Prehospital Emergency Care

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/ipec20

Prehospital Airway Management: A Systematic Review

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To cite this article: Nancy Carney, Annette M. Totten, Tamara Cheney, Rebecca Jungbauer, Matthew R. Neth, Chandler Weeks, Cynthia Davis-O'Reilly, Rongwei Fu, Yun Yu, Roger Chou & Mohamud Daya (2022) Prehospital Airway Management: A Systematic Review, Prehospital Emergency Care, 26:5, 716-727, DOI: 10.1080/10903127.2021.1940400

To link to this article: https://doi.org/10.1080/10903127.2021.1940400

ORIGINAL CONTRIBUTIONS

PREHOSPITAL AIRWAY MANAGEMENT: A SYSTEMATIC REVIEW

Nancy Carney, Ph.D., Annette M. Totten, Ph.D., Tamara Cheney, M.D., Rebecca Jungbauer, DrPH, Matthew R. Neth, M.D., Chandler Weeks, M.P.H., Cynthia Davis-O'Reilly, B.S., Rongwei Fu, Ph.D., Yun Yu, M.S., Roger Chou, M.D. and Mohamud Daya, M.D., M.S.

ABSTRACT

Objective: To assess comparative benefits and harms across three airway management approaches (bag valve mask [BVM], supraglottic airway [SGA], and endotracheal intubation [ETI]) used by prehospital emergency medical services (EMS) to treat patients with trauma, cardiac arrest, or medical emergencies, and how they differ based on techniques and devices, EMS personnel and patient characteristics. **Data sources:** We searched electronic citation databases (Ovid® MEDLINE®, CINAHL®, the Cochrane Central Register of Controlled Trials, the Cochrane Database of Systematic Reviews, and Scopus®) from 1990 to September 2020. **Review methods:** We followed Agency for Healthcare Research and Quality Effective Health Care Program Methods guidance. Outcomes included mortality, neurological function, return of spontaneous circulation (ROSC), and successful advanced airway insertion. Meta-analyses using profile-likelihood random effects models were conducted, with analyses stratified by study design, emergency type, and age. **Results:** We included 99 studies involving 630,397 patients. We found few differences in primary outcomes across airway management approaches. For survival, there was no difference for BVM versus ETI or SGA in adult and pediatric patients with cardiac arrest or trauma. For neurological function, there was no difference for BVM versus ETI and SGA versus ETI in pediatric patients with cardiac arrest. There was no difference in BVM versus ETI in adults with cardiac arrest, but improved neurological function with BVM or ETI versus SGA. There was

Received April 8, 2021, from Pacific Northwest Evidence-Based Practice Center, Department of Medical Informatics and Clinical Epidemiology, Oregon Health & Science University, Portland, OR (NC, AMT, TC, RJ, CW, CD-O, RF, RC); Department of Emergency Medicine, Oregon Health & Science University, Portland, OR (MRN, MD); School of Public Health, Oregon Health & Science University, Portland, OR (RF); Biostatistics Shared Resurce, Knight Cancer Institute, Oregon Health & Science University, Portland, OR (YY). Revision received May 31, 2021; accepted for publication June 4, 2021.

This work was based on an evidence report, Prehospital Airway Management: A Systematic Review, by the Evidence-based Practice Center of the Agency for Healthcare Research and Quality (AHRQ). The authors thank the following individuals and groups for their contributions to this project: AHRQ Medical Officer David W. Niebuhr, MD, MPH, MSc; members of the Key Informant and Technical Expert panels; external and federal partner peer reviewers; and EPC staff member Tracy Dana, MLS. The external reviewers and federal partner reviewers did not receive financial compensation for their contributions.

The authors report no conflict of interest. The authors of this manuscript are responsible for its content. Statements in the manuscript do not necessarily represent the official views of or imply endorsement by AHRQ or HHS.

This work was supported by the National Highway Traffic Safety Administration, Office of Emergency Medical Services through an Interagency Agreement with the Agency for Healthcare Research and Quality, U.S. Department of Health and Human Services (HHS) under Contract No. HHSA2902015000091, task order 75Q80119F32023.

Address correspondence to Mohamud Daya, Department of Emergency Medicine, Oregon Health & Science University, 3181 SW Sam Jackson Park Rd, Portland, OR, USA. E-mail: dayam@ohsu.edu

