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Evidence-Based Guideline for Prehospital Airway Management

Jeffrey L. Jarvis[a], Ashish R. Panchal[b], John W. Lyng[c], Nichole Bosson[d], Joelle J. Donofrio-Odmann[e], Darren A. Braude[f], Lorin R. Browne[g], Michael Arinder[h], Scott Bolleter[i], Toni Gross[j], Michael Levy[k], George Lindbeck[b], Lauren M. Maloney[l], Connie J. Mattera[k], Cheng-Teng Wang[m], Remle P. Crowe[n], Christopher B. Gage[o], Eddy S. Lang[p], and J. Matthew Sholl[b]

[a]Office of the Medical Director, Metropolitan Area EMS Authority, Fort Worth, Texas; [b]National Registry of Emergency Medical Technicians, Columbus, Ohio; [c]Emergency Medicine, North Memorial Health Hospital Level 1 trauma center, Minneapolis, Minnesota; [d]EMS, Los Angeles County Department of Health Services, Los Angeles, California; [e]Department of Emergency Medicine, University of California San Diego, La Jolla, California; [f]Department of Emergency Medicine, The University of New Mexico, Albuquerque, New Mexico; [g]Department of Emergency Medicine, Medical College of Wisconsin, Milwaukee, Wisconsin; [h]EMS, Global Medical Response Inc., Greenwood Village, Colorado; [i]EMS, Healthcare Innovation & Sciences Centre, Spring Branch, Texas; [j]Department of Emergency Medicine, LCMC Health, New Orleans, Louisiana; [k]EMS, Anchorage, Arkansas, US; [l]Department of Emergency Medicine, Stony Brook Medicine, Stony Brook, New York; [m]Department of Emergency Medicine, Robert Wood Johnson University Hospital, New Brunswick, New Jersey; [n]Research, ESO Solutions Inc., Austin, Texas; [o]Research, National Registry of Emergency Medical Technicians, Columbus, Ohio; [p]Department of Emergency Medicine, Alberta Health Services, Edmonton, Canada

ABSTRACT

Airway management is a cornerstone of emergency medical care. This project aimed to create evidence-based guidelines based on the systematic review recently conducted by the Agency for Healthcare Research and Quality (AHRQ). A technical expert panel was assembled to review the evidence using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) methodology. The panel made specific recommendations on the different PICO (population, intervention, comparison, outcome) questions reviewed in the AHRQ review and created good practice statements that summarize and operationalize these recommendations. The recommendations address the use of ventilation with bag-valve mask ventilation alone *vs.* supraglottic airways *vs.* endotracheal intubation for adults and children with cardiac arrest, medical emergencies, and trauma. Additional recommendations address the use of video laryngoscopy and drug-assisted airway management. These recommendations, and the associated good practice statements, offer EMS agencies and clinicians an opportunity to review the available evidence and incorporate it into their airway management strategies.

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Introduction

One of the first reported US civilian field endotracheal intubations was performed in the early 1970s by John Moon, a paramedic with Freedom House Ambulance in Pittsburgh (1). Since then, airway management has expanded greatly to become foundational in prehospital emergency medical care. While there is little debate regarding the importance of prehospital airway management, there is less clarity surrounding the optimal approach to maximize patient outcomes and mitigate risk of harm. Many important questions remain about the most effective approaches to prehospital airway management in different patient populations and settings.

To help address the knowledge gaps in best practices for prehospital airway management, the National Highway Traffic Safety Administration (NHTSA) funded the Agency for Healthcare Research and Quality (AHRQ) to perform a systematic review of the available literature comparing approaches to prehospital airway management using structured PICO (population, intervention, comparison, outcome) questions (2). To build on this systematic review, NHTSA separately funded the present work of developing a set of evidence-based guidelines (EBG) and recommendations through a rigorous evidence evaluation strategy (3, 4). The final goal of this work is to generate evidence-based recommendations for airway management in the prehospital setting with good practice statements to facilitate the dissemination and implementation of guideline recommendations.

Methods

A technical expert panel composed of individuals with broad expertise in emergency and EMS medicine, education, research methods, and evidence evaluation was assembled (Table 1). The panel leveraged the established Grading of Recommendations Assessment, Development, and

CONTACT Jeffrey L. Jarvis jjarvis@medstar911.org
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Table 1. Members of the technical expert panel.

Name	Affiliation	Expertise
Michael Arinder	American Ambulance Association	Paramedic, educator
Scott Bolleter	Centre for Emergency Health Sciences	Paramedic, educator, researcher
Nichole Bosson	National Association of EMS Physicians	EM and EMS physician
Darren Braude	National Association of EMS Physicians	EM and EMS physician
Lorin R. Browne	National Association of EMS Physicians	Pediatric EM and EMS physician
Remle Crowe	ESO	Researcher, methodologist
Joelle Donofrio	National Association of EMS Physicians	EM, pediatric, and EMS physician
Toni Gross	National Association of EMS Physicians	EM, pediatric, and EMS physician
Jeff Jarvis*	NEMSQA	EM and EMS physician
Eddy Lang**	National Association of EMS Physicians	EM and EMS physician, researcher, methodologist
Mike Levy	National Association of EMS Physicians	EM and EMS physician
George Lindbeck	National Association of State EMS Officials	EM and EMS physician
John Lyng	National Association of EMS Physicians	EM and EMS physician
Lauren Maloney	National Association of EMS Physicians	EM and EMS physician
Connie Mattera	National Association of EMS Educators	EMS educator
Nick Nudell	The Paramedic Foundation	Paramedic
Ashish R. Panchal**	National Registry of EMTs	EM and EMS physician, researcher, methodologist
Matt Sholl*	National Association of State EMS Officials	EM and EMS physician
Cheng-Teng "Bill" Wang	National EMS Quality Alliance	EM and EMS physician

*Co-principal investigator.
**Project methodologist.

Table 2. Recommendations for airway management during out of hospital cardiac arrest.

	Recommendation	Strength	Certainty of evidence
Adult	*We suggest that either BVM alone or SGA may be used in airway management for adults with OHCA.*	Conditional recommendation	Very low
	We suggest that either ventilation with BVM alone or ETI may be used in airway management for adults with OHCA.	Conditional recommendation	Low
	1. We suggest in favor of SGA over ETI in airway management for adults in OHCA in systems without demonstrated high ETI proficiency.	Conditional recommendation	Low-moderate
	2. We suggest either SGA or ETI may be used in airway management for adults in OHCA in systems with demonstrated high ETI proficiency.		
Pediatric	*We suggest that either BVM or SGA may be used in airway management for pediatric patients with OHCA.*	Conditional recommendation	Very low
	We suggest in favor of ventilation with BVM alone over ETI in airway management for pediatric patients with OHCA.	Conditional recommendation	Low
	We suggest in favor of SGA over ETI in airway management for pediatric patients with OHCA.	Conditional recommendation	Very low

Evaluation (GRADE) methodology with rigorous recommendation development techniques to review the findings of the AHRQ systematic review and generate evidence-based guidelines for airway management in the prehospital setting (4). The detailed methodology, including the summary of findings tables and evidence-to-decision tables, is presented in the companion methods paper (5).

Recommendations and Good Practice Statements

The AHRQ systematic review considered three general domains: indication for airway management, patient age, and device type. The panel generated practice recommendations for each combination of these domains based on the PICO questions and evidence from the AHRQ review. These recommendations were consistent with the GRADE methodology and the process met the seven criteria discussed by the GRADE working group (6).

To aid with implementation into practice, recognizing that these recommendations often work together when making patient care decisions, the panel summarized and operationalized the recommendations for each indication and age group with good practice statements (7) (Appendix A). These good practice statements are written from the perspective of the clinicians, who often only have the patient's age (adult or pediatric) and condition to make decisions on airway and ventilatory management choices [(bag-valve-mask (BVM), supraglottic airway (SGA), or endotracheal intubation (ETI)]. The good practice statements leverage each developed recommendation, anchored in the evidence, to describe the best prehospital airway management approach for each age group and condition. This document focuses on the good practice statements developed in conjunction with the evidence-based recommendations.

In this evidence-based guideline, the panel provides 22 recommendations derived from the AHRQ-reviewed literature using a robust and transparent methodology (Tables 2–5).

Out-of-Hospital Cardiac Arrest

Recommendation 1: We suggest that either ventilation with BVM alone or SGA may be used in airway management for adults with out-of-hospital cardiac arrest (OHCA) (conditional recommendation/very low certainty of evidence)

There is inadequate evidence to support the superiority of either BVM ventilation alone or SGA for airway management in adults with OHCA. Data from three randomized controlled trials (RCT) showed equivalence in survival, and

Table 3. Recommendations for airway management of patients with traumatic injuries.

