Appendix A

Basic Life Support – 2026 Evidence to Decision Tables

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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. Unpublished studies (e.g., conference abstracts, trial protocols), simulation studies, animal studies, studies with an outcome of fatigue or psychological harm, and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. 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. 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. 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. 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] Furthermore, this review excluded fatigue. Although fatigue is significant, the duration and level of discomfort do not meet the definition of harm. 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 Is the problem a priority?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**

○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ 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] 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. 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] 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 ○ Small ○ Moderate ○ Large ● Varies ○ 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] The studies identified were heterogeneous, which did not support a more specific systematic review. 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. 6 studies reported risks associated with electrical exposure, including defibrillation during resuscitation [9,16,21-23]. Two studies reported physical risks associated with attempted resuscitation [1,17]. Three studies that reported risks associated with water exposure, including resuscitation of a drowning victim [10,12,14].	

Undesirable Effects How substantial are the undesirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ 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). 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. 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. 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] Three studies demonstrated direct evidence of rescue-related fatal drowning from attempted rescue in aquatic environments [10,12,14].	
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 ● 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 ○ Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ○ 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 ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention Favors the intervention ○ Varies ● 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 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 ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ● Varies ○ 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 ○ Low ○ Moderate ○ High ● 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 ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	no included studies	

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	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 ○ Probably no ○ Probably yes ○ Yes ● Varies ○ Don't know	Performing standard resuscitation is acceptable to the stakeholders. The risk to rescuers is perceived to be low.	

Feasibility

Is the intervention feasible to implement?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ○ Yes ○ 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. • 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. • 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). • The other authors did not declare any conflicts. • The SAC rep has no COI to disclose on this subject

ASSESSMENT

Problem

Is the problem a priority?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ 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 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. 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). 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). 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 ● Small ○ Moderate ○ Large ○ Varies ○ 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. 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 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 ○ Small ○ Moderate ○ Large ○ Varies ○ 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 ○ Low ○ Moderate ○ High ○ 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 ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ 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 ○ Probably favors the comparison ● Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ○ 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 ○ Probably no ● Probably yes ○ Yes ○ Varies ○ 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 ○ Probably no ● Probably yes ○ Yes ○ Varies ○ 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 ○ Probably no ○ Probably yes ● Yes ○ Varies ○ 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. 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	

	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 ○ Small ● Moderate ○ Large ○ Varies ○ 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. 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. 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. 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. 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 How substantial are the undesirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**

○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ 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 ○ Low ○ Moderate ○ High ○ 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 ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ 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 ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ● Varies ○ 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 ○ Moderate costs ● Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ 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 ● Low ○ Moderate ○ High ○ 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 ○ Probably favors the comparison ● Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ○ 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 ○ Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ● Varies ○ 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 ○ Probably no ● Probably yes ○ Yes ○ Varies ○ 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 ○ Probably no ● Probably yes ○ Yes ○ Varies ○ 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 ○ Probably no ○ Probably yes ● Yes ○ Varies ○ 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. 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. 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. 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 ○ Small ● Moderate ○ Large ○ Varies ○ 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. The magnitude of these changes varies by setting and provider experience but is observed across simulation and physiologic clinical studies. 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 ○ Small ● Moderate ○ Large ○ Varies ○ 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. 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. 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 ○ Low ○ Moderate ○ High ○ 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 ○ Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ● 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 ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ●Varies ○ 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 ○ Moderate costs ● Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ 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 ● Low ○ Moderate ○ High ○ 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 ○ Probably favors the comparison ● Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ○ 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 ○ Probably reduced ● Probably no impact ○ Probably increased ○ Increased ○ Varies ○ 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 ○ Probably no ● Probably yes ○ Yes ○ Varies ○ 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 ○ Probably no ● Probably yes ○ Yes ○ Varies ○ 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.