Supplemental data for this article is available online at https://doi.org/10.1080/10903127.2021.1940400

doi:10.1080/10903127.2021.1940400

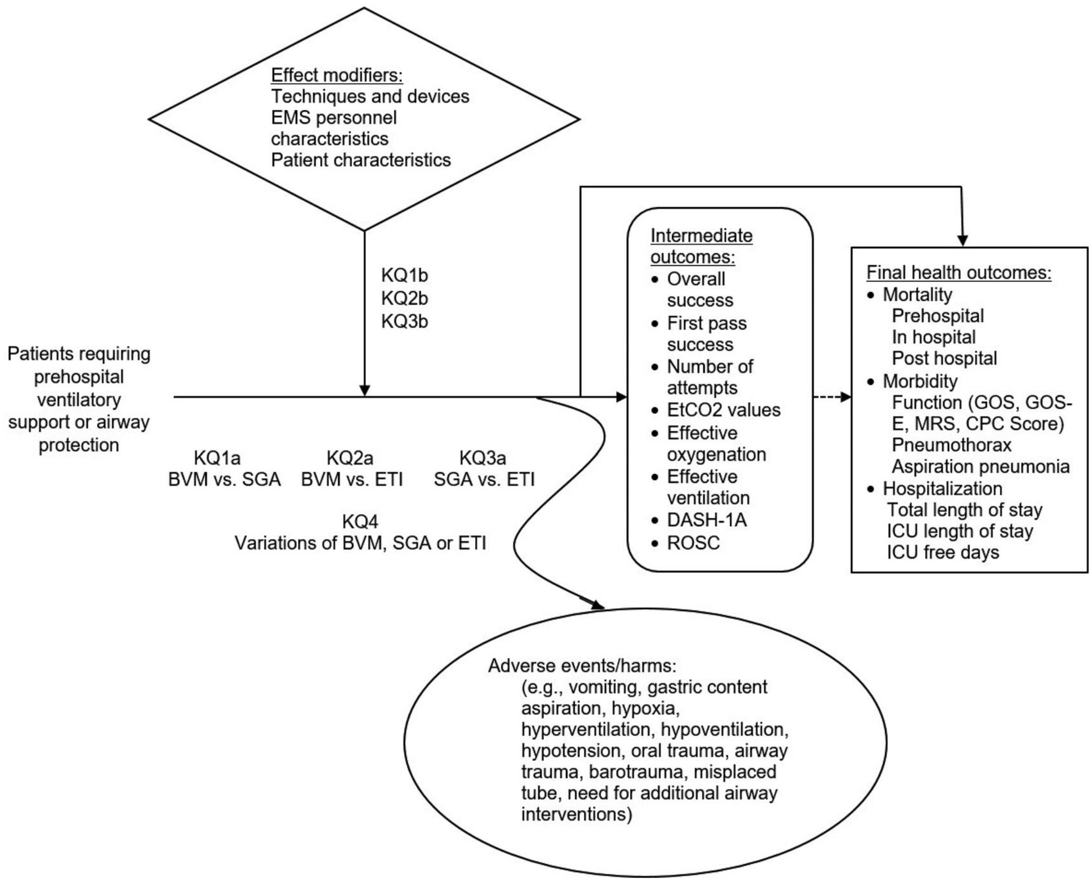

FIGURE 1. Analytic framework. BVM = bag valve mask; CPC Score = Cerebral Performance Category Score; DASH-1A = Definitive Airway Sans Hypoxia on First Attempt; EMS = emergency medical services; ETI = endotracheal intubation; GOS = Glasgow Outcome Scale; GOS-E = Glasgow Outcome Scale Extended: Hypoxia/Hypotension on First Attempt; ICU = intensive care unit; KQ = Key Question; MRS = modified Rankin Scale; ROSC = return of spontaneous circulation; SGA = supraglottic airway.

no difference in ROSC for patients with cardiac arrest for BVM versus ETI or SGA in adults and pediatrics, or SGA versus ETI in pediatrics. There was higher frequency of ROSC in adults with SGA versus ETI. For successful advanced airway insertion, there was higher first-pass success with SGA versus ETI for all patients except adult medical patients (no difference), and no difference in overall success using SGA versus ETI in adults. **Conclusions:** The currently available evidence does not indicate benefits of more invasive airway approaches based on survival, neurological function, ROSC, or successful airway insertion. Strength of evidence was low or moderate; most included studies were observational. This supports the need for high-quality randomized controlled trials to advance clinical practice and EMS education and policy, and improve patient-centered outcomes. **Key words:** airway management; prehospital; systematic review; comparative effectiveness

PREHOSPITAL EMERGENCY CARE 2022;26:716–727

INTRODUCTION

Airway management is one of the most important aspects of prehospital emergency care, critical to both immediate survival and patients' potential for recovery. Of the three techniques routinely used by emergency medical services (EMS)—bag valve mask (BVM), supraglottic airway devices (SGA), and endotracheal intubation (ETI)—ETI has long been considered the gold standard for airway management. Although this is true for highly controlled environments, prehospital airway management success rates for ETI vary considerably and high rates of complications have been attributed to multiple factors (1–5).

The choice of technique and the potential for success depend on the severity of the patient's condition, the training and skills of the EMS personnel, setting (e.g., distance, level of care), and available equipment. EMS care is regulated by a Scope of Practice which vary from state to state in the United States and across countries, with some more restrictive than others. Thus, training and skills, resources, and scope of practice all influence choices. A key challenge in prehospital airway management is to determine the appropriate approach for individual patients given these factors, in the context of a wide range of practice and policy settings.

