in healthcare institutions from resource-limited countries. When powered with more analyzable data, these should be stratified by resource availability e.g. Gross National Income or Sociodemographic Index status of the country. | |

## Acceptability

Is the intervention acceptable to key stakeholders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes | The administration of epinephrine improved ROSC rates in advanced EMS systems that can or already provide advanced paediatric life support in paediatric out-of-hospital cardiac arrest. | |

| | | |
|---|---|---|
| ● Yes<br>○ Varies<br>○ Don't know | In developing EMS systems or healthcare settings with significant resource limitations, the feasibility of administrating epinephrine in paediatric out-of-hospital cardiac arrests is unknown due to a lack of studies on its cost-effectiveness. | |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | In advanced EMS systems that can provide advanced paediatric life support for paediatric out-of-hospital cardiac arrests, the evidence suggests that administration of epinephrine improved outcomes of ROSC and survival to hospital discharge; favoring the intervention.<br><br>In developing EMS systems or countries with significant resource limitations, the feasibility of administrating epinephrine in paediatric out-of-hospital cardiac arrests is unknown due to a lack of studies. | |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | Small | Moderate | **Large** | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Trivial | Small | Moderate | Large | | **Varies** | Don't know |
| **CERTAINTY OF EVIDENCE** | Very low | **Low** | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | Probably no important uncertainty or variability | **No important uncertainty or variability** | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | **Probably favors the intervention** | Favors the intervention | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | Negligible costs and savings | Moderate savings | Large savings | **Varies** | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | **Varies** | No included studies |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **EQUITY** | Reduced | Probably reduced | Probably no impact | Probably increased | Increased | Varies | **Don't know** |
| **ACCEPTABILITY** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |

# TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ○ | ● | ○ |

# CONCLUSIONS

## Recommendation

We suggest the use of epinephrine in pediatric out-of-hospital cardiac arrest (weak recommendation, very low-certainty evidence).
We suggest the use of epinephrine in pediatric in-hospital cardiac arrest (Good Practice Statement).

## Justification

While there is limited evidence in paediatric out-of-hospital cardiac arrest, administration of epinephrine did improve ROSC and survival to hospital discharge. While there was no data available for the IHCA setting, the Task Force considered that the OHCA data should be used as indirect evidence.
There is a paucity of studies looking at patient-centered clinical outcomes, such as long-term neurological outcomes. Administering epinephrine in paediatric out-of-hospital cardiac arrest would be justifiable in existing EMS systems that provide advanced paediatric life support.

There is a paucity of studies looking at resources required to train, maintain skillsets, and provide the necessary equipment for EMS systems to administer epinephrine in paediatric out-of-hospital cardiac arrests. Future studies should be undertaken to evaluate the ability of EMS systems to provide advanced care in paediatric out-of-hospital cardiac arrest, to better inform equity issues of such systems in both resource-rich healthcare but also in resource-limited countries.

## Subgroup considerations

· Age-subgroups: infants, children and adolescents in out-of-hospital cardiac arrest
· Early versus Late epinephrine in shockable rhythms
· Non-shockable rhythms – asystole versus PEA (versus bradycardia)
· Resource high versus resource low settings (eg Low & middle income countries).
· Single-tiered versus Tiered EMS response (BLS/ALS) systems

## Implementation considerations

· Resourcing
· Feasibility
· Cost-effectiveness
· Equity and Acceptability

## Monitoring and evaluation

Evidence updates will be reviewed annually for the PICOST

## Research priorities

· Future studies should include patient-centered outcomes such as long-term neurological outcomes.
· Further studies should address whether specific sub-populations might potentially benefit (or not) from the administration of epinephrine in the pre-hospital settings.
· Cost-effectiveness and feasibility of the provision of advanced paediatric life support in the pre-hospital settings to facilitate the administration of adrenaline/epinephrine, in paediatric out-of-hospital cardiac arrest while ensuring high-quality basic life support, should be explored in all healthcare settings, including in LMICs. The task force considers the biological plausibility and equipoise sufficient to justify pediatric trials comparing initial dosing of IM epinephrine to IV, IO, alternate routes (eg, intranasal), or no epinephrine (eg, in low-resource settings where intravascular access is unavailable)

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# Temperature Control After Cardiac Arrest in Children: ATM at 32-34°C vs. ATM at 36-37.5°C (PLS 4210.03, part 1)

## QUESTION

| Should Active temperature management (ATM) 32-34°C vs. ATM 36-37.5°C be used for children post cardiac arrest? | |
|---|---|
| **POPULATION:** | Children post cardiac arrest |
| **INTERVENTION:** | Active temperature management (ATM) 32-34°C |
| **COMPARISON:** | ATM 36-37.5°C |
| **MAIN OUTCOMES:** | Favorable neurological outcome; Favorable neurological outcome (Bayesian); Health related quality of life; Survival; Survival (Bayesian) |
| **SETTING:** | paediatric critical care environment |
| **PERSPECTIVE:** | The perspectives include those of children and their families, clinicians, and healthcare systems. Families generally prioritize survival with good neurological outcome, but there is variability in values regarding acceptable outcomes, as highlighted by the P-COSCA initiative. Clinicians seek evidence-based strategies to improve outcomes after pediatric cardiac arrest, while healthcare systems must consider resource allocation, feasibility, and equity in access to advanced therapies. |
| **BACKGROUND:** | Cardiac arrest in children is a rare but devastating event, with a significant proportion of survivors experiencing severe neurological injury. Active temperature management (ATM) has been proposed as a neuroprotective strategy, based on evidence from preclinical models and neonatal hypoxic-ischemic injury. However, clinical trials in children have not demonstrated clear superiority of hypothermia over normothermia for survival or neurological outcomes. Both approaches require intensive care resources, and there is ongoing debate regarding optimal temperature targets, implementation strategies, and the impact on long-term outcomes. |
| **CONFLICT OF INTERESTS:** | The following intellectual conflicts of interest have been declared. B Scholefield, A Guerguerian and A Topjian were co-investigators on the THAPCA-IH trial. A Topjian, H Krishnan, and A-M Guerguerian are co-investigators/site PIs in the P-ICECAP study. B Scholefield, A Topjian, H Krishan and A-M Guerguerian will be excluded from study selection, data abstraction and risk of bias assessment. No members of the writing group have any financial conflicts of interest. |

## ASSESSMENT

### Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | A significant number of pediatric cardiac arrest survivors are left with severe neurologic injury. Active targeted temperature management (ATM) (as part of post-cardiac arrest care), has been shown in pre-clinical models of pediatric cardiac | |

| | | |
|---|---|---|
| | arrest and as part of care after neonatal hypoxic ischemic injury, to improve rates of survival and neurologic outcome by modifying post-cardiac arrest syndrome. Clinical interventions that improve pediatric outcomes from cardiac arrest would be viewed as important and desirable by society. | |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>● Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | Improvement in the important outcome of favorable neurological outcome is a highly desired effect from the neuro-protective intervention. The systematic review identified two approaches to analysis of the THAPCA out of hospital cardiac arrest trial data. The original primary analysis using frequentist statistical analysis and a secondary Bayesian analytical approach. The Pediatric Life Support Task Force considered both types of analysis in addition to non-randomized controlled evidence in children.<br>**Good neurobehavioral survival**:<br>For the critical outcome of long-term good neurobehavioral survival (1 year), from 2 RCTs (Moler 2015 , Moler 2017), (1 out-of-hospital (OH) and 1 in-hospital cardiac arrest (IHCA) study) with 517 children who achieved return of circulation but remained comatose with a Glasgow Coma Scale Motor Score <5, showed no statistical benefit or harm of ATM 32-34°C compared to ATM 36-37.5°C (RR=1.05, 95% CI 0.80-1.39). | The SR examined both estimates of effect for the pooled analysis (OHCA and IHCA) and OHCA or IHCA alone. The TF also reviewed the new analysis since the previous systematic review, which included the Bayesian re-analysis of the THAPCA-OH study (Harhay 2023), and a study reporting on the Health-Related Quality of Life at a median of 3 years outcome in a mixed cohort of IHCA and OHCA patients (Magee 2022).<br>For the critical outcome of long-term good neurobehavioral survival (1 year) using Bayesian analysis in the OHCA population only, the evidence of low certainty (downgraded for imprecision) from 1 Bayesian reanalysis of the THAPCA-OH RCT (Harhay 2022) showed a posterior median absolute benefit of 6.8% (95% Credible Interval: -1.9% to 15.4%) with a probability of any benefit of 94%.<br>For the critical outcome of long-term survival (1 year) using Bayesian analysis in the OHCA population only, the evidence of low certainty (downgraded for imprecision) from 1 Bayesian reanalysis of the THAPCA-OH RCT (Harhay 2022) showed a posterior median absolute benefit of 6.8% (95% Credible Interval: -1.9% to 15.4%) with a probability of any benefit of 94%. |

| | | |
|---|---|---|
| | For the critical outcome of intermediate-term good neurobehavioral survival (6 months), from 1 adjusted observational cohort study (Doherty 2009) with 79 children who achieved ROSC after OH or IHCA, showed no statistical benefit or harm of ATM <35°C compared to ATM 36-37.5°C or no ATM (aOR=0.50, 95% CI 0.11-2.22)<br>**Survival:**<br>For the critical outcome of long-term survival (1 year), from 2 RCTs (Moler 2015, Moler 2017), (1 OH and 1 IHCA study) with 614 children who achieved return of circulation but remained comatose with a Glasgow Coma Scale Motor Score <5, showed no statistical benefit or harm of ATM 32-34°C compared to ATM 36-37.5°C (RR=1.14, 95% CI 0.94-1.37)<br>For the critical outcome of intermediate-term survival (6 months), from 1 adjusted observational cohort study (Doherty 2009) with 79 children who achieved ROSC after OH or IHCA showed no statistical benefit or harm of ATM <35°C compared to ATM 36-37.5°C or no ATM (aOR=0.50, 95% CI 0.11-2.22)<br><br>For the critical outcome of short-term survival (30 days or hospital discharge), from 3 non-randomized observational cohort studies (Doherty 2009 , Fink 2010, Magee 2022) with 388 children who achieved ROSC showed no statistical benefit or harm of ATM 32-36°C compared to ATM 36-37.5°C or no ATM. Due to significant clinical | |

| | | |
|---|---|---|
| | heterogeneity, these studies could not be pooled.<br>**Health-Related Quality of Life:**<br>For the important outcome of health-related quality of life (HRQoL), from 1 adjusted observational cohort study (Magee 2022) with 128 children after OH or IHCA showed improved HRQoL physical summary scores in the ATM 33°C group compared to the ATM 36°C group (MD=11.2 HRQoL score higher, 95% CI 3.1 higher to 19.3 higher). | |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large<br>○ Moderate<br>● Small<br>○ Trivial<br>○ Varies<br>○ Don't know | | ATM of 32-34°C may result in increased duration of stay in ICU owing to later assessment of neurological prognosis. This could result in increased costs for uncertain benefit |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | The overall certainty of effect was very low when assessed with GRADE. Summary of data is presented below.<br>*See Appendix 1* | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly | The main outcome for children after cardiac arrest is survival with good neurological function, which is generally | |

| | | |
|---|---|---|
| important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | considered highly important by families and clinicians. However, the P-COSCA (Pediatric Core Outcome Set for Cardiac Arrest) identified that stakeholders also value outcomes such as: Quality of life, Functional status, and Long-term neurodevelopment. There is considerable variability in values: Some families prioritize any survival, even with severe disability. Others consider survival without meaningful neurological recovery unacceptable. Cultural, social, and individual factors influence these preferences, creating uncertainty about how much weight different families place on neurological outcomes versus survival alone. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>● Varies<br>○ Don't know | The point estimate for the two randomized controlled trial primary analysis did not identify a benefit of the intervention over the comparison for the clinically important outcomes. The Bayesian re-analysis of the THAPCA-OH study (Harhay 2023), and a study reporting on the Health-Related Quality of Life at a median of 3 years outcome in a mixed cohort of IHCA and OHCA patients (Magee 2022) were in favor of the intervention (temperature target 33C). | |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>○ Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>● Don't know | The cost of active temperature management was not assessed in the identified literature. | Delivery of active temperature management within the included studies required a high resource environment (e.g. ICU), invasive temperature monitoring and the use of servo-controlled external cooling devices. These would require significant resources to acquire, use and maintain. |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | True cost of the intervention is unknown. No literature assessing cost was identified. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● No included studies | No studies examined the cost-effectiveness of the intervention compared to the comparison. | Both ATM 32-34°C and ATM 36-37.5°C require ICU-level care, continuous temperature monitoring, and trained staff. It is unknown if ATM 32-34°C increases nursing workload which would raise costs compared to ATM 36-37.5°C. |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>○ Probably no impact | The impact on health equity was not identified in the literature. | Implementation of active temperature management after pediatric cardiac arrest may increase health inequities. Temperature Management protocols require specialized |

| | | |
|---|---|---|
| ○ Probably increased<br>○ Increased<br>○ Varies<br>● Don't know | | equipment, trained personnel, and intensive monitoring, which are more available in high-resource settings. Hospitals in low-resource or rural areas may lack these capabilities, limiting access for certain populations. This could widen disparities in survival and neurological outcomes for children. |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | No studies directly examined the acceptability of the intervention. | Active temperature management use after cardiac arrest in children has been described in numerous studies. However, recent studies also include a proportion of children after cardiac arrest not receiving active temperature management. |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | ATM is in use in many institutions. This approach requires considerable investment in personnel, training and other resources. Feasible in larger centers with sufficient resources. | |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | **Small** | Moderate | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Large | Moderate | **Small** | Trivial | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | **Varies** | Don't know |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **RESOURCES REQUIRED** | Large costs | Moderate costs | Negligible costs and savings | Moderate savings | Large savings | Varies | **Don't know** |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | Probably reduced | Probably no impact | Probably increased | Increased | Varies | **Don't know** |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

# TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | **Conditional recommendation for either the intervention or the comparison** | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ● | ○ | ○ |

# CONCLUSIONS

## Recommendation

We recommend using active temperature management* (ATM) for comatose infants and children following OHCA or IHCA (strong recommendation, low certainty evidence).
We recommend using ATM to prevent central temperatures >37.5°C (strong recommendation, low certainty evidence).
We suggest that ATM protocols follow one of the published THAPCA trial interventions: (a) ATM 32–34°C for 48 hours, followed by gradual rewarming and maintenance at 36–37.5°C until a total of 120 hours, or (b) ATM 36–37.5°C for 120 hours total, as current evidence does not show superiority of either temperature target and there is insufficient evidence to recommend alternative durations (weak recommendation, low certainty evidence).
*Active temperature management (ATM) is defined as intentionally controlling a patient's body temperature to a specific temperature target range using a standardized management protocol. This includes all cooling and warming methods, temperature maintenance duration, pharmacotherapy, and monitoring strategies to achieve and sustain the desired target temperature.

## Justification

The recommendation for either active temperature management at 32–34°C (ATM hypothermia) or 36–37.5°C (ATM normothermia) in comatose infants and children after cardiac arrest is conditional and based on low certainty of evidence. The available randomized controlled trials (RCTs) and observational studies do not demonstrate a clear benefit or harm of hypothermia compared to normothermia for the critical outcomes of survival and favorable neurological outcome at one year. The primary frequentist analysis of RCTs showed no statistically significant difference, while a Bayesian re-analysis suggested a possible benefit for hypothermia, but with wide credible intervals and moderate certainty, limiting confidence in the result.

The PLS TF agreed that following IHCA, there is insufficient evidence to support or refute the use of induced hypothermia (ATM 32-34°C) compared with active temperature management at normothermia (ATM 36-37.5°C) (or an alternative temperature).
However, following OHCA, there is some evidence supporting the use of induced hypothermia (ATM 32-34°C for 48 hours) compared with active temperature management at normothermia (ATM 36-37.5°C) in comatose patients. However, the body of evidence remains insufficient to provide a separate treatment recommendation.
Health-related quality of life data is limited, with one non-randomized study suggesting improved physical summary scores in the hypothermia group, but the certainty of evidence is very low due to methodological limitations and confounding. Both interventions require ICU-level care, invasive temperature monitoring, and specialized equipment, resulting in significant resource requirements. The true cost and cost-effectiveness of hypothermia versus normothermia are unknown, as no studies directly addressed these outcomes.
Equity concerns are notable, as implementation of active temperature management protocols may increase disparities in access and outcomes between high-resource and low-resource settings. There is also important variability in how families and clinicians value outcomes, as highlighted by the P-COSCA statement, with some prioritizing survival regardless of neurological status and others emphasizing meaningful neurological recovery.
Given the lack of clear superiority of either approach, the balance of effects varies depending on the analytic method and outcome considered. The intervention is probably acceptable and feasible in well-resourced centers but may be challenging to implement universally. Therefore, a conditional recommendation for either hypothermia or normothermia is appropriate, allowing for individualized decision-making based on patient context, available resources, and family values

## Subgroup considerations

**Out-of-Hospital Cardiac Arrest (OHCA):** Evidence from the THAPCA-OH trial and its Bayesian re-analysis suggests a possible benefit of induced hypothermia (32–34°C) compared to normothermia (36–37.5°C) for favorable neurological outcome and survival, although the certainty of evidence remains low and the credible intervals are wide. As such, while some support exists for hypothermia in OHCA, the data are insufficient to make a strong recommendation for one approach over the other.
**In-Hospital Cardiac Arrest (IHCA):** The THAPCA-IH randomized controlled trial found no significant difference between hypothermia and normothermia for the main outcomes of survival and favorable neurological outcome at one year. This suggests that, for IHCA, either temperature management strategy may be appropriate, or there is no evidence to support the superiority of hypothermia over normothermia.
Given these findings, recommendations should acknowledge that the evidence base and potential benefits may differ between OHCA and IHCA populations. Individualized decision-making is warranted, considering the setting of cardiac arrest, patient characteristics, and available resources.
**Patient stratification:** no studies were identified using a risk stratification approach to select patients to receive ATM 32–34°C or ATM 36–37.5°C . Future research into whether risk-stratification tools could determine whether children with moderate risk of hypoxic-ischemic encephalopathy (HIE), who may not be at the extremes of severity, could experience improved outcomes with either ATM therapy would be helpful.