	Recommendation	Strength	Certainty of evidence
Adult	*We suggest that either BVM alone or SGA may be used in airway management for adults with trauma.*	Conditional recommendation	Very low
	We suggest that either ventilation with BVM alone or ETI may be used in airway management for adults with trauma.	Conditional recommendation	Low
	We suggest that either SGA or ETI may be used in airway management for adults with trauma.	Conditional recommendation	Very low
Pediatric	*We found insufficient evidence to make a recommendation on the use of BVM alone compared with SGA for pediatric patients with trauma.*	No recommendation	
	We suggest that either ventilation with BVM alone or ETI may be used in airway management of pediatric patients with trauma.	Conditional recommendation	Low
	We suggest in favor of SGA over ETI in airway management for pediatric patients with trauma.	Conditional recommendation	Very low

Table 4. Recommendations for airway management of patients with medical emergencies.

	Recommendation	Strength	Certainty of evidence
Adult	*We found insufficient evidence to make a recommendation on the use of BVM alone compared with SGA for adults with medical emergencies.*	No recommendation	
	We found insufficient evidence to make a recommendation on the use of BVM alone compared with ETI for adults with medical emergencies.	No recommendation	
	We suggest that either SGA or ETI may be used in airway management for adults with medical emergencies.	Conditional recommendation	Very low
Pediatric	*We found insufficient evidence to make a recommendation on the use of BVM alone compared with SGA for pediatric patients with medical emergencies.*	No recommendation	
	We found insufficient evidence to make a recommendation on the use of BVM alone compared with ETI for pediatric patients with medical emergencies.	No recommendation	
	We suggest that either SGA or ETI may be used in airway management for pediatric patients with medical emergencies.	Conditional recommendation	Very low

Table 5. Recommendations for airway management of patients using technique modifiers.

Recommendation	Strength	Certainty of evidence
In patients requiring medication-assisted airway management, we suggest rapid sequence induction over no-medication approaches to facilitate airway placement under specific conditions, but only in well-resourced and high-functioning settings.	Conditional recommendation	Very low
In patients requiring medication-assisted airway management, we suggest rapid sequence induction over sedation without paralysis approaches.	Conditional recommendation	Very low
In patients requiring intubation, we chose not to make a recommendation concerning intubation with sedation only compared with the use of no medications due to the particularly uncertain nature of the supporting evidence.	No recommendation	

multiple observational studies showed no difference in rates of return of spontaneous circulation (ROSC) (8–23). Contrary to this, the PART trial, an RCT of SGA vs. ETI, had an as-treated subgroup analysis of BVM ventilation *vs.* SGA that showed improved neurologic function with BVM ventilation (10). This subgroup analysis was limited by baseline differences and indication bias, limiting the ability to generalize the results. As a result, the panel recommends using either BVM ventilation alone or SGA. The panel did, however, recognize that effective BVM ventilations often require more clinicians than effective ventilations with SGA. As a result, resource availability may appropriately influence the decision to use an SGA over BVM ventilation alone.

Recommendation 2: We suggest that either ventilation with BVM alone or SGA may be used in airway management for pediatric patients with OHCA (conditional recommendation/very low certainty of evidence)

There was no convincing evidence for the superiority of either BVM ventilation alone or SGA in pediatric patients with OHCA. The AHRQ systematic review identified two observational studies that reported the outcome of survival with one also reporting on the effect on ROSC and neurologically intact survival (24, 25). No difference was noted for survival or ROSC, but improved neurological function was noted with BVM ventilation (25). However, due to the observational nature of this study, there was a concern for indication bias since patients who achieve ROSC quickly may not have the opportunity for an advanced airway, thus favoring BVM ventilation. Additionally, using an SGA as a rescue device after a failed airway may have favored BVM ventilation. Therefore, the panel could not draw conclusions based on this evidence but did, however, recognize that effective BVM ventilations often require more clinicians than effective ventilations with SGA. As a result, resource availability may appropriately influence the decision to use an SGA over BVM ventilation.

Recommendation 3: We suggest that either ventilation with BVM alone or ETI may be used in airway management for adults with OHCA (conditional recommendation/low certainty of evidence)

There was no clear evidence favoring ventilation with either BVM alone or ETI in adult OHCA. One RCT of prehospital arrests directly compared BVM ventilation with ETI in a non-inferiority study and failed to show superiority (or non-inferiority) of either strategy in ROSC, survival at 28 days, or neurologically intact survival (26). A sub-group analysis of the PART trial analyzed patients treated with only BVM ventilation compared to ETI or SGA and found improved functional survival with BVM ventilation, but was limited by indication bias (27). Other studies were mixed, with some showing no difference in survival and others, with a strong concern for indication bias, showing improved survival with BVM ventilation (10, 11, 13–15, 17–22, 28–30). Because of the lack of direct evidence and concerns for indication bias, the panel believes that either ventilation with BVM alone or ETI might be appropriate airway management depending on the arrest circumstances and EMS system resources.

Recommendation 4: We suggest in favor of ventilation with BVM alone over ETI in airway management for pediatric patients with OHCA (conditional recommendation/low certainty of evidence).

An RCT comparing BVM ventilation alone to ETI use for pediatric airway management in various indications demonstrated no clear evidence for improved survival, neurological function, or ROSC for either technique in any subgroup (31). In contrast, registry-based observational studies demonstrated improved survival and neurological function with BVM ventilation over ETI (24, 25). As with other comparisons, these observational data are limited by indication bias, making it difficult to form conclusions from these results.

The panel favored ventilation with BVM alone over ETI for several reasons. First, the panel recognized that a limitation in the evidence is that pediatric patients were treated as one group, regardless of age, when considering airway management approaches. The differences in airway anatomy by age in pediatric patients are dramatic and likely affect procedural success. The panel was also influenced by evidence of lower ETI success rates in pediatric patients and the association between failed intubation and adverse outcomes (32, 33). Given these factors, if ventilation with BVM works well, there may be no need to progress to ETI, where risks may be more significant for the patient.

The panel also recognized that having access to laryngoscopes, even if not used for primary intubation of pediatric patients, may be necessary for other indications, such as foreign body removal.

Ultimately, EMS agencies and medical directors considering ETI in pediatric patient care guidelines should carefully consider their ability to provide robust training and quality assurance programs and adequate patient contacts to provide the opportunity for optimum success.

Recommendation 5A: We suggest in favor of SGA over ETI in airway management for adults in OHCA in systems without demonstrated high ETI proficiency. (Conditional recommendation/low-moderate certainty of evidence)

Recommendation 5B: We suggest either SGA or ETI may be used in airway management for adults in OHCA in systems with demonstrated high ETI proficiency. (Conditional recommendation/low-moderate certainty of evidence)

Three RCTs included in the AHRQ systematic review directly compare survival from OHCA between SGA and ETI (10, 34, 35). Each compared ETI to a different type of SGA (Combitube, King-LT, and i-Gel, respectively) and had contrasting results. Rabitsch and Benger found no difference in survival, while Wang found a slight survival advantage with SGA. The pooled results of these trials showed no difference. Low ETI success rates limited each trial, and there is evidence that additional intubation attempts in OHCA are associated with worse survival (32). Pooled RCT results showed no difference in survival between SGA and ETI with moderate certainty of evidence. Four observational trials with similar findings support these pooled results (13, 17, 19, 20).

When making these recommendations, the panel recognized that though the evidence above shows equivalence, the ease of use of SGA devices and chest compression interruptions often seen with ETI justify the conditional recommendation in agencies without demonstrated high ETI proficiency.

Recommendation 6: We suggest in favor of SGA over ETI in airway management for pediatric patients with OHCA (conditional recommendation/very low certainty of evidence).

There was no patient-oriented evidence favoring SGA or ETI for pediatric patients with OHCA. A pooled analysis of three observational trials showed no difference in ROSC, neurological outcome, and survival rates between SGA and ETI (24, 25, 36). However, there was evidence from two observational studies that demonstrated greater first-pass success with SGA *vs.* ETI (24, 32). No RCTs compared first-pass success rates between SGA and ETI in pediatric patients.

Following the evaluation and discussion of this evidence, the panel favored SGA over ETI for pediatric OHCA for several reasons. First, since data per age subgroups are unavailable, the pooled analyses evaluated here may miss the challenges, and potentially the clinical effects, associated with ETI in younger children. Additionally, the panel favored SGA over ETI due to the higher first-pass success rates and the lower potential training burden of SGA. The panel believes this approach may improve airway management success and lower complications by placing these concepts in the context of the low frequency of prehospital pediatric airway management.