Guideline developers and EMS system leaders wish to develop evidence-based recommendations based on research in an environment of expanding options for prehospital airway management. The purpose of this systematic review was to identify and synthesize evidence available to support the development of evidence-based recommendations and guidelines for prehospital airway management in the United States.

METHODS

Scope of the Review

The full review addressed 4 key questions (KQs) (Figure 1) comparing the benefits and harms for patients with trauma, cardiac arrest, or medical emergencies requiring prehospital ventilatory support or airway protection of BVM versus SGA (KQ1), BVM versus ETI (KQ2), SGA versus ETI (KQ3), and variations of any one of the three included airway interventions (KQ4). This review also considered how the benefits and harms for the three airway interventions differed across the following factors:

1. Specific techniques including modifications and devices used for each airway management approach,
2. Characteristics of the EMS personnel (e.g., training, certification, and expertise), and
3. Patient characteristics (e.g., demographics, type and severity of illness or injury, and location/environment).

This review followed methods suggested in the Agency for Healthcare Research and Quality (AHRQ) Methods Guide for Effectiveness and Comparative Effectiveness Reviews (6). *This article includes results from KQs 1–3; a subsequent publication will report results from KQ4.* Detailed methods are available in the full evidence report [AHRQ Airway Report; https://effectivehealthcare.ahrq.gov/products/prehospital-airway-management/research].

Data Sources and Searches

Searches were conducted by a research librarian in Ovid MEDLINE, CINAHL, the Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, and Scopus from January 1990 through September 2020. These were supplemented by reference lists from relevant systematic reviews and a Federal Register notice requesting unpublished data (Appendix A).

Study Selection

Two investigators independently reviewed titles, abstracts, and full-text articles using pre-defined eligibility criteria (Appendix A). Disagreements regarding study inclusion were resolved by consensus of the investigators, or by a third investigator when required. Populations included adult and pediatric patients requiring ventilatory support or airway protection treated in the prehospital setting by EMS personnel (paramedic, emergency medical technician at any level of training, emergency medical responder, nurse, physician, etc.). Eligible airway interventions included the use of BVM, SGA, or ETI. Only studies that included comparative data were included. International studies published in English were eligible for inclusion. Randomized controlled trials (RCT), controlled clinical trials (CCT), comparative observational studies, and case-control studies in the prehospital setting were eligible for inclusion. Reviews, case reports, and case series were not included.

The primary outcomes were survival, morbidity (especially neurologic function), and length of stay, focusing on outcomes measured within 30 days of the event requiring airway management. Secondary outcomes included success rates of advanced airway placement (SGA and ETI only), effective ventilation, definitive airway without hypoxia/hypotension on first attempt (DASH-1A), return of spontaneous circulation (ROSC), arterial or venous blood gases obtained on ED arrival, and harms (Figure 1).

Data Abstraction and Quality Rating

One investigator abstracted details about each study's design, patient population, setting, interventions, analysis, follow-up, and results. A second investigator reviewed the abstracted data for accuracy. Two investigators independently assessed the quality using predefined criteria in accordance with the AHRQ Methods Guide (6) specifically Cochrane Risk of Bias (ROB) for RCTs (7) and U.S. Preventive Services Task Force (8) for observational studies. Disagreements in quality ratings were resolved by consensus of the investigators, or by a third investigator when required. Authors of any included paper who were part of the research team did not participate in review of their own publications.

Data Synthesis

Data were synthesized separately for each KQ by outcome. We prioritized the following patient-centered outcomes for meta-analyses: survival in-hospital or at one-month post-incident; neurological function at discharge or one-month post-incident; ROSC; and, for KQ3 (SGA vs. ETI), successful advanced airway insertion. When pooling these outcomes was not appropriate, findings were summarized qualitatively. These qualitative assessments did not impact the

