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Prehospital Airway Management: A Systematic Review

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This report is based on research conducted by the [To be provided in the final report] an Evidence-based Practice Center (EPC) under contract to the Agency for Healthcare Research and Quality (AHRQ), Rockville, MD (Contract No. [To be provided in the final report.]). The findings and conclusions in this document are those of the authors, who are responsible for its contents; the findings and conclusions do not necessarily represent the views of AHRQ. Therefore, no statement in this report should be construed as an official position of AHRQ or of the U.S. Department of Health and Human Services.

None of the investigators has any affiliations or financial involvement that conflicts with the material presented in this report.

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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-based Practice Centers (EPCs), sponsors the development of evidence reports and technology assessments to assist public- and private-sector organizations in their efforts to improve the quality of healthcare in the United States.

The National Highway Traffic Safety Administration, Office of Emergency Medical Services requested this report from the EPC Program at AHRQ and provided funding for the report. AHRQ assigned this report to the following EPC: [To be provided in the final report.] Evidence-based Practice Center (Contract Number: [To be provided in the final report.]).

The reports and assessments provide organizations with comprehensive, evidence-based information on common medical conditions and new healthcare technologies and strategies. They also identify research gaps in the selected scientific area, identify methodological and scientific weaknesses, suggest research needs, and move the field forward through an unbiased, evidence-based assessment of the available literature. The EPCs systematically review the relevant scientific literature on topics assigned to them by AHRQ and conduct additional analyses when appropriate prior to developing their reports and assessments.

To bring the broadest range of experts into the development of evidence reports and health technology assessments, AHRQ encourages the EPCs to form partnerships and enter into collaborations with other medical and research organizations. The EPCs work with these partner organizations to ensure that the evidence reports and technology assessments they produce will become building blocks for healthcare quality improvement projects throughout the Nation. The reports undergo peer review and public comment prior to their release as a final report.

AHRQ expects that the EPC evidence reports and technology assessments, when appropriate, will inform individual health plans, providers, and purchasers as well as the healthcare system as a whole by providing important information to help improve healthcare quality.

If you have comments on this evidence report, they may be sent by mail to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 5600 Fishers Lane, Rockville, MD 20857, or by email to epc@ahrq.hhs.gov.

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The authors gratefully acknowledge the following individuals for their contributions to this project: [To be provided in the final report.]

Key Informants

In designing the study questions, the EPC consulted several Key Informants who represent the end-users of research. The EPC sought the Key Informant input on the priority areas for research and synthesis. Key Informants are not involved in the analysis of the evidence or the writing of the report. Therefore, in the end, study questions, design, methodological approaches, and/or conclusions do not necessarily represent the views of individual Key Informants.

Key Informants must disclose any financial conflicts of interest greater than $5,000 and any other relevant business or professional conflicts of interest. Because of their role as end-users, individuals with potential conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any conflicts of interest.

The list of Key Informants who provided input to this report follows:

[To be provided in the final report.]

Technical Expert Panel

In designing the study questions and methodology at the outset of this report, the EPC consulted several technical and content experts. Broad expertise and perspectives were sought. Divergent and conflicted opinions are common and perceived as healthy scientific discourse that results in a thoughtful, relevant systematic review. Therefore, in the end, study questions, design, methodologic approaches, and/or conclusions do not necessarily represent the views of individual technical and content experts.

Technical Experts must disclose any financial conflicts of interest greater than $5,000 and any other relevant business or professional conflicts of interest. Because of their unique clinical or content expertise, individuals with potential conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential conflicts of interest identified.

The list of Technical Experts who provided input to this report follows:

[To be added for the final report.]

Peer Reviewers

Prior to publication of the final evidence report, EPCs sought input from independent Peer Reviewers without financial conflicts of interest. However, the conclusions and synthesis of the scientific literature presented in this report does not necessarily represent the views of individual reviewers.

Peer Reviewers must disclose any financial conflicts of interest greater than $5,000 and any other relevant business or professional conflicts of interest. Because of their unique clinical or content expertise, individuals with potential non-financial conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential non-financial conflicts of interest identified.

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Prehospital Airway Management

Structured Abstract

Objective. To assess the comparative benefits and harms across three airway management approaches (bag valve mask [BVM], supraglottic airway [SGA], and endotracheal intubation [ETI]) by emergency medical services in the prehospital setting and how these benefits and harms differ based on patient characteristics, and techniques and devices used.

Data sources. Electronic databases (Ovid® MEDLINE®, CINAHL®, the Cochrane Central Register of Controlled Trials, the Cochrane Database of Systematic Reviews, and Scopus®) from January 1990 through November 2019; reference lists; and a Federal Register notice requesting unpublished data.

Review methods. Review methods followed Agency for Healthcare Research and Quality Evidence-based Practice Center Methods guidance. Using pre-established criteria, studies were selected, dual reviewed, data abstracted, and evaluated for risk of bias. Meta-analyses using profile-likelihood random effects models were conducted when data were available from studies reporting on similar outcomes, with analyses stratified by emergency type and age. Heterogeneity was assessed using I^2 statistic and sensitivity analyses were conducted. Where meta-analysis was not feasible, results were qualitatively summarized. Strength of evidence (SOE) was assessed for each airway comparison and primary outcome (survival, neurological function, return of spontaneous circulation [ROSC], and successful insertion of airway).

Results. We identified and included 81 studies (17 randomized controlled trials, 6 controlled clinical trials, and 58 observational studies) involving 19,749 participants. Overall, few findings detected differences in primary outcomes across the three types of airway management studied (BVM, SGA, and ETI). Moderate SOE supports twelve findings: when comparing BVM with SGA, no difference in survival was found in adults or in patients with out-of-hospital cardiac arrest (OHCA); BVM resulted in better survival for trauma patients, and better neurological function in patient samples of all ages. When BVM was compared with ETI, there was no difference in survival in adults and patients with OHCA, and no difference in function for adults; one RCT, in which physicians provided the intubation, favored ETI in adults for ROSC. When SGA was compared with ETI, there was no difference in function in adults; first pass successful advanced airway insertion favored SGA in OHCA patients; and there was no difference in overall successful advanced airway insertion in adults and patients with medical emergencies.