## Implementation considerations

Implementation of either ATM 32–34°C or ATM 36–37.5°C for children post cardiac arrest requires ICU-level care, invasive temperature monitoring, and trained staff, making it feasible primarily in well-resourced centers. Standardized protocols, ongoing staff education, and monitoring for complications are essential for safe and effective delivery. In resource-limited settings, strict normothermia may be a more practical alternative, and equity in access should be considered. Engaging families in shared decision-making and clearly communicating risks, benefits, and uncertainties are crucial, while institutions should monitor outcomes and participate in quality improvement to optimize care. TTM has been successfully implemented in many tertiary pediatric centers internationally

## Monitoring and evaluation

Institutions implementing active temperature management (ATM) for children after cardiac arrest should routinely monitor key clinical outcomes, including survival rates, neurological function at discharge and follow-up, and health-related quality of life. Adverse events such as arrhythmias, infections, electrolyte disturbances, and complications related to temperature management should be tracked. Compliance with standardized temperature management protocols and timeliness of initiation should be evaluated. Data collection should support ongoing quality improvement. Participation in multicenter registries or collaborative research can enhance benchmarking and contribute to the evidence base.

## Research priorities

- Conduct further high-quality randomized controlled trials comparing hypothermia (32–34°C) and normothermia (36–37.5°C) in children after cardiac arrest, focusing on long-term neurological outcomes and survival.
- Ascertain rate of cooling/rewarming and duration
- Evaluate health-related quality of life and functional outcomes using standardized measures, such as those recommended by the P-COSCA initiative.
- Assess cost-effectiveness and resource utilization for both temperature management strategies in diverse healthcare settings, including low-resource environments.
- Investigate implementation barriers and facilitators, especially in centers with limited access to specialized equipment or trained personnel.
- Perform subgroup analyses to distinguish effects in patients supported on ECLS or following ECPR.
- Encourage participation in multicenter registries and collaborative research to enhance data quality and generalizability.
- Future studies should focus on developing and validating risk stratification tools to guide individualized treatment decisions and optimize outcomes for these patients

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# APPENDICES

Appendix 1

| Outcomes | Anticipated absolute effects* (95% CI) | | Relative effect (95% CI) | № of participants (studies) | Certainty of the evidence (GRADE) | Comments |
|---|---|---|---|---|---|---|
| | Risk with ATM 36-37C | Risk with ATM 32-34C | | | | |
| Favorable neurological outcome 1-year RCT | Study population | | **RR 1.05** (0.80 to 1.39) | 517 (2 RCTs)[1,2] | ⨁◯◯◯ Very low[a,b] | |
| | 256 per 1,000 | **269 per 1,000** (356 to 205) | | | | |
| Favorable neurological outcome (Bayesian) (follow-up: median 12 months) | Posterior median absolute benefit: 6.8% (95% CrI: –1.9% to 15.4%) Probability of any benefit: 94% | | - | (1 RCT)[3] | ⨁⨁◯◯ Low[c,d] | |
| Non-Randomized, Favorable Neurological Outcome, Medium-term Outcome follow-up: 6 months | Study population | | **OR 0.50** (0.11 to 2.22) | 79 (1 non-randomised study)[4] | ⨁◯◯◯ Very low[c,e,f,g,h] | |
| | 580 per 1,000 | **408 per 1,000** (754 to 132) | | | | |
| Health related quality of life, non-randomized, - adjusted. Mean difference in HRQoL | The mean health related quality of life, non-randomized, - adjusted. Mean difference in HRQoL was **0** HRQoL score | MD **11.2 HRQoL score higher** (3.1 higher to 19.3 higher) | - | 128 (1 non-randomized study)[5] | ⨁◯◯◯ Very low[i,j] | |
| RCT, Survival, 1 year outcome | Study population | | **RR 1.14** (0.94 to 1.37) | 614 (2 RCTs)[1,2] | ⨁◯◯◯ Very low[a,b] | |
| | 380 per 1,000 | **434 per 1,000** (521 to 358) | | | | |
| Survival, RCT. (Bayesian) (follow-up: median 12 months) | Posterior median absolute benefit: 6.8% (95% CrI: –1.9% to 15.4%) Probability of any benefit: 94% | | - | (1 RCT)[3] | ⨁⨁◯◯ Low[c,d] | |
| Non-randomized, Survival, Short-term outcome | Study population | | **OR 0.93** (0.40 to 2.12) | 479 (3 non-randomized studies)[4,5,6] | ⨁◯◯◯ Very low[b,e,f,k,l,m,n,o] | |
| | 577 per 1,000 | **559 per 1,000** (743 to 353) | | | | |
| Non-Randomized, Survival, Medium-term Outcome (follow-up: 6 months) follow-up: 6 months | Study population | | **OR 0.50** (0.11 to 2.22) | 79 (1 non-randomized study)[4] | ⨁◯◯◯ Very low[c,e,f,g,p] | |
| | 620 per 1,000 | **449 per 1,000** (784 to 152) | | | | |

a. One study population was OHCA and the other IHCA.
b. Reported risk ratio and confidence interval inconclusive.
c. Single study
d. Based on conventional sample size calculations for a clinically meaningful effect, the study is underpowered.
e. Doherty 2009- Severe confounding by indication: hypothermia group had significantly worse baseline characteristics (more infants, longer arrest duration, higher ECMO use, higher organ dysfunction scores)
f. Doherty 2009- Significant practice variation: 2 of 5 centers never used hypothermia
g. 94% in-hospital cardiac arrests, only 6% out-of-hospital 68-72% cardiac etiology (vs. typical OHCA with predominantly respiratory/asphyxial causes) 56-66% occurred within 14 days after surgery (mostly cardiac surgery) Predominantly post-surgical population not representative of general pediatric cardiac arrest patients
h. Adjusted OR for unfavorable outcome (PCPC 4-6): 2.00 (95% CI 0.45-9.01)
i. No randomization. Treatment at discretion of clinician. Propensity score matching attempted, but significant loss of patients in attempt to match.
j. Wide confidence intervals. Exclusion of several patients through propensity score matching (including most severe patient population)
k. Fink-2010 hypothermia patients had more unwitnessed arrests, more epinephrine doses, longer CPR duration
l. Fink 2010- No protocolized treatment allocation
m. Magee-2022- hypothermia group was younger, had longer CPR duration, higher lactate, lower pH, much higher ECMO use (72% vs. 22%)
n. Doherty 2009 adjusted OR: 2.50 (95% CI 0.55-11.49), P=0.238 (favoring normothermia, not significant) Fink 2010 adjusted OR for hypothermia mortality: 0.47, P=0.2 (favoring hypothermia, not significant) Magee 2022 adjusted OR: 1.30 (95% CI 0.57-2.98) (favoring normothermia, not significant)
o. Outcome timing varies across studies: Doherty: 30-day mortality Fink: Hospital discharge Magee: PICU mortality
p. adjusted mortality OR 1.99, 95% CI 0.45 to 8.85, P=0.502

# Temperature Control After Cardiac Arrest in Children: any Active Temperature Management (ATM) vs no ATM (PLS 4210.03, part 2)

## QUESTION

| Should Comparison of Active Temperature Management (any temperature) vs. No Active Temperature Management be used for children after cardiac arrest? | |
|---|---|
| **POPULATION:** | Children after cardiac arrest |
| **INTERVENTION:** | Active Temperature Management (any temperature) |
| **COMPARISON:** | No Active Temperature Management |
| **MAIN OUTCOMES:** | Favorable neurological outcome, survival |
| **SETTING:** | paediatric critical care environment |
| **PERSPECTIVE:** | The perspectives include those of children and their families, clinicians, and healthcare systems. Families generally prioritize survival with good neurological outcome, but there is variability in values regarding acceptable outcomes, as highlighted by the P-COSCA initiative. Clinicians seek evidence-based strategies to improve outcomes after pediatric cardiac arrest, while healthcare systems must consider resource allocation, feasibility, and equity in access to advanced therapies. |
| **BACKGROUND:** | Cardiac arrest in children is a rare but devastating event, with a significant proportion of survivors experiencing severe neurological injury. Active temperature management (ATM) has been proposed as a neuroprotective strategy, based on evidence from preclinical models and neonatal hypoxic-ischemic injury. However, clinical trials in children have not demonstrated clear superiority of hypothermia over normothermia for survival or neurological outcomes. The use of ATM protocols also allows the avoidance of fever. Absence of an ATM protocol may therefore increase risk of secondary brain injury following cardiac arrest in children. ATM requires intensive care resources, and there is ongoing debate regarding optimal temperature targets, implementation strategies, and the impact on long-term outcomes. |
| **CONFLICT OF INTERESTS:** | The following intellectual conflicts of interest have been declared. B Scholefield, A Guerguerian and A Topjian were co-investigators on the THAPCA-IH trial. A Topjian, H Krishnan, and A-M Guerguerian are co-investigators/site PIs in the P-ICECAP study. B Scholefield, A Topjian, H Krishan and A-M Guerguerian will be excluded from study selection, data abstraction and risk of bias assessment. No members of the writing group have any financial conflicts of interest. |

## ASSESSMENT

| Problem<br>Is the problem a priority? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | A significant number of pediatric cardiac arrest survivors are left with severe neurologic injury. Active targeted temperature management (ATM) (as part of post-cardiac arrest care), has been shown in pre-clinical models of pediatric cardiac arrest and as part of care after neonatal hypoxic ischemic injury, to | |

| | | |
|---|---|---|
| | improve rates of survival and neurologic outcome by modifying post-cardiac arrest syndrome. Clinical interventions that improve pediatric outcomes from cardiac arrest would be viewed as important and desirable by society. | |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>● Moderate<br>○ Large<br>○ Varies<br>○ Don't know | Three non-randomized observational studies were identified to address this question. (1)(2)(3) Two studies used data from the same registry (2)(3) and were not combined in pooled analysis where they reported the same outcome. All patients included in the three studies had OHCA.<br><br>**Favorable Neurological Outcome:**<br>For the critical outcome of short-term good neurobehavioral survival (at hospital discharge), from 2 adjusted observational cohort studies (1)(3) with 877 children who achieved ROSC showed statistical benefit of ATM (any temperature) compared to no active temperature management (OR=1.21, 95% CI 1.05-1.40; ARR=3.0%, or 30 more patients/1000, 95% CI 7 more to 56 more patients/1000).<br><br>**Survival:**<br>For the critical outcome of short-term survival (30 days or hospital discharge), from 2 adjusted observational cohort studies (1)(2) with 830 children who achieved ROSC showed no statistical benefit or harm of ATM (any temperature) compared to no active temperature management (OR=1.06, 95% CI 0.67-1.68; ARR=1.4%, or 14 more patients/1000, 95% CI 92 fewer to 129 more patients/1000). | Three non-randomized observational studies reported different ATM protocols. In Chang 2016 (1), the intervention group received mild therapeutic hypothermia (MTH) with a target temperature of 32–34°C, and the median achieved temperature was 33.0°C (IQR 32.6–33.6). The duration of hypothermia was at least 12 hours but was not strictly protocolized, and the total duration was not reported. The control group did not receive hypothermia, with a median temperature of 35.4°C (IQR 34.7–36.2), and no active temperature management was provided; duration details were not reported. Matsui 2022 (2) investigated targeted temperature management (TTM) with a target range of 33–36°C, but both the duration of intervention and the actual temperatures achieved were not reported. The control group received no active TTM, and temperature or duration details were also not reported. In Namba 2025 (3), the intervention consisted of TTM with a target temperature of 32–36°C, typically maintained for 24 hours, although the total duration was not specified. The control group did not receive active TTM, and temperature and duration details were not reported. Across all studies, the control groups received no active temperature management, with limited reporting on actual temperature and duration parameters. |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Large<br>○ Moderate<br>● Small<br>○ Trivial<br>○ Varies<br>○ Don't know | Unknown.<br>A concern of providing no ATM in patients after cardiac arrest, is the development of fever. This has been reported to be associated with worse neurobehavioral outcome followin g cardiac arrest and brain injury in children. | Across these three pediatric OHCA studies, adverse events were not systematically collected or reported (including rates of fever or temperature about 38C without ATM). Only Chang 2016 flags (in discussion) the general risk of unintended overcooling with certain cooling methods, but this was not quantified in their cohort. Consequently, the magnitude of undesirable effects for TTM vs control is uncertain based on these data. |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | Overall certainty of evidence was very low across both important clinical outcomes.<br>*See Appendix 1* | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertaint y or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | The main outcome for children after cardiac arrest is survival with good neurological function, which is generally considered highly important by families and clinicians. However, the P-COSCA (Pediatric Core Outcome Set for Cardiac Arrest) identified that stakeholders also value outcomes such as: Quality of life, Functional status, and Long-term neurodevelopment. There is considerable variability in values: Some families prioritize any survival, even with severe disability. Others consider survival without meaningful neurological recovery unacceptable. Cultural, social, and individual factors influence these preferences, creating uncertainty about how much weight different families place on neurological outcomes versus survival alone. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>● Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | | |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>● Moderate costs<br>○ Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | The cost of active temperature management was not assessed in the identified literature. However, in comparison to no active temperature management the task force assumed that moderate to large cost is required to deliver the intervention. | Delivery of active temperature management within the included studies required a high resource environment (e.g. ICU), invasive temperature monitoring and the use of servo-controlled external cooling devices. These would require significant resource to acquire, use and maintain. I t is possible that may lengthen ICU stay before neurological prognostication. |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | True cost of the intervention is unknown. No literature assessing cost was identified. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● No included studies | No studies examined the cost-effectiveness of the intervention compared to the comparison. | ATM at any temperature requires ICU-level care, continuous temperature monitoring, and trained staff. |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>○ Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>● Don't know | The impact on health equity was not identified in the literature. | Implementation of active temperature management after pediatric cardiac arrest may increase health inequities. Temperature Management protocols require specialized equipment, trained personnel, and intensive monitoring, which are more available in high-resource settings. Hospitals in low-resource or rural areas may lack these capabilities, limiting access for certain populations. This could widen disparities in survival and neurological outcomes for children. |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | No studies directly examined the acceptability of the intervention. | Active temperature management use after cardiac arrest in children has been described in numerous studies. However, the included studies also identify a proportion of children after cardiac arrest not receiving active temperature management. |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | ATM is in use in many institutions. This approach requires considerable investment in personnel, training and other resources. Feasible in larger centers with sufficient resources. | |

## SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | Small | **Moderate** | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Large | Moderate | **Small** | Trivial | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | **Probably favors the intervention** | Favors the intervention | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | **Moderate costs** | Negligible costs and savings | Moderate savings | Large savings | Varies | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | Probably reduced | Probably no impact | Probably increased | Increased | Varies | **Don't know** |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | **Conditional recommendation for the intervention** | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ○ | ● | ○ |

## CONCLUSIONS

**Recommendation**

We recommend using active temperature management* (ATM) for comatose infants and children following OHCA or IHCA (strong recommendation, low certainty evidence).
We recommend using ATM to prevent central temperatures >37.5°C (strong recommendation, low certainty evidence).

## Related recommendation(s)

**1. Should Active temperature management (ATM) 32-34°C vs. ATM 36-37.5°C be used for children post cardiac arrest?**

We suggest that ATM protocols follow one of the published THAPCA trial interventions: (a) ATM 32–34°C for 48 hours, followed by gradual rewarming and maintenance at 36–37.5°C until a total of 120 hours, or (b) ATM 36–37.5°C for 120 hours total, as current evidence does not show superiority of either temperature target and there is insufficient evidence to recommend alternative durations (weak recommendation, low certainty evidence).

*Active temperature management (ATM) is defined as intentionally controlling a patient's body temperature to a specific temperature target range using a standardized management protocol. This includes all cooling and warming methods, temperature maintenance duration, pharmacotherapy, and monitoring strategies to achieve and sustain the desired target temperature.

## Justification

The recommendation to use active temperature management (ATM) for children after cardiac arrest is based on very low certainty evidence from three non-randomized observational studies, all in out-of-hospital cardiac arrest (OHCA) populations. These studies suggest a moderate benefit for favorable neurological outcome (OR 1.21, 95% CI 1.05–1.40), but no significant effect on short-term survival (OR 1.06, 95% CI 0.67–1.68). The magnitude of undesirable effects, including fever, arrhythmias, bleeding, and accidental overcooling, is unknown, as adverse events were not systematically reported. The risk of fever in the absence of ATM is a concern, given its association with worse neurological outcomes, but rates were not reported. Implementation of ATM requires moderate to large resources, including ICU-level care, invasive monitoring, and specialized equipment, which may limit feasibility and equity in resource-limited settings. There is variability in values and preferences among families and clinicians, but survival with good neurological outcome is generally prioritized. Overall, the balance of effects probably favors the intervention, but the recommendation remains weak due to low certainty of evidence and resource considerations.
This recommendation is made in tandem with the other EtD table: Should Active temperature management (ATM) 32-34°C vs. ATM 36-37.5°C be used for children post cardiac arrest?

## Subgroup considerations

No subgroup analysis was performed. All patients in the studies evaluated or ATM (any temperature) versus no ATM included children following OHCA only.

## Implementation considerations

Active temperature management protocols require standardized procedures, trained ICU staff, and access to continuous temperature monitoring and cooling devices. Institutions should ensure clear documentation of temperature targets, duration, and management of complications. Resource limitations may affect feasibility, especially in smaller or less-resourced centers. Equity should be considered, as access to ATM may be limited in rural or low-resource settings. Ongoing staff education and protocol review are recommended to optimize delivery and safety

## Monitoring and evaluation

Institutions should monitor key outcomes including survival, neurological status at discharge, and adverse events such as fever, arrhythmias, bleeding, and accidental overcooling. Compliance with ATM protocols, timeliness of initiation, and duration of therapy should be tracked. Data collection should support continuous quality improvement, and regular review of outcomes should inform protocol adjustments. Where possible, participation in multicenter registries or collaborative research is encouraged to enhance benchmarking and contribute to the evidence base.

## Research priorities

- Systematically assess adverse events, including fever rates, arrhythmias, bleeding, and accidental overcooling, in both intervention and control groups.
- Evaluate cost-effectiveness and resource utilization for ATM in diverse healthcare settings.
- Explore family and clinician perspectives on acceptable outcomes and treatment choices.
- Develop and validate risk stratification tools to identify subgroups who may benefit most from ATM.
- Encourage participation in multicenter registries and collaborative research to improve data quality and generalizability

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# APPENDICES

Appendix 1

| Outcomes | Anticipated absolute effects[·] (95% CI) | | Relative effect (95% CI) | Nº of participants (studies) | Certainty of the evidence (GRADE) | Comments |
|---|---|---|---|---|---|---|
| | Risk with No Active Temperature Management | Risk with Comparison of Active Temperature Management (any temperature) | | | | |
| Favorable neurological outcome, non-randomized, adjusted, short term outcome. | Study population | | **OR 1.21** (1.05 to 1.40) | 877 (2 non-randomized studies)[1,2] | ⨁◯◯◯ Very low[a,b,c,d,e,f] | |
| | 182 per 1,000 | **212 per 1,000** (238 to 189) | | | | |
| Survival, non-randomized, adjusted, short-term outcome | Study population | | **OR 1.06** (0.67 to 1.68) | 830 (2 non-randomized studies)[1,3] | ⨁◯◯◯ Very low[a,b,g,h,i] | |
| | 406 per 1,000 | **420 per 1,000** (534 to 314) | | | | |

a. Chang 2016- Hypothermia group had higher proportion of shockable rhythms (23.5% vs. 7.6%, P<0.01)
b. Chang 2016- 13 patients with unknown neurological status excluded
c. Namba 2024- Significant baseline differences between TTM and no-TTM groups: Different primary causes of arrest (P=0.01) Different initial rhythms (26.4% VF/VT in TTM vs. 5.6% in no-TTM, P<0.001) TTM group had shorter time to ROSC (34 vs. 40 minutes, P=0.008) Higher ECMO use in TTM group (17.6% vs. 5.1%, P<0.001)
d. Namba 2024- TTM decision based on clinician judgment, potentially influenced by perceived prognosis
e. Used propensity score only for first to fourth quintiles
f. Chang 2016: Adjusted OR 1.22 (95% CI 0.59-2.51) Namba 2024:adjusted OR (first to fourth quintiles only): 1.21 (95% CI 1.04-1.40), P=0.014

g. Mastsui 2022- Confounding by indication: Significant baseline differences between TTM and non-TTM groups Different first documented rhythms (shockable rhythm higher in TTM group: 51.1% vs. 10.0%) TTM group more likely to have cardiac cause (46.8% vs. 25.8%) Higher ECLS use in TTM group (25.5% vs. 6.7%)
h. Chang 2016: Adjusted OR 1.05 (95% CI 0.59-1.88), P not significant
i. Matsui 2022: IPTW OR 1.07 (95% CI 0.50-2.31), not significant

# Temperature Control After Cardiac Arrest in Children: temperature duration (PLS 4120.03, part 1)

## QUESTION

| Should Active temperature management (ATM) for one duration (e.g. 24 hrs.) vs. ATM for another duration (e.g. 72 hrs.) be used for children after cardiac arrest? | |
|---|---|
| **POPULATION:** | Children after cardiac arrest |
| **INTERVENTION:** | Active temperature management (ATM) for one duration (e.g. 24 hrs.) |
| **COMPARISON:** | ATM for another duration (e.g. 72 hrs.) |
| **MAIN OUTCOMES:** | Favorable neurological outcome, survival |
| **SETTING:** | paediatric critical care environment |
| **PERSPECTIVE:** | The perspectives include those of children and their families, clinicians, and healthcare systems. Families generally prioritize survival with good neurological outcome, but there is variability in values regarding acceptable outcomes, as highlighted by the P-COSCA initiative. Clinicians seek evidence-based strategies to improve outcomes after pediatric cardiac arrest, while healthcare systems must consider resource allocation, feasibility, and equity in access to advanced therapies. |
| **BACKGROUND:** | Cardiac arrest in children is a rare but devastating event, with a significant proportion of survivors experiencing severe neurological injury. Active temperature management (ATM) has been proposed as a neuroprotective strategy, based on evidence from preclinical models and neonatal hypoxic-ischemic injury. However, clinical trials in children have not demonstrated clear superiority of hypothermia over normothermia for survival or neurological outcomes. Both approaches require intensive care resources, and there is ongoing debate regarding optimal temperature targets, implementation strategies, and the impact on long-term outcomes. |
| **CONFLICT OF INTERESTS:** | The following intellectual conflicts of interest have been declared. B Scholefield, A Guerguerian and A Topjian were co-investigators on the THAPCA-IH trial. A Topjian, H Krishnan, and A-M Guerguerian are co-investigators/site PIs in the P-ICECAP study. B Scholefield, A Topjian, H Krishan and A-M Guerguerian will be excluded from study selection, data abstraction and risk of bias assessment. No members of the writing group have any financial conflicts of interest |

## ASSESSMENT

| Problem<br>Is the problem a priority? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | A significant number of pediatric cardiac arrest survivors are left with severe neurologic injury. Active targeted temperature management (ATM) (as part of post-cardiac arrest care), has been shown in pre-clinical models of pediatric cardiac arrest and as part of care after neonatal hypoxic | |

| | | |
|---|---|---|
| | ischemic injury, to improve rates of survival and neurologic outcome by modifying post-cardiac arrest syndrome. Clinical interventions that improve pediatric outcomes from cardiac arrest would be viewed as important and desirable by society. | |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>○ Varies<br>○ Don't know | One pilot RCT was identified to address this question.<br>**Favorable Neurological Outcome:**<br>For the critical outcome of short-term good neurobehavioral survival (at hospital discharge), from 1 RCT (Fink 2017) with 34 children showed no statistical benefit or harm of 24 hours ATM 33°C compared to 72 hours ATM 33°C (RR=0.86, 95% CI 0.36-2.02; ARR= -5.8%, or 58 fewer patients/1000, 95% CI 264 fewer to 420 more patients/1000).<br>**Survival:**<br>For the critical outcome of short-term survival (at hospital discharge), from 1 RCT (Fink 2017) with 34 children showed no statistical benefit or harm of 24 hours ATM 33°C compared to 72 hours ATM 33°C (RR=0.69, 95% CI 0.41-1.16; ARR= -23.7%, or 237 fewer patients/1000, 95% CI 451 fewer to 122 more patients/1000). | One pilot RCT was identified to address this question. An ongoing multi-center RCT, The Pediatric Influence of Cooling Duration on Efficacy in Cardiac Arrest Patients (P-ICECAP) trial (https://www.clinicaltrials.gov/study/NCT05376267) was also identified, but no results have been reported.<br>The taskforce noted the two THAPCA trials (1, 2) used protocolized time-based therapy in both intervention and comparison arms (ATM 32-34C: 48 hours at target temperature, gradual rewarming and maintenance at 36-37.5C until 120 hours total duration of ATM, verses ATM 36-37.5C for 120 hours total duration).<br>A systematic review with a network meta-analysis was also identified (3); however, the task force did not feel the comparison groups of normothermia equated to zero hours of therapy. Therefore, the task force did not use the studies comparing ATM 32-34C for a set duration with a comparison group of ATM 36-37.5C or no temperature control. |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large<br>○ Moderate<br>○ Small<br>● Trivial<br>○ Varies<br>○ Don't know | | A prolonged period of ATM therapy may increase risk of adverse effects or side effects of the therapy. |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | *See Appendix 1* | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | The main outcome for children after cardiac arrest is survival with good neurological function, which is generally considered highly important by families and clinicians. However, the P-COSCA (Pediatric Core Outcome Set for Cardiac Arrest) identified that stakeholders also value outcomes such as: Quality of life, Functional status, and Long-term neurodevelopment. There is considerable variability in values: Some families prioritize any survival, even with severe disability. Others consider survival without meaningful neurological recovery unacceptable. Cultural, social, and individual factors influence these preferences, creating uncertainty about how much weight different families place on neurological outcomes versus survival alone. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>● Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | The point estimate for the one randomized controlled trial primary analysis did not identify a benefit of the intervention over the comparison for the clinically important outcomes. | |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>○ Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>● Don't know | The cost of active temperature management was not assessed in the identified literature. | Delivery of active temperature management within the included study required a high resource environment (e.g. ICU), invasive temperature monitoring and the use of servo-controlled external cooling devices. These would require significant resources to acquire, use and maintain. Increased duration of ATM therapy may be associated with increased cost related to ICU length of stay. |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | True cost of the intervention is unknown. No literature assessing cost was identified. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● No included studies | No studies examined the cost-effectiveness of the intervention compared to the comparison. | Both ATM 32-34°C for 24 hours and ATM 32-34°C for 72 hours require ICU-level care, continuous temperature monitoring, and trained staff. It is unknown if ATM 32-34°C for 72 hours increases nursing workload which would raise costs compared to 24 hours. |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>○ Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>● Don't know | The impact on health equity was not identified in the literature. | Implementation of active temperature management after pediatric cardiac arrest may increase health inequities. Temperature Management protocols require specialized equipment, trained personnel, and intensive monitoring, which are more available in high-resource settings. Hospitals in low-resource or rural areas may lack these capabilities, limiting access for certain populations. This could widen disparities in survival and neurological |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>○ Yes<br>○ Varies<br>● Don't know | No studies directly examined the acceptability of the intervention. | Active temperature management use after cardiac arrest in children has been described in numerous studies. However, recent studies also include a proportion of children after cardiac arrest not receiving active temperature management. |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | ATM is in use in many institutions. This approach requires considerable investment in personnel, training and other resources. Feasible in larger centers with sufficient resources. | |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | **Trivial** | Small | Moderate | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Large | Moderate | Small | **Trivial** | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | **Does not favor either the intervention or the comparison** | Probably favors the intervention | Favors the intervention | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | Negligible costs and savings | Moderate savings | Large savings | Varies | **Don't know** |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | Probably reduced | Probably no impact | Probably increased | Increased | Varies | **Don't know** |
| **ACCEPTABILITY** | No | Probably no | Probably yes | Yes | | Varies | **Don't know** |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | **Conditional recommendation for either the intervention or the comparison** | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ● | ○ | ○ |

## CONCLUSIONS

**Recommendation**

We suggest that ATM protocols follow one of the published THAPCA trial interventions: (a) ATM 32–34°C for 48 hours, followed by gradual rewarming and maintenance at 36–37.5°C until a total of 120 hours, or (b) ATM 36–

37.5°C for 120 hours total, as current evidence does not show superiority of either temperature target and there is insufficient evidence to recommend alternative durations (weak recommendation, low certainty evidence).

## Related recommendation(s)

**1. Should Active temperature management (ATM) 32-34°C vs. ATM 36-37.5°C be used for children post cardiac arrest?**

We recommend using active temperature management* (ATM) for comatose infants and children following OHCA or IHCA (strong recommendation, low certainty evidence).

We recommend using ATM to prevent central temperatures >37.5°C (strong recommendation, low certainty evidence).

*Active temperature management (ATM) is defined as intentionally controlling a patient's body temperature to a specific temperature target range using a standardized management protocol.

## Justification

The recommendation regarding the optimal duration of active temperature management (ATM) for children after cardiac arrest is based on very limited evidence. Only one small pilot randomized controlled trial directly compared 24 hours versus 72 hours of hypothermia and found no statistically significant difference in short-term survival or favorable neurological outcome between the two durations. (4) The certainty of evidence is very low due to the small sample size, methodological limitations, and wide confidence intervals. No studies have assessed longer-term outcomes, cost-effectiveness, or acceptability of different durations. Both approaches require significant ICU resources, and longer durations may increase costs and risk of adverse effects, but these have not been systematically studied. Given the lack of clear benefit or harm and the absence of robust comparative data, there is insufficient evidence to recommend a duration of ATM different from the protocols used in the THAPCA-OH and THAPCA-IH trials. (1, 2) Further research is needed to determine if specific durations confer greater benefit or risk.

## Subgroup considerations

No subgroups were considered.

## Implementation considerations

Implementation of active temperature management for varying durations requires standardized protocols, trained ICU staff, and access to invasive temperature monitoring and servo-controlled cooling devices. Centers should ensure clear documentation of the chosen duration, monitor for complications, and provide ongoing education for clinical teams. Resource limitations may affect the feasibility of longer durations, and institutions should consider local capacity when selecting protocols.

## Monitoring and evaluation

Institutions should routinely monitor clinical outcomes such as survival, neurological status at discharge, and adverse events (e.g., infections, electrolyte disturbances, arrhythmias) associated with different ATM durations. Compliance with protocol, timeliness of initiation, and duration of therapy should be tracked. Data collection should support continuous quality improvement and inform future protocol adjustments.

## Research priorities

- Conduct adequately powered randomized controlled trials comparing different durations of ATM in children after cardiac arrest, focusing on both short- and long-term neurological outcomes and survival.
- Assess the impact of ATM duration on adverse events, ICU length of stay, and resource utilization.
- Evaluate cost-effectiveness and feasibility of various ATM durations in diverse healthcare settings.
- Explore family and clinician perspectives on acceptable durations and outcomes.

- Develop and validate risk stratification tools to identify subgroups who may benefit from specific ATM durations.
- Evaluate effect of duration of ATM in specific subgroups (OHCA, IHCA and those requiring ECLS/ECPR).

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# APPENDICES

Appendix 1

| Outcomes | Anticipated absolute effects[a] (95% CI) | | Relative effect (95% CI) | Nº of participants (studies) | Certainty of the evidence (GRADE) | Comments |
|---|---|---|---|---|---|---|
| | Risk with ATM for another duration (e.g. 72 hrs.) | Risk with ATM for one duration (e.g. 24 hrs.) | | | | |
| Favorable neurological outcome. RCT. Short term outcome | Study population | | **RR 0.86** (0.36 to 2.02) | 34 (1 RCT)[4] | ⨁◯◯◯ Very low[a,b,c,d,e] | |
| | 412 per 1,000 | **354 per 1,000** (832 to 148) | | | | |
| Survival RCT. Short term outcome 24H vs 72H | Study population | | **RR 0.69** (0.41 to 1.16) | 34 (1 RCT)[4] | ⨁◯◯◯ Very low[a,b,c,d,f] | |
| | 765 per 1,000 | **528 per 1,000** (887 to 314) | | | | |

a. very small sample size, pilot study
b. Hypothermia was initiated for clinical reasons prior to the consent process and randomization, this raises concerns about true randomization and selection bias
c. Two children in the 72-hour group did not receive the entire assigned treatment: one was rewarmed after 43 hours and progressed to brain death, another had supportive care withdrawn without rewarming during the treatment period These deviations were not clearly accounted for in the analysis
d. Single study
e. Wide confidence intervals 0.36-2.02
f. Wide confidence interval 0.41-1.16

## Appendix A

## Neonatal Life Support – 2026 Evidence to Decision Tables

# Table of Contents

# Respiratory Function Monitor (RFM) Feeback Devices for Training (NLS 5854)

## QUESTION

| Respiratory function monitor (RFM) feedback during neonatal resuscitation training | |
|---|---|
| **POPULATION:** | Trainees or health care professionals who receive neonatal resuscitation training |
| **INTERVENTION:** | Use of a respiratory function monitoring device (RFM) during simulation training |
| **COMPARISON:** | no use of RFM device during simulation training |
| **MAIN OUTCOMES:** | ***Outcomes:***<br>*Training performance (measured in simulation setting):*<br>• Knowledge at training conclusion, up to 1 year and beyond 1 year (important)<br>• Skill performance at training conclusion, up to 1 year and beyond 1 year (important). Outcomes related to skill performance included mask leak, tidal volume ($V_T$), peak inflation pressure (PIP), ventilation rate, positive end expiratory pressure (PEEP), time to effective ventilation, duration of sustained effective ventilation, and time to identify and correct any problems with positive pressure ventilation (PPV). These outcomes were evaluated at various time points, including during and immediately after the training session, and at various follow-up intervals up to a maximum of three months after the initial training.<br>*Transfer to clinical performance (measured in delivery room (DR) setting):*<br>• Quality of performance in actual resuscitations. (critical)<br>*Clinical outcomes (effectiveness of training in improving clinical outcomes):*<br>• Patient survival (critical)<br>• Respiratory clinical outcomes during PPV in the DR (important)<br>• Time to heart rate ≥ 100 breaths per minute. (important)<br>*Financial outcomes:*<br>• Cost-effectiveness of using RFM in neonatal resuscitation training (important) |
| **SETTING:** | Simulation-based training setting |
| **PERSPECTIVE:** | Training outcomes: the trainee; Clinical outcomes: the patient |
| **BACKGROUND:** | The International Liaison Committee on Resuscitation has identified the need for high-quality randomized trials of training interventions that improve the effectiveness of resuscitation skills. PPV is a critical skill during neonatal life support, that must be performed effectively, to avoid harm from underventilation or overventilation. Mask PPV skills have been found to be poor even after training, indicating the need for better teaching methods and/or technology. [1] RFM can be used to evaluate the effectiveness of face mask PPV. [2-4] RFM is capable of measuring and displaying $V_T$, gas flow, airway pressure, and mask leak in real time. [2-4]<br>This review is complementary to NLS 5360 - Respiratory Function Monitoring for Neonatal Resuscitation – which examined the impact of RFMs during actual resuscitations on clinical outcomes. [5] |
| **CONFLICT OF INTERESTS:** | The following Task Force members and other authors declared an intellectual conflict of interest, and this was acknowledged and managed by the Task Force Chairs and Conflict of Interest committees:<br>• Author Schmölzer has conducted and published articles related to respiratory function monitoring (RFM) during simulation. [2,6-11]<br>• Author Thio has conducted and published studies evaluating RFM in simulation. [3,12]<br>These authors were excluded from participation in decisions about inclusion of studies and risk of bias adjudication for the articles that they have authored. |

## ASSESSMENT

## Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | While most neonates breathe immediately after birth, a proportion require PPV, which can be lifesaving. PPV using a face mask is widely used at birth. Optimal mask PPV is a difficult skill to master. It requires recognition and correction of any gas leak around the mask, recognition of airway obstruction and prevention of under- and over-ventilation. [13,14] Avoiding under- and over-ventilation requires awareness of $V_T$, PIP, and ventilation rate. [1] RFM devices provide real-time direct feedback on these variables, and when used in the setting of simulation-based task training they have the potential to improve trainees' proficiency in PPV. [2-4] This feedback may be particularly valuable during face mask ventilation, because of the specific risks of leak between the mask and the face and of pharyngeal obstruction. Chest rise and fall has been shown to be an unreliable measure of tidal volume. [15,16] | |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>● Moderate<br>○ Large<br>○ Varies<br>○ Don't know | Sixteen studies, including three RCTs [3,6,17], five crossover RCTs [2,7,18-20], two observational studies with crossover designs [21,22] and six other studies [4,12,23-26] were included in the systematic review. All studies were conducted in simulation settings and all examined PPV provided to term or preterm infant mannikins using a face mask, except one which assessed PPV via a tracheal tube. [23]<br>None of the included studies reported on any of the pre-specified critical outcomes namely, quality of performance in actual resuscitations and survival.<br>Outcomes in simulation of the PICOST question were assessed by three types of comparison. Comparison 1 most directly addressed the PICOST question by comparing the use of RFM with a screen visible or concealed. Comparison 2 addressed transfer of skills from training with an RFM to performance without an RFM. Comparison 3 addressed the RFM use as an alternative to feedback from an instructor using an RFM or to enhance team leader feedback in a simulated resuscitation.<br>**Comparison 1. RFM screen visible to the participants in the intervention group and masked in the control group during both training and outcome assessment phase.**<br>Three RCTs [3,6,17], three crossover RCTs [7,19,20], and three non-RCTs [21,22,24] addressed this comparison, although not all of the presented data were suitable for meta-analysis. One study assessed skill retention at follow up. [12]<br>*Face Mask Leak (important)*<br>Evidence from RCTs:<br>The **use of RFM with screen visible** during training **probably reduced the mean percentage of mask leak** (measured as a proportion of inspired $V_T$) when participants were assessed at the completion of training. Mean mask leak was 43.8% | |

in participants when the RFM screen was concealed and absolute risk difference (ARD) was 21% lower (95% confidence intervals (CI) 32% lower to 9% lower) when the RFM screen was visible in 2 RCTs including 499 participants; **moderate certainty evidence**, downgraded for serious inconsistency. [3,6].

Evidence from non-RCTs and cross-over RCTs:

The **use of RFM with screen visible** during training **probably reduced the mean percentage of mask leak** (measured as a proportion of inspired $V_T$). Mean mask leak was 37.2% when the RFM screen was concealed and ARD was 7% lower (95% CI 14% lower to 1% lower) when the RFM screen was visible in 3 non-randomized studies including 108 participants; **moderate certainty evidence**, downgraded for serious imprecision. [7,20,22]

*Tidal volume ($V_T$) (important)*

Evidence from RCTs:

The **use of RFM with screen visible** during training **probably increased the delivered $V_T$** (measured as expiratory $V_T$ in mL). Mean $V_T$ was 18.2 mL when the RFM screen was visible vs 14.9 mL when the screen was concealed, (mean difference (MD) 3.5 mL, 95% CI 2.4 mL higher to 4.6 mL higher) in 1 RCT including 388 participants, **moderate certainty evidence,** downgraded for serious imprecision. [3]

*Peak inflation pressure (PIP) and inflation rate*

In RCTs and non RCTs that reported **PIP** and **inflation rate** there was either little or no difference, and certainty of evidence ranged from very low to moderate. [3,6,7,19,20,22,23,25,26] In one study, the use of RFM with screen visible possibly increased the proportion of inflations delivered to a term manikin using a self-inflating bag within a PIP range of 20-35 cm $H_2O$ (very low certainty evidence). [25]

**Table 1. Improvement in face mask leak and tidal volume with use of an RFM for training.**

| Outcomes (importance) | Participants (studies) | Certainty of evidence (GRADE) | Anticipated absolute effect (95% CI) | |
|---|---|---|---|---|
| | | | Mean* with RFM screen concealed | Mean Difference (95% CI) with RFM screen visible |
| Face mask leak (% of inspired $V_T$) (important) | 499 participants (2 RCTs) [3,6] | Moderate | 43.8% | 21% lower (32% lower to 9% lower) |
| | 318 participants (2 crossover RCTs [7,20] and non RCT [22] | Moderate | 37.2% | 7% lower (14% lower to 1% lower) |
| Tidal volume ($V_T$) (mL or mL/Kg) (important) | 388 participants (1 RCT) [3] | Moderate | N/A | 3.5 mL higher (2.4 mL higher to 4.6 mL higher) |
| | 204 participants (1 crossover RCT) [20] | Moderate | N/A | 1.1 mL higher (0.3 mL lower to 2.5 higher) |
| | 32 participants (1 crossover RCT) [7] | Low | N/A | 1.2 mL/kg** higher (1.3 mL/kg** lower to 3.7 mL/kg higher) |

* Means were calculated from medians reported in studies [27]
** Weights estimated by authors, not actual manikin weights

Effective ventilation (author's definition) was probably achieved earlier and sustained longer, and the time to correct airway assessment (in conditions where gas leak or airway obstruction had been created in a manikin by the investigators) was probably reduced in one RCT including 300 participants [17] (moderate certainty evidence).
Three varied studies with small numbers of participants assessed whether the use of an RFM improved the provision of PPV within an investigator-defined range of safety. [19,21,24] All three suggested improvement (very low certainty evidence).

**Comparison 2. RFM screen masked during a baseline phase, visible to the participants during a training phase, and masked again in the outcome assessment phase. The outcome phase was compared to the baseline phase, to measure transfer of skills to performance when no RFM was available.**

Three single arm (pre- and post-training) studies including a total of 463 participants, [22,25,26] measured this outcome. Two studies assessed skill retention at follow up. [4,23]

*Tidal volume ($V_T$)*

The **use of RFM during training probably improved delivered $V_T$ (or $V_{TE}$)** after training compared to before training, both with RFM concealed (MD 3.7 mL higher, 95% CI 3.1 mL higher to 4.3 mL higher) in one non-RCT including 412 participants; **moderate certainty evidence,** downgraded for serious risk of bias. [26]

For all other outcomes reported, there was either no difference, or the certainty of evidence was very low, or both. [22,23,25,26]

**Table 2. Transfer of skills acquired during training with a visible RFM to condition with concealed RFM**

| Outcomes (importance) | Participants (studies) | Certainty of evidence (GRADE) | Anticipated absolute effect (95% CI) | |
|---|---|---|---|---|
| | | | Mean with RFM screen concealed | Mean Difference (95% CI) with RFM screen visible |
| Face mask leak (% of inspired $V_T$) (important) | 437 participants (2 non-RCTs) [22,26] | Very low | N/A | 17% lower (35% lower to 2% higher) |
| Tidal volume ($V_T$) (mL or mL/Kg) (important) | 412 participants (1 non-RCT) [26] | Moderate | N/A | 3.7 mL higher (3.1 mL higher to 4.3 mL higher) |
| * Means were calculated from medians reported in studies. [27] | | | | |

Four studies assessed whether training with a visible RFM improved the trainees provision of PPV within an investigator-defined range of safety when assessed after training with a concealed RFM. [22,23,25,26] One study utilised an intubated preterm manikin. [23] All four suggested improvement (very low certainty of evidence).

**Skill retention at follow-up:** Two studies addressed this outcome at one month [4] and two months [23] after training. Results suggested that

| | | |
|---|---|---|
| | transfer and retention were not achieved, (very low certainty evidence).<br><br>**Comparison 3. Inclusion of instructor/team leader's feedback**: Two studies addressed this comparison. [2,6] Binder et al. assessed a simulation scenario where manikins received chest compressions. Participants providing face mask ventilation received feedback from either an RFM screen or from a simulated team leader, or both. There was inconclusive evidence of better performance by the participant in response to feedback from a team leader using an RFM (very low certainty evidence). [2]<br>Dvorsky et al recruited novice medical students to electively intubate a manikin in preparation for surgery. [6] The study suggested that verbal feedback from an instructor visualising an RFM may have improved inflations within a predefined target range and reduced mask leak (very low certainty evidence.) | |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large<br>○ Moderate<br>○ Small<br>○ Trivial<br>○ Varies<br>● Don't know | None of the studies were designed to examine adverse outcomes in detail. Such adverse outcomes could include cognitive overload or excessive task load complexity, that might paradoxically lead to reduced retention of knowledge and skills. These concerns might be most important in inexperienced trainees and for those with lower psychological flexibility. [28]<br>One included study suggested that visual attention to the manikin was reduced by using an RFM, and improved by using a complementary LED light indicator for HR and ventilation quality. [19]<br>One study compared two devices, one with coloured graphic display vs another which displayed flow curves. Only the coloured graphic display improved face mask leak [20]<br>The design and location of the RFM device screens and the characteristics of the display varied between the included studies. This may impact on visual attention and cognitive load but it has not been sufficiently studied. | Optimal duration of attention on an RFM display is unknown.<br><br>Devices that depend on user interpretation of waveforms or complex numerical displays may add additional levels of task load complexity. |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | The overall certainty of evidence for the important outcomes was **very low,** although **for a few outcomes the certainty of evidence was moderate.** | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | The Task Force considered that there would be no important uncertainty about the value of the critical outcomes, but no evidence was found for these. The relative importance of each of the specific training knowledge and skill outcomes has not been measured, nor has their relationship to resuscitation performance in clinical settings. However, it is likely that awareness of mask leak and the need to achieve optimal tidal volumes during PPV are key to performance in clinical settings. | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>● Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | There was very low to moderate certainty evidence for improvement and no harms were demonstrated. | |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>● Moderate costs<br>○ Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | The additional cost of implementing RFM in neonatal resuscitation training includes the RFM devices themselves, its accessories and maintenance, leak-free manikins, time & cost to train the trainers on RFM use, and the extended training time for learners.<br>An Australian study reported that the cost of one RFM device ('Juno RFM') was approximately 950 USD (2025 base value) [12] Another study from Tanzania calculated the cost of another RFM device (“AIR”) to be 125 USD [29] | The approximate costs of RFM devices may vary based on device model and setting. |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | No included studies assessed or reported a full estimate of resources. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● No included studies | No included studies reported the cost-effectiveness. | One modelling simulation cost-effectiveness study assessed the implementation of HBB program in Tanzania including the AIR RFM device. [30] However, this study did not model the specific effects of the RFM. |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>○ Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>● Don't know | No studies evaluated effects in equity.<br>There was insufficient data for subgroup analysis by study participants' level of experience. | Most studies have been done in high-income settings. Equity might be increased if RFMs improved clinical performance of face mask PPV in settings where few other options are available. However the cost of the devices may be a barrier in low-resource settings. |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | In one included study, clinicians of all experience levels reported a high level of satisfaction with a training package including an RFM. [12] Participants in a Nepalese study also reported improved confidence in mask ventilation skills after participating in a training package including an RFM. [18] | A study nested within a clinical RCT, reported high user satisfaction with the use of an RFM. [31] |

**Feasibility**

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>○ Yes<br>● Varies<br>○ Don't know | The implementation of RFM in training is theoretically feasible because it has been utilised in studies in both high and low income countries, but its widespread implementation has not been reported. | |

## SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | Small | **Moderate** | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Large | Moderate | Small | Trivial | | Varies | **Don't know** |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | **Probably favors the intervention** | Favors the intervention | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | **Moderate costs** | Negligible costs and savings | Moderate savings | Large savings | Varies | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | Probably reduced | Probably no impact | Probably increased | Increased | Varies | **Don't know** |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | Probably yes | Yes | | **Varies** | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | **Conditional recommendation for the intervention** | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ○ | ● | ○ |

## CONCLUSIONS

### Recommendation

In training health care providers to perform neonatal resuscitation during simulation with manikins, where resources permit, respiratory function monitoring may be used as an adjunct to improve face mask ventilation skills (conditional recommendation, very low certainty of evidence).

### Justification

The moderate certainty evidence for improvement in trainees' awareness and performance in relation to mask leak and tidal volume suggested that utilizing RFMs during training in face mask ventilation can improve training outcomes. However, the overall evidence for transfer of skills, even immediately after training, to providing PPV to a manikin without a visible RFM display and of retention of skills after training was inconclusive and of very low certainty. No studies addressed effects of simulation-based training using an RFM on performance (with or without an RFM) in clinical settings after training, or on patient outcomes. There were also no studies that had comprehensively examined costs, cost benefits or effects on equity. Hence, resource implications may limit adherence to the treatment recommendation.

### Subgroup considerations

There were insufficient data for the following pre-planned subgroup analyses: type of RFM, type of PPV device, manikin type and operator experience.

### Implementation considerations

- Widespread implementation of RFMs in training will require specific training programs designed to make best use of the RFM.
- The training workforce (trainers or trainers-to-be) will also require specific training on RFM, which increases the task complexity for the trainer.
- A training budget will be required which will include not only devices and leak-free manikins, but also any additional training time for both trainers and trainees.

### Monitoring and evaluation

RFM devices allow downloading of data which could potentially be used to monitor the effectiveness of training.

### Research priorities

- The best user-interface and location for display of RFM information
- Whether follow-up with high frequency, short duration reinforcement skill stations using an RFM improve transfer (both to skills without an RFM and to clinical settings) and retention, with or without enhancement by an instructor
- Whether the added cognitive load of having RFM data displayed affects overall operator or team performance during simulation
- Costs and cost-effectiveness of routine use of RFMs in neonatal resuscitation

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# Initial Vascular Access for Neonatal Resuscitation (NLS 5652)

## QUESTION

| Initial vascular access for neonatal resuscitation | |
|---|---|
| **POPULATION:** | Infants requiring emergency vascular access between birth and 28 days of age or 44 weeks postmenstrual age |
| **INTERVENTION:** | Any type of vascular access (umbilical vein, intraosseous, peripheral vein or other) |
| **COMPARISON:** | Any other type of vascular access (umbilical vein, intraosseous, peripheral vein or other) |
| **MAIN OUTCOMES:** | Main outcomes<br>• Time to achieve heart rate >100 bpm (important)<br>• Time required to successfully place the device (important)<br>Additional outcomes<br>• Successful vascular access at the first attempt (important)<br>• Number of attempts until successful vascular access (important)<br>• Complications associated with the procedure (important)<br>• Death during the event requiring emergency vascular access (critical)<br>• Death before hospital discharge (critical)<br>The prioritization of critical and important outcomes was made according to Strand et al. [1] Task force discussion was used for outcomes not included in Strand. |
| **SETTING:** | Birthing area, critical care unit, emergency department, or out-of-hospital environment |
| **PERSPECTIVE:** | Individual patients, their families and providers caring for those patients |
| **BACKGROUND:** | Establishing emergency vascular access for the administration of medications, fluid, or blood products is an important procedure during resuscitation and stabilization of newborn infants with persistent bradycardia that do not respond to assisted ventilation and chest compressions, cardiopulmonary arrest, cardiac arrythmias, and shock. This procedure may be required for infants in the birthing area, critical care unit, emergency department (ED), or out-of-hospital environment. Establishing vascular access can be challenging, especially in the setting of cardiac arrest or altered perfusion. Although few infants will require this intervention [2,3] healthcare professionals in various settings must be proficient at establishing emergency vascular access because delayed administration of resuscitation medications is associated with decreased survival.[4,5] In the first hours after birth, the umbilical vein is usually patent, accessible, and provides direct central access. The duration of umbilical vein patency varies and may not extend throughout the neonatal period. In some clinical scenarios, including infants with periumbilical congenital anomalies, umbilical vein catheterization may not be feasible. Moreover, healthcare professionals without neonatology specialty training may lack confidence and proficiency in umbilical vein catheterization [6].<br>Healthcare professionals working in pre-hospital settings and the emergency department may prefer to insert an intraosseous access device into the medullary cavity of a long bone. [7,8] While this procedure may provide rapid access, serious complications have been described. [8] Peripheral intravenous administration may offer another alternative; however, successful cannulation is more difficult in young children, may delay medication administration, and may not be feasible among infants with cardiovascular collapse. [9,10]<br>The International Liaison Committee on Resuscitation (ILCOR) Neonatal Life Support Task Force (NLS TF) has identified emergency vascular access as a priority for review. The topic was last reviewed in 2020 as part of a larger (nodal) systematic review including adult and pediatric populations (NLS 616). At the time, no neonatal studies were identified to include in the review. In 2024, an evidence update (NLS 652) identified potentially relevant observational studies suggesting that a new systematic review focused on the neonatal population was justified.<br>Although the focus of this PICOST is to make treatment recommendations for emergency vascular access during delivery room resuscitation, the studies included in this systematic |

| | |
|---|---|
| | review extend beyond the delivery room setting. The inclusion criteria for the population, intervention, and comparison are broader than typically included in NLS TF systematic reviews and, therefore, may provide indirect evidence related to delivery room resuscitation. The primary indication for emergency vascular access during the first minutes after birth is to administer epinephrine for treatment of persistent bradycardia or asystole unresponsive to assisted ventilation or chest compressions. This is a rare event and there may be insufficient direct evidence to answer the question for this very narrow population and indication. In making the decision to include a broader population, we recognized that emergency vascular access may be needed during the neonatal period (first 28 days after birth or until 44 weeks postmenstrual age) in multiple settings and for a wide range of indications including volume resuscitation or medications for sepsis, hemorrhage, shock, arrythmias, or congenital heart disease. Emergency vascular access may be inserted outside the hospital by first responders, in the emergency department, or in the neonatal intensive care unit (NICU). We appreciate that the preferred method of vascular access may vary based on the time after birth, location, and indication but suggest that a broader review may be valuable for health care providers that encounter newborn infants in these settings. We have, therefore, included neonates who have any emergency indication in the population for this PICOST, not just resuscitation immediately after birth, recognizing that we may need to use indirect evidence to support recommendations made for emergency vascular access during DR resuscitation. |
| **CONFLICT OF INTERESTS:** | The following Task Force members have no conflicts of interest to declare: Daniele Trevisanuto, Gary M Weiner, Juin Yee Kong, Mandira D Kawakami, Maria Fernanda de Almeida, Marta Thio, Nicole Yamada, Ruth Guinsburg, Tetsuya Isayama, Helen G Liley, Yacov Rabi, Georg M. Schmölzer.<br><br>Dr. Myra Wyckoff is a co-author of studies examining the response to epinephrine administered through an umbilical vein catheter and did not participate in decisions related to inclusion of these studies. [4,11-13] |

## ASSESSMENT

| **Problem**<br>Is the problem a priority? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | Although only 0.1% to 0.8% of newborn infants will receive epinephrine (adrenaline) for resuscitation after birth [3,14], rapidly establishing emergency vascular access is critically important because delayed administration of epinephrine is associated with decreased survival. [4,5] Establishing vascular access can be challenging, especially in the setting of cardiac arrest or altered perfusion. Identifying the most rapid, safe, and effective procedure for establishing vascular access has been prioritized by the ILCOR NLS TF. | Establishing emergency vascular access for the administration of anti-arrhythmic medications, vasopressors, prostaglandin E1, fluids, antibiotics, or blood products may be a lifesaving procedure during resuscitation and stabilization of newborn infants with persistent bradycardia that does not respond to ventilation and chest compressions, cardiopulmonary arrest, cardiac arrythmias, and shock. |
| **Desirable Effects**<br>How substantial are the desirable anticipated effects? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |

| | | |
|---|---|---|
| ○ Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>○ Varies<br>● Don't know | Our review did not find any clinical trials directly comparing one vascular access device with another. Because of the variable and often small number of included infants, heterogeneous settings and indications, and lack of within study comparisons between infants receiving different types of vascular access, no summary effect estimate for desirable effects could be generated. Instead, the results were narratively summarized.<br>The included studies consisted of ten descriptive case series [11,12,15-22] and six case reports.[23-28] In the included case series, both umbilical vein catheters (UVC) inserted in the delivery room and intraosseous (IO) access devices inserted in the ED, NICU, and out-of-hospital settings frequently achieved vascular access in a timeframe consistent with neonatal resuscitation guidelines.<br>The desirable effects of establishing effective emergency vascular access are anticipated to be large, but the evidence is insufficient to compare the efficacy of UVCs with IO access devices, or any other device.<br>Peripheral vein (PIV) access was achieved in a small case series in the delivery room; however, none of the infants included in this series were bradycardic at the time of catheter insertion. [15] In another study, attempts at PIV access were successful in 0/3 newborn infants during resuscitation with chest compressions after birth and in 3/7 neonates <28 days in an out-of-hospital setting. [17] | In a newborn lamb model of asphyxial arrest, epinephrine administered through a low-lying UVC (inserted to a tip position below the porta hepatis) achieved a similar return of spontaneous circulation (ROSC), time to ROSC, and peak plasma epinephrine levels by 1 minute as epinephrine administered directly into the right atrium. [13]<br>In another newborn lamb model of asphyxial arrest, epinephrine administered through an IO needle inserted into the femur achieved ROSC at a similar rate, with a similar number of epinephrine doses, and achieved similar peak plasma epinephrine levels as epinephrine administered into the central venous circulation via a jugular vein catheter. [29] Simulation studies suggest that clinicians with neonatal resuscitation training may achieve emergency vascular access faster using an IO device compared with inserting a low-lying UVC. [30,31] |

**Undesirable Effects**

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>○ Varies<br>● Don't know | Our review did not find any clinical trials directly comparing one vascular access device or route of access with another. Because of the variable and often small numbers of included infants, heterogeneous settings and indications, and lack of within study comparisons between infants receiving different types of vascular access, no summary effect estimate for undesirable effects could be generated. Instead, the results were narratively summarized. We recognize that the reporting of complications associated | Unsuccessful, delayed, or ineffective emergency vascular access during neonatal resuscitation may delay or compromise the success of the resuscitation efforts. Delayed administration of epinephrine for bradycardia or asystolic newborn infants after birth is associated with a decreased probability of ROSC. [4]<br>Although no studies described complications specifically associated with emergency UVC insertion, accessing the central venous circulation with a UVC for routine administration of |

| | | |
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| | with emergency vascular access devices in case series and case reports is subject to publication bias and confounding by indication.<br>We did not identify studies describing complications associated with emergency UVC insertion. One study described gangrene of the buttocks following attempted umbilical vein needle puncture for epinephrine administration. [24] Severe complications associated with IO device insertion have been described including tibial fractures, compartment syndrome, severe soft tissue necrosis, osteomyelitis, soft tissue infection, and limb amputation. [16,19-21,23,25-28] In the largest case series, IO access was associated with a 35% (55/155) risk of all complications and a 6% (9/155) risk of serious complications. [21]<br>The undesirable effects of unsuccessful, delayed, or ineffective emergency vascular access are anticipated to be large, but the evidence is insufficient to compare the safety of the UVC with the IO access device.<br>No complications were reported with the insertion of a PIV in the delivery room; however, none of the included infants in the small case series were in cardiac arrest or bradycardic at the time of PIV insertion. [15] | parenteral nutrition, medications, blood products, and fluids is associated with complications including thrombosis, vessel perforation, arrhythmia, hepatic injury, and bloodstream infection. [32-34]<br>Insertion of an IO access device requires penetrating the infant's skin and bone cortex. Insertion of a UVC may require transection of the umbilical cord, with a risk of bleeding, but does not require puncture of the infant's skin or other structure.<br>Cadaver studies suggest that correct positioning of the IO access device within the bone marrow cavity may be difficult to achieve with a commercially available IO needles whether inserted by hand-twisting or using a semi-automatic drill, particularly among very-low birthweight infants. [35,36] Successful placement in the bone marrow cavity was < 50% for a commercially available access device (43% hand twisted, 40% drill inserted) and 61% using a butterfly needle. Among preterm and term stillborn infants (median 29.2 weeks, IQR 27.2-38.4 weeks), the median diameter of the bone marrow cavity was only 4.0 mm (IQR 3.3-4.7).<br>An ultrasound study suggested that insertion of an IO needle in the proximal tibia of both term and preterm infants would frequently violate the study authors' pre-defined safe distance (10 mm) from the tibial growth plate. [37] |
| **Certainty of evidence**<br>What is the overall certainty of the evidence of effects? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies? | The overall certainty of the evidence was very low due to the absence of studies directly comparing the different intravascular access devices. The evidence is limited to case series and case reports. | No clinical trials directly comparing one vascular access device with another were found. The included studies consist of ten descriptive case series and six case reports. |
| **Values**<br>Is there important uncertainty about or variability in how much people value the main outcomes? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Important uncertainty or | The evaluation of the main outcomes is consistent with the importance assigned by | |

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|---|---|---|
| variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | the ILCOR NLS Task Force and a larger group of neonatal resuscitation experts. [1] | |

**Balance of effects**

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>● Varies<br>○ Don't know | There are no human clinical trials to directly compare the safety and efficacy of the UVC, IO device, and PIV for emergency vascular access during neonatal resuscitation. | Given the accessibility of the umbilical vein immediately after birth without the need to puncture the infant's skin or bone cortex, it is reasonable to assume that the balance of effects favors a low-lying UVC for emergency vascular access in the delivery room. If the umbilical vein is no longer patent, or UVC insertion is not feasible, it is reasonable to assume that the balance of effects favors insertion of an IO access device.<br>There is insufficient evidence to evaluate the balance of effects for the use of a PIV for emergency vascular access in the setting of neonatal cardiac arrest or bradycardia. In the setting of cardiovascular collapse, it is reasonable to assume that it may be difficult to insert a PIV. |

**Resources required**

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>○ Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>● Don't know | There are no published data on the resources required to train clinicians or to use the different vascular access devices during neonatal resuscitation. | The cost of purchasing and maintaining IO access devices that require dedicated equipment (needles and/or drills) that would be used infrequently may be higher than a UVC or PIV because these devices, and the necessary supplies, are already routinely used in many newborn infant care settings. However, sterile UV catheters are also expensive and may not be routinely available in low-resource settings or alternate locations where neonates are resuscitated (out-of-hospital settings, emergency departments).<br>Because severe adverse effects have been mainly reported when using intraosseous access devices, further |

| | | |
|---|---|---|
| | | resources may be necessary to care for potential complications. |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | There are no published data on the resources required to train clinicians or to use different vascular access devices during neonatal resuscitation. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention○ Varies<br>● No included studies | No studies reported the cost-effectiveness of the vascular access devices. | The UVC and PIV may be more cost-effective because these devices, and the supplies required to insert them, are already routinely maintained in many newborn infant care settings. Purchasing and maintaining the supplies required to insert an IO device, which would be used infrequently, may be less cost-effective. However, in low-resource settings, neither sterile UVCs nor IO devices may be routinely available. |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced○ Probably reduced<br>○ Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>● Don't know | No studies reported the impact on health equity. | All included studies were from high resource countries, and the findings may not be generalizable to other contexts.<br>In low-resource settings, equipment and personnel trained in advanced vascular access, such as umbilical vein or intraosseous access, are often limited.<br>An intervention that relies on simpler, widely teachable techniques is more likely to improve health equity globally, particularly in settings with the highest burden of critically ill newborns who require emergency vascular access. |

## Acceptability

Is the intervention acceptable to key stakeholders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | No included study evaluated the acceptability of the different vascular devices. | The acceptance of a particular vascular access by different clinicians may be influenced by their experience, clinical setting, and the infant's postmenstrual age.<br>In a survey of clinicians working in German NICUs and special care nurseries, 61% of neonatologists and 53% of non-neonatologists preferred insertion of an emergency UVC compared to an IO access device for DR resuscitation of a term newborn. [6] However, emergency UVC placement was rated very difficult to impossible by 27% of neonatologists and 46% of non-neonatologists. In contrast, non-emergency placement of a UVC in the DR was only rated as very difficult or impossible by 4% of neonatologists and 14% of non-neonatologists. Emergency placement of an IO device in the DR was rated very difficult or impossible by 3% of neonatologists and 6% of non-neonatologists. Respondents cited lack of clinical experience as the primary reason for their hesitation to place either a UVC or IO access device. 50% of participants stated they had never inserted an IO device and 30% had never inserted a UVC.<br>It is reasonable to assume that both UVC and IO devices are acceptable to key stakeholders because they are both recommended in current national and regional neonatal resuscitation guidelines. [38,39] |

| **Feasibility**<br>Is the intervention feasible to implement? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ No<br>○ Probably no<br>○ Probably yes<br>○ Yes<br>● Varies<br>○ Don't know | The included case series demonstrate that UVC and IO insertion are generally feasible, but the feasibility and implementation may vary based on the setting, device availability, provider's training, the patency of the umbilical vein (infant's age, presence of abdominal wall anomalies), and the size of the bone marrow cavity. [11,12,16,18-22] The feasibility of PIV insertion in the setting of cardiovascular compromise could not be established from the included studies. [15,17] | |

## SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **DESIRABLE EFFECTS** | Trivial | Small | Moderate | Large | | Varies | **Don't know** |
| **UNDESIRABLE EFFECTS** | Trivial | Small | Moderate | Large | | Varies | **Don't know** |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | Probably no important uncertainty or variability | **No important uncertainty or variability** | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | **Varies** | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | Negligible costs and savings | Moderate savings | Large savings | Varies | **Don't know** |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **EQUITY** | Reduced | Probably reduced | Probably no impact | Probably increased | Increased | Varies | **Don't know** |
| **ACCEPTABILITY** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | Probably yes | Yes | | **Varies** | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ● | ○ | ○ |

## CONCLUSIONS

### Recommendation

During resuscitation of infants immediately after birth, we suggest inserting an umbilical vein catheter as the primary method to obtain emergency vascular access (conditional recommendation, very low certainty evidence).
During resuscitation of infants immediately after birth, if insertion of an umbilical vein catheter is not successful or not feasible, we suggest that inserting an intraosseous device may be a reasonable alternative to obtain emergency vascular access (conditional recommendation, very low certainty evidence).
After the immediate newborn period, when the umbilical vein is no longer patent, we suggest that inserting an intraosseous device is a reasonable method to obtain emergency vascular access (conditional recommendation, very low certainty evidence).
There is insufficient evidence to make a recommendation on the use of a peripheral vein catheter for emergency vascular access in the setting of neonatal cardiac arrest or bradycardia.

## Justification

In making this recommendation for newborn infants requiring emergency vascular access for neonatal resuscitation and stabilization, the Task Force considered that there were no human clinical studies comparing the different access devices (UVC, IO, PIV), so conclusions are based on case series and case reports. Efficacy, effectiveness, cost, resources, equity, acceptability, and safety of one procedure over another could not be directly assessed due to the small number of included infants, heterogeneity of settings and indications, and lack of comparisons between the devices within the same study. This limited evidence base inevitably increases the subjectivity of the judgements, which were concluded by TF consensus.

In the included case series and case reports, emergency vascular access was successfully established using either a UVC or an IO device in a wide range of settings, including the DR, emergency department, NICU, and out-of-hospital locations. When the umbilical vein is patent, insertion of a UVC does not require puncture of the infant's skin or bone cortex. Serious complications have been associated with the use of IO access devices during neonatal resuscitation. Moreover, neither the equipment nor training required to insert an IO device may be routinely available in the birth setting leading to concerns about feasibility. However, insertion of a UVC may not be successful or feasible if an abdominal wall defect is present, after the immediate newborn period when the umbilical vein is no longer patent, or in settings where the provider does not have the training or equipment to access the umbilical vein. In these circumstances, an IO device may be a reasonable method to secure emergency vascular access. The evidence to assess the efficacy and safety of attempting emergency PIV access during neonatal cardiovascular collapse is too limited to make any recommendation.

## Subgroup considerations

No data for the planned subgroup analyses were available.
The UVC was primarily used during initial birth resuscitation of term and preterm infants in delivery rooms for severe bradycardia or asystole requiring epinephrine and fluids. [11,12,18,22] The IO device was used in both hospital and out-of-hospital settings with a broader mix of indications and providers. It was used mostly within the first week after birth, but the studies included infants up to 44 weeks' postmenstrual age. [16,17,19-21] The lowest gestational age and birthweight reported for UVC insertion was 23 weeks and 750 grams. [11,12,18,22] The lowest gestational age and birthweight reported for IO access was 24 weeks and 515 grams. [16,19,20] Peripheral vein access was reported in two studies. One described infants immediately after birth in the DR and one reported events occurring among infants <28 days of age receiving chest compressions administered by emergency services personnel outside the hospital setting. [15,17] The lowest gestational age and birthweight reported for PIV access was 24 weeks and 630 grams. [15,17]

## Implementation considerations

We anticipate that implementing different methods to secure emergency vascular access into routine clinical practice would require training and cost, and should consider the clinician's experience, the resuscitation setting, and important infant characteristics (size, gestational and postmenstrual age, congenital anomalies). Capable personnel and appropriate equipment and supplies should always be available to establish emergency vascular access during resuscitation and stabilization of newborn infants.

## Monitoring and evaluation

Prospective local and international registries should collect information regarding time to achieve heart rate >100 bpm, time required to successfully insert an emergency vascular access device, successful vascular access at the first attempt, number of attempts until successful vascular access is achieved, and complications associated with the procedure. Death during the event requiring emergency vascular access and before hospital discharge should also be recorded.

The clinical context (during initial birth resuscitation vs. any other indication), resuscitation setting (delivery room, emergency department, NICU, out of hospital event), provider (neonatology trained provider vs. other), population (post-menstrual age and calendar age at the time of device insertion) should be monitored.

## Research priorities

- Prospective local and international registries should collect information on the success and complications associated with emergency vascular access procedures.
- Future studies should compare the different vascular access methods in newborn infants needing resuscitation and stabilization in different settings (delivery ward, emergency department, NICU and out of hospital settings).
- Studies should evaluate the training of healthcare providers in vascular access procedures and the impact on important outcomes.
- Economic studies should measure the cost-effectiveness of the different vascular access procedures in a range of clinical settings, including high- and low-resource settings.

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**Appendix A**
**Education Implementation and Teams – 2026 Evidence to Decision Table**

# Targeted BLS training for likely rescuers of high-risk populations (EIT 6105

## QUESTION

| **Should targeted BLS training of likely rescuers (e.g family or caregivers) vs. no such targeting be used for adults and children at risk of out-of-hospital cardiac arrest (OHCA)?** | |
|---|---|
| **POPULATION:** | adults and children at risk of out-of-hospital cardiac arrest (OHCA) |
| **INTERVENTION:** | targeted BLS training of likely rescuers (e.g family or caregivers) |
| **COMPARISON:** | no such targeting |
| **MAIN OUTCOMES:** | Patient outcomes (Critical)<br>• Survival with favourable neurological outcome at discharge and 30 days<br>• Survival to hospital discharge/30 days<br>• Return of spontaneous circulation<br>• Bystander CPR quality during OHCA (any available CPR metrics)<br>Process outcomes (Critical)<br>• Rates of bystander CPR (subsequent use of skills)<br>• Rates of AED use (subsequent utilisation of skills)<br>• Bystander CPR quality during OHCA (any available CPR metrics)<br>Education outcomes (Important)<br>• CPR quality and AED competency post training completion and within 12 months of training<br>• CPR and AED knowledge post training completion and within 12 months of training<br>• Confidence to perform CPR post training and within 12 months of training<br>• Willingness to perform CPR post training and within 12 months of training<br>• Secondary training of others |
| **SETTING:** | lay person BLS training |
| **CONFLICT OF INTERESTS:** | Kevin Nation is employed by the NZ and Australian Resuscitation Councils |

## ASSESSMENT

| **Problem**<br>Is the problem a priority? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ No<br>○ Probably no<br>○ Probably yes | Out-of-hospital cardiac arrest (OHCA) is a significant cause of death and a high proportion of OHCA occur in the home. Bystander CPR rates are low.[1] | Institutions treating cardiac arrest patients have the opportunity to reach these groups and can |

| | | |
|---|---|---|
| ● Yes<br>○ Varies<br>○ Don't know | This topic was reviewed by ILCOR in 2015 and again in 2022.[2, 3] An earlier systematic review was published in 2016.[1]<br>The 2015 ILCOR review found 32 studies relating to BLS training in likely rescuers of high-risk OHCA groups.[2]<br>The 2021 ILCOR updated search found 12 new studies published since the 2015 review.[3] All the studies used varying methods for BLS training, control groups and assessment of outcomes and were too heterogeneous for meta-analysis for any outcome to be performed.<br>There continues to be insufficient evidence found on trainees' use of BLS skills and OHCA patient outcomes following the training of likely rescuers of patients at high-risk of cardiac arrest. | potentially teach them CPR with low effort. |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>● Moderate<br>○ Large<br>○ Varies<br>○ Don't know | An updated systematic review has been published in 2025.[4] A total of 48 studies (17 new non-randomised studies) were found.<br>We conducted an updated search run on 20 November 2025 and found one additional non-randomised study, of moderate risk of bias.[5]<br>**Subsequent use of BLS skills**<br>For the critical patient outcomes including subsequent use of BLS skills, 17 studies (including 3 RCTs) reported at least one critical outcome, with periods of follow-up ranging from 3 months to 10 years and most studies relied on self-reported outcomes.[6-22] Both the adult (n=919) and pediatric (n=818,) studies often reported significant loss to follow-up with few subsequent OHCA events making the effect of the interventions on patient outcomes unclear. [4]<br>Among the studies examining patient outcomes, there were two large RCTs.[6, 8] The Home Automated External Defibrillator Trial (HAT) randomized 7001 adult patients with acute myocardial infarction to have an AED with BLS training compared to CPR training alone.[8] In this study, with 100% follow-up, 160 OHCAs occurred over a median follow-up of 37 months, but only 58 (36%) arrests were witnessed by trained family members. It is unclear how many received CPR, but 29 (50%) patients had an AED applied. Notably, in this study, there were seven instances of study AEDs being used for individuals not included in the study (e.g. neighbors). There was no difference in mortality between the 2 study groups (n=228/3506 (6.5%) in the control group vs n=222/3495 (6.4%) in the AED group (hazard ratio, 0.97; 95% CI, 0.81 to 1.17; P=0.77) | These groups are likely willing to be trained and are unlikely to have any or recent BLS training.<br><br>They are also unlikely to seek training on their own. |

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| | The largest pediatric RCT, which trained parents of 462 infants discharged from a neonatal intensive care unit, compared three methods of CPR training in addition to a control group with no training.[6] At one year, only 58% were followed up, with parents of these infants reporting 13 OHCA events in the home. All these children were successfully resuscitated (not defined), and all had received CPR training, with no events reported in the control group.<br>We found moderate certainty evidence (downgraded for risk of bias) from one additional non-RCT that surveyed family members of patients with chronic diseases six months after training, 10 individuals (7.1%) had performed CPR.[5] Two cases of CPR were successful (not defined).<br>**CPR Quality and AED competency**<br>For the important educational outcome of CPR Quality and AED competency 19 studies (1 RCT, 18 non-RCTs) were found.[15, 23-39] For non-RCTs the certainty of evidence was upgraded from very low to low for consistency in findings and RCT certainty of evidence remained as moderate, downgraded for risk of bias. Studies that reported an overall quality or competency metric (and not specific measures) generally found improvements post-training. Beyond training completion, 7 non-RCTs reported on CPR quality and AED competency.[10, 23, 31, 35, 40-42] The time points of follow-up varied from 2 months to 1-year after the initial training. Recent studies (2012 – 2020) were able to measure and report on each aspect of CPR skills.[23, 33, 35, 36, 38, 40, 41, 43] Most studies reported an improvement in compression rate/depth or rates being at guidelines standard from baseline skills or immediately post-training. Correct use of an AED was assessed in one study and showed an improvement from baseline immediately after training.[23] One study reported retention over time by comparing skills at different time points, they identified that refresher training resulted in less decay of skills (rate, depth, hand position and recoil) over time compared to once-off training.[35]<br>**CPR and AED knowledge**<br>For the important educational outcomes of CPR and AED knowledge, 13 studies (1 RCT, 12 non-RCTs) were found.[8, 22, 28, 30, 31, 34, 37, 39, 44-48] Knowledge was often reported using a test created by the study authors. Most studies found an increase in knowledge immediately post-training. Only two non-RCTs examined knowledge beyond training completion, one at two months and one at 12 months.[31, 42] The 12-month study examined the impact of reminders to refresh training, and showed CPR knowledge at 12- | |

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| | months was significantly higher in the two intervention groups (audio-visual and audio-visual-practice training with reminders) compared to control (booklet and DVD with no reminders). No initial post-training assessment was done to assess retention over time.[42]<br>**Confidence to perform CPR**<br>For the important outcome of confidence to perform CPR, five non-RCTs with a low certainty of evidence (downgraded for risk of bias, upgraded for consistency) were found.[23, 33, 35-37] All five studies identified increased confidence following any type of CPR training. However, for studies with ongoing follow-up, a decay in confidence over time was identified.[23, 37]<br>We found moderate certainty evidence (downgraded for risk of bias) from one additional non-RCT that surveyed family members of patients with chronic diseases, six months after training, to evaluate their confidence to perform CPR. 43.6% expressed confidence in their ability to perform CPR, 45.7% had moderate confidence, 10.7% lacked confidence.[5]<br>**Willingness to provide CPR**<br>For the important outcome of willingness to provide CPR, moderate certainty of evidence from one RCT and a low certainty of evidence from nine non-RCTs was found.[10, 12, 15, 32, 33, 43, 45, 46, 49, 50] Evidence from the RCT was downgraded to moderate for risk of bias and evidence from non-RCTs was rated as low after being downgraded for risk of bias but upgraded for consistency. Three studies reported a significant increase in willingness to provide CPR after training compared to before training.[12, 33, 49] Willingness based on the relationship to the patient was described in two studies, with lower rates as the example theoretical patient (i.e. imagine the patient was your father) became less “known” to the participant.[10, 49] The method of CPR training was examined in two studies, with one finding slight increases in willingness to perform continuous compression CPR compared to standard CPR, and the other identified traditional “didactic” training to be superior to other forms such as video training.[50]<br>**Secondary training**<br>For the important outcome of secondary training, we found a low certainty of evidence from one RCT (downgraded for risk of bias) and eight non-RCTs (downgraded for risk of bias but upgraded for consistency).[14, 17, 23, 33, 36, 41, 43, 51, 52] These studies describe participants sharing of CPR training and/or teaching materials with others. Of these studies, five reported the proportion of participants providing secondary training with rates varying between 22% to 72%.[23, 33, 36, 41, | |

| | | |
|---|---|---|
| | [42] One study reported 96% of participants had an intention to teach others, but ultimately only 42% of participants did with one patient-spouse pair training multiple peers.[33] | |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large<br>○ Moderate<br>○ Small<br>○ Trivial<br>● Varies<br>○ Don't know | The systematic review conducted this year identified only one study demonstrating retention over time, it identified the need for refresher training. [4] | Previous CoSTRs and systematic review suggested no increase in anxiety after training.[2, 3] Degradation in BLS skills and knowledge is seen in all trained groups without further training. |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Very low<br>○ Low<br>● Moderate<br>○ High<br>○ No included studies | Two of the RCTs were deemed to have a low risk of bias overall, with the remaining two RCTs assessed as critical due to randomisation, missing data and outcome measurement. Most non-RCTs (n = 10) were at serious or critical risk of bias for patient outcomes. For educational outcomes, nine non-RCTs were assessed as having low risk of bias. The remainder (n = 27) ranged from moderate to critical risk of bias, most (n = 19) frequently due to high rates of missing data.[4] The additional study found was assessed as moderate risk of bias downgraded for moderate confounding, selection of participants and outcome measurement.[5] | The variation between studies for methods of training and outcome measurement precluded any meta-analysis. |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or | Initial outcomes were decided and prioritised by the EIT Task Force. Outcomes were applied as determined by the 2025 systematic review.[4] | Critical patient outcomes are survival with favourable neurological outcome. COSCA has confirmed the importance of these outcomes.(53) |

| | | |
|---|---|---|
| variability<br>○ No important uncertainty or variability | | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>● Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ Don't know | Balance of effect favours BLS training in these groups. Higher value is placed on:<br>• the improvements in BLS skills when compared to baseline data or no training groups<br>• the potential benefits of patients receiving early CPR by a family-member or caregiver<br>in the case of OHCA<br>• the willingness of this group to be trained and to use skills if required.<br>• the potential multiplier effect of trainees training others. | BLS training in high-risk groups is already adopted. |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>○ Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>● Varies<br>○ Don't know | Varies.<br>There are a number of resources required to set-up CPR training and refresh BLS skills (e.g. personnel, equipment). These costs are potentially reduced with self-instruction (e.g. CPR-kits self-training). | In one study recommendation by a healthcare professional to attend CPR training was an important contributing factor in prompting persons to participate.<br><br>Encouragement, rational and providing direction or resources to refresh skills during initial training may support BLS skill and knowledge refreshment. |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Very low<br>● Low<br>○ Moderate<br>○ High<br>○ No included studies | No evidence identified. | Self-training kits are now reasonably priced. |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>● Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ No included studies | No evidence was found that examined the cost-effectiveness of this intervention in this group. | |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>○ Probably no impact<br>○ Probably increased<br>○ Increased<br>● Varies<br>○ Don't know | Varies.<br><br>Could be incorporated into existing programs and sites (e.g. cardiac rehabilitation, hospital discharge education, hospital out-patients) to reduce inequality. There are known BLS training inequities –training high-risk groups may help to reduce these inequities. | |

## Acceptability

Is the intervention acceptable to key interest-holders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies | High proportions of eligible participants took up training. Patients, family members and staff generally have positive feedback about the training. | |

| | | |
|---|---|---|
| ○ Don't know | | |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>○ Yes<br>● Varies<br>○ Don't know | Varies.<br><br>Likely to require a local champion until integrated into practice. | Referral to BLS training alone is unlikely to increase training in these groups.<br><br>One study has demonstrated that cardiac rehabilitation is an effective and feasible environment to provide CPR training. Using video self-instruction CPR training kits enabled further training reach to the target population.[33] |

# SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | Small | **Moderate** | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Large | Moderate | Small | Trivial | | **Varies** | Don't know |
| **CERTAINTY OF EVIDENCE** | Very low | Low | **Moderate** | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | **Probably favors the intervention** | Favors the intervention | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | Negligible costs and savings | Moderate savings | Large savings | **Varies** | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | **Low** | Moderate | High | | | No included studies |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor | **Probably favors the intervention** | Favors the intervention | Varies | No included studies |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | either the intervention or the comparison | | | | |
| **EQUITY** | Reduced | Probably reduced | Probably no impact | Probably increased | Increased | **Varies** | Don't know |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | Probably yes | Yes | | **Varies** | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | **Strong recommendation for the intervention** |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ● |

## CONCLUSIONS

### Recommendation

- We recommend BLS training for likely rescuers of adults and children at high-risk of out-of-hospital cardiac arrest (strong recommendation, low-to-moderate certainty of evidence).
- We recommend health care professionals encourage and direct likely rescuers of adults and children at high-risk of cardiac arrest to attend BLS training (ungraded, good practice statement).

### Justification

In making this recommendation, the EIT Task Force placed higher value on:
• the improvements or competency in BLS skills and confidence when compared to baseline data or guideline standards;
• the improvements in confidence to perform BLS;
• the multiplier effect of trained individuals training others.
• the high proportion of OHCA that occur in the home and the potential benefits of patients receiving BLS by a family-member or caregiver in the case of OHCA;
• the willingness of this group to be trained and to use skills if required;
• BLS training doesn't increase anxiety in trainees; and
• that these groups are unlikely to undertake training on their own.
Given these facts we considered it important to recommend that health care professionals encourage and direct these groups to attend BLS training even though they may not take up training.

### Subgroup considerations

The majority of the research is in cardiac patients or high-risk infants.

### Implementation considerations

It is important that opportunity to practice BLS skills is provided with training.

## Monitoring and evaluation

## Research priorities

Research should focus on reporting objective measurements when reporting skill performance and standardised assessment tools when reporting knowledge to allow inter-study comparisons.
Gaps include:

- New methods, such as cardiac arrest registries, are needed to study the long-term impact of on patient outcomes.
- Best methods for training and retraining to achieve high attendance and long term skill retention.
- Whether health care providers suggesting the need for BLS training influences likely rescuers to seek training.
- Strategies to enhance secondary training where those trained educate others.

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**Appendix A**
**First Aid – 2026 Evidence to Decision Tables**

# Table of Contents

**Virtual Opioid Poisoning Education and Naloxone Distribution (OPEND) (FA 7443)**

# QUESTION

| VIRTUAL OPIOID POISONING EDUCATION AND NALOXONE DISTRIBUTION | |
|---|---|
| **POPULATION:** | People at risk of opioid poisoning or likely to witness opioid poisoning or otherwise interested in OPEND program participation. |
| **INTERVENTION:** | Any opioid poisoning education programming with or without naloxone distribution that is conducted entirely at a distance and without in-person interaction between that program personnel and participant. |
| **COMPARISON:** | Any comparison. |
| **MAIN OUTCOMES:** | Any outcomes. |
| **SETTING:** | Worldwide. |
| **PERSPECTIVE:** | As opioid poisoning education and naloxone distribution (OPEND) programs are powerful tools against the opioid poisoning crisis, but are often difficult to access for rural, remote, small, and mid-sized communities, virtual OPEND programs can provide life-saving training to underserved areas. |
| **BACKGROUND:** | The opioid poisoning and drug toxicity crisis is a complex and multi-faceted public health epidemic, with far-reaching population effects.[1] Opioid-related harms can affect people in all communities, ages, and socioeconomic groups.[2] Opioid poisoning education and naloxone distribution (OPEND) programs include education on the effects of opioid poisoning, how to respond to opioid poisoning including naloxone administration, and distribution of naloxone,[3,4] and are a powerful tool against the opioid poisoning crisis. However, there remain issues of access to OPEND, such as stigma and location. During the COVID-19 pandemic, the potential of remote OPEND programs to improve issues of access was demonstrated.<br>While remote programs already existed prior to the pandemic and were shown to be effective in improving knowledge of opioids and opioid poisoning response, they have not been widely implemented as alternatives to conventional in-person OPEND programs.[5] In compiling a cohesive overview of existing remote OPEND programs and their advantages and disadvantages, we aim to support the development of future remote OPEND programs and promote them as effective solutions to the various issues of access surrounding traditional, in-person OPEND programs. |
| **CONFLICT OF INTERESTS:** | None declared. |

# ASSESSMENT

## Problem

Is the problem a priority?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | The opioid poisoning and drug toxicity crisis is a complex and multi-faceted public health epidemic with high fatality rates globally.[1] Opioid poisoning education and naloxone distribution (OPEND) programs can train and equip people to provide intervention, including naloxone administration, in case of opioid poisoning.[3,4] OPEND programs are powerful tools against the opioid poisoning | |

| | | |
|---|---|---|
| | crisis, but are predominantly conducted in person, potentially inhibiting consistent access to those in rural and remote communities, or affected by substance use stigma.[5] Virtual OPEND programs are a potential way to reduce barriers to accessing OPEND.[5] There are no current ILCOR recommendations for virtual OPEND. | |

## Desirable Effects

How substantial are the desirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>○ Varies<br>● Don't know | The scoping review search identified 9,167 studies for screening, of which 117 were selected for full-text screening. Forty-two studies were included in the study: 20 quasi-experimental pre-post design studies, 13 descriptive studies, 6 randomized controlled trials, 2 program evaluations, and 1 non-randomized controlled trial. Appraisal of studies was not done; thus, certainty of the presented evidence is unclear.<br>**Knowledge, confidence, and preparedness to respond**<br>Most studies reported an increase in the outcome of knowledge about opioids, opioid use disorder, opioid poisoning and risks, naloxone, and opioid misuse.[5–27] Berland et al. (2019)[23] noted increased preparedness to intervene in opioid poisoning. Studies also reported increases in confidence in recognizing poisoning and administering naloxone [11,17,18,25,28,29] However, many of the included studies lack longitudinal data, and thus it is not known whether increases in knowledge are sustained. The studies that do discuss knowledge levels at follow-up portray conflicting data, with Adams et al. (2020)[7] showing the knowledge increase from their virtual training sustained at 6-months, but Cerles et al. (2021)[8] showing that knowledge was not sustained at 3-month follow-up, and Bergeria et al. (2019)[19] noting a small decrease in knowledge at the 30-day mark.<br>**Stigma**<br>For the outcome of stigma reduction, several studies saw improvement in attitudes and decreases in stigma around opioid use disorder and opioid poisoning.[7,9,13,15,20,25,30,31] However, results were mixed, with Giordano et al. (2020)[32] noting worsened attitudes regarding opioid poisoning, and Hohmann et al. (2022)[28] and Berland et al. (2019) [14] finding no differences in attitudes toward naloxone, illicit opioid use, or prescribed opioid misuse. | |

## Undesirable Effects

How substantial are the undesirable anticipated effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Trivial<br>○ Small<br>○ Moderate<br>○ Large<br>○ Varies<br>● Don't know | No undesirable effects were reported in the included studies. | |

## Certainty of evidence

What is the overall certainty of the evidence of effects?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | The certainty of evidence was interpreted as very low. No quality appraisal was done on any of the included studies, as the review in question is a scoping review. | |

## Values

Is there important uncertainty about or variability in how much people value the main outcomes?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>○ Probably no important uncertainty or variability<br>● No important uncertainty or variability | There is no important uncertainty or variability in how much people value the reported upon outcomes. However, most studies reported that participants were satisfied or highly satisfied with the virtual trainings and naloxone kit distribution.[5,7,8,10,11,13–15,17–21,23–25,29,33–37] | |

## Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>● Don't know | Due to the uncertainty of evidence, it is difficult to balance the undesirable and desirable effects in favour of the intervention or comparison. | While some prefer in-person OPEND, it is difficult to balance the benefits of the accessibility of virtual programs with qualms about online learning. |

## Resources required

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Large costs<br>○ Moderate costs<br>○Negligible costs and savings<br>● Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | While no studies explicitly discussed the costs of virtual OPEND programs, virtual education programs would likely save on costs, as they would remove the required costs associated with a dedicated space for programming. Additionally, options for asynchronous virtual learning would remove costs associated with instructors. However, programs which offer naloxone distribution will likely experience costs associated with distribution and delivery of naloxone, and medication acquisition. | |

## Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | Studies that mentioned costs associated with naloxone distribution noted it as a potential barrier to obtaining naloxone.[18,38] However, most studies did not explicitly discuss cost. | |

## Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>● Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ No included studies | Although cost effectiveness was not directly discussed in the included studies, OPEND is consistently considered a cost-effective solution against the opioid poisoning crisis.[39–42] The accessibility of virtual programs may encourage more to get trained in OPEND, further improving cost-effectiveness. | |

## Equity

What would be the impact on health equity?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Reduced<br>○ Probably reduced<br>○ Probably no impact<br>● Probably increased<br>○ Increased<br>○ Varies<br>○ Don't know | Those most likely to be impacted by the opioid poisoning crisis are marginalized and vulnerable populations, including people living in rural and remote areas, those experiencing homelessness or living in poverty, incarcerated individuals, and Black, Indigenous, and People of Colour. As such, virtual OPEND likely increases health equity, as it provides a more accessible option against a massive public health crisis.<br>However, very few of the included studies reported on the characteristics listed in the Cochrane checklist for equity, PROGRESS-Plus. As most of the included studies did not report on these variables, it is difficult to conclude whether issues with representativeness occurred, potentially limiting the impacts of these interventions on health equity. | |

## Acceptability

Is the intervention acceptable to key stakeholders?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | Most participants in the included studies were highly satisfied or satisfied and found the trainings acceptable. | |

## Feasibility

Is the intervention feasible to implement?

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes | The included studies did not note any extreme implementation difficulties, other than potential preference for in person training and costs associated with naloxone distribution. Given the likely cost- | |

| | | |
|---|---|---|
| ○ Varies<br>○ Don't know | effectiveness of virtual training, it is likely this intervention is feasible to implement. | |

## SUMMARY OF JUDGEMENTS

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | Small | Moderate | Large | | Varies | **Don't know** |
| **UNDESIRABLE EFFECTS** | Trivial | Small | Moderate | Large | | Varies | **Don't know** |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | Probably no important uncertainty or variability | **No important uncertainty or variability** | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **Don't know** |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | Negligible costs and savings | **Moderate savings** | Large savings | Varies | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | **Very low** | Low | Moderate | High | | | No included studies |
| **COST EFFECTIVENESS** | Favors the comparison | **Probably favors the comparison** | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | No included studies |
| **EQUITY** | Reduced | Probably reduced | Probably no impact | **Probably increased** | Increased | Varies | Don't know |
| **ACCEPTABILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

## TYPE OF RECOMMENDATION

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | **Conditional recommendation for the intervention** | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ○ | ● | ○ |

**CONCLUSIONS**

## CONCLUSIONS

## Recommendation

Virtual and in-person opioid poisoning education and naloxone distribution programs are effective and appropriate for improving knowledge and preparedness on opioid poisoning response, especially when combined with naloxone distribution.
Virtual programs, in particular, can teach opioid poisoning response anywhere there is a need, such as rural and underserved communities, and can provide life-saving education on opioid poisoning response with or without naloxone distribution.

## Justification

This topic was introduced by the FA Task Force as the opioid poisoning and drug toxicity crisis is a complex and multi-faceted public health epidemic. Opioid-related harms can affect people of all communities, ages, and socioeconomic status. Opioid poisoning education and naloxone distribution (OPEND) programs are powerful tools against the opioid poisoning crisis. These programs educate on the effects of opioid poisoning, how to respond to opioid poisoning, and stigma, as well as distribute naloxone. OPEND programs destigmatize and legitimize harm reduction measures and increase understanding of naloxone use in opioid poisoning emergencies. However, there remain several barriers to consistent OPEND program access, such as stigma and program location. Rural, remote, small, and mid-sized communities experiencing the opioid poisoning crisis face unique barriers to treatment and opioid poisoning education, such as stigma due to smaller population, and geographical issues accessing resources due to transportation difficulties, distance, and dispersed population. During the COVID-19 pandemic, health services that were previously only conducted in person were adapted to be conducted remotely and across long distances, demonstrating the potential of remote OPEND programs. While such programs existed pre-pandemic and were shown to be effective in improving knowledge of opioid poisoning response, they have not yet been implemented as alternatives to in-person OPEND programs. The FA Task force aimed to support the development of future remote OPEND programs in compiling an overview of existing remote programs.
In making this recommendation, the FA Task force considered:

- That both in-person and virtual opioid poisoning education are effective and appropriate for improving knowledge and preparedness.
- That in jurisdictions with no existing naloxone distribution program, virtual overdose prevention and response training is still effective in providing education on recognizing and responding to opioid poisoning.
- That the learnings from the included studies are useful wherever there is a need for opioid poisoning response, and that virtual opioid poisoning education and naloxone distribution is able to reach communities which would otherwise be unlikely to receive opioid poisoning education and naloxone distribution.

• In making a weak recommendation, we considered that the adolopment was conducted on a scoping review, and thus, critical appraisal of studies was not completed. However, the included studies were positive on the effects on knowledge, confidence, and preparation of virtual OPEND.

## Subgroup considerations

Subgroup analysis was not possible, as the conducted review was a scoping review.

## Implementation considerations

See above

## Monitoring and evaluation

See above

## Research priorities

- More studies are necessary to address the long-term outcomes of virtual OPEND interventions, particularly the duration of knowledge retention, and the necessity for retraining.
- More controlled studies are required. Additionally, studies with comparisons to in-person training are required.
- Studies that report more explicitly on aspects of equity, as reported in PROGRESS-Plus, as necessary.

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# First Aid Interventions for Caustic Agent Attack (FA 7445)

## QUESTION

| First Aid Interventions for a Caustic Agent Attack in Adults and Children | |
|---|---|
| **POPULATION:** | Adults or children in the out of hospital setting subjected to a caustic agent attack to the skin or eye |
| **INTERVENTION:** | Any intervention immediately available to the trained or untrained first aid provider (e.g. irrigation, cold compression, washing with soap, baking soda) and duration |
| **COMPARISON:** | Any other treatment and duration, or no treatment |
| **MAIN OUTCOMES:** | Any clinical outcomes including pain relief, reduction in pain score, need for analgesia, extent of burn or tissue damage, intervention needed for burn or tissue damage, survival, adverse reaction from use of treatment (e.g. pain, erythema, allergy), and including harm to first aid providers |
| **SETTING:** | Pre-hospital |
| **PERSPECTIVE:** | First Aid providers |
| **BACKGROUND:** | The global incidence of caustic agent attacks is rising, with an estimated 10,000 cases annually worldwide ("Acid Survivors Trust International," 2025). These assaults are typically intended to cause permanent scarring, disfigurement, and long-term disability, and they are associated with profound psychological trauma and socioeconomic hardship (Burd 2010 29; Grundlingh 2017 358; Mannon 2007 159). Data from the United Kingdom highlight the public health significance of these injuries: in an 8-year review of 185 patients, chemical burns represented only about 10% of all burn cases yet were responsible for a disproportionately high share of burn-related mortality. Over a 25-year period, industrial chemical injuries declined, while domestic chemical burns increased, comprising 42% of exposures in the more recent cohort (Hardwicke 2012 383). Data regarding the optimal treatment of caustic attacks is lacking and there is a need for evidence-based guidelines on the topic. |
| **CONFLICT OF INTERESTS:** | None |

**ASSESSMENT**

| **Problem**<br>Is the problem a priority? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | The global incidence of caustic agent attacks, also referred to as chemical assaults, is rising, with an estimated 10,000 cases annually worldwide ("Acid Survivors Trust International," 2025). These assaults are rarely fatal but are typically intended to cause permanent scarring, disfigurement, and long-term disability, and they are frequently associated with profound psychological trauma and socioeconomic hardship (Burd 2010 29; Grundlingh 2017 358; Mannon 2007 159). Data from the United Kingdom highlight the public health significance of these injuries: in an 8-year review of 185 patients, chemical burns represented only about 10% of all burn cases | Caustic attack may disproportionally effect women and may reflect trends in intimate partner violence. |

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| | yet were responsible for a disproportionately high share of burn-related mortality. Over a 25-year period, industrial chemical injuries declined, while domestic chemical burns increased, comprising 42% of exposures in the more recent cohort (Hardwicke 2012 383). Commonly implicated agents include nitric and sulfuric acids, sodium hydroxide, and in some regions, hydrofluoric acid, which is easily accessible through household and industrial cleaning products (Atley 2015 157; Mannan 2006 235; Milton 2010 924).<br><br>1. Acid Survivors Trust International. (2018). Retrieved November 11, 2025, from https://asti.org.uk/<br>2. Burd A, Ahmed K. The acute management of acid assault burns: A pragmatic approach. Indian J Plast Surg. 2010 Jan;43(1):29-33. doi: 10.4103/0970-0358.63952. PMID: 20924446; PMCID: PMC2938618..<br>3. Grundlingh J, Payne J, Hassan T. Attacks with corrosive substances are increasing in UK. BMJ. 2017 Aug 2;358:j3640. doi: 10.1136/bmj.j3640. PMID: 28768634.<br>4. Mannan A, Ghani S, Clarke A, Butler PE. Cases of chemical assault worldwide: a literature review. Burns. 2007 Mar;33(2):149-54. doi: 10.1016/j.burns.2006.05.002. Epub 2006 Nov 13. PMID: 17095164.<br>5. Hardwicke J, Hunter T, Staruch R, Moiemen N. Chemical burns--an historical comparison and review of the literature. Burns. 2012 May;38(3):383-7. doi: 10.1016/j.burns.2011.09.014. Epub 2011 Oct 28. PMID: 22037150.<br>6. Atley K, Ridyard E. Treatment of hydrofluoric acid exposure to the eye. Int J Ophthalmol. 2015 Feb 18;8(1):157-61. doi: 10.3980/j.issn.2222- | |

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| | 3959.2015.01.28. PMID: 25709926; PMCID: PMC4325260.<br>7. Mannan A, Ghani S, Clarke A, White P, Salmanta S, Butler PE. Psychosocial outcomes derived from an acid burned population in Bangladesh, and comparison with Western norms. Burns. 2006 Mar;32(2):235-41. doi: 10.1016/j.burns.2005.08.027. Epub 2006 Jan 31. PMID: 16448773.<br>8. Milton R, Mathieu L, Hall AH, Maibach HI. Chemical assault and skin/eye burns: two representative cases, report from the Acid Survivors Foundation, and literature review. Burns. 2010 Sep;36(6):924-32. doi: 10.1016/j.burns.2009.10.020. Epub 2010 Jan 18. PMID: 20080356. | |
| **Desirable Effects**<br>How substantial are the desirable anticipated effects? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Trivial<br>○ Small<br>● Moderate<br>○ Large<br>○ Varies<br>○ Don't know | A prospective cohort from Das et al. (2015) observational evidence that first aid water irrigation reduces burn depth and subsequent scarring in victims of acid assault (Das 2015 484). Among 126 patients with acid burns, those who received immediate water irrigation (n=93) had significantly lower rates of hypertrophic scarring (11.4% vs 48.5%) with a relative risk of 0.24 (95% CI 0.13–0.47). Water-irrigated patients more frequently presented with superficial or superficial partial-thickness injuries, requiring fewer surgical interventions. A controlled porcine skin model (Matar 2024 1968) demonstrated that water-based decontamination (wet or combined dry-then-wet) performed within 10 seconds of acid exposure improved receptor chamber pH and reduced sulfur content. A case series by Kessel in 2015 describes severe ammonium hydroxide ocular injuries among 13 patients (Kessel 2015 e230). Although saline irrigation was used initially, the authors did not evaluate its effectiveness relative to other treatments. Outcomes appeared primarily driven by initial injury severity; many eyes progressed to evisceration or phthisis. | |

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| | 1. Das KK, Olga L, Peck M, et al. Management of acid burns: experience from Bangladesh. Burns. 2015 May;41(3):484-92. doi: 10.1016/j.burns.2014.08.003.2.<br>2. Kessel L, Lindegaard J, Boberg-Ans G, et al. Assault cases involving ammoniumhydroxide - a series of 19 eye alkali eye injuries. Acta Ophthalmol. 2015 May;93(3):e230-1. doi: 10.1111/aos.12539.<br>3. Matar H, Vuddanda PR, Chilcott RP. Evaluation of emergency skin decontamination protocols in response to an acid attack (vitreolage). Burns. 2024;50(8):1968-1976. doi:10.1016/j.burns.2024.07.003 | |
| **Undesirable Effects**<br>How substantial are the undesirable anticipated effects? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Large<br>○ Moderate<br>○ Small<br>● Trivial<br>○ Varies<br>○ Don't know | A prospective cohort from Das et al. (2015) observational evidence that first aid water irrigation reduces burn depth and subsequent scarring in victims of acid assault (Das 2015 484). Among 126 patients with acid burns, those who received immediate water irrigation (n=93) had significantly lower rates of hypertrophic scarring (11.4% vs 48.5%) with a relative risk of 0.24 (95% CI 0.13–0.47). However, irrigation did not eliminate the risk of scaring. Similarly in a controlled porcine skin model (Matar 2024 1968) early decontamination performed within 10 seconds of acid exposure improved receptor chamber pH and reduced sulfur content. However, delayed irrigation (>30 seconds) resulted in loss of benefit, reflecting the extremely narrow window before irreversible tissue damage occurs. Several case reports and case series (Kadivar 1991 171; Satbir 2025 11; D'Alessandro 2020 e123; Leung 2015 223) document irrigation as either a first aid measure or initial hospital treatment but in these cases irrigation did not fully eliminate the risk of scaring.<br>1. D'Alessandro AD, Sikon JR, Lacy AJ, et al. Vitriolage by | Irrigation appears important in reducing the risk of injury, including scaring, but may not totally remove the risk. Immediate irrigation appears essential as injury can rapidly occur. |

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| | | Sulfuric Acid: Unique Challenges and Considerations in Patient Resuscitation. J Emerg Med. 2020 Oct;59(4):e123-e126. doi: 10.1016/j.jemermed.2020.06.038 .<br>2. Das KK, Olga L, Peck M, et al. Management of acid burns: experience from Bangladesh. Burns. 2015 May;41(3):484-92. doi: 10.1016/j.burns.2014.08.003.<br>3. Kadivar H, Adams SC. Treatment of chemical and biological warfare injuries: insights derived from the 1984 Iraqi attack on Majnoon Island. Mil Med. 1991 Apr;156(4):171-7.<br>4. Leung BC, Burd A. A case of chemical assault in Hong Kong (case report). Int J Surg Case Rep. 2015;10:223-7. doi: 10.1016/j.ijscr.2015.03.059.<br>5. Matar H, Vuddanda PR, Chilcott RP. Evaluation of emergency skin decontamination protocols in response to an acid attack (vitreolage). Burns. 2024;50(8):1968-1976. doi:10.1016/j.burns.2024.07.003<br>6. Satbir SG, Fatimah MJ, Ahmad SH, et al. Unmasking the silent threat: deep tissue impacts of chemical burns – a case report. Burns Open. 2025;11:100412. doi.org/10.1016/j.burnso.2025.100412. | |
| **Certainty of evidence**<br>What is the overall certainty of the evidence of effects? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |

| | | |
|---|---|---|
| ○ Very low<br>● Low<br>○ Moderate<br>○ High<br>○ No included studies | Overall evidence is based on observational cohort studies, case series/reports and animal studies. | |
| **Values**<br>Is there important uncertainty about or variability in how much people value the main outcomes? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>● Probably no important uncertainty or variability<br>○ No important uncertainty or variability | No direct studies available. | Permanent scarring, disfigurement, and long-term disability, is associated with psychological trauma and socioeconomic hardship in these individuals (Burd 2010 29; Grundlingh 2017 358; Mannon 2007 159). It is reasonable to assume that people would value treatments that would limit these morbidities.<br>1. Burd A, Ahmed K. The acute management of acid assault burns: A pragmatic approach. Indian J Plast Surg. 2010 Jan;43(1):29-33. doi: 10.4103/0970-0358.63952. PMID: 20924446; PMCID: PMC2938618.<br>2. Grundlingh J, Payne J, Hassan T. Attacks with corrosive substances are increasing in UK. BMJ. 2017 Aug 2;358:j3640. doi: 10.1136/bmj.j3640. PMID: 28768634.<br>3. Mannan A, Ghani S, Clarke A, White P, Salmanta S, Butler PE. Psychosocial outcomes derived from an acid burned population in Bangladesh, and comparison with Western norms. Burns. 2006 Mar;32(2):235-41. doi: 10.1016/j.burns.2005.08.027. Epub 2006 Jan 31. PMID: 16448773. |
| **Balance of effects**<br>Does the balance between desirable and undesirable effects favor the intervention or the comparison? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>● Favors the intervention<br>○ Varies<br>○ Don't know | No direct evidence is available to compare the desirable and undesirable effects of the intervention. However, immediate irrigation with water or saline appears to result in a decreased severity of chemical burns with no reported side effects. | |

| **Resources required**<br>How large are the resource requirements (costs)? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Large costs<br>○ Moderate costs<br>● Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>○ Varies<br>○ Don't know | No available studies | Water is an available resource in most areas. Typically, this is of negligible cost. There may be some resource limited areas in which water is of higher cost or unavailable. In these areas saline is also an option for irrigation. |

| **Certainty of evidence of required resources**<br>What is the certainty of the evidence of resource requirements (costs)? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | No available studies | |

| **Cost effectiveness**<br>Does the cost-effectiveness of the intervention favor the intervention or the comparison? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |

| | | |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>● Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ No included studies | No available studies | Water and saline would vary in cost and availability by geographical region, with water likely being more readily available than saline in most instances. The cost of water in most areas is likely negligible. Saline may be more available in some hospital settings. |
| **Equity**<br>What would be the impact on health equity? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Reduced<br>○ Probably reduced<br>● Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>○ Don't know | Water is likely the most available decontamination substance worldwide. Some individuals or hospitals may have more access to physiologic solution/normal saline. Evidence pertaining to specialized irrigation solutions (Diphoterine®) is limited coming from a single study, but suggested improved outcomes in ocular alkali injuries (Merle 2005 205). While there may be some benefit of commercial agents, such as Diphoterine®, over other irrigation media in some instances or for some chemicals, these agents may not be readily available to most individuals and recommending such substances may increase health disparities.<br>1. Merle H, Donnio A, Ayeboua L, et al. Alkali ocular burns in Martinique (French West Indies) Evaluation of the use of an amphoteric solution as the rinsing product. Burns. 2005;31(2):205-211. doi:10.1016/j.burns.2004.09.001 | Water is likely the most available decontamination substance worldwide. Recommending water as the primary decontamination solution would likely not impact health equity. |
| **Acceptability**<br>Is the intervention acceptable to key stakeholders? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes | No available studies | Water or saline irrigation are likely all acceptable interventions to key stakeholders. |

| | | |
|---|---|---|
| ○ Varies<br>○ Don't know | | |

| **Feasibility**<br>Is the intervention feasible to implement? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | No available studies | Water is likely to be the least costly and most readily available intervention worldwide. However, water may not always be available in some resource limited settings. In these cases saline is an acceptable alternative for irrigation. |

**SUMMARY OF JUDGEMENTS**

| | JUDGEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | Small | **Moderate** | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Large | Moderate | Small | **Trivial** | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | Very low | **Low** | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability | | | |
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | **Favors the intervention** | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | **Negligible costs and savings** | Moderate savings | Large savings | Varies | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | **Favors the intervention** | Varies | No included studies |
| **EQUITY** | Reduced | Probably reduced | **Probably no impact** | Probably increased | Increased | Varies | Don't know |
| **ACCEPTABILITY** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

**TYPE OF RECOMMENDATION**

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ○ | ● | ○ |

**CONCLUSIONS**

## Good Practice Statement

Following a caustic attack, immediately irrigate the injured person's affected area with copious amounts of water or saline.