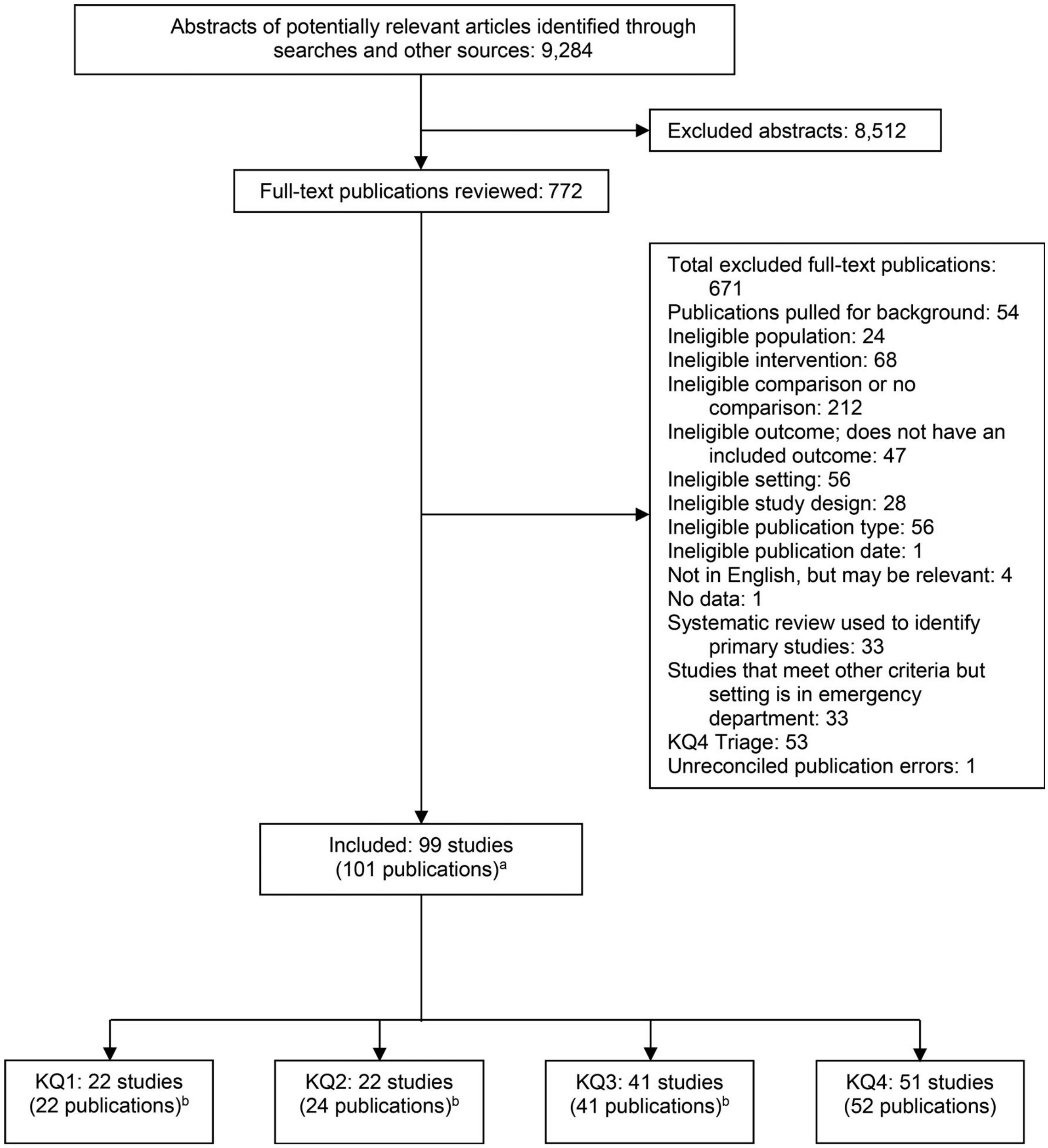

FIGURE 2. Literature flow diagram. KQ = Key Question. [a]Some included publications are counted in multiple sections. [b]Evans, 2016 was counted as two trials.

conclusions reported here, and are described in the full report available online [ARQ Airway Report; https://effectivehealthcare.ahrq.gov/products/prehospital-airway-management/research].

Findings regarding harms from qualitative synthesis are summarized for each KQ in this article.

Definitions. A number of included studies reported on samples with mixed emergency types and mixed ages. In consultation with topic experts, the following assumptions were adopted. Studies in which >85% of the participants included cardiac arrest patients were categorized as such at the study level. Studies or subgroups were categorized as pediatric based on each study's age-based definition. Studies in which <10% of included patients were pediatric were categorized as adult at the study level. Studies for which age distribution was not explicitly defined were categorized as "mixed-age" at the study level. For meta-analysis, included studies were categorized as either RCTs or observational, based on the characteristics of the individual studies.

There was considerable variation in how provider training and experience were reported in the included studies. For this project, we categorized providers as "ETI-capable, ETI-not capable, and mixed" (a team including both ETI capabilities).