Conclusions. As most of the studies included in this review were observational, the findings may reflect study limitations. Due to the dynamic nature of the prehospital environment, the results are particularly vulnerable to indication and survival biases. However, these findings may reflect the reality that no one airway approach is consistently more effective across different patient needs and the multitude of confounding factors in the prehospital environment. High quality randomized controlled trials designed to account for the variability and dynamic nature of prehospital airway management could better advance and inform clinical practice, emergency medical services education and policy, and improve patient outcomes.

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Evidence Summary

Main Points

- The most common finding, across emergency types and age groups, is of no differences in primary outcomes when prehospital airway management approaches are directly compared.
- None of the outcomes were supported by high SOE; thus, studies that are more rigorous could change conclusions in the future.
- The following conclusions are supported by moderate SOE:
  - When bag valve mask (BVM) was compared with supraglottic airway (SGA):
    - Adults: no difference in survival measured in-hospital or at one month post-incident
    - Patient samples of all ages (mixed ages): neurological function at discharge or one month post-incident is better with BVM than with SGA
    - Out-of-hospital cardiac arrest (OHCA) patients: no difference in survival in-hospital or at one month post-incident
    - Trauma patients: survival in-hospital or at one month post-incident is better with BVM than with SGA
  - When BVM was compared with endotracheal intubation (ETI):
    - Adults: return of spontaneous circulation (ROSC) is better with ETI than BVM; no difference in survival in-hospital or at one month post-incident or neurological function at discharge or at one month post-incident
    - OHCA patients: no difference in survival in-hospital or at one month post-incident
  - When SGA was compared with ETI:
    - Adults: no difference in neurological function at discharge or at one month post-incident or overall successful advanced airway insertion
    - OHCA patients: first-pass successful advanced airway insertion is better with SGA than ETI
    - Medical emergencies: no difference in overall successful advanced airway insertion
- For other comparisons and outcomes, the SOE of the conclusion is either low or the evidence is insufficient to support a conclusion.
- Implications based on the current body of evidence and finding that no one airway management approach is consistently superior are:
  - It is possible all three airway management types have a role in prehospital care and the preferred airway depends on setting, patient age and type, and available provider expertise and equipment.
  - Future research should:
    - Focus on rigorous studies, preferably RCTs, given that important and frequent sources of bias in prehospital airway research are difficult to address in observational studies.
    - Construct comparisons that are more clearly defined by specific emergency types, patient groups, and EMS resources including training.

Background and Purpose

Emergency medical services (EMS) care for people who experience emergencies with the goal of stabilizing, treating and then transporting people to emergency departments. A key component of prehospital care is management of the patient's airway, which is critical to immediate survival and impacts potential recovery.

Three types of airway management are routinely used by EMS: bag valve mask (BVM), supraglottic airway devices (SGA), and endotracheal intubation (ETI). Each require different training and equipment. Individual research studies, experience with hospitalized patients, and provider and EMS agency resources and experience have led to questions about what type of prehospital airway management is best.

Given the complexity of the prehospital environment, many factors are likely to influence patient outcomes, in addition to the airway type. **The purpose of this review is to provide a synthesis of the research evidence on the comparative effectiveness of these three airway types in prehospital care in order to help inform EMS practice guidelines and policy.**

Methods

We employed methods consistent with those outlined in the Agency for Healthcare Research and Quality Evidence-based Practice Center Program Methods Guidance (https://effectivehealthcare.ahrq.gov/topics/cer-methods-guide/overview). We identified and synthesized studies published between January 1, 1990 and November 20, 2019. We included studies that compared two types of airways or compared variations of one type of airway, such as video and direct ETI. Details about our search strategies, inclusion criteria, assessment, and synthesis of the evidence are included in the full report.

Our approach and results are specific to characteristics of airway management and research on this topic. A key characteristic is that for prehospital emergency trauma, cardiac arrest, and other medical needs, there are fundamental differences in airway management requirements. Similarly, the needs and challenges of airway management for children differ significantly from those for adults. Given these differences, studies were not combined across these groups; as such combinations would not be clinically meaningful. Estimates were pooled using meta-analyses and reported separately by emergency type and by age group. Pooled estimates were generated separately for RCTs and observational studies; however, the conclusions and strength of evidence assessments we present include all study designs. When there were conflicting findings, we prioritized the RCTs.

Results

Our results synthesize the findings of 81 studies that compare BVM to SGA (Key Question 1 [KQ1], 20 studies), BVM to ETI (KQ2, 19 studies), SGA to ETI (KQ3, 38 studies), or compare variations of one of the three airway approaches (KQ4, 34 studies). The results for Key Questions 1, 2, and 3 for the outcomes of survival in-hospital or at one month post-incident, neurological function at discharge or at one month post-incident, and ROSC are presented in Tables ES-1 and ES-2 below. When results of RCTs and observational studies [OBSs] were not consistent, the results from the RCTs are reported.

The overall findings suggested that there are few differences in primary outcomes between the three methods of airway management studied. In particular, survival to hospital discharge and survival with good neurological function are not different. Similarly, few differences were found in studies that compared variations of one type of airway (e.g., video to direct ETI).