Trauma

Recommendation 7: We suggest that either ventilation with BVM alone or SGA may be used in airway management for adults with trauma (conditional recommendation/very low certainty of evidence)

The panel found limited evidence concerning ventilation with BVM alone *vs.* SGA in adult patients with trauma. A single retrospective study conducted in a combat setting was included in the AHRQ review that compared SGA to BVM ventilation alone and found no difference in mortality between the two groups (37). While some benefits were found in patients with SGA management, there were several important differences between the groups, including less severe injuries in the SGA group and indication bias, that may limit the ability to generalize these findings. Ultimately, the panel believed the data did not favor one modality over the other. The panel further recognized that using an SGA in a patient who is not unconscious and has an intact gag reflex likely requires medication-assisted placement, which adds complexity and risk. Therefore, the panel concluded that the decision of SGA or effective BVM ventilation should be driven by the goal of optimizing oxygenation and ventilation, and avoiding hypoxia, hypotension, and hyperventilation.

Recommendation 8: We make no recommendation concerning ventilation with BVM alone vs. SGA for pediatric patients with trauma based on a lack of evidence to review.

No studies were available to inform the decision to use BVM ventilation alone *vs.* SGA in pediatric patients with trauma. As such, the panel considered the current evidence for adult patients discussed above and the evidence for using BVM ventilation vs. SGA in pediatric patients suffering from OHCA. In pediatric patients with OHCA, limited data did not favor one modality (24, 25). Given the indirectness of these data and the lack of published evidence comparing SGA to BVM in the pediatric population, the panel could not recommend airway management with an SGA *vs.* ventilation with BVM alone in pediatric patients with trauma.

Recommendation 9: We suggest that either ventilation with BVM alone or ETI may be used in airway management for adults with trauma (conditional recommendation/low certainty of evidence)

One randomized trial and two observational cohort studies were available to inform the panel on ventilation with BVM *vs.* ETI in adults suffering trauma. Bernard randomized 312 EMS patients with severe traumatic brain injury (TBI) to rapid sequence intubation (RSI) or BVM ventilation and found better neurological function at 6 months with ETI but no difference in survival to discharge (38). In contrast, two observational studies looked at ETI without RSI *vs.* BVM ventilation and found higher mortality among patients intubated by paramedics in the field; however, there was significant concern for indication bias in both studies (39, 40). Intubation, with or without RSI, carries potential risks, including peri-intubation hypoxia and hypotension, which are detrimental to patients with TBI (41, 42). Further, ETI in patients with intact gag reflexes typically require medications to facilitate intubation, which adds additional complexity and risk (43, 44). Given the potential for harm and lack of survival benefit from ETI, the panel concluded that the optimal airway management modality of BVM ventilation alone *vs.* ETI should be determined by the individual patient circumstances, recognizing that the goal is optimizing oxygenation and ventilation while avoiding hypoxia, hypotension, and hyperventilation.

Recommendation 10: We suggest that either ventilation with BVM alone or ETI may be used in airway management for pediatric patients with trauma (conditional recommendation/very low certainty of evidence)

A single retrospective registry study evaluated ventilation with BVM alone *vs.* ETI in pediatric patients with severe head injuries and found no difference in mortality between the two groups (45). The study was limited by a relatively small sample size from a voluntary registry with significant imbalances between the two groups, including older age among patients with ETI. Further, intubation success is lower in pediatric patients than in adults (33). Clinician inexperience, in concert with anatomical differences in younger children, presents more challenging intubation, whereas children 10 years or older approximate adult anatomy (31, 46). Gausche-Hill conducted a randomized trial of BVM ventilation *vs.* ETI in pediatric patients and included a sub-group with trauma that found no difference in mortality or neurologic function (31). Therefore, based on existing evidence, the panel could not recommend one modality over another.

While the existing literature is insufficient to make anything other than a neutral recommendation supporting either BVM ventilation or ETI, the panel does have significant reservations about this neutral recommendation being misconstrued as an endorsement of ETI in this patient population. That is decidedly not the intent of the panel. In fact, the panel believes that ETI in children is extremely challenging, and the potential benefits are likely outweighed by potential pitfalls. This belief is formed for several reasons.

First, ETI success decreases with patient age (33). Pediatric patients are often inappropriately described as a homogenous, rather than heterogenous, group. In reality, neonates and infants have much different anatomy and physiology than older children, increasing intubation difficulty (33, 46, 47). Second, there are, fortunately, limited opportunities for intubation in younger patients, which presents limited experience for EMS clinicians. Given the large number of EMS clinicians and the limited opportunities for experience, skill dilution can occur, resulting in lower competence and success (48, 49). Finally, because the anatomy and etiology of respiratory failure in young children are different than in adults, the potential harms of intubation likely outweigh the recognized technical difficulties with effective BVM ventilation.

The panel also recognizes the challenges associated with BVM ventilation and cautions that this recommendation should not be construed to mean that a basic intervention is preferred because it is easy. Indeed, the panel strongly believes that any positive pressure ventilation in pediatric patients, regardless of technique, is challenging and requires focused and ongoing training.

Recommendation 11: We suggest that either SGA or ETI may be used in airway management for adults with trauma (conditional recommendation/very low certainty of evidence)

A single observational study, which included data on management with SGA and ETI in adults with trauma, found that while any invasive airway was associated with higher mortality compared with no invasive airway, ETI was associated with lower mortality when compared with SGA (50). Notably, at the time of the study in 2005, SGAs were typically used in EMS systems only as "rescue airways" following failed attempts at ETI. It is unknown if SGAs were used as primary airways or whether the lower survival in this group may reflect complications from failed ETI attempts, injury severity, or more challenging airway management since only the successful airway modality is reported. Further, the SGA in use at the time was the Combitube. Since newer generation SGAs are simpler to insert and ventilate through, it is unclear how these results apply to current EMS practices. More recent studies have demonstrated higher first pass success and higher overall success with SGA compared with ETI in patients with trauma (33). Higher first-pass success is associated with reduced complications, including hypoxia and hypotension, which are detrimental in patients with trauma, particularly those with TBI (51–53). Given the limited data comparing SGA to ETI in patients with trauma evaluating patient-centered outcomes, the panel concluded that the current evidence does not support one modality over another.

Recommendation 12: We suggest in favor of SGA over ETI in airway management for pediatric patients with trauma (conditional recommendation/very low certainty of evidence).

No studies directly compared patient-oriented outcomes, such as survival in pediatric trauma, between SGA and ETI. A single study in the AHRQ review demonstrated lower first-pass success rates in pediatric patients with ETI than SGA, confirming findings in additional papers (31, 33, 46). Evidence from other disease states has failed to demonstrate a mortality benefit from ETI compared with SGA in pediatric patients. However, an association between failed ETI attempts and adverse events, including hypoxia, hypotension, and cardiac arrest, is noted (24, 25, 36, 51, 52, 54). Finally, pediatric airway management is rare, and, as a result, EMS clinicians have little experience with this population. Noting the association between these adverse events and mortality in patients with TBI, we believe that first-pass success is a reasonable surrogate for harm. Given the combination of procedure rarity, lower success rates with ETI, lack of evidence of benefit, and harm associated with failed airway attempts, the panel has recommended in favor of SGA over ETI for prehospital airway management of pediatric patients with trauma.

Medical Emergencies

Recommendation 13: We make no recommendation concerning ventilation with BVM alone vs. SGA for adult patients with medical emergencies based on a lack of evidence to review.

Recommendation 14: We make no recommendation concerning ventilation with BVM alone vs. SGA for pediatric patients with medical emergencies based on a lack of evidence to review.

Recommendation 15: We make no recommendation concerning ventilation with BVM alone vs. ETI for adult patients with medical emergencies based on a lack of evidence to review.

Recommendation 16: We make no recommendation concerning ventilation with BVM alone vs. ETI for pediatric patients with medical emergencies based on a lack of evidence to review.

Recommendation 17: We suggest that either SGA or ETI may be used in airway management for adults with medical emergencies (conditional recommendation/very low certainty of evidence)

No trials reporting on patient-oriented outcomes, such as survival were included in the AHRQ review that compared SGA to ETI in patients experiencing non-OHCA medical emergencies. A single RCT compared procedural success and time to placement with ETI and King-LT, which showed equivalence (55). An observational study using the NEMSIS dataset found overall success rates among patients with medical emergencies were similar between ETI placement facilitated with medication and SGA, but higher with SGA than ETI without medication assistance (43). Additionally, another study of a large national dataset found that, for any given age, first-pass success was higher with SGA than ETI, regardless of age, and that first-pass success for ETI decreased with decreasing age but did not for SGA (33).

Without evidence regarding patient-oriented outcomes, the panel considered the evidence on procedural success and other literature documenting adverse events associated with additional airway insertion attempts (51–54). As with other disease etiologies, the panel noted higher first-pass success rates with SGA and challenges associated with achieving high ETI first-pass success, including the likely need for medication assistance. As a result, the panel recommends either SGA or ETI in agencies with documented high ETI success. For those agencies without documented high ETI success, we recommend SGA over ETI.