Table 1. Overview of conclusions: comparison by emergency types and age groups

Outcome	Emergency type and age	KQ1: BVM vs. SGA	KQ2: BVM vs. ETI	KQ3: SGA vs. ETI
Survival	Cardiac arrest: Adults/Mixed	No difference	**No difference**	No difference
	Cardiac arrest: Pediatrics	No difference[a]	No difference	No difference[a]
	Trauma: Adults	*No conclusion*[a]	No difference	*No conclusion*[a]
	Trauma: Pediatrics	No evidence	*No conclusion*[a]	No evidence
Neurological function	Cardiac arrest: Adults	mRS: No evidence CPC: Favors BVM	mRS: No evidence CPC: **No difference**	mRS: No difference CPC: Favors ETI[a]
	Cardiac arrest: Pediatrics	*No conclusion*[a]	No difference	No difference[a]
	Trauma: Adults	No evidence	No evidence	No evidence
	Trauma: Pediatrics	No evidence	No evidence	No evidence
ROSC[b]	Cardiac arrest: Adults	No difference	No difference	Favors SGA
	Cardiac arrest: Pediatrics	*No conclusion*[a]	No difference[a]	No difference[a]
First-pass success[c]	Cardiac arrest: Adults	NA	NA	Favors SGA
	Cardiac arrest: Pediatrics	NA	NA	Favors SGA[a]
	Trauma: Adults	NA	NA	*No conclusion*[a]
	Trauma: Pediatrics	NA	NA	*No conclusion*[a]
	Medical: Adults	NA	NA	No difference
	Medical: Pediatrics	NA	NA	*No conclusion*[a]
	Mixed: Adults	NA	NA	Favors SGA[a]
	Mixed: Pediatrics	NA	NA	No evidence
Overall success[c]	Cardiac arrest: Adults	NA	NA	**No difference**
	Cardiac arrest: Pediatrics	NA	NA	No evidence
	Trauma: Adults	NA	NA	*No conclusion*[a]
	Trauma: Pediatrics	NA	NA	No evidence
	Medical: Adults	NA	NA	**No difference**
	Medical: Pediatrics	NA	NA	No evidence
	Mixed: Adults	NA	NA	**No difference**[a]
	Mixed: Pediatrics	NA	NA	No evidence
Harms[d]	All groups	**No difference**	**No difference**	**No difference:** Aspiration, oral/airway trauma, regurgitation **Favors SGA:** Multiple insertion attempts **Favors ETI:** Inadequate ventilation

BVM = bag valve mask; CPC = Cerebral Performance Category; ETI = endotracheal intubation; KQ = Key Question; mRS = modified Rankin Scale; NA = not applicable; ROSC = return of spontaneous circulation; SGA = supraglottic airway.
Bold Text = Moderate SOE, Standard text = Low SOE, Italicized text = Insufficient SOE.
[a]Results based only on observational studies.
[b]ROSC was only reported in studies of cardiac arrest.
[c]Success was qualitatively synthesized for KQ1 and 2; results available in full report.
[d]Harms were qualitatively synthesized; meta-analysis not possible as harms are different.

ETI-capable providers were classified as those who could perform endotracheal intubaton in the prehospital environment. For EMS providers in the U.S., this included paramedic and more advanced providers (e.g., "critical care paramedic" (no universal definition for this), flight nurse, nurse practitioner/physician assistant, or physician). For EMS providers outside the U.S., this was classified based on the information in the study. If the information was not provided, it was taken from other articles from the reference country or the governmental/agency website listing the provider skill set.

Meta-analyses. Meta-analyses were stratified first by study design (RCTs or observational studies), and then by emergency type (cardiac arrest, trauma, medical) and population age (adult, pediatric, mixed-age). All meta-analysis outcomes were reported as favoring one of the two compared approaches, or no difference. Risk ratios (RR) were used as the effect measure, and reported with 95% confidence intervals (CIs). Studies were combined using random effects models based on profile-likelihood (9). Statistical heterogeneity was assessed using the χ^2 test, and the magnitude of heterogeneity using the I^2 statistic (10). When available, intention to treat and propensity score matched results for RCTs and observational studies, respectively, were prioritized. Sensitivity analyses were conducted using other data (e.g., data from perprotocol, or as treated analysis for RCTs and results using all data from observational studies), or by excluding outlier studies (see full report for details [AHRQ Airway Report; https://effectivehealthcare.ahrq.gov/products/prehospital-airway-management/research]). All analyses were performed by using STATA®16.1 (StataCorp, College Station, TX).

Strength of Evidence. The strength of evidence (SOE) for each KQ was initially assessed by one researcher for each clinical outcome as low, moderate, high, or insufficient as per the AHRQ Methods Guide (6) (Appendix A). RCTs and observational studies were not combined in the pooled estimates, and are reported separately by study design. However, SOE assessments were based on the entire body of evidence (RCTs and observational studies). For overall SOE ratings, RCTs with low or moderate risk of bias were prioritized over observational studies. In addition, if findings from observational studies conflicted with those of RCTs, the conclusion and final SOE were based on findings from the RCTs.

ROB ratings were provided based on outcomes used in studies. Therefore, some studies were given an overall rating of low, moderate, or high ROB, whereas other studies were given multiple ROB ratings specific to different outcomes. Study-specific ratings can be found in Appendix G of the full report [AHRQ Airway Report; https://effectivehealthcare.ahrq.gov/products/prehospital-airway-management/research].

RESULTS

A total of 9,284 abstracts and 772 full-text articles were reviewed (Figure 2). Of the 99 included studies from 101 publications (N=630,397), 22 were RCTs, 20 were prospective and 50 retrospective observational studies, and 7 used before/after study designs. Most studies were conducted in the U.S. and Canada, followed by Europe, then Asia. Most studies enrolled adults and patients with cardiac arrest; care was most often provided by ETI-capable or mixed EMS personnel levels, using ground transport in urban or mixed prehospital settings.

Summary of Overall Results

The overall results are summarized as follows and in Table 1. Detailed results are presented in the individual KQ sections. Sufficient evidence was not available to address all outcomes and all patient characteristics, provider characteristics, and variations in techniques that were specified a priori.