Table ES-1. Overview of conclusions: Comparisons by age groups (regardless of emergency type)

Outcome	Age Group	KQ1: BVM vs. SGA	KQ2: BVM vs. ETI	KQ3: SGA vs. ETI
Survival	Adults	**No difference**	**No difference**	No difference
	Pediatrics	*Insufficient*[a]	No difference	*Insufficient*[a]
	Mixed ages	No difference	Favors BVM[a]	Favors ETI[a]
Neurological function	Adults	No difference[a]	**No difference**	mRS: No difference CPC: **No difference[a]**
	Pediatrics	*Insufficient*[a]	No difference	mRS – No evidence CPC - *Insufficient*[a]
	Mixed ages	**Favors BVM[a]**	*Insufficient*[a]	mRS - No evidence CPC - *Insufficient*[a]
ROSC[b]	Adults	No difference	**Favors ETI**	Favors SGA
	Pediatrics	*Insufficient*[a]	No difference[a]	*Insufficient*[a]
	Mixed ages	*Insufficient*[a]	No difference[a]	*Insufficient*[a]

BVM = bag valve mask; CPC = Cerebral Performance Category; ETI = endotracheal intubation; KQ = Key Question; mRS = modified Rankin Scale; 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 OHCA, so results are not stratified by emergency type

Table ES-2. Overview of conclusions: Comparisons by emergency types (regardless of age)

Outcome[b]	Emergency Type	KQ1: BVM vs. SGA	KQ2: BVM vs. ETI	KQ3: SGA vs. ETI
Survival	OHCA	**No difference**	**No difference**	No difference
	Trauma	**Favors BVM[a]**	No difference	Favors ETI[a]
	Mixed emergencies	No evidence	No difference	No evidence
Neurological function	OHCA	No evidence	No difference	No evidence
	Trauma	No evidence	No evidence	No evidence
	Mixed emergencies	No evidence	No difference	No evidence

BVM = bag valve mask; ETI = endotracheal intubation; OHCA = out-of-hospital cardiac arrest; 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 OHCA, so it cannot be compared across emergency types

Also included in the full report are studies that were analyzed qualitatively, which compared SGA devices, variations on ETI, or reported other outcomes.

Strengths and Limitations

We identified and pooled studies that compared primary outcomes for different types of airway management used in prehospital care. Given the challenges of this environment, the size of the body of evidence is a key strength. It is also useful that most studies included outcomes important to patients and were not limited to process measures that may be less relevant. The most important limitations are that most studies employed weaker observational study designs, rendering them vulnerable to indication and survival biases. Bias, confounding, and incomplete data are difficult to avoid, given the nature of airway management in the field. Specifically, use of more than one airway is the norm, yet the order and duration of use is rarely adequately documented and included in analyses. Additionally, the influence of prehospital ventilation has not been adequately assessed in the literature, so differences noted in outcomes after various airway management strategies may be related to the ventilation provided and not the airway method. Finally, variations within types of airways based on differences in devices and training make generalizations difficult.

Conclusion and Implications

Overall, this review found no strongly supported differences in primary outcomes, with most of the results being "no difference" across the three common methods of airway management in prehospital care. Whereas this may be due in part to study limitations, it also may reflect the reality that no one airway approach is consistently more effective across different patient needs and the widely variable prehospital environment. Attempting to derive algorithmic protocols that identify single approach recommendations based solely on effectiveness may not be possible or desirable given this heterogeneity. Future research should focus on rigorous studies, particularly RCTs, given the multiple possible sources of bias likely in studies of prehospital airway management that are difficult to address in observational research designs. This research should focus on patient subgroups and factors where there are in consistencies in the currently available evidence.

Introduction

Background

Airway management is one of the most important aspects of prehospital care. It is critical to patient survival, and it affects the potential for recovery from emergent illness or injury. Effective airway management ensures airway patency to allow for oxygenation and ventilation and may protect against aspiration depending on the management approach. The primary objective in the prehospital setting is to ensure adequate oxygenation and ventilation until the transfer of patient care to an emergency department (ED) or hospital.

Historically, endotracheal intubation (ETI) has been considered the gold standard for airway management. However, while this is true in a controlled environment, prehospital setting success rates vary, and high rates of complications attributed to a range of factors have been reported.[1-5] In addition, different airways require management that involves varying levels of invasiveness and complexity, and require distinct technologies and expertise. The simplest approaches are part of general first aid, while the most complex involve the use of drugs and surgical techniques. Basic airway management includes the use of manual maneuvers (e.g., jaw thrust or chin lift) and airway adjuncts (e.g., oropharyngeal airway [OPA] or nasopharyngeal airway [NPA]), which are devices inserted orally or nasally to assist with airway patency. Ventilation is often achieved using a bag valve mask (BVM). In addition to ETI, other advanced airway management techniques include placement of supraglottic airway (SGA) devices, pharmacologically facilitated intubation (rapid sequence intubation [RSI] or delayed sequence intubation [DSI]), and percutaneous or surgical techniques. (Note: We use the term "supraglottic airway" to indicate the various "extraglottic airway" methods. While "extraglottic airway" may be more technically correct, due to its more common use in the literature, this report uses the term "supraglottic airway" to classify advanced airway devices that are placed outside of the trachea to facilitate oxygenation and ventilation.)

The choice of technique and the potential for success depend on the severity of the patient's condition, the training and skills of emergency medical services (EMS) personnel, setting, and available equipment. Field personnel with less training than is required for SGA or ETI can administer basic approaches.

The challenge in prehospital airway management is to determine the appropriate approach given patient needs, and the skills and equipment available. Addressing this challenge includes considering a wide range of issues such as: (1) correct identification of patients appropriate for prehospital airway management, (2) appropriate use of advanced techniques, (3) what provider level should be certified to perform various prehospital airway interventions, (4) comparison of the benefit and harms across different airway management approaches (basic and advanced), (5) types of devices to use, (6) the setting for the airway intervention (e.g., on scene or during transport), (7) first pass and overall success rates, and (8) influence of patient characteristics on success rates (e.g., cardiac vs. noncardiac, trauma vs. nontrauma, traumatic brain injury vs. no brain injury, age, and comorbidities). Thus, a core decisional dilemma in prehospital care is to match the airway management approach with the needs of the patient, the resources available, and EMS personnel training and experience, in order to select the strategies most likely to produce the best patient outcomes.

In addition, prehospital airway management is related to several practice and policy challenges that influence the quality of prehospital care. One policy challenge is defining the skill levels for different personnel classifications and estimating how many EMS providers at each level are required to meet the needs of each community. Another is that barriers differ across rural and urban communities, with prehospital care playing a particularly vital role in areas with long transport-to-hospital distances/time[6] and underserved areas. Furthermore, direct linkages among prehospital care and inpatient, outpatient, and emergency care have been established and strengthened by technology (e.g., telehealth) and organizational changes. These are transforming prehospital care and contributing to higher quality care as EMS becomes integrated into learning healthcare systems and health information exchange systems.