Recommendation 18: We suggest in favor of SGA over ETI in airway management for pediatric patients with medical emergencies (conditional recommendation/very low certainty in evidence).

Studies included in the AHRQ review found that first-pass success was higher across age groups with SGA than ETI. ETI first-pass success decreased with decreasing age, but there were no age-related differences in first-pass success with SGA (33, 43, 47, 56). Fewer pediatric patients need invasive airway management, leading to less airway intervention experience for EMS clinicians and less opportunity to maintain clinical competence (57). We again noted the association between increasing adverse events and additional intubation attempts (51–54).

We recognize that invasive airway management in pediatric medical emergencies usually requires some form of medication assistance. Some agencies, such as high-volume critical care transport programs, may have sufficient pediatric ETI first-pass success, patient volume, education, and oversight to safely support pediatric intubation programs. However, most agencies should focus on SGA over ETI for pediatric patients with medical emergencies.

Technique Modifiers

Recommendation 19: In patients requiring medication-assisted airway management, we suggest rapid sequence

intubation over no-medication approaches to facilitate airway placement under specific conditions, but only in well-resourced and high-functioning settings. (Conditional recommendation/very low certainty of evidence)

Patients requiring invasive airway management, not in cardiac arrest, whether from trauma or medical emergencies, will likely require medications to overcome resistance from masseter muscles and gag reflexes (43, 44). There were no RCTs, but six observational studies, comparing RSI to no medications (43, 58–62). Overall, the evidence on survival was mixed with limitations from indication bias, but combined results showed greater intubation success with RSI. Missed intubations are associated with increased adverse events, including peri-intubation hypoxia and hypotension (51, 52, 54, 58). Hypoxia and hypotension are associated with increased mortality in patients with TBI (42). For these reasons, the panel recommends using RSI over airway management with no medications for adults and pediatric patients not in cardiac arrest who require intubation.

Recommendation 20: In patients requiring medication-assisted airway management, we suggest rapid sequence intubation over sedation without paralysis approaches. (Conditional recommendation/very low certainty of evidence)

There were no RCTs and three observational studies comparing RSI to sedation-only intubation among adults requiring intubation for reasons other than cardiac arrest, one of which also included pediatric patients (57, 63). None of these papers included survival outcomes, reporting only on intubation first-pass success. The pooled estimates showed greater first-pass success with RSI in adults but no difference in pediatric patients (although trends favored RSI, because of small numbers, the trends were not significant). Again, recognizing the association between first-pass success and fewer adverse events, such as hypoxia and hypotension, and the association between these adverse events and mortality, the panel recommends using RSI over sedation-only intubation for both adults and pediatric patients not in cardiac arrest who need medication-assisted intubation. The panel also recognizes the greater complexity and potential harm of RSI and recommends it only be used by EMS agencies with established education, measurement, and quality improvement processes in place. Regardless of the approach to invasive airway management, the panel believes that continuous physiologic monitoring of blood pressure, heart rates, oxygen saturation, and waveform end-tidal CO_2 throughout the patient interaction is mandatory. Finally, the panel reiterates that AHRQ did not evaluate the use of ketamine-only intubation, and this was not considered as part of "sedation-only" intubation when answering this question.

Recommendation 21: In patients requiring intubation, we chose not to make a recommendation concerning intubation with sedation only compared with the use of no medications due to the particularly uncertain nature of the supporting evidence.

Three observational studies reported on first-pass success intubation rates and compared sedation-only intubation to intubation with no medications among adult and pediatric patients not in cardiac arrest (33, 57, 64). The pooled estimates for first-pass success in these papers were not significant; however, all three had very serious risks of bias, especially indication bias where patients needing sedation were likely less severely injured than those who, although not in cardiac arrest, still had no airway reflexes allowing intubation attempts with no medications. For this reason, the panel chose not to make a recommendation on this question. Additionally, the panel identifies the lack of evidence to inform this question and recommends that future research address this topic.

Recommendation 22: We suggest using either video or direct laryngoscopy across conditions for airway management. (Conditional recommendation/low certainty of evidence)

The AHRQ focused its systematic review on evidence specific to the prehospital environment and did not consider indirect in-hospital evidence (2). This evidence included five observational trials comparing direct laryngoscopy to different video laryngoscopy devices (King Vision, GlideScope, and Pentax) with mixed evidence of association with first-pass success and overall success and no differences in survival (65–69). Since the publication of the AHRQ review, two additional systematic reviews have been published comparing direct to video laryngoscopy. A Cochrane review that included both in-hospital and prehospital papers showed greater first-pass success with video laryngoscopy, driven by the in-hospital evidence (70). In addition, another recent prehospital systematic review and meta-analysis, including paramedics in critical care settings that were excluded from the AHRQ evaluation, similarly demonstrated greater first-pass success with video over direct laryngoscopy (71). Despite knowledge of this evidence published subsequent to the AHRQ systematic review, for methodologic reasons, we limited consideration only to those papers included in the review.

The panel recommendation supports the concept that either direct or video laryngoscopy may be used in prehospital airway management, and continued evaluation of video laryngoscopy in rigorous studies is needed. We recognize that multiple types of video laryngoscopy and blade geometries are commonly evaluated together without distinction. These differences can affect intubation success and are not often clearly identified in the literature (72). We also recognized that experience and training with each type of device and blade geometry likely affect success, making local training and education critical to the success of both approaches.

Discussion

Prehospital airway management is a complex process that requires understanding and integrating many techniques strategically to optimize outcomes for the patient. The panel's recommendations represent an opportunity for EMS system leaders to reflect on their current practices in light of available evidence. Additionally, recognizing the interactions of the panel's recommendations with each other, the panel generated good practice statements coalescing these recommendations to enhance the dissemination and implementation of evidence-based guidance. These good practice statements can be used to guide initial and continuing training to enhance evidence-based approaches to prehospital airway management.

One fundamental challenge noted by the panel is the lack of sufficient evidence to generate strong recommendations. This challenge was noted throughout the guideline development process, with the highest certainty of evidence noted for adult OHCA (low to moderate). This serves as a clear indicator that many of the concepts affecting airway decisions in the prehospital setting are driven by low levels of evidence. High-certainty evaluations of airway management performance and strategies to optimize clinician decision-making must be prioritized in prehospital research.

A distinct advantage of the GRADE methodology the panel used is the development of good practice statements that encompass the multiple evidence-based recommendations into a cogent practice guideline for frontline clinicians. This approach contrasts with other processes that derive practice recommendations from guided literature reviews (73). Rather, in this approach, a transparent and validated evidence evaluation process generates recommendations that lead to clear, evidence-based, good practice statements for EMS clinicians to use in patient care.

Several recurring themes concerning airway management were identified through the panel's discussions. First, while BVM ventilation alone is commonly used in prehospital care, supporting data on the quality and outcomes are lacking. Though BVM ventilation is included in the scope of practice of all EMS clinicians, this may lead to the assumption that BVM is easy to perform. We noted that there are challenges with BVM ventilation that require regular training and may require the use of technology to assess the effectiveness of ventilation in real time (74, 75).

Second, the panel recognizes the need to optimize the patient's physiology, specifically assuring appropriate oxygenation, ventilation, and hemodynamic status, to assure optimal airway management outcomes (76). Unfortunately, attention solely on the successful placement of invasive airway devices can interfere with achieving and maintaining these goals. Proper pre-oxygenation and blood pressure support before beginning placement attempts, and achieving first-pass success, minimize physiologic disruption and adverse events (41, 77). This concept of first-pass success without hypoxia or hypotension has been described as DASH-1A (Definitive Airway, Sans Hypoxia/Hypotension on 1st Attempt) (78). It is incumbent on EMS clinicians to ensure continuous physiologic monitoring of patients throughout airway management attempts, including waveform $EtCO_2$ to confirm successful initial and ongoing device placement and to assure efficacy of ventilation through the duration of patient care.

Third, the panel recognizes that on-scene factors in the prehospital environment can affect the decisions of EMS clinicians on which airway management techniques to use. For example, while the evidence suggests either ventilation with BVM alone or SGA can be used in cardiac arrest, effective mask ventilation is challenging with a single clinician. In the context of resuscitating a patient with cardiac arrest with limited clinicians, it may be appropriate to rapidly ventilate through an SGA without prior BVM ventilation.

Fourth, the panel recognizes the importance of continuing education and competency maintenance for low-frequency procedures. For agencies with documentation of high intubation first-pass success rates, the panel recommends that either ETI or SGA is appropriate for OHCA. However, the literature does not establish a definition of high first-pass success. Recent papers describe that first-pass success among paramedics varies from 52 to 88% (10, 33, 34, 57). This is lower than the rates between 86 and 95% by emergency physicians in the emergency department across multiple indications (72, 79–82). In making these recommendations for SGA and ETI use based on ETI success, the panel was cognizant that SGA competence is likely easier to achieve and maintain than ETI (83–85). For these reasons, and with awareness of the negative association between poor ETI success and worse outcomes, agencies unable to invest sufficient training and education resources to help their EMS clinicians develop and maintain documented high success rates may wish to emphasize SGA use over ETI use.

Limitations

The panel recognizes several limitations with these recommendations. First, there is limited evidence for prehospital airway management, leading to almost all recommendations being derived from low or very low certainty of evidence. Because of the overall paucity of direct prehospital evidence, data from the 1990s and early 2000s needed to be included. These data, therefore, include airway adjuncts that are no longer in widespread use and predate current standards of care, such as continuous waveform $EtCO_2$ for the confirmation and ongoing monitoring of airway placement, which has undoubtedly made airway management safer for the patient. In addition, most evidence includes retrospective or observational data, limiting our ability to generalize or determine causation. Given the cost and resources required to carry out RCTs, it is unlikely that the future evidence base will include many more RCTs than it currently does. As such, we encourage agencies to contribute to local and national data registries that can be used to compare interventions using techniques, such as multiple regression or propensity matching to adjust for confounding in studies using these registries (86, 87). Further, we recommend the development and publication of standardized definitions of key concepts, such as first-pass success and duration of the peri-intubation period.

The panel limited its evaluation of evidence to that summarized in the AHRQ review; however, we know that additional literature has been published since that systematic review. Additionally, the AHRQ systematic review did not include PICO questions about delayed sequence intubation, rapid sequence airway (sedation and paralytics used to facilitate SGA placement), or ketamine-only intubation. There was also insufficient evidence to make recommendations between different types of SGA devices.

Finally, any approach to creating clinical recommendations is subject to bias from the underlying evidence and the composition of the recommendations panel. We limited the effects of such bias through rigorous adherence to the GRADE methodology and the use of AGREE II criteria in development, which begins with the evidence and derives recommendations from it (4, 6). Our adherence to this methodology in the formation of this document, therefore, distinguishes it from other projects, such as the recent airway compendium consensus statements from the National Association of EMS Physicians (73).

Conclusion

While limited high-quality evidence was available, the panel used a systematic review of existing literature to generate recommendations and good practice statements intended to guide practice. Key recommendations or themes include the need to master BVM ventilation as the foundation of care, confirmation of any invasive airway with waveform $EtCO_2$, and the importance of procedural competency and training with invasive airway management, particularly endotracheal intubation, with a focus on prevention of complications, such as peri-intubation hypoxia and hypotension. These recommendations and good practice statements offer EMS agencies and clinicians an opportunity to review and incorporate the available evidence into their airway management strategies. In recognition of the limited high-quality evidence, the panel recommends increasing focus on research efforts to better inform future evidence-based guidelines.

Author Contributions

JLJ, JMS, ARP, CBG, and ESL directed the design of the project, discussion of the data, grading of the evidence, and development of the recommendations. JLJ, JWL, ARP, NB, JDO, DBB, LMM, RPC, and JMS drafted the manuscript. All authors/Technical Expert Panel members contributed substantially to the discussion and development of the recommendations and contributed to the manuscript. JLJ takes responsibility for the manuscript as a whole.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

ORCID

Jeffrey L. Jarvis http://orcid.org/0000-0002-1435-5115
Ashish R. Panchal http://orcid.org/0000-0001-7382-982X
John W. Lyng http://orcid.org/0000-0001-5191-5700
Nichole Bosson http://orcid.org/0000-0001-8356-0772
Toni Gross http://orcid.org/0000-0003-2458-2140
Michael Levy http://orcid.org/0000-0002-5245-5352
Lauren M. Maloney http://orcid.org/0000-0001-7073-055X
Remle P. Crowe http://orcid.org/0000-0001-9733-9294
Christopher B. Gage http://orcid.org/0000-0001-5150-0740
Eddy S. Lang http://orcid.org/0000-0003-0850-4337
J. Matthew Sholl http://orcid.org/0000-0003-4522-4748

References

1. Hazzard K. American sirens: the incredible story of the black men who became America's first paramedics. New York (NY): Hachette Books; 2022.
2. Carney N, Cheney T, Totten AM, Jungbauer R, Neth MR, Weeks C, Davis-O'Reilly C, Fu R, Yu Y, Chou R, et al. Prehospital airway management: a systematic review. Prehosp Emerg Care. 2022;26(5):716–727. doi:10.1080/10903127.2021.1940400.
3. Brouwers MC, Kho ME, Browman GP, Burgers JS, Cluzeau F, Feder G, Fervers B, Graham ID, Grimshaw J, Hanna SE, et al. AGREE II: advancing guideline development, reporting and evaluation in health care. CMAJ. 2010;182(18):E839–E842. doi:10.1503/cmaj.090449.
4. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, Schünemann HJ, GRADE Working Group. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ. 2008;336(7650):924–926. doi:10.1136/bmj.39489.470347.AD.
5. Gage C. Evidence-based guidelines for prehospital airway management: literature and methods. Prehosp Emerg Care. 2023.
6. Schünemann HJ, Brennan S, Akl EA, Hultcrantz M, Alonso-Coello P, Xia J, Davoli M, Rojas MX, Meerpohl JJ, Flottorp S, et al. The development methods of official GRADE articles and requirements for claiming the use of GRADE – a statement by the GRADE guidance group. J Clin Epidemiol. 2023;159:79–84. doi:10.1016/j.jclinepi.2023.05.010.
7. Dewidar O, Lotfi T, Langendam MW, Parmelli E, Saz Parkinson Z, Solo K, Chu DK, Mathew JL, Akl EA, Brignardello-Petersen R, et al. Good or best practice statements: proposal for the operationalisation and implementation of GRADE guidance. BMJ Evid Based Med. 2023;28(3):189–196. doi:10.1136/bmjebm-2022-111962.
8. Maignan M, Koch F-X, Kraemer M, Lehodey B, Viglino D, Monnet M-F, Pham D, Roux C, Genty C, Rolland C, et al. Impact of laryngeal tube use on chest compression fraction during out-of-hospital cardiac arrest. A prospective alternate month study. Resuscitation. 2015;93:113–117. doi:10.1016/j.resuscitation.2015.06.002.
9. Rumball CJ, MacDonald D. The ptl, combitube, laryngeal mask, and oral airway: a randomized prehospital comparative study of ventilatory device effectiveness and cost-effectiveness in 470 cases of cardiorespiratory arrest. Prehosp Emerg Care. 1997;1(1):1–10. doi:10.1080/10903129708958776.
10. Wang HE, Schmicker RH, Daya MR, Stephens S, Idris AH, Carlson J, Colella MR, Herren H, Hansen M, Richmond N, et al. Effect of a strategy of initial laryngeal tube insertion vs endotracheal intubation on 72-hour survival in adults with out-of-hospital cardiac arrest: a randomized clinical trial. JAMA. 2018;320(8):769–778. doi:10.1001/jama.2018.7044.
11. Noda E, Zaitsu A, Hashizume M, Takahashi S. Prognosis of patient with cardiopulmonary arrest transported to Kyushu University Hospital. Fukuoka Igaku Zasshi. 2007;98(3):73–81.
12. SOS-KANTO. Comparison of arterial blood gases of laryngeal mask airway and bag-valve-mask ventilation in out-of-hospital cardiac arrests. Circ J. 2009;73(3):490–496.
13. Hanif M, Kaji AH, Niemann JT. Advanced airway management does not improve outcome of out-of-hospital cardiac arrest: cardiac arrest airway. Acad Emerg Med. 2010;September17(9):926–31. doi:10.1111/j.1553-2712.2010.00829.x.
14. Takei Y, Enami M, Yachida T, Ohta K, Inaba H. Tracheal intubation by paramedics under limited indication criteria may improve the short-term outcome of out-of-hospital cardiac arrests with noncardiac origin. J Anesth. 2010;24(5):716–725. doi:10.1007/s00540-010-0974-6.
15. Shin SD, Ahn KO, Song KJ, Park CB, Lee EJ. Out-of-hospital airway management and cardiac arrest outcomes: a propensity score matched analysis. Resuscitation. 2012;83(3):313–319. doi:10.1016/j.resuscitation.2011.10.028.