- Survival measured in-hospital or at 1-month post incident:
  - No difference in outcomes across all three comparisons in adult/mixed-age and pediatric patients with cardiac arrest.
  - No difference when BVM was compared with ETI in adult patients with trauma.
- Neurological function measured by the Cerebral Performance Category (CPC), Pediatric CPC, or modified Rankin Scale (mRS) in-hospital or at 1-month post incident:
  - When BVM was compared with SGA, outcomes favored BVM in adult patients with cardiac arrest.
  - When SGA was compared with ETI, outcomes measured by the CPC favored ETI in adult patients with cardiac arrest; there was no difference in outcomes measured by the mRS in this group.
  - When BVM was compared with ETI, there was no difference in outcomes in adult patients with cardiac arrest.
  - When ETI was compared with BVM or SGA, there was no difference in outcomes in pediatric patients with cardiac arrest.
- Return of spontaneous circulation (ROSC) (prehospital, sustained, or overall):
  - When BVM was compared with SGA or ETI, there was no difference in outcomes in adult patients with cardiac arrest.
  - When SGA was compared with ETI, outcomes favored SGA in adult patients with cardiac arrest.
  - When ETI was compared with BVM or SGA, there was no difference in outcomes in pediatric patients with cardiac arrest.
- Successful advanced airway insertion when SGA is compared with ETI:
  - First-pass success favored SGA in adult patients with cardiac arrest and with mixed emergency types, and in pediatric patients with cardiac arrest; no difference was noted in adult patients with medical emergencies.
  - No difference in overall airway insertion success in adult patients with cardiac arrest, medical emergencies, or mixed emergency types.

Key Question 1: What Are the Comparative Benefits and Harms of BVM versus SGA for Patients Requiring Prehospital Ventilatory Support or Airway Protection?

Twenty-two studies ($n = 70{,}718$) provided data to compare BVM versus SGA in survival (patients with cardiac arrest or trauma), neurological function (cardiac arrest), and ROSC (cardiac arrest) (11–31). Meta-analysis indicated no significant difference in survival measured in-hospital or at one-month post-incident in adult/mixed-age (14 studies; SOE: Low) and pediatric (2 studies; SOE: Low) patients with cardiac arrest (Table 1). While the primary analysis of observational studies enrolling adults favored BVM, sensitivity analyses excluding high ROB studies suggested no difference between these two methods, similar to the primary results from the RCTs.

There was insufficient evidence to assess comparative benefits and harms in trauma patients, as only one observational study was eligible for inclusion, resulting in no conclusion (Table 1).

Data for neurological function, measured by the Cerebral Performance Category (CPC) or Pediatric CPC at discharge or 1-month post-incident favored BVM over SGA in adults in RCTs and observational studies (9 studies; SOE: Low), although sensitivity analyses excluding high ROB indicated no difference in observational studies. Evidence was insufficient to make conclusions about effects of BVM versus SGA on pediatric patients for neurological function (Table 1).

Rates of ROSC (pre-hospital, sustained, or overall) were not significantly different between BVM and SGA for adults with cardiac arrest (12 studies; SOE: Low); there was insufficient evidence to support a conclusion for pediatric patients (Table 1).

A qualitative analysis of four studies (2 RCTs and 2 observational) indicated no difference in the majority of reported harms between BVM and SGA (SOE: Moderate) (14, 17, 21, 25). One study reported lower rates of aspiration pneumonia within 72 hours with use of BVM versus SGA (5% vs. 33%) (17).

Key Question 2: What Are the Comparative Benefits and Harms of BVM versus ETI for Patients Requiring Prehospital Ventilatory Support or Airway Protection?

Twenty-two studies ($n = 106{,}325$) provided data to compare BVM versus ETI in survival (patients with cardiac arrest or trauma), neurological function (cardiac arrest), and ROSC (cardiac arrest) (11, 13, 15–17, 19, 20, 22–24, 27, 29–41). Meta-analysis indicated no significant difference in survival measured in-hospital or at 1-month post-incident in adult/mixed age (10 studies; SOE: Moderate) and pediatric cardiac arrest patients (3 studies; SOE: Low), and in adult/mixed-age trauma patients (3 studies: SOE: Low) (Table 1). There was insufficient evidence to support a conclusion for pediatric trauma patients.

For neurological function, measured by the CPC or Pediatric CPC in-hospital or at 1-month post-incident, there was no significant difference in adult (7 studies; SOE: Moderate) and pediatric (2 studies; SOE: Low) patients with cardiac arrest (Table 1).

There was no significant difference in rates of ROSC (pre-hospital, sustained, or overall) in adult (10 studies; SOE: Low) and pediatric (1 study; SOE: Low) patients with cardiac arrest (Table 1).

A qualitative analysis of five studies (2 RCTs, 1 CCT, and 2 observational) indicated no difference in the majority of reported harms between BVM and ETI (17, 32–36, 38). One study reported a lower rate of regurgitation for ETI compared with BVM; 7.7% difference (95% CI 4.9 to 10.4), $p < 0.001$ (33).