A key challenge is determining the comparative effectiveness, and balancing potential benefits and harms, of the use of different airway approaches for individual patients. This is made more difficult by the lack of a definitive gold standard in prehospital care and the wide range of possible prehospital care scenarios.[1-5]

Guideline developers and EMS system leaders wish to develop recommendations based on research in an environment of expanding options for prehospital airway management. Evidence-based guidelines are needed to establish a standardized approach to airway management in the prehospital setting, and national and local efforts are currently underway.

EMS agencies are part of larger healthcare systems and are essential components of the healthcare safety net for many communities. Medical direction is now required for all levels of prehospital personnel, and the most seriously ill or injured patients seen in the ED often arrive through EMS. Expanded EMS system capacities, including the availability of data collection and information integration, have made possible research examining the relationships between prehospital care and patient outcomes. As a result, there is a body of literature that may provide evidence about the association of airway management approaches with outcomes across different types of patients and environments.

Purpose and Scope of the Systematic Review

The purpose of this systematic review is to identify and synthesize the evidence available to support the development of evidence-based recommendations and guidelines for prehospital airway management. The sponsoring funder in this effort is the National Highway Traffic Safety Administration (NHTSA), Office of Emergency Medical Services, who will utilize the review as a foundation for developing guidelines.

Specifically, this review will focus on comparing the benefit and harms across three different airway management approaches: BVM, SGA, and ETI. Given the possible variations in the prehospital setting, this review will also consider how the benefits and harms may differ across the following factors: (1) specific techniques and devices used for each airway management approach, (2) the 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 the patient location/environment).

The scope of this systematic review was determined based on factors such as:

- The safety and efficacy of the inherently higher risk of pharmacologically facilitated prehospital intubation when utilized;
- The likelihood that multiple attempts or delays increase the probability of poor outcomes;
- Difficulties in triage and decision making outside the hospital;
- The initial and ongoing training as well as maintenance of skill needed for the different airway techniques;
- The availability of new advanced supraglottic devices which may be easier to utilize and provide effective oxygenation and ventilation in the prehospital setting; and

- Uncertainty surrounding advanced recent technological initiatives such as video laryngoscopy and use of the gum elastic bougie.

Research exists on these topics, but in most cases, individual studies are not sufficient to inform policy as they are conducted in single populations or environments, may ask narrow questions, or are unable to reach definitive conclusions. In this report, we aggregate the individual studies both quantitatively and qualitatively to provide a synthesis of the evidence on the comparative benefits and harms from the use of BVM, SGA, and ETI, modified by techniques or devices used, provider characteristics, and patient characteristics.

Methods

Review Approach

This systematic review follows the methods suggested in the Agency for Healthcare Research and Quality (AHRQ) *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*[7] (hereafter "AHRQ Methods Guide"). All methods were determined a priori, and a protocol was published on the AHRQ website (https://effectivehealthcare.ahrq.gov/products/prehospital-airway-management/protocol) and submitted to PROSPERO, the systematic reviews registry (registration no. CRD42020170201). Below is a summary of the specific methods used in this review. A more detailed description of methods, including literature search strategies, is provided in Appendix A.

Key Questions

Key Questions were posted for public comment November 22, 2019, through December 20, 2019. Comments received emphasized the value of stratifying results as much as possible by modifiers such as airway types, patient characteristics, and provider level of training and experience. The need for precision in definitions was also emphasized and comments described new technologies. Concern was expressed about the ability of the literature to reflect and report on unrecognized failures to provide adequate airway management. Public comments were considered to inform the review process; however, the comments did not lead to substantive changes in the proposed Key Questions.

Key Question 1

a. What are the comparative benefits and harms of bag valve mask versus supraglottic airway for patients requiring prehospital ventilatory support or airway protection?
b. Are the comparative benefits and harms modified by:
    i. Techniques or devices used?
    ii. Characteristics of emergency medical services personnel (including training, proficiency, experience, certification, licensure level, and/or scope of practice level)?
    iii. Patient characteristics?

Key Question 2

a. What are the comparative benefits and harms of bag valve mask versus endotracheal intubation for patients requiring prehospital ventilatory support or airway protection?
b. Are the comparative benefits and harms modified by:
    i. Techniques or devices used?
    ii. Characteristics of emergency medical services personnel (including training, proficiency, experience, certification, licensure level, and/or scope of practice level)?
    iii. Patient characteristics?

Key Question 3

a. What are the comparative benefits and harms of supraglottic airway versus endotracheal intubation for patients requiring prehospital ventilatory support or airway protection?

b. Are the comparative benefits and harms modified by:
   i. Techniques or devices used?
   ii. Characteristics of emergency medical services personnel (including training, proficiency, experience, certification, licensure level, and/or scope of practice level)?
   iii. Patient characteristics?