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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 (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 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. 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. 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]. 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 ○ Probably no ○ Probably yes ● Yes ○ Varies ○ 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. Prior treatment recommendations in adults (2015): *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 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).* *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).* Prior treatment recommendations in children (2015): *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 ○ Small ○ Moderate ○ Large ● Varies	**CHEST COMPRESSION RATE – ADULTS** **Favourable neurological survival at discharge or 30-days:** one RCT and three observational studies **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 **ROSC:** one RCT and nine observational studies **Physiological outcomes:** five observational studies **Other:** one observational study (first shock success in VF) **CHEST COMPRESSION RATE – INFANTS AND CHILDREN** **Favourable neurological survival at discharge or 30-days:** one observational study **Survival to hospital discharge / 30-days / one month:** three observational studies **Survival to 24hrs:** one observational study **ROSC:** two observational studies **Physiological outcomes:** five observational studies **CHEST COMPRESSION DEPTH – ADULTS** **Favourable neurological survival at discharge or 30-days:** one observational study **Survival to hospital discharge / 30-days / one month:** five observational studies **Survival to ED or hospital admission / similar:** one RCT and three observational studies **ROSC:** five observational studies **Physiological outcomes:** three observational studies **Other:** two observational studies (first shock success in VF; CPR-induced injuries) **CHEST COMPRESSION DEPTH – INFANTS AND CHILDREN** **Favourable neurological survival at discharge or 30-days:** two observational studies **Survival to hospital discharge / 30-days / one month:** three observational studies **Survival to 24hrs:** two observational studies **ROSC:** three observational studies **Physiological outcomes:** three observational studies **INTERACTIONS – ADULTS** **Favourable neurological survival at discharge or 30-days:** four observational studies **Survival to hospital discharge / 30-days / one month:** four observational studies **Survival to 24hrs:** one observational study **ROSC:** three observational studies	

	Physiological outcomes: two observational studies **INTERACTIONS – INFANTS AND CHILDREN** **Physiological outcomes:** one observational study 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 ○ Small ○ Moderate ○ Large ○ Varies ○ 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 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 ○ Low ○ Moderate ○ High ○ No included studies	Most evidence on chest compression depth and rate came from observational studies, and results varied. There was no available evidence about recoil/leaning. Evidence in the adult population was mainly in OHCA patients Evidence in the infant and child population was mainly in IHCA patients 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 ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ 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 ○ Probably favors the comparison ● Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ○ 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 ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ● Don't know	Training materials and equipment already exist to measure chest compression depth / rate – costs to amend/reprogram these would likely be small There is likely to be significant research cost to design suitable trial(s) 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 ○ Low ○ Moderate ○ High ● 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 ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	This was not examined.	

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	not applicable	

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ○ Yes ○ Varies ● Don't know	Not applicable	

Feasibility

Is the intervention feasible to implement?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ○ Yes ○ Varies ● Don't know	Not applicable 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.

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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 Return of spontaneous circulation (ROSC) was ranked as an important outcome 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. 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. 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. 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 ○ Probably no ○ Probably yes ● Yes ○ Varies ○ 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 ○ Small ○ Moderate ○ Large ○ Varies ● 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. Survival to hospital discharge with good neurological outcome and survival to hospital discharge 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]). Return of Spontaneous Circulation For the important outcome of ROSC we identified no studies. CPR Quality Metrics 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). 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). 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 ○ Moderate ○ Small ○ Trivial ○ Varies ● Don't know	Both the de Graaf paper and the Clement Derkenne paper did not seem to show any undesirable effects of the Intervention. 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 ○ Low ○ Moderate ○ High ○ 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 ○ Possibly important un certainty or variability ○ Probably no important uncertainty or variability ●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 ○ Probably favors the comparison ○Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● Don't know	Data for critical outcomes is lacking Data for CPR quality metrics looks promising But we do not have trials giving us high certainty of evidence No obvious undesirable effects of the Intervention identified 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 ● Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ 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 ○ Low ○ Moderate ○ High ● 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 ○ Probably favors the comparison Does not ○favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● 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 ● Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ○ Varies ○ 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 ○ Probably no ● Probably yes ○Yes ○ Varies ○ 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 ○ Probably no ● Probably yes ○ Yes ○ Varies ○ 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.

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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 ○ Probably no ○ Probably yes ● Yes ○ Varies ○ 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 ● Small ○ Moderate ○ Large ○ Varies ○ Don't know	**Favourable neurological survival at discharge or 30-days** 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] **Survival to hospital discharge or 30-day survival** 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). **Return of spontaneous circulation (ROSC) and event survival** 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] CPR quality 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] • 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] • 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] • 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] • 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] • 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 ○ Small ○ Moderate ○ Large ○ Varies ○ 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 ○ Low ○ Moderate ○ High ○ 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 ● Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ○ 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 ○ Probably favors the comparison ● Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ○ 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 ○ Moderate costs ● Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ 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 ○ Low ○ Moderate ○ High ● 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 ○ Probably favors the comparison ● Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ○ 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 ○ Probably reduced ● Probably no impact ○ Probably increased ○ Increased ○ Varies ○ 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 ○ Probably no ● Probably yes ○ Yes ○ Varies ○ 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 ○ Probably no ○ Probably yes ● 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 ○ 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 ●	○	○

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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