Key Question 3: What Are the Comparative Benefits and Harms of SGA versus ETI for Patients Requiring Prehospital Ventilatory Support or Airway Protection?

Forty-one studies ($n = 383{,}953$) provided data to compare SGA versus ETI in survival (patients with cardiac arrest or trauma), neurological function (cardiac arrest), ROSC (cardiac arrest), and first-pass and overall successful advanced airway insertion (cardiac arrest, trauma, medical, and mixed emergency types) (11, 13, 15–17, 19, 20, 22–24, 27, 29–31, 37, 42–67). Meta-analysis indicated no significant difference in survival measured in-hospital or at 1-month post-incident in adult/mixed-age (16 studies; SOE: Low) and pediatric (3 studies; SOE: Low) patients with cardiac arrest (Table 1). There was insufficient evidence to support a conclusion about patients with trauma.

Neurological function favored ETI over SGA for adult cardiac arrest patients when measured at discharge in studies using the CPC score (11 studies; SOE: Low), but there was no difference at discharge when measured in studies using the mRS (3 studies; SOE: Low). There was no difference between SGA versus ETI in pediatric cardiac arrest patients when measured at discharge by the Pediatric CPC (2 studies; SOE: Low) (Table 1).

Rates of ROSC (pre-hospital, sustained, or overall) favored SGA over ETI for adult patients with cardiac arrest (16 studies; SOE: Low) (Table 1). These findings were inconsistent between RCTs and observational studies, resulting in low SOE. There was no significant difference for pediatric patients with cardiac arrest (2 studies; SOE: Low).

First-pass insertion success favored SGA over ETI for adult (5 studies; SOE: Low) and pediatric (2 studies; SOE: Low) patients with cardiac arrest, and for adult patients with mixed emergency types (2 studies; SOE: Low) (Table 1). There was no significant difference in adult patients with medical emergencies (2 studies; SOE: Low). There was insufficient evidence to support conclusions in adult and pediatric patients with trauma, and in pediatric patients with medical emergencies.

There was no significant difference in overall airway insertion success between SGA versus ETI in adult patients with cardiac arrest (9 studies; SOE: moderate), medical emergencies (3 studies; SOE: Moderate), and mixed emergency types (3 studies; SOE: Moderate) (Table 1). There was insufficient evidence to support a conclusion about adult patients with trauma.

A qualitative analysis of seven studies (2 RCTs, 5 observational) indicated no difference between SGA versus ETI for aspiration (2 studies), oral/airway trauma (2 studies), or regurgitation (1 study). SGA was favored over ETI for multiple insertion attempts (1 study); ETI was favored over SGA for inadequate ventilation (1 study) (17, 30, 45, 53, 54, 60, 65). The SOE for each of these harms was moderate.

Discussion

An essential part of prehospital care is airway management, which enables patients to receive adequate oxygenation and ventilation. There are currently three main approaches to airway management: BVM (usually with airway adjuncts such as oropharyngeal airway [OPA] and nasopharyngeal airway [NPA]), SGA, and ETI. While guidelines and best practices exist, individual experiences, policies, and research do not definitively support one airway approach over another. Furthermore, airway management approaches are often used in a complementary fashion so that one serves as a backup when the other is deemed ineffective. Our review quantitatively synthesized results from pairwise comparisons of the three primary approaches for survival in-hospital or at 1-month post-incident, neurological function, ROSC and successful advanced airway insertion. Overall, evidence indicated few differences between airway approaches; when statistically significant differences occurred, they were for specific outcomes/comparisons and did not indicate a pattern favoring one airway over another across multiple outcomes.

For KQ1 (BVM versus SGA), our confidence in the findings is limited, as it often was not clear whether the comparison was BVM versus SGA directly, or BVM versus BVM initially, followed by SGA insertion. Studies did not always clearly identify whether other devices (e.g., OPA and NPA) were used in conjunction with BVM, or describe how BVM was actually performed (e.g., by one- vs. two-person technique). Finally, some studies assessed efficacy of BVM using chest rise and fall, which is not always measured reliably or consistently across providers. More objective measures of ventilation effectiveness, such as waveform capnography or tidal volume measurements, would be useful, as blood gas analysis is not practical in the prehospital setting.

There is a strong possibility that resuscitation time bias influenced results favoring BVM (68). Resuscitation time bias refers to interventions that are applied at varying time points; those applied later are less effective in part due to their delayed application. As BVM typically is the first airway management technique used in the field, effects of successful BVM would be favorably confounded by the shorter time between EMS arrival and airway intervention. This is particularly true for patients presenting with cardiac arrest with favorable features such as being witnessed, receiving bystander CPR, and a shockable initial rhythm. Another contributing factor is hyperventilation, which may occur more frequently with advanced airways (SGA or ETI) than with BVM. Hyperventilation has been shown to adversely impact patient outcomes in part by increasing intrathoracic pressure and decreasing venous return, ultimately leading to decreased cerebral and coronary perfusion pressures (69–73).