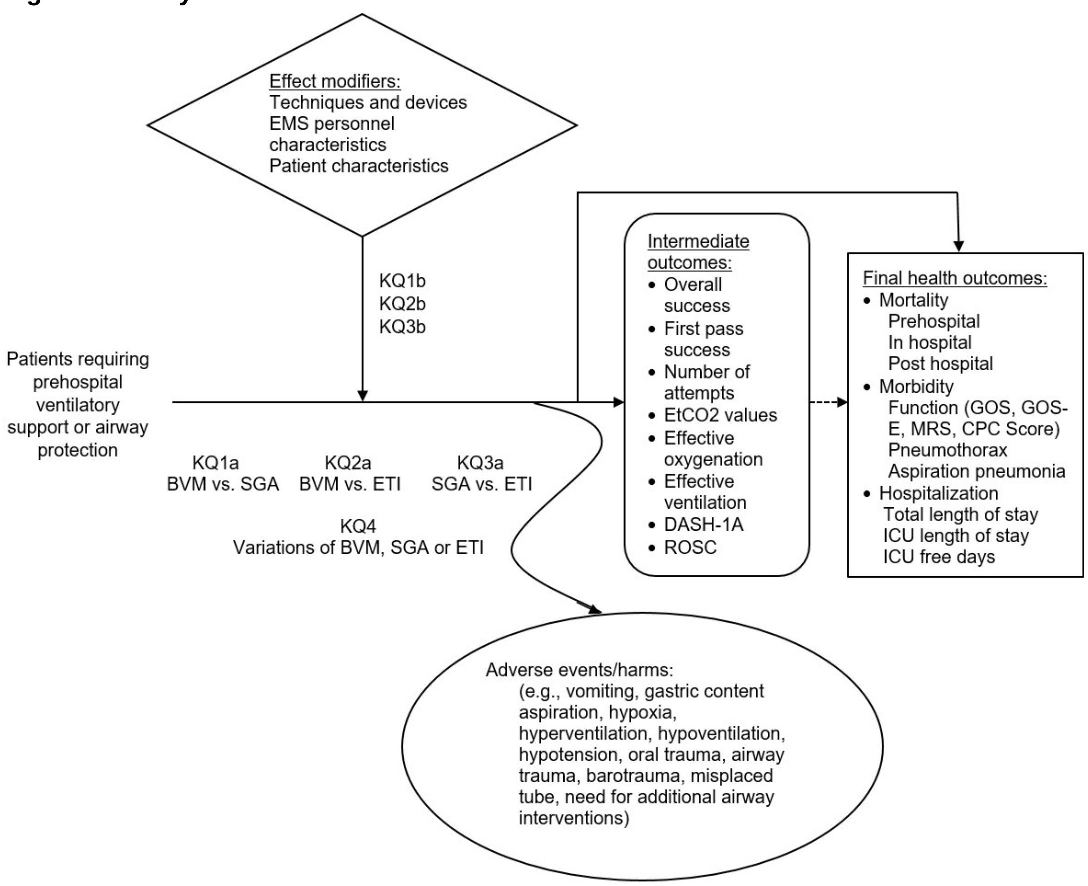
Key Question 4

What are the comparative benefits and harms of the following variations of any one of the three included airway interventions (bag valve mask, supraglottic airways, or endotracheal intubation) for patients requiring prehospital ventilatory support or airway protection:

i. Techniques or devices used?
ii. Characteristics of emergency medical services personnel (including training, proficiency, experience, certification, licensure level, and/or scope of practice level)?
iii. Patient characteristics?

Analytic Framework

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

Study Selection

Criteria used to triage abstracts and review full texts of research articles for inclusion and exclusion were pre-established, in accordance with the AHRQ Methods Guide,[7] and were developed based on the Key Questions and PICOS specified for this project (populations, interventions, comparators, outcomes, setting; see Appendix A). To ensure accuracy, all excluded abstracts were dual reviewed to confirm exclusion. All abstracts deemed potentially appropriate for inclusion by at least one reviewer triggered retrieval of the full-text article. Each full-text article, including any articles suggested by peer reviewers or any that arose from the public posting process, was then independently reviewed for eligibility by two team members. During full-text review, all RCTs and comparative observational studies were retained and categorized according to which Key Questions they addressed. The literature flow appears in Appendix B.

Authors of a paper who were on the research team did not review their own publications. Disagreements between two team members regarding study inclusion were resolved by consensus of the investigators involved.

Data Extraction and Risk of Bias Assessment

After studies were selected for inclusion, data were abstracted including study design, year, setting, country, sample size, eligibility criteria, population and clinical characteristics, intervention characteristics, and results relevant to each Key Question, as outlined in the PICOS table (Appendix A). Data from included studies (Appendix C) were abstracted into an interactive database in order to facilitate meta-analyses. Studies in which a vast majority (>85%) of the participants were OHCA patients were categorized as OHCA at the study level. Studies or subgroups were categorized as pediatric based on each study's definition. All abstracted data were verified for accuracy and completeness by a second team member. A record of studies excluded at the full-text level with reasons for exclusion is provided in Appendix D.

Predefined criteria were used to assess the quality of included studies. The criteria used were dependent on the study design as recommended in the chapter, "Assessing the Risk of Bias of Individual Studies When Comparing Medical Interventions" in the AHRQ Methods Guide.[7] Randomized controlled trials were evaluated using Cochrane risk of bias criteria,[8] and observational studies were evaluated using criteria developed by the U.S. Preventive Services Task Force.[9]

For full data extraction (Appendix E and Appendix F) and risk of bias assessment (Appendix G), please see the Methods Appendix A.

Data Synthesis and Analysis

We constructed evidence tables including study characteristics, results, and quality ratings for all included studies, along with summary tables that highlight the main findings provided in the Results section of this report. Results were organized by Key Question, and stratified by major subgroups.

Meta-analyses (Appendix H and Appendix I), using profile-likelihood random effects model,[10] were conducted to summarize data and obtain more precise estimates where there are at least two studies reporting outcomes that were homogeneous enough to provide a meaningful combined estimate. To determine whether meta-analyses were appropriate, we considered the quality of individual studies, the heterogeneity across several variables including patient characteristics, interventions, and outcomes, as well as the completeness of the same reported outcomes. All meta-analyzable outcomes were binary and risk ratio (RR) was the effect measure. Adjusted RRs or odds ratios (OR) were used in the meta-analysis if reported (an adjusted OR was first converted to an adjusted RR).[11] Otherwise, the RR was calculated from the reported raw numbers. Statistical heterogeneity was assessed using the χ^2 test, and the magnitude of heterogeneity using the I^2 statistic.[12]

Meta-analyses were stratified by study design (e.g., randomized controlled trials [RCTs] or observational studies). Controlled clinical trials (CCTs) were included as RCTs in meta-analyses. The Key Questions were designed to assess the comparative effectiveness and harms by airway, emergency medical services (EMS) personnel, and patient characteristics. Based on availability of reported data, we conducted subgroup analysis based on population age (adults vs. pediatric vs. mixed) and emergency type (cardiac vs. trauma vs. other medical needs), and evaluated the impact of study quality. In primary analyses, we used data from the intent-to-treat (ITT) analysis for RCTs, and if reported, propensity score matched results for observational studies. Sensitivity analyses were conducted by using other reported data (e.g., data from per-protocol, or as treated analysis for RCTs, results using all data from observational studies), or by excluding outlying studies.

All analyses were performed by using STATA® 16.1 (StataCorp, College Station, TX), and all results were provided with 95 percent confidence intervals (95% CIs).

Where pooling studies was not appropriate, qualitative syntheses, which include summary tables, tabulations of important study features, and narratives, were created and are presented by Key Questions and outcomes (see Results and Appendix F). As the Key Questions include assessment of the impact of technique, provider, and patient characteristics, we stratified results by these characteristics when possible in order to identify divergent results.

Grading the Strength of the Body of Evidence

Regardless of whether evidence was synthesized quantitatively or qualitatively, the strength of evidence (Appendix J) for each Key Question/body of evidence was initially assessed by one researcher for each clinical outcome (see PICOS, Appendix Table A-1) by using the approach described in the AHRQ Methods Guide.[7] To ensure consistency and validity of the evaluation, the strength of evidence was reviewed by the entire team of investigators prior to assigning a final grade on the following factors:

- Risk of bias across included studies (low, moderate, or high level of risk of bias)
- Consistency of results (consistent, inconsistent, or unknown/not applicable)
- Directness (direct or indirect)
- Precision of effect estimates (precise or imprecise)
- Reporting bias (suspected or undetected)

The strength of evidence (SOE) was determined for each outcome by each airway comparison. Randomized controlled trials and observational studies were not mixed in the pooled estimates, and are reported separately by study design. However, the SOE assessment is for the entire body of evidence, with study designs combined. In making the SOE determination and specifying what can be concluded from the evidence, 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.

For description of overall grades, please see Methods (Appendix A).

Results

Introduction

Our literature search produced 8,837 abstracts of potentially relevant articles. Seven hundred twenty full-text publications were reviewed. Of those, 81 studies from 82 publications were included for this review (Appendix B).

In this section we present the results of our quantitative and qualitative analyses of the studies included for the review that address one or more of the four Key Questions. We begin with a summary of the overall findings across Key Questions 1-3, and then provide individual summaries for Key Questions 1-4. The list of included studies can be found in Appendix C. Table 1 presents characteristics of the included studies. Table 2 shows the number of studies by study design.

For quantitative analysis, we identified outcomes with studies that could be combined in meta-analyses (see Appendix H and I). These include survival in-hospital or at one month post-incident, neurological function at discharge or one month post-incident, and return of spontaneous circulation (ROSC) for Key Questions 1-3, successful advanced airway insertion for Key Questions 3 and 4 only, and survival in-hospital or at one month post-incident for Key Question 4 (Tables 3-5). Forest plots for the primary analyses are included in Appendix H. In the sections below that address individual Key Questions, we provide tables with the number of studies and number of patients included in the studies; we provide the pooled relative risk (RR) with confidence interval (CI) and I^2 for randomized controlled trials (RCTs) and observational studies separately; and the overall SOE is provided for age and emergency type subgroup. Bolded outcomes in tables are those for which results are substantiated by moderate strength of evidence (SOE).

Details on the determinations that contributed to the SOE are in Appendix J. We conducted sensitivity analyses for all outcomes and discuss relevant findings in the individual sections below (forest plots for sensitivity analyses are included in Appendix I).

For qualitative analysis, we summarized studies that could not be included in meta-analyses and present the findings in the sections below that address individual Key Questions.

Table 1. Characteristics of included studies

Category	**Characteristics**	**Overall N (%)** N=81[a]	**KQ1** N=20[a]	**KQ2** N=19[a]	**KQ3** N=38[a]	**KQ4** N=34
Year of publication	1990-2000	9 (11.1%)	1 (5.0%)	2 (10.5%)	3 (7.9%)	5 (14.7%)
	2001-2010	20 (24.7%)	5 (25.0%)	7 (36.8%)	9 (23.7%)	7 (20.6%)
	2011-2020	52 (64.2%)	14 (70.0%)	10 (52.6%)	26 (68.4%)	22 (64.7%)
Study design	RCT	17 (21.0%)	2 (10.0%)	2 (10.5%)	4 (10.5%)	10 (29.4%)
	Prospective cohort	12 (14.8%)	3 (15.0%)	2 (10.5%)	8 (21.1%)	4 (11.8%)
	Retrospective cohort	39 (48.1%)	12 (60.0%)	14 (73.7%)	23 (60.5%)	13 (38.2%)
	Controlled clinical trial	6 (7.4%)	2 (10.0%)	1 (5.3%)	2 (5.3%)	2 (5.9%)
	Before/after	7 (8.6%)	1 (5.0%)	0	1 (2.6%)	5 (14.7%)
Geographic location	United States/Canada	43 (53.1%)	6 (30.0%)	8 (42.1%)	20 (52.6%)	23 (67.6%)
	Europe	19 (23.5%)	4 (20.0%)	2 (10.5%)	7 (18.4%)	9 (26.5%)
	Asia	14 (17.3%)	10 (50.0%)	8 (42.1%)	10 (26.3%)	4 (11.8%)

Category	Characteristics	Overall N (%) N=81[a]	KQ1 N=20[a]	KQ2 N=19[a]	KQ3 N=38[a]	KQ4 N=34
	Australia	5 (6.2%)	0	1 (5.3%)	1 (2.6%)	3 (8.8%)
Prehospital setting	Urban	39 (48.1%)	7 (35.0%)	11 (57.9%)	18 (47.4%)	17 (50.0%)
	Rural	2 (2.5%)	1 (5.0%)	0	1 (2.6%)	0
	Mixed settings	29 (35.8%)	7 (35.0%)	6 (31.6%)	16 (42.1%)	11 (32.4%)
	Not reported	11 (13.6%)	5 (25.0%)	2 (10.5%)	3 (7.9%)	6 (17.6%)
Number of agencies/ institutions	Single	36 (44.4%)	6 (30.0%)	7 (36.8%)	15 (39.5%)	19 (55.9%)
	Multiple	44 (54.3%)	14 (70.0%)	12 (63.2%)	23 (60.5%)	14 (41.2%)
	Not reported	1 (1.2%)	0	0	0	1 (2.9%)
EMS provider level[b]	ETI-capable No	6 (7.4%)	5 (25.0%)	0	0	2 (5.9%)
	ETI-capable Yes	35 (43.2%)	7 (35.0%)	11 (57.9%)	16 (42.1%)	18 (51.3%)
	Advanced	9 (11.1%)	1 (5.0%)	1 (5.3%)	0	7 (20.5%)
	Mixed levels	31 (38.3%)	7 (35.0%)	7 (36.8%)	22 (57.9%)	7 (23.1%)
Mode of transport	Ground	49 (60.5%)	12 (60.0%)	10 (52.6%)	25 (65.8%)	18 (51.9%)
	Air	7 (8.6%)	0	0	0	7 (20.6%)
	Mixed modes	14 (17.3%)	3 (15.0%)	3 (15.8%)	6 (15.8%)	6 (17.6%)
	Not reported	11 (13.6%)	5 (25.0%)	6 (31.6%)	7 (18.4%)	3 (8.8%)
Age group	Pediatric	4 (4.9%)	1 (5.0%)	3 (15.8%)	1 (2.6%)	2 (5.9%)
	Adult	50 (61.7%)	13 (65.0%)	9 (47.4%)	27 (71.1%)	16 (47.1%)
	Mixed ages	21 (25.9%)	5 (25.0%)	6 (31.6%)	8 (21.1%)	12 (35.3%)
	Not reported	6 (7.4%)	1 (5.0%)	1 (5.3%)	2 (5.3%)	4 (11.8%)
Emergency type	Trauma	14 (17.3%)	3 (15.0%)	6 (31.6%)	4 (10.5%)	5 (14.7%)
	Out-of-hospital cardiac arrest	40 (49.4%)	17 (85.0%)	12 (63.2%)	26 (68.4%)	9 (26.5%)
	Medical	2 (2.5%)	0	0	2 (5.3%)	0
	Mixed emergency types	23 (28.4%)	0	1 (5.3%)	6 (15.8%)	18 (52.9%)
	Not reported	2 (2.5%)	0	0	0	2 (5.9%)

EMS = emergency medical services; ETI = endotracheal intubation; KQ = Key Question; RCT = randomized controlled trial
[a] Evans, 2016 counted as two studies
[b] EMS Provider Level Categorization: Two topic experts reviewed all included studies and categorized EMS Provider Levels as ETI-capable No; ETI-capable Yes; Advanced (physicians, nurses, physician assistants) or Mixed levels (the EMS team included two or more of these 3 provider levels).

Table 2. Number of studies by Key Question and study design

Key Question	Randomized Controlled Trials	Observational Studies	Total
Key Question 1	2	18	20
Key Question 2	2	17	19
Key Question 3	4	34	38
Key Question 4	10	24	34

Summary of Overall Results

The overall results are summarized in the bullet points and Table 3. Detailed results are presented in the individual Key Question sections.

- Survival measured in-hospital or at one month post-incident: No differences in outcomes when bag valve mask (BVM) was compared with supraglottic airway (SGA) or endotracheal intubation (ETI) in adult patients and in patients sustaining out-of-hospital cardiac arrest (OHCA). BVM resulted in better survival in trauma patients when compared with SGA.
- Neurological function measured by the Cerebral Performance Category (CPC), Pediatric CPC, or modified Rankin Scale (mRS) in-hospital or at one month post-incident: No differences in outcomes when ETI was compared with BVM or SGA in adult patients. There were better outcomes for BVM versus SGA in patients of mixed ages.
- Return of spontaneous circulation (ROSC) (pre-hospital, sustained, or overall – out-of-hospital cardiac arrest [OHCA] patients only): better for ETI than BVM based on one randomized controlled trial (RCT) of adult patients (with physicians as field providers, conducted in Europe).
- Successful advanced airway insertion: SGA had a higher first-pass success rate than ETI for OHCA patients, and there were no differences for overall success by age or emergency type.

Table 3. Overview of conclusions: Comparisons by age groups and emergency types

Outcome	Age Group or Emergency Type	KQ1: BVM vs. SGA	KQ2: BVM vs. ETI	KQ3: SGA vs. ETI
Survival	Adults	**No difference**	**No difference**	No difference
	Pediatrics	*Insufficient*[a]	No difference	*Insufficient*[a]
	Mixed ages	No difference	Favors BVM[a]	Favors ETI[a]
Neurological function	Adults	No difference[a]	**No difference**	mRS: No difference CPC: **No difference[a]**
	Pediatrics	*Insufficient*[a]	No difference	mRS – No evidence CPC - *Insufficient*[a]
	Mixed ages	**Favors BVM[a]**	*Insufficient*[a]	mRS - No evidence CPC - *Insufficient*[a]
ROSC[b]	Adults	No difference	**Favors ETI**	Favors SGA
	Pediatrics	*Insufficient*[a]	No difference[a]	*Insufficient*[a]
	Mixed ages	*Insufficient*[a]	No difference[a]	*Insufficient*[a]
Survival	OHCA	**No difference**	**No difference**	No difference
	Trauma	**Favors BVM[a]**	No difference	Favors ETI[a]
	Mixed emergencies	No evidence	No difference	No evidence
Neurological function	OHCA	No evidence	No difference	No evidence
	Trauma	No evidence	No evidence	No evidence
	Mixed emergencies	No evidence	No difference	No evidence

BVM = bag valve mask; CPC = Cerebral Performance Category; ETI = endotracheal intubation; KQ = Key Question; mRS = modified Rankin Scale; OHCA = out-of-hospital cardiac arrest; 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 OHCA, so results are not stratified by emergency type

Table 4. Overview of conclusions: Successful advanced airway insertion: Key Question 3

Outcome	**Key Question 3: SGA vs. ETI**
First-pass success	SGA resulted in higher rates of successful advanced airway insertion on the first attempt compared with ETI in some populations: • Patients with OHCA (SOE: Moderate) • Mixed emergency types (SOE: Low)
Overall success	No differences • Adults and patients with medical emergencies (SOE: Moderate) • Mixed ages and patients with OHCA and mixed emergency types (SOE: Low)

ETI = endotracheal intubation; OHCA = out-of-hospital cardiac arrest; RCT = randomized controlled trial; SGA = supraglottic airway; SOE = strength of evidence

Table 5. Overview of conclusions: Outcomes for modifiers of endotracheal intubation: Key Question 4

Outcome	**Emergency type**	**Video vs. Direct Laryngoscopy**	**RSI vs. No RSI**
Survival	No evidence	No evidence	No difference • Adults and patients with trauma emergencies (SOE: Low) *Insufficient* • Mixed ages and OHCA patients
First-pass success	No difference • Mixed ages: trauma vs. medical (SOE: Low) *Insufficient* • Adults: trauma vs. medical • Mixed ages: OHCA vs. medical; OHCA vs. trauma, OHCA vs. non-OHCA	No difference • Adults, mixed ages, patients with OHCA and mixed emergency types (SOE: Low) *Insufficient* • Pediatrics, medical and trauma emergencies	No difference • Mixed ages (SOE: Low) *Insufficient* • Adults and patients with OHCA, trauma, and mixed emergency types
Overall success	No difference • Mixed ages: OHCA vs. medical; OHCA vs. trauma. (SOE: Low) *Insufficient* • Adults: trauma vs. medical • Mixed ages: OHCA vs. non-OHCA; trauma vs. medical	No difference • Adults, mixed ages, patients with OHCA and mixed emergency types (SOE: Low)	No difference • Adults and mixed ages, and patients with mixed emergency types (SOE: Low) *Insufficient* • OHCA and trauma patients

OHCA = out-of-hospital cardiac arrest; RSI = rapid sequence intubation; SOE = strength of evidence

Individual Key Question Summaries

Key Question 1: Bag valve mask compared with supraglottic airway

Key Results

When BVM was compared with SGA for prehospital airway management:

- Survival in-hospital or at one month post-incident was similar between BVM and SGA based on 14 studies (N=45,373)
  - No difference
    - Moderate SOE: adults and OHCA patients

        - Low SOE: patients of mixed ages
    - Favors BVM
        - Moderate SOE: trauma patients
    - Insufficient SOE: pediatric patients
- Neurological function, defined as good neurological outcomes at discharge measured by the CPC or Pediatric CPC, was similar between BVM and SGA based on eight studies (N=88,627)
    - No difference
        - Low SOE: adults
    - Favors BVM
        - Moderate SOE: patients of mixed ages
    - Insufficient SOE: pediatric patients
- ROSC was similar between BVM and SGA based on 11 studies (N=44,143)
    - No difference
        - Low SOE: adults
    - Insufficient SOE: pediatric patients and patients of mixed ages
- Harms: no differences based on 3 studies (N=675; Moderate SOE)

Summary of Results

We identified and analyzed 20 studies (in 19 publications; 2 studies were included in one publication)[13] that compared patient outcomes for BVM and SGA (N=94,399) (See Appendix C for the list of included studies).

These included 2 RCTs,[14,15] 2 controlled clinical trials,[16,17] 3 prospective cohorts,[18-20] 12 retrospective cohorts,[13,21-30] and 1 before-after study.[31] The studies included 50 to 45,685 participants; 6 were conducted in the United States and Canada,[13,15,22-24] 6 in Japan,[17,20,26-28,30] 3 in Austria,[14,18,19] 2 each in Taiwan[21,31] and South Korea,[25,29] and 1 in France.[16] Six of these studies were rated low ROB,[17,18,21-23,28] 11 moderate,[13-16,20,24,26,29-31] and one high.[27] Two were rated low ROB on certain outcomes and moderate on others (Appendix G).[19,25]

Meta-Analysis

Nineteen studies were pooled to obtain estimates for survival, neurological function, and ROSC, stratified by age or emergency type and study design (Appendix H-1 to H-4).[13-19,21-31] The results for each outcome by subgroup are reported in Tables 6 to 8.

BVM was associated with survival benefit over SGA in an observational trial enrolling trauma patients (SOE: Moderate) and in an observational study of pediatric patients (SOE: Insufficient) (Table 6). There was no difference in survival comparing BVM and SGA in studies enrolling adults (SOE: Moderate) or OHCA patients (SOE: Moderate). In the mixed ages subgroup, results were mixed but suggest no difference between BVM and SGA, as observational trials were assessed to have moderate and high ROB (SOE: Low). No changes in effect were detected in sensitivity analyses for any subgroup (Appendix I-1 to I-6).

Table 6. BVM vs. SGA: Survival by age groups and emergency type

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size n=patients	Summary of Results RR (95% CI), I^2 Reference: BVM
Adults **Moderate** **No difference**	1 RCT[16]	n=82	0.98 (0.06 to 15.09); NA
	7 Observational[17-19,21,22,24,25]	N=41,998	0.87 (0.46 to 1.51); 70.4%
Pediatrics Insufficient	No RCT	-	-
	1 Observational[23]	n=996	0.35 (0.14 to 0.89); NA
Mixed ages Low No difference	1 RCT[15]	n=464	1.34 (0.40 to 4.49); NA
	4 Observational[13,27,29]	N=1,833	0.42 (0.25 to 0.66); 0.0%
OHCA **Moderate** **No difference**	2 RCTs[15,16]	n=546	1.28 (0.29 to 5.07); 0.0%
	9 Observational[17-19,21-23,25,27,29]	N=43,789	0.68 (0.40 to 1.10); 74.5%
Trauma **Moderate** **Favors BVM**	No RCT	-	-
	3 Observational[13,24]	N=1,038	0.42 (0.18 to 0.99); 0.0%
Mixed emergency types	No studies	-	-

BVM = bag valve mask; CI = confidence interval; NA = not applicable; OHCA = out-of-hospital cardiac arrest; RCT = randomized controlled trial; RR = relative risk; SGA = supraglottic airway; SOE = strength of evidence
Bold Text = Moderate SOE

BVM was associated with good neurological outcome ratings at discharge versus SGA in observational studies enrolling mixed ages (SOE: Moderate) and pediatrics (SOE: Insufficient) (Table 7). No changes in effