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| Question | |
| **Advanced airway interventions in pediatric cardiac arrest** | |
| **Population:** | Infants (excluding newborns) and children in cardiac arrest |
| **Intervention:** | A specific advanced airway intervention - tracheal intubation (TI) or supraglottic airway (SGA) during cardiac arrest |
| **Comparison:** | A different advanced airway intervention (eg. SGA) or no advanced airway management method [bag-mask ventilation (BMV) only] during cardiac arrest. |
| **Main outcomes:** | Survival with Good Neurologic Function (SGNF); Survival to Hospital Discharge (SHD) |
| **Setting:** | All study settings. Subgroup analysis was performed for (a) OHCA and (b) IHCA settings. |
| **Perspective:** |  |
| **Background:** |  |
| **Conflict of interests:** | nil |

# Assessment

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| Problem Is the problem a priority? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know | Airway management is vital in pediatric resuscitation, especially since respiratory conditions are frequently the primary cause of pediatric cardiac arrest.  Maintaining an open airway and delivering sustained effective ventilations using a bag-mask device can be difficult (even in skilled hands). Advanced airway interventions, such as placement of a supraglottic airway (SGA) or tracheal intubation (TI), may facilitate more effective resuscitation than bag-mask ventilation (BMV) but require more skilled personnel. Also, the time taken to perform the procedure may interfere with other vital components of resuscitation eg. chest compressions.  Potential benefits of advanced airway interventions include more effective ventilation; prevention of aspiration of gastric contents; delivery of continuous as opposed to interrupted chest compressions; and more effective monitoring of CPR effectiveness/ROSC detection via EtCO2.  Potential harms include incorrect tube placement or tube displacement leading to lack of lung ventilation or oxygenation; reduction in CPR quality secondary to prolonged interruption of chest compressions; and hyperventilation leading to respiratory alkalosis, reduced cerebral perfusion, or pneumothorax. | A recent ILCOR PLS task force systematic review (Lavonas, 2019 114) identified that neither tracheal intubation (TI) nor supraglottic airway (SGA) placement were associated with better outcomes than bag-mask ventilation (BMV) in pediatric cardiac arrest. This resulted in a change in treatment recommendation to a preference for the use of BMV rather than TI or SGA in the management of children during cardiac arrest in the out-of-hospital setting.  The current analysis represents an update to the previous systematic review (Lavonas, 2019 114) to explore more recently published studies, in both out-of-hospital and in-hospital arrest settings. |
| Desirable Effects How substantial are the desirable anticipated effects? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know | Overall, based on current evidence the updated systematic review results suggest with low to very low certainty that neither TI-based nor SGA-based interventions are superior to BMV-based resuscitation for cardiac arrest in children for the critically important outcomes of survival to hospital discharge (SHD) and survival to hospital discharge with good neurologic function (SGNF).  Data from 5 propensity- adjusted cohort studies, including 4,093 children with cardiac arrest reported reduced survival with good neurologic outcome associated with the TI intervention (67 fewer survivors per 1,000 resuscitations; CI: 104 fewer to 0 fewer). Data from 2 other cohort studies, including 372 children with cardiac arrest also reported reduced SGNF associated with the TI intervention (131 fewer survivors per 1,000 resuscitations; CI: 212 fewer to 27 fewer).  Data from 4 propensity- adjusted cohort studies, involving 3,123 patients showed no significant difference to SGNF associated with SGA ventilation (33 fewer survivors per 1,000 resuscitations; CI 95%: 56 fewer to 18 more). Data from these 4 propensity-adjusted cohort studies also showed no significant difference to SHD associated with SGA ventilation (14 fewer survivors per 1,000 resuscitations; CI 95%: 58 fewer to 58 more).  Additional very low certainty evidence from two observational studies of 3,085 children found no significant effect on SHD associated with SGA placement (43 fewer survivors per 1,000 treated with SGA; CI 95%: 71 fewer to 31 more). | Although the size of effect from the studies is small, the potential impact on the number of survivors on a global scale, particularly in resource-limited environments, could be large. |
| Undesirable Effects How substantial are the undesirable anticipated effects? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ Don't know | Specific undesirable effects (outside of the lack of SGNF/SHD) were not consistently reported in the studies identified eg. regurgitation/aspiration, difficult airway management, CPR quality measures including compression fraction and interruptions to CPR.  None of these outcomes were proposed *a priori* as important or critical by the PLS Task Force. | There might be specific subgroups where the presumed desired effects do not uphold and where an unidentified benefit of advanced airway management exists. For example, we might think about long distance transportation, prolonged resuscitation situations, with highly experienced airway operators, if advanced airway placement is only attempted in specific situations. |
| Certainty of evidence What is the overall certainty of the evidence of effects? | | |
| Judgement | Research evidence | Additional considerations |
| ● Very low ○ Low ○ Moderate ○ High ○ No included studies | Twenty studies were included in the systematic review. Only 1 study provided clinical trial data. (Gausche 2000 783) This study provided low certainty evidence comparing TI to BMV for the critical outcomes of SGNF and SHD in pediatric cardiac arrest. The remaining 19 studies were all cohort studies and provided very low certainty evidence for the comparisons (TI-BMV, SGA-BMV, TI-SGA) with the critical outcomes described. Five studies provided propensity-adjusted cohort data amenable to meta-analysis. (Andersen 2016 1786) (Hansen 2017 51) (Ohashi-Fukuda 2017 66) (Okubo 2019 175) (Tham 2022 9) Ten other studies provided retrospective cohort data amenable to meta-analysis. (Abe 2012 612) (Aijian 1989 489) (Deasy 2010 1095) (del Castillo 2015 340) (Guay 2004 373) (Handley 2021 14) (Hansen 2020 53) (Pitetti 2002 283) (Sirbaugh 1999 174) Four studies provided retrospective cohort data in adjusted form only, not amenable to meta-analysis.(Fink 2016 121) (Tijssen 2015 1) (LeBastard 2021 191) (Cheng 2021 723327) | Most of the available data has been obtained from registries and an unknown proportion of events labelled as BMV resuscitation may have had failed TI and/or SGA attempts (which would bias against BMV). Conversely, most of the included studies are susceptible to resuscitation-time bias ie. the longer the child is in cardiac arrest, the more likely they will receive interventions but the less likely they will survive (which should bias against TI/SGA). |
| 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 ○ Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ● No important uncertainty or variability | The ILCOR P-COSCA initiative developed a core outcome set specific for pediatric cardiac arrest studies. The design and methods of the initiative included use of a Delphi process to develop consensus on a core domain set. (Topjian 2020 e246)  The P-COSCA outcomes of SGNF and SHD were chosen as critical outcomes for this review and are highly valued.  We have not identified any airway studies that specifically addressed how patients valued the different 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 ● Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know | Acknowledging the very low level of certainty, the current available data suggest that the critical outcomes of SGNF and SHD are not significantly better or worse when resuscitation is performed with either TI or SGA, compared with BMV alone.  Data from 5 propensity- adjusted cohort studies, including 4,093 children with cardiac arrest reported reduced survival with good neurologic outcome associated with the TI intervention (67 fewer survivors per 1,000 resuscitations; CI: 104 fewer to 0 fewer). Data from 2 other cohort studies, including 372 children with cardiac arrest also reported reduced SGNF associated with the TI intervention (131 fewer survivors per 1,000 resuscitations; CI: 212 fewer to 27 fewer).  Separate analyses of studies of IHCA and OHCA produced similar results. However, the body of evidence for IHCA is particularly small (consisting of 1 propensity-matched cohort study and 3 other cohort studies) and provides very low certainty evidence. (Andersen 2016 1786) (del Castillo 2015 340) (Guay 2004 373) (Handley 2021 165) The studies are very heterogenous and showed inconsistent results. | The benefit or harm associated with advanced airway interventions resuscitation is likely to differ depending upon the context. |
| Resources required How large are the resource requirements (costs)?" | | |
| Judgement | Research evidence | Additional considerations |
| ○ Large costs ○ Moderate costs ● Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know | While no studies evaluated this specifically (including cost effectiveness) BMV requires fewer resources because it is and always has been the default technique. | Paediatric advanced airway interventions require a moderate investment in equipment and a significant investment in training, skills maintenance, and quality control programs to be successful. While TI is supported in essentially all hospital settings in the developed world, and a standard component of care for respiratory arrest and in post-ROSC care, advanced life (ALS) support-capable emergency medical services agencies and IHCA teams will need to maintain this capability as well. |
| Certainty of evidence of required resources What is the certainty of the evidence of resource requirements (costs)? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Very low ○ Low ○ Moderate ○ High ● No included studies | No studies regarding resource requirements were included in this systematic review. |  |
| Cost effectiveness Does the cost-effectiveness of the intervention favor the intervention or the comparison? | | |
| Judgement | Research evidence | Additional considerations |
| ○ 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 | Cost effectiveness data was not identified in this systematic review. |  |
| Equity What would be the impact on health equity? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Reduced ○ Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ● Varies ○ Don't know |  | Varies, and is related to acceptability. Advanced airway interventions are currently offered in hospitals and in EMS systems with ALS capability. This varies by country and region.  Paediatric advanced airway interventions require a moderate investment in equipment and a significant investment in training, skills maintenance, and quality control programs to be successful. While TI is supported in essentially all hospital settings in the developed world, and a standard component of care for respiratory arrest and in post-ROSC care, advanced life (ALS) support-capable emergency medical services agencies and IHCA teams will need to maintain this capability as well. |
| Acceptability Is the intervention acceptable to key stakeholders? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes ○ Yes ● Varies ○ Don't know |  | Essentially all hospital resuscitation teams and all ALS-based emergency medical services (EMS) systems already provide advanced airway interventions.  It is uncertain whether the removal of advanced airway capabilities would be acceptable to key stakeholders. Accepted practice based on long-held beliefs (unsupported by data) mean these interventions are considered highly beneficial to perform paediatric advanced life support. Some might believe their local system and skills to differ from the population represented in the included studies.  Also, during the COVID pandemic, many pre-hospital services and hospitals prioritised early intubation to reduce risk of infection with COVID. |
| Feasibility Is the intervention feasible to implement? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes ○ Yes ● Varies ○ Don't know |  | Varies, and is related to acceptability. Advanced airway interventions are currently offered in hospitals and in prehospital services with ALS capability. This varies by country and region. |