16. Roth D, Hafner C, Aufmesser W, Hudabiunigg K, Wutti C, Herkner H, Schreiber W. Safety and feasibility of the laryngeal tube when used by EMTs during out-of-hospital cardiac arrest. Am J Emerg Med. 2015;33(8):1050–1055. doi:10.1016/j.ajem.2015.04.048.
17. Evans CCD, Petersen A, Meier EN, Buick JE, Schreiber M, Kannas D, Austin MA, Resuscitation Outcomes Consortium Investigators. Prehospital traumatic cardiac arrest: management and outcomes from the resuscitation outcomes consortium epistry-trauma and PROPHET registries. J Trauma Acute Care Surg. 2016;81(2):285–293. doi:10.1097/TA.0000000000001070.
18. Kang K, Kim T, Ro YS, Kim YJ, Song KJ, Shin SD. Prehospital endotracheal intubation and survival after out-of-hospital cardiac arrest: results from the Korean nationwide registry. Am J Emerg Med. 2016;34(2):128–132. doi:10.1016/j.ajem.2015.09.036.
19. Chiang W-C, Hsieh M-J, Chu H-L, Chen AY, Wen S-Y, Yang W-S, Chien Y-C, Wang Y-C, Lee B-C, Wang H-C, et al. The effect of successful intubation on patient outcomes after out-of-hospital cardiac arrest in Taipei. Ann Emerg Med. 2018;71(3):387–396.e2. doi:10.1016/j.annemergmed.2017.08.008.
20. Sulzgruber P, Datler P, Sterz F, Poppe M, Lobmeyr E, Keferböck M, Zeiner S, Nürnberger A, Schober A, Hubner P, et al. The impact of airway strategy on the patient outcome after out-of-hospital cardiac arrest: a propensity score matched analysis. Eur Heart J Acute Cardiovasc Care. 2018;7(5):423–431. doi:10.1177/2048872617731894.
21. Yanagawa Y, Sakamoto T. Analysis of prehospital care for cardiac arrest in an urban setting in Japan. J Emerg Med. 2010;38(3):340–345. doi:10.1016/j.jemermed.2008.04.037.
22. Ohashi-Fukuda N, Fukuda T, Yahagi N. Effect of pre-hospital advanced airway management for out-of-hospital cardiac arrest caused by respiratory disease: a propensity score–matched study. Anaesth Intensive Care. 2017;45(3):375–383. doi:10.1177/0310057X1704500314.
23. Fiala A, Lederer W, Neumayr A, Egger T, Neururer S, Toferer E, Baubin M, Paal P. EMT-led laryngeal tube vs. face-mask ventilation during cardiopulmonary resuscitation – a multicenter prospective randomized trial. Scand J Trauma Resusc Emerg Med. 2017;25(1):104. doi:10.1186/s13049-017-0446-1.
24. Hansen M, Wang H, Le N, Lin A, Idris A, Kornegay J, Schmicker R, Daya M. Prospective evaluation of airway management in pediatric out-of-hospital cardiac arrest. Resuscitation. 2020;156:53–60. doi:10.1016/j.resuscitation.2020.08.003.
25. Hansen ML, Lin A, Eriksson C, Daya M, McNally B, Fu R, Yanez D, Zive D, Newgard C, CARES Surveillance Group. A comparison of pediatric airway management techniques during out-of-hospital cardiac arrest using the CARES database. Resuscitation. 2017;120:51–56. doi:10.1016/j.resuscitation.2017.08.015.
26. Jaber S, Jung B, Corne P, Sebbane M, Muller L, Chanques G, Verzilli D, Jonquet O, Eledjam JJ, Lefrant JY. An intervention to decrease complications related to endotracheal intubation in the intensive care unit: a prospective, multiple-center study. Intensive Care Med. 2010;36(2):248–255. doi:10.1007/s00134-009-1717-8.
27. Lupton JR, Schmicker RH, Stephens S, Carlson JN, Callaway C, Herren H, Idris AH, Sopko G, Puyana JCJ, Daya MR, et al. Outcomes with the use of bag-valve-mask ventilation during out-of-hospital cardiac arrest in the pragmatic airway resuscitation trial. Acad Emerg Med. 2020;27(5):366–374. doi:10.1111/acem.13927.
28. Nagao T, Kinoshita K, Sakurai A, Yamaguchi J, Furukawa M, Utagawa A, Moriya T, Azuhata T, Tanjoh K. Effects of bag-mask versus advanced airway ventilation for patients undergoing prolonged cardiopulmonary resuscitation in pre-hospital setting. J Emerg Med. 2012;42(2):162–170. doi:10.1016/j.jemermed.2011.02.020.
29. Jabre P, Penaloza A, Pinero D, Duchateau FX, Borron SW, Javaudin F, Richard O, Longueville D, Bouilleau G, Devaud ML, et al. Effect of bag-mask ventilation vs endotracheal intubation during cardiopulmonary resuscitation on neurological outcome after out-of-hospital cardiorespiratory arrest: a randomized clinical trial. JAMA. 2018;319(8):779–787. 27doi:10.1001/jama.2018.0156.
30. Yuksen C, Phattharapornjaroen P, Kreethep W, Suwanmano C, Jenpanitpong C, Nonnongku R, Sittichanbuncha Y, Sawanyawisuth K. Bag-valve mask versus endotracheal intubation in out-of-hospital cardiac arrest on return of spontaneous circulation: a national database study. Open Access Emerg Med. 2020;12:43–46. doi:10.2147/OAEM.S229356.
31. Gausche M, Lewis RJ, Stratton SJ, Haynes BE, Gunter CS, Goodrich SM, Poore PD, McCollough MD, Henderson DP, Pratt FD, et al. Effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome: a controlled clinical trial. JAMA. 2000;283(6):783–790. doi:10.1001/jama.283.6.783.
32. Murphy DL, Bulger NE, Harrington BM, Skerchak JA, Counts CR, Latimer AJ, Yang BY, Maynard C, Rea TD, Sayre MR. Fewer tracheal intubation attempts are associated with improved neurologically intact survival following out-of-hospital cardiac arrest. Resuscitation. 2021;167(Oct 2021):289–296. doi:10.1016/j.resuscitation.2021.07.001.
33. Jarvis JL, Wampler D, Wang HE. Association of patient age with first pass success in out-of-hospital advanced airway management. Resuscitation. 2019;141:136–143. doi:10.1016/j.resuscitation.2019.06.002.
34. Benger JR, Kirby K, Black S, Brett S, Clout M, Lazaroo M, Nolan J, Reeves B, Robinson M, Scott L, et al. Effect of a strategy of a supraglottic airway device vs tracheal intubation during out-of-hospital cardiac arrest on functional outcome: the airways-2 randomized clinical trial. JAMA. 2018;320(8):779–791. doi:10.1001/jama.2018.11597.
35. Rabitsch W, Schellongowski P, Staudinger T, Hofbauer R, Dufek V, Eder B, Raab H, Thell R, Schuster E, Frass M. Comparison of a conventional tracheal airway with the Combitube in an urban emergency medical services system run by physicians. Resuscitation. 2003;57(1):27–32. doi:10.1016/s0300-9572(02)00435-5.
36. Fukuda T, Sekiguchi H, Taira T, Hashizume N, Kitamura Y, Terada T, Ohashi-Fukuda N, Kukita I. Type of advanced airway and survival after pediatric out-of-hospital cardiac arrest. Resuscitation. 2020;150:145–153. doi:10.1016/j.resuscitation.2020.02.005.
37. Hardy GB, Maddry JK, Ng PC, Savell SC, Arana AA, Kester A, Bebarta VS. Impact of prehospital airway management on combat mortality. Am J Emerg Med. 2019;37(2):349–350. doi:10.1016/j.ajem.2018.02.007.
38. Bernard SA, Nguyen V, Cameron P, Masci K, Fitzgerald M, Cooper DJ, Walker T, Std BP, Myles P, Murray L, et al. prehospital rapid sequence intubation improves functional outcome for patients with severe traumatic brain injury: a randomized controlled trial. Ann Surg. 2010;252(6):959–965. doi:10.1097/SLA.0b013e3181efc15f.
39. Eckstein M, Chan L, Schneir A, Palmer R. Effect of prehospital advanced life support on outcomes of major trauma patients. J Trauma. 2000;48(4):643–648. doi:10.1097/00005373-200004000-00010.
40. Stockinger ZT, McSwain NE. Additional evidence in support of withholding or terminating cardiopulmonary resuscitation for trauma patients in the field. J Am Coll Surg. 2004;198(2):227–231. doi:10.1016/j.jamcollsurg.2003.10.012.
41. Jarvis JL, Gonzales J, Johns D, Sager L. Implementation of a clinical bundle to reduce out-of-hospital peri-intubation hypoxia. Ann Emerg Med. 2018;72(3):272–279.e1. doi:10.1016/j.annemergmed.2018.01.044.
42. Spaite DW, Hu C, Bobrow BJ, Chikani V, Barnhart B, Gaither JB, Denninghoff KR, Adelson PD, Keim SM, Viscusi C, et al. The effect of combined out-of-hospital hypotension and hypoxia on mortality in major traumatic brain injury. Ann Emerg Med. 2017;69(1):62–72. doi:10.1016/j.annemergmed.2016.08.007.

43. Nwanne T, Jarvis J, Barton D, Donnelly JP, Wang HE. Advanced airway management success rates in a national cohort of emergency medical services agencies. Resuscitation. 2020;146:43–49. doi:10.1016/j.resuscitation.2019.11.006.
44. Okubo M, Gibo K, Hagiwara Y, Nakayama Y, Hasegawa K, Japanese EMNI. The effectiveness of rapid sequence intubation (RSI) versus non-RSI in emergency department: an analysis of multicenter prospective observational study. Int J Emerg Med. 2017;10(1):1. doi:10.1186/s12245-017-0129-8.
45. Cooper A, DiScala C, Foltin G, Tunik M, Markenson D, Welborn C. Prehospital endotracheal intubation for severe head injury in children: a reappraisal. Semin Pediatr Surg. 2001;10(1): 3–6. doi:10.1053/spsu.2001.19379.
46. Hanlin ER, Chan HK, Hansen M, Wendelberger B, Shah MI, Bosson N, Gausche-Hill M, VanBuren JM, Wang HE. Epidemiology of out-of-hospital pediatric airway management in the 2019 national emergency medical services information system data set. Resuscitation. 2022;173:124–133. doi:10.1016/j.resuscitation.2022.01.008.
47. Reichert RJ, Gothard M, Gothard MD, Schwartz HP, Bigham MT. Intubation success in critical care transport: a multicenter study. Prehosp Emerg Care. 2018;22(5):571–577. doi:10.1080/10903127.2017.1419324.
48. Persse DE, Key CB, Bradley RN, Miller CC, Dhingra A. Cardiac arrest survival as a function of ambulance deployment strategy in a large urban emergency medical services system. Resuscitation. 2003;59(1):97–104. doi:10.1016/s0300-9572(03)00178-3.
49. Pouliot R. Failed prehospital tracheal intubation: a matter of skill dilution? Anesth Analg. 2010;110(5):1507–1508; author reply 1509. doi:10.1213/ANE.0b013e3181d47c89.
50. Davis DP, Heister R, Poste JC, Hoyt DB, Ochs M, Dunford JV. Ventilation patterns in patients with severe traumatic brain injury following paramedic rapid sequence intubation. NCC. 2005;2(2):165–171. doi:10.1385/NCC:2:2:165.
51. Sakles JC, Chiu S, Mosier J, Walker C, Stolz U. The importance of first pass success when performing orotracheal intubation in the emergency department. Acad Emerg Med. 2013;20(1):71–78. doi:10.1111/acem.12055.
52. Hypes C, Sakles J, Joshi R, Greenberg J, Natt B, Malo J, Bloom J, Chopra H, Mosier J. Failure to achieve first attempt success at intubation using video laryngoscopy is associated with increased complications. Intern Emerg Med. 2017;12(8):1235–1243. doi:10.1007/s11739-016-1549-9.
53. Mort TC. The incidence and risk factors for cardiac arrest during emergency tracheal intubation: a justification for incorporating the ASA Guidelines in the remote location. J Clin Anesth. 2004;16(7):508–516. doi:10.1016/j.jclinane.2004.01.007.
54. Hasegawa K, Shigemitsu K, Hagiwara Y, Chiba T, Watase H, Brown CA III, Brown DF, Japanese Emergency Medicine Research Alliance Investigators. Japanese Emergency Medicine Research Alliance I: association between repeated intubation attempts and adverse events in emergency departments: an analysis of a multicenter prospective observational study. Ann Emerg Med. 2012;60(6):749–754 e2. doi:10.1016/j.annemergmed.2012.04.005.
55. Frascone RJ, Wayne MA, Swor RA, Mahoney BD, Domeier RM, Olinger ML, Tupper DE, Setum CM, Burkhart N, Klann L, et al. Treatment of non-traumatic out-of-hospital cardiac arrest with active compression decompression cardiopulmonary resuscitation plus an impedance threshold device. Resuscitation. 2013;84(9): 1214–1222. Septemberdoi:10.1016/j.resuscitation.2013.05.002.
56. Bigelow AM, Gothard MD, Schwartz HP, Bigham MT. Intubation in pediatric/neonatal critical care transport: national performance. Prehosp Emerg Care. 2015;19(3):351–357. doi:10.3109/10903127.2014.980481.
57. Wang HE, Yealy DM. How many attempts are required to accomplish out-of-hospital endotracheal intubation? Acad Emergency Med. 2006;13(4):372–377. doi:10.1111/j.1553-2712.2006.tb00311.x.
58. Cudnik MT, Newgard CD, Daya M, Jui J. The impact of rapid sequence intubation on trauma patient mortality in attempted prehospital intubation. J Emerg Med. 2010;38(2):175–181. doi:10.1016/j.jemermed.2008.01.022.
59. Vilke GM, Hoyt DB, Epperson M, Fortlage D, Hutton KC, Rosen P. Intubation techniques in the helicopter. J Emerg Med. 1994;12(2):217–224. doi:10.1016/0736-4679(94)90702-1.
60. Bulger EM, Copass MK, Sabath DR, Maier RV, Jurkovich GJ. The use of neuromuscular blocking agents to facilitate prehospital intubation does not impair outcome after traumatic brain injury. J Trauma. 2005;58(4):718–724; discussion 723–724. doi:10.1097/01.ta.0000159239.14181.bc.
61. Bendinelli C, Ku D, Nebauer S, King KL, Howard T, Gruen R, Evans T, Fitzgerald M, Balogh ZJ. A tale of two cities: prehospital intubation with or without paralysing agents for traumatic brain injury. ANZ J Surg. 2018;88(5):455–459. doi:10.1111/ans.14479.
62. Fouche PF, Smith K, Jennings PA, Boyle M, Bernard S. The association of paramedic rapid sequence intubation and survival in out-of-hospital stroke. Emerg Med J. 2019;36(7):416–422. doi:10.1136/emermed-2019-208613.
63. Jarvis JL, Barton D, Wang H. Defining the plateau point: when are further attempts futile in out-of-hospital advanced airway management. Resuscitation. 2018;130:57–60. doi:10.1016/j.resuscitation.2018.07.002.
64. Eberlein CM, Luther IS, Carpenter TA, Ramirez LD. First-pass success intubations using video laryngoscopy versus direct laryngoscopy: a retrospective prehospital ambulance service study. Air Med J. 2019;38(5):356–358. doi:10.1016/j.amj.2019.06.004.
65. Ducharme S, Kramer B, Gelbart D, Colleran C, Risavi B, Carlson JN. A pilot, prospective, randomized trial of video versus direct laryngoscopy for paramedic endotracheal intubation. Resuscitation. 2017;114:121–126. doi:10.1016/j.resuscitation.2017.03.022.
66. Arima T, Nagata O, Miura T, Ikeda K, Mizushima T, Takahashi A, Sakaida K. Comparative analysis of airway scope and Macintosh laryngoscope for intubation primarily for cardiac arrest in prehospital setting. Am J Emerg Med. 2014;32(1):40–43. doi:10.1016/j.ajem.2013.09.026.
67. Risse J, Volberg C, Kratz T, Plöger B, Jerrentrup A, Pabst D, Kill C. Comparison of videolaryngoscopy and direct laryngoscopy by German paramedics during out-of-hospital cardiopulmonary resuscitation; an observational prospective study. BMC Emerg Med. 2020;20(1):22. doi:10.1186/s12873-020-00316-z.
68. Jarvis JL, McClure SF, Johns D. EMS intubation improves with king vision video laryngoscopy. Prehosp Emerg Care. 2015;19(4): 482–489. doi:10.3109/10903127.2015.1005259.
69. Jarman AF, Hopkins CL, Hansen JN, Brown JR, Burk C, Youngquist ST. Advanced airway type and its association with chest compression interruptions during out-of-hospital cardiac arrest resuscitation attempts. Prehosp Emerg Care. 2017;21(5): 628–635. doi:10.1080/10903127.2017.1308611.
70. Hansel J, Rogers AM, Lewis SR, Cook TM, Smith AF. Videolaryngoscopy versus direct laryngoscopy for adults undergoing tracheal intubation: a cochrane systematic review and meta-analysis update. Br J Anaesth. 2022;129(4):612–623. doi:10.1016/j.bja.2022.05.027.
71. Pourmand A, Robinson C, Dorwart K, O'Connell F. Pre-oxygenation: implications in emergency airway management. Am J Emerg Med. 2017;35(8):1177–83. doi:10.1016/j.ajem.2017.06.006.
72. Driver BE, Prekker ME, Reardon RF, Fantegrossi A, Walls RM, Brown CA. Comparing emergency department first-attempt intubation success with standard-geometry and hyperangulated video laryngoscopes. Ann Emerg Med. 2020;76(3):332–338. doi:10.1016/j.annemergmed.2020.03.011.
73. Wang HE, Levy M, Cone DC. The National Association of EMS Physicians Compendium of Airway Management position statements and resource documents. Prehosp Emerg Care. 2022; 26(sup1):1–2. doi:10.1080/10903127.2021.1988776.

74. Cereceda-Sánchez FJ, Molina-Mula J. Systematic review of capnography with mask ventilation during cardiopulmonary resuscitation maneuvers. J Clin Med. 2019;8(3):358. doi:10.3390/jcm8030358.
75. Lyng JW, Guyette FX, Levy M, Bosson N. Prehospital manual ventilation: an NAEMSP position statement and resource document. Prehosp Emerg Care. 2022;26(sup1):23–31. doi:10.1080/10903127.2021.1981506.
76. Davis DP, Bosson N, Guyette FX, Wolfe A, Bobrow BJ, Olvera D, Walker RG, Levy M. Optimizing physiology during prehospital airway management: an NAEMSP position statement and resource document. Prehosp Emerg Care. 2022;26(sup1):72–79. doi:10.1080/10903127.2021.1992056.
77. Jarvis JL, Lyng JW, Miller BL, Perlmutter MC, Abraham H, Sahni R. Prehospital drug assisted airway management: An NAEMSP position statement and resource document. Prehosp Emerg Care. 2022;26(sup1):42–53. doi:10.1080/10903127.2021.1990447.
78. Powell EK, Hinckley WR, Stolz U, Golden AJ, Ventura A, McMullan JT. Predictors of definitive airway sans hypoxia/hypotension on first attempt (DASH-1A) success in traumatically injured patients undergoing prehospital intubation. Prehosp Emerg Care. 2020;24(4):470–477. doi:10.1080/10903127.2019.1670299.
79. Brown CA, Kaji AH, Fantegrossi A, Carlson JN, April MD, Kilgo RW, Walls RM, National EAR (NEAR). IVideo laryngoscopy compared to augmented direct laryngoscopy in adult emergency department tracheal intubations: A National Emergency Airway Registry (NEAR) study. Acad Emerg Med. 2020;27(2):100–108. doi:10.1111/acem.13851.
80. Dean P, Edmunds K, Shah A, Frey M, Zhang Y, Boyd S, Kerrey BT. Video laryngoscope screen visualization and tracheal intubation performance: a video-based study in a pediatric emergency department. Ann Emerg Med. 2022;79(4):323–332. doi:10.1016/j.annemergmed.2021.11.019.
81. Trent SA, Kaji AH, Carlson JN, McCormick T, Haukoos JS, Brown CA, National EARI. Video laryngoscopy is associated with first-pass success in emergency department intubations for trauma patients: a propensity score matched analysis of the National Emergency Airway Registry. Ann Emerg Med. 2021;78(6):708–719. doi:10.1016/j.annemergmed.2021.07.115.
82. Nikolla DA, Carlson JN, Jimenez Stuart PM, Asar I, April MD, Kaji AH, Brown CA. Impact of video laryngoscope shape on first-attempt success during non-supine emergency department intubations. Am J Emerg Med. 2022;57:47–53. doi:10.1016/j.ajem.2022.04.024.
83. Ruetzler K, Roessler B, Potura L, Priemayr A, Robak O, Schuster E, Frass M. Performance and skill retention of intubation by paramedics using seven different airway devices—a manikin study. Resuscitation. 2011;82(5):593–597. doi:10.1016/j.resuscitation.2011.01.008.
84. Youngquist ST, Henderson DP, Gausche-Hill M, Goodrich SM, Poore PD, Lewis RJ. Paramedic self-efficacy and skill retention in pediatric airway management. Acad Emerg Med. 2008;15(12):1295–1303. doi:10.1111/j.1553-2712.2008.00262.x.
85. Kovacs GJ, Law JA. Airway management in emergencies. 2nd ed. People's Medical Publishing House; 2011.
86. Austin PC. An introduction to propensity score methods for reducing the effects of confounding in observational studies. Multivariate Behav Res. 2011;46(3):399–424. doi:10.1080/00273171.2011.568786.
87. Grant SW, Hickey GL, Head SJ. Statistical primer: multivariable regression considerations and pitfalls. Eur J Cardiothorac Surg. 2019;55(2):179–185. doi:10.1093/ejcts/ezy403.

Appendix A: Good Practice Statements

Adult	Pediatric
Out of hospital cardiac arrest	
BVM ventilation is the starting point of positive pressure ventilation for adults with OHCA. Progression to invasive modalities may be necessary but should not compromise chest compression quality. SGA should be considered as the primary invasive modality. In systems with appropriate resources and established programs for continual assessment of intubation performance demonstrating high ETI success, ETI may be considered. All decisions should be guided by the clinical status of the patient based on ongoing assessment, monitoring, transport, and environmental considerations.	Pediatric patients are a heterogenous group where a common etiology of cardiac arrest is respiratory impairment. Airway management strategies must optimize ventilation and oxygenation in children while minimizing complications. BVM ventilation is the starting point of positive pressure ventilation for pediatric patients with OHCA and may progress to SGA as needed. However, progression to ETI should be done rarely in the face of lower patient volumes leading to decreased experience, lower ETI success, and higher complication rates. All decisions should be guided by the clinical status of the patient based on ongoing assessment, monitoring, transport, and environmental considerations.
Trauma	
BVM ventilation is the starting point of care for adults with trauma requiring positive pressure ventilation and may progress to SGA or ETI as needed. We suggest that either SGA or ETI may be used, though EMS agencies must consider ETI success when implementing airway management strategies. Patients requiring invasive airway management who are not in cardiac arrest likely require medication assistance for airway placement. All decisions should be guided by the clinical status of the patient based on ongoing assessment, monitoring, transport, and environmental considerations.	Pediatric patients are a heterogeneous group with a high prevalence of traumatic brain injury. Airway management strategies must optimize ventilation and oxygenation in children while minimizing complications. BVM ventilation is the starting point of care for pediatric patients with trauma who require positive pressure ventilation and may progress to SGA as needed. Progression to ETI should be done rarely in the face of lower patient volumes, leading to decreased experience, lower ETI success, and higher complication rates. Invasive airway management likely requires medication assistance. All decisions should be guided by the clinical status of the patient based on ongoing assessment, monitoring, transport, and environmental considerations.
Medical emergencies	
BVM ventilation is the starting point of care for adults with medical emergencies requiring prehospital positive pressure ventilation and may progress to SGA or ETI as needed. We suggest that either SGA or ETI may be used, though EMS agencies must consider ETI success when implementing airway management strategies. Adult patients requiring invasive airway management who are not in cardiac arrest likely require medication assistance to facilitate airway placement. All airway management decisions should be guided by the clinical status of the patient based on ongoing assessment and monitoring and by recognition of in-transport challenges and environmental considerations.	Pediatric patients are a heterogenous group, and airway management strategies must optimize ventilation and oxygenation in children while minimizing complications. BVM ventilation is the starting point of care for pediatric patients with medical emergencies and may progress to SGA. However, progression to ETI should be done rarely in the face of lower volumes, leading to decreased experience, lower ETI success rates, and higher complication rates in this population. Invasive airway management likely requires medication assistance. All decisions should be guided by the clinical status of the patient based on ongoing assessment, monitoring, etiology, and expected clinical course.
Drug-assisted airway management	
Successful invasive airway management in patients without cardiac arrest is likely to require drug-assisted airway management (DAAM). DAAM has the advantage of higher first-pass success but also has the potential for harm if poorly performed. To maximize the benefit while mitigating the harm, DAAM should be performed by clinicians working in agencies with active medical oversight, airway management education, measurement, and quality improvement processes. If agencies elect to use DAAM, rapid sequence intubation (RSI) using both sedation and paralysis should be used preferentially over sedation-only or non-medication approaches. All decisions should be guided by the clinical status of the patient based on ongoing assessment, monitoring, transport, and environmental considerations.	
Video *vs.* direct laryngoscopy	
Video laryngoscopy is increasingly used instead of, or in addition to, direct laryngoscopy. Agencies and clinicians should use the laryngoscopy technique and device(s) with which they are most familiar and successful. Additionally, we suggest those using video laryngoscopy, particularly with hyperacute geometry blades, ensure that their clinicians are competent in the different approaches to tube delivery required by these devices.	