## Justification

In making these recommendations, the FA Task Force considered the following:

- This topic was prioritized by the FA Task Force based on the global morbidity that caustic attacks cause throughout the world.
- The Task Force discussed that these is a lack of available evidence-based recommendations for the treatment of caustic attack and acknowledges that the lack of such recommendations may lead to the improper first aid treatment, including decontamination, of the individual.
- Immediate irrigation is of primarily importance. Both human and animal data suggest that immediate irrigation is associated with improved outcomes.
- The Task Force believes that water is likely the most available decontamination substance worldwide. However, some individuals or hospitals may have more access to physiologic solution/normal saline.
- While there may be some benefit of commercial agents, such as Diphoterine®, over other irrigation media in some instances or for some chemicals, these agents may not be readily available to most individuals and recommending such substances may increase health disparities.
- Little data is available regarding the efficacy for removal of contaminated clothing. However, clothing, shoes, and jewelry that are saturated with corrosive substances can retain and continue to deliver the chemical to the skin, deepening tissue injury and extending exposure time. Therefore, contaminated items should be carefully removed as soon as possible, ideally while ensuring that individuals avoid secondary contamination.
- No studies assess the benefit of contact lens removal from the eyes following caustic exposure. However, similar to clothing removal, the prompt removal of contact lenses is expected to decrease the chemical contact with the eye.

**References**


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13. Leung BC, Burd A. A case of chemical assault in Hong Kong (case report). Int J Surg Case Rep. 2015;10:223-7. doi: 10.1016/j.ijscr.2015.03.059.
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16. Merle H, Donnio A, Ayeboua L, et al. Alkali ocular burns in Martinique (French West Indies) Evaluation of the use of an amphoteric solution as the rinsing product. Burns. 2005;31(2):205-211. doi:10.1016/j.burns.2004.09.001

# Single-stage Concussion Scoring Systems in the First Aid Setting (FA 7341)

## QUESTION

| Simple single-stage concussion scoring system(s) in the first aid setting: a scoping review | |
|---|---|
| **POPULATION:** | Adults and children with suspected head injury. |
| **INTERVENTION:** | Use of concussion triage recognition tool. |
| **COMPARISON:** | Use of a standard first aid assessment without a scoring system or triage tool. |
| **MAIN OUTCOMES:** | Any clinical outcomes (detection/recognition outcomes as proxies). |
| **SETTING:** | Out-of-hospital or hospital-based strategies feasible by a provider of first aid. |
| **PERSPECTIVE:** | Adults or children with a mild traumatic brain injury (mTBI). |
| **BACKGROUND:** | In the past ten years, there has been a resurgence globally related to early recognition, management (including removal from activity), and prevention of concussions, led mainly through the sports world. International summary, agreement, and consensus statements related to sport-related concussion have dramatically evolved over the past 20 years and now assist in guiding current clinical practice (Schneider 2022 615) for healthcare providers, but not necessarily for non-trained, non-healthcare providers (i.e., lay responders). Common causes include motor vehicle collisions, falls, sports injuries, and bicycle accidents. Risk factors include drinking alcohol. The mechanism may involve either a direct blow to the head or forces transmitted from elsewhere on the body to the head. Either mechanism may result in neuron dysfunction, as there are increased glucose requirements but insufficient blood supply.<br><br>In June 2023, the *British Journal of Sports Medicine* published The Amsterdam 2022 International Consensus Statement on Concussion in Sport (Patricios 2023 695) (and its associated works), which summarizes published evidence at the conference on concussions in sport. The Concussion in Sport Group revised several concussion assessment tools for healthcare providers (non-lay providers), including the Concussion Recognition Tool-6 (CRT6) and Sport Concussion Assessment Tool-6 (SCAT6, Child SCAT6), as well as a new tool, the Sport Concussion Office Assessment Tool-6 (SCOAT6, Child SCOAT6).<br><br>In situations where a medically trained and licensed healthcare provider is present, any person suspected of having a concussion should be stopped from activity or play and assessed using a standardized approach. Several concussion assessment tools have been developed, and in some settings, these assessment tools are required to manage a concussed person. These standardized measures, acquired from the assessment tools, are intended to reduce the subjectivity encountered by healthcare providers responsible for making rapid and accurate injury assessment and concussion diagnosis decisions. The assessment examination date should be compared to a reliable pre-injury baseline. |
| **CONFLICT OF INTERESTS:** | None declared. |

**ASSESSMENT**

| **Problem**<br>Is the problem a priority? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ No<br>○ Probably no | Concussions are estimated to affect more than 6 out of every 1,000 people each year (Cassidy 2004, 28) and | |

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| ○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | are the most common type of TBI (Cassidy 2004 28; Voss 2015, 32). Annually, there are over 300,000 sports-related TBIs in the United States, with most being concussions and representing between 9%-13% of all high school athletic injuries (Gardner 2019 768).<br><br>Concussions are estimated to affect more than 6 per 1,000 people yearly (Cassidy 2004 28). It is the most common type of TBI. Males and young adults are the most affected. Outcomes are generally good. Another concussion before the symptoms of a prior concussion have resolved is associated with worse outcomes. Repeated concussions may also increase the risk in later life of chronic traumatic encephalopathy, Parkinson's disease and depression, and behavior issues in children (Fujiwara 2014 79) | |
| **Desirable Effects**<br>How substantial are the desirable anticipated effects? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Trivial<br>○ Small<br>● Moderate<br>○ Large<br>○ Varies<br>○ Don't know | A review by Guskiewicz and Broglio (2011 603) emphasized that systematic management of sports-related concussions (SRCs) is essential for athlete safety. They recommend individualized approaches using baseline data and advocate for caution, adhering to the principle "When in doubt, sit them out."<br><br>McCrory et al. (2012 268) highlighted the challenges in diagnosing SRCs, lacking definitive tools, and called for a comprehensive diagnostic framework that includes sideline assessments and observation. Athletes showing clear physical or cognitive signs of injury must be removed from play for evaluation, as symptoms often peak within 24–48 hours and may resolve over days to weeks.<br><br>McLeod and Jhala (2022 40) noted that SRC can arise from various forms of trauma, and recognizing subtle signs is vital, particularly in amateur sports with limited medical access. Immediate removal from play is recommended for any evident signs of concussion, aligning with the principle "If in doubt, sit them out."<br><br>Various guidelines underscore the importance of healthcare professionals in recognizing and managing concussions. Organizations like the European Resuscitation Council (Zideman 2021 270) and ANZCOR (ANZCOR Guidelines 2024) advocate for immediate evaluation and the "recognize, remove, refer" approach, utilizing tools like SCAT5 and CRT5 for screening, but stressing the need for thorough clinical assessments. | |

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| | Three observational studies highlighted innovative tools for managing pediatric concussion. Clarke et al (2020 595) found that the HeadCheck app increased parental awareness of concussion recovery. McDonald et al. (2021 104) reported high follow-up adherence after a triage protocol, while Hall et al (2021 A89) demonstrated a triage screening tool's effectiveness in clinical settings. These studies underscore the need for accessible tools to enhance recognition and management of pediatric concussions. | |
| **Undesirable Effects**<br>How substantial are the undesirable anticipated effects? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Large<br>○ Moderate<br>○ Small<br>● Trivial<br>○ Varies<br>○ Don't know | The undesirable effects are minimal and manageable compared to the high risk of depression and deconditioning associated with prolonged strict rest, but this varies with severity of injury and personal characteristics. | |
| **Certainty of evidence**<br>What is the overall certainty of the evidence of effects? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ● Very low<br>○ Low<br>○ Moderate<br>○ High<br>○ No included studies | This scoping review did not identify any direct evidence for a concussion triage recognition tool that could be used as a one-time scoring system by lay first aid responders with little to no training in out-of-hospital settings. The task force scoping review team found no randomized controlled studies during their initial search that specifically addressed this issue. Additionally, the team highlighted the complex nature of concussion symptoms, which can include memory impairment, attentional deficits, balance disturbances, and headaches. The first aid task force acknowledged that recognizing a concussion is challenging due to its varied symptoms and the absence of a validated triage recognition tool that lay first aid responders can easily use. | |
| **Values**<br>Is there important uncertainty about or variability in how much people value the main outcomes? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Important uncertainty or variability<br>○ Possibly important uncertainty or variability<br>○ Probably no important uncertainty or variability<br>● No important uncertainty or variability | Most of the people would value the use of a single stage concussion triage recognition tool.<br><br>Many people would prefer survival rather than long term brain injury or death. | |
| **Balance of effects**<br>Does the balance between desirable and undesirable effects favor the intervention or the comparison? | | |

| JUDGEMENT | RESEARCH EVIDENCE | ADDITIONAL CONSIDERATIONS |
|---|---|---|
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>○ Probably favors the intervention<br>● Favors the intervention<br>○ Varies<br>○ Don't know | No direct evidence regarding a concussion triage recognition tool that can be used as a one-time scoring tool by lay first aid responders requiring little to no training in the out-of-hospital setting. | |
| **Resources required**<br>How large are the resource requirements (costs)? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Large costs<br>○ Moderate costs<br>○ Negligible costs and savings<br>○ Moderate savings<br>○ Large savings<br>● Varies<br>○ Don't know | To use a single stage concussion triage recognition tool, the cost would focus on education to teach first aid responders to utilizing a three-question screening process.<br>1. Did a potential injury occur?<br>2. Was the mechanism associated with a potential head injury?<br>3. Was there any altered mental status? | Educational efforts must address the importance of initial assessment based on observed mechanisms of injury (or self-reported), overt signs, and self-reported symptoms. Initial examination prioritizes ruling out life-threatening conditions such as severe bleeding or spinal injuries. |
| **Certainty of evidence of required resources**<br>What is the certainty of the evidence of resource requirements (costs)? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Very low<br>○ Low<br>○ Moderate<br>○ High<br>● No included studies | There were no included studies on the costs of the single-stage concussion triage recognition tool in the first aid setting for recognizing concussions. | Human resources and printed materials are the main requirements in educating men about the use of a single-stage concussion triage recognition tool. |
| **Cost effectiveness**<br>Does the cost-effectiveness of the intervention favor the intervention or the comparison? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Favors the comparison<br>○ Probably favors the comparison<br>○ Does not favor either the intervention or the comparison<br>● Probably favors the intervention<br>○ Favors the intervention<br>○ Varies<br>○ No included studies | There were no included studies investigating the cost-effectiveness of the single-stage concussion triage recognition tool in the first aid setting for recognizing concussions. | Considering the benefits of educational interventions to increase the identification of concussions in the first aid setting is likely cost-effective. |

| **Equity**<br>What would be the impact on health equity? | | |
|---|---|---|
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ Reduced<br>● Probably reduced<br>○ Probably no impact<br>○ Probably increased<br>○ Increased<br>○ Varies<br>○ Don't know | An additional requirement of human resources and printed materials for educational would potentially decrease health equity. Requirement of training on the single-stage concussion triage recognition tool in the first aid setting for recognizing concussions would also increase the cost.<br>Characteristics like socioeconomic status, ethnicity, and education level are rarely addressed in studies, leaving gaps in understanding how these factors influence concussion recognition, triage, and outcomes. | |
| **Acceptability**<br>Is the intervention acceptable to key stakeholders? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ No<br>○ Probably no<br>○ Probably yes<br>● Yes<br>○ Varies<br>○ Don't know | Most of the stakeholders would accept the use of a simple, single-stage concussion triage recognition tool in the first aid setting for recognizing concussions, utilizing a three-question screening process.<br>1. Did a potential injury occur?<br>2. Was the mechanism associated with a potential head injury? | |
| **Feasibility**<br>Is the intervention feasible to implement? | | |
| **JUDGEMENT** | **RESEARCH EVIDENCE** | **ADDITIONAL CONSIDERATIONS** |
| ○ No<br>○ Probably no<br>● Probably yes<br>○ Yes<br>○ Varies<br>○ Don't know | No feasibility issues. | |

**SUMMARY OF JUDGEMENTS**

| | **JUDGEMENT** | | | | | | |
|---|---|---|---|---|---|---|---|
| **PROBLEM** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **DESIRABLE EFFECTS** | Trivial | Small | **Moderate** | Large | | Varies | Don't know |
| **UNDESIRABLE EFFECTS** | Large | Moderate | Small | **Trivial** | | Varies | Don't know |
| **CERTAINTY OF EVIDENCE** | **Very low** | Low | Moderate | High | | | No included studies |
| **VALUES** | Important uncertainty or variability | Possibly important uncertainty or variability | Probably no important uncertainty or variability | **No important uncertainty or variability** | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **BALANCE OF EFFECTS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | **Favors the intervention** | Varies | Don't know |
| **RESOURCES REQUIRED** | Large costs | Moderate costs | Negligible costs and savings | Moderate savings | Large savings | **Varies** | Don't know |
| **CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES** | Very low | Low | Moderate | High | | | **No included studies** |
| **COST EFFECTIVENESS** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | **Probably favors the intervention** | Favors the intervention | Varies | No included studies |
| **EQUITY** | Reduced | **Probably reduced** | Probably no impact | Probably increased | Increased | Varies | Don't know |
| **ACCEPTABILITY** | No | Probably no | Probably yes | **Yes** | | Varies | Don't know |
| **FEASIBILITY** | No | Probably no | **Probably yes** | Yes | | Varies | Don't know |

**TYPE OF RECOMMENDATION**

| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | Strong recommendation for the intervention |
|---|---|---|---|---|
| ○ | ○ | ○ | ● | ○ |

**CONCLUSIO**

**Good Practice Statement**

Considering the evidence reviewed and based on the first aid task force consensus of expert opinion, the following good practice statements are made:

When attempting to determine if a concussion has occurred, non-medically trained, non-healthcare providers (i.e., lay first aid responders) may consider utilizing a three-question screening process.

1. Did a potential injury occur?
2. Was the mechanism associated with a potential head injury?
3. Was there any altered mental status?

*If the answer to all three questions is "yes," the existing literature suggests that these individuals be removed from the activity and EMS be **activated, or the patient be referred** to a qualified healthcare professional.*

Since concussion symptoms vary, first aid responders who are unsure if a concussion occurred may consider removing the individual from the activity until **a qualified healthcare professional can evaluate them**.

## Justification

In making this good practice statement, the first aid task force agreed that recognition of a concussion is complicated by its variable symptomatology and the lack of a validated concussion triage recognition tool that can be used as a one-time scoring tool by lay first aid responders. Rather, signs and self-reported symptoms will fall into THINKING AND REMEMBERING, PHYSICAL, EMOTIONAL, and BEHAVIORAL (See Appendix). Symptoms may evolve rapidly (within seconds to minutes) or develop over hours, with acute symptoms such as dizziness and nausea presenting early, while irritability and sleep disturbances emerge later.

The task force agrees that altered mental status (AMS) refers to a significant change in a person's level of consciousness, cognition, or behavior. It can manifest as a range of symptoms, including confusion, disorientation, lethargy, agitation, delirium, difficulty concentrating, slurred speech, and altered sleep patterns.

The task force scoping review team noted the "recognize," "remove," and "refer" approach underscores the need for immediate removal from activity and referral to appropriate medical care when a concussion is suspected.

The task force scoping review team agrees that educational efforts must address the importance of initial assessment based on observed mechanisms of injury (or self-reported), overt signs, and self-reported symptoms. Initial examination prioritizes ruling out life-threatening conditions such as severe bleeding or spinal injuries.

## Subgroup considerations

Characteristics like socioeconomic status, ethnicity, and education level are rarely addressed in studies, leaving gaps in understanding how these factors influence concussion recognition, triage, and outcomes.

## Implementation considerations

Implementation of a single-stage concussion triage recognition tool in patients with suspected concussion requires education of the public and first aid providers with no medical training. The preparedness of using a A one-time scoring tool for lay first aid responders, who require little to no training in the out-of-hospital setting, necessitates funding from stakeholders, especially in institutions with high-risk patients.

## Research priorities

While tools like the HeadCheck app and triage protocols for children exist, more research is needed to validate their effectiveness in diverse pediatric populations and to understand how age-related differences affect concussion symptom presentation and recovery.

While apps like the HeadCheck app show promise, the potential of digital tools, AI, and wearable technology for concussion triage and recognition still needs to be explored.

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