# Summary of judgements

|  | **Judgement** | | | | | | |
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| **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

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| 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

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| Recommendation |
| We suggest the use of BMV rather than TI or SGA in the management of children during cardiac arrest in the out-of-hospital setting (weak recommendation, very low certainty evidence).  There is insufficient quality evidence to make a recommendation for or against the use of the BMV compared to TI or SGA for in-hospital cardiac arrest.  The main goal of cardiopulmonary resuscitation is effective ventilation and oxygenation, by whatever means, without compromising quality of chest compressions. We suggest that clinicians consider transitioning to an advanced airway intervention (SGA or TI) when the team has sufficient expertise, resources and equipment to allow TI/SGA placement to occur with minimal interruptions to chest compressions or when BMV is not providing adequate oxygenation/ventilation [Good Practice Statement]. |
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| Justification |
| There is currently no supporting evidence that an advanced airway (supraglottic airway or tracheal intubation) during CPR improves survival or survival with a good neurological outcome after pediatric cardiac arrest in any setting when compared with bag-mask ventilation.  Advanced airway (AAW) interventions, particularly TI, have been long-established components of the advanced life support bundle of care in children. As a result of inherent limitations in their design and data sources, the available studies, though individually well conducted, can provide only very low certainty evidence about whether attempting advanced airway placement prior to ROSC improves resuscitation outcomes.  Most of the available data has been obtained from registries and an unknown proportion of events labelled as BMV resuscitation may have had failed TI and/or SGA attempts (which would bias against BMV). Conversely, most of the included studies are susceptible to resuscitation-time bias ie. the longer the child is in cardiac arrest, the more likely they will receive interventions but the less likely they will survive (which should bias against TI/SGA).  The best available data show no benefit from advanced airway interventions, and some suggested association with harm, for the critical outcome of survival with good neurologic outcome. Effective BMV, TI, and SGA are all difficult skills that require good initial training, retraining, and quality control to be done consistently, safely, and effectively. Pediatric advanced airway programs require a moderate investment in equipment and a significant investment in training, skills maintenance, and quality control programs to be successful. |

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| Subgroup considerations |
| The benefit or harm associated with advanced airway interventions in paediatric resuscitation may differ across settings. Importantly, the available data do not inform the questions of whether better outcomes might be achieved by advanced airway-based strategies in long distance transportation, in prolonged resuscitation situations, with highly experienced airway operators, when advanced airway placement is only attempted when BMV is difficult, etc. The analyzed data are only relevant to advanced airway interventions during CPR and do not pertain to airway management in other critical situations. |

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| Implementation considerations |
| Those needed to be able to perform advanced airway management outside CPR practice might differ from those who would do this as part of advanced CPR.  It is uncertain whether the removal of advanced airway capabilities would be acceptable to key stakeholders. Accepted practice based on long-held beliefs (unsupported by data) mean these interventions are considered highly beneficial to perform pediatric advanced life support. Some might believe their local system and skills to differ from the population represented in the included studies. |

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| Monitoring and evaluation |
| See below |

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| Research priorities |
| Prehospital, ED-based, and in-hospital studies, ideally comparing TI, SGA and BMV with planned subgroup analyses based on patient age and etiology of arrest (trauma vs non-trauma) are ethical, necessary, and critically important to help guide clinicians in making these complex decisions.  Further examination of the benefit of advanced airway interventions in particular settings (including patients with poor pulmonary compliance, long distance transportation) would be helpful.  The efficacy and speed of placement of advanced airway using newer technologies, such as video assisted laryngoscopy (compared to regular laryngoscopy), is not known during resuscitation and would benefit from further studies.  Future studies would benefit from including measures of quality of ventilation (& cardiac metrics), timing of airway intervention, duration of CPR and measures of the training and experience of the clinicians performing the interventions. |

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