For KQ2 (BVM versus ETI), the same caveats apply as identified for KQ1 with respect to study limitations. For example, whether ETI was preceded by BVM or not, the lack of precise details on BVM use and subjective measurement of its effectiveness, as well as resuscitation time bias, potential hyperventilation following ETI, and provider level/experience, all limit conclusions for this question.

For KQ3 (SGA vs. ETI), compared with ETI, SGA had higher first-pass success in specific subgroups. However, no difference was noted in rates of overall insertion success. It is thought that SGAs may not protect against aspiration and thus may not work well for patients with vomitous, fluid, or blood in the airway. While overall rates of aspiration were similar between groups, aspiration may be more common during or after an advanced airway attempt with SGA as compared to ETI. Since the SGA is placed above the glottis, it may also be more difficult for EMS clinicians to hyperventilate with the SGA than with ETI, but our ability to assess this is limited by the lack of ventilation data in the included studies. This is an important topic for future research.

Most studies reported that ROSC outcomes were improved with SGA versus ETI. Survival and neurological function are influenced by post-resuscitation care, including hospital procedures (e.g., targeted temperature management, cardiac catheterization, and critical care expertise) and shared decision making with family regarding prognosis and withdrawal of life sustaining treatments. Best practices regarding neuroprognostication are evolving, and unfortunately at present patients may be moved too quickly to comfort care, especially following cardiac arrest (74). Therefore, post-resuscitation care differences deserve detailed attention in future airway management comparison studies in cardiac arrest.

Limitations

The most serious limitations of this review were related to the comparatively weak study designs used to compare airway management approaches and the risk of biases that are common challenges in prehospital and emergency care research. While the body of evidence did include randomized clinical trials, the majority of included studies were retrospective observational studies based on analyses of data from national or regional registries or administrative data from a single health system or EMS agency. Observational studies are more susceptible to bias. Indication bias, classifying patients by the treatment received, and survival bias, including only patients who survive a treatment, are variants of selection bias that are likely to occur in observational studies of prehospital care. Furthermore, data on important confounding variables are often limited in large databases, and retrospective analyses may not account for all relevant potential confounders, even with matched propensity score analyses.

Importantly, EMS clinicians acquire skill in all airway procedures over time and with practice. The skillset of the provider with each technique was rarely controlled for in the studies included in this review. It is possible that providers have greater skill with one technique more than another, which introduces another potential source of bias into the body of evidence.

Other limitations are specific to advanced airway management in the prehospital setting. In the field, use of more than one airway is typical with a progression through different approaches as the patient is assessed. The use of multiple airways, and the order and duration of each may affect outcomes, but this information is rarely documented precisely and included in analyses. Another concern is resuscitation time bias (i.e., the intervention is influenced by duration of resuscitation) and the patient's status and course of treatment preceding airway placement, which may influence both the intervention received and outcomes (68). The preparation time needed for different airway management techniques and the differences in skill and experience may be confounders, and the impact is often difficult to separate from the airway technique itself.

Finally, there is a paucity of data regarding prehospital ventilation; most airway trials to date have not addressed what happens after the airway is secured. Findings regarding ventilation as an outcome are limited by the lack of consistent measurement methods. Better tools are needed to measure ventilation parameters, in particular rate, tidal volume, and airway pressures.

Future Research

Research is needed to clarify whether there are situations in which certain airway approaches are superior, in particular in pediatric populations. Ideally, trials would compare all three airway approaches. Studies should clearly identify devices and airway management methods used (e.g., whether adjuncts were used with BVM [OPA, NPA]) to allow for more accurate and direct comparisons of the different airway methods. Research should incorporate objective measures of success in oxygenation and ventilation (e.g., waveform capnography, video monitoring, in-line ventilation rate, flow, tidal volume, and pressure, etc.). Resuscitation time bias remains an important issue in cardiac arrest studies, and efforts should be made to accurately capture airway intervention times to mitigate this concern. Research also is needed to identify optimal methods to acquire and maintain airway management skills in the prehospital setting. Further studies are also needed with regard to the impact of race and sex on the outcomes of different airway management strategies.

Conclusion

Overall, there is limited evidence to suggest differences in patient-centered outcomes between use of BVM, SGA, and ETI in prehospital airway management. This topic converges vast variation in multiple factors (patient characteristics, emergency types, provider level) in an emergent environment that defies control, thereby limiting the ability to systematically apply and study interventions. The findings from this review are detailed and comprehensive, and can inform policy, practice, education, and future research to improve prehospital airway management and ventilation support to optimize patient outcomes.

ORCID

Nancy Carney http://orcid.org/0000-0002-1199-3277
Annette M. Totten http://orcid.org/0000-0002-9100-8678
Matthew R. Neth http://orcid.org/0000-0002-3882-9637
Roger Chou http://orcid.org/0000-0001-9889-8610
Mohamud Daya http://orcid.org/0000-0002-6910-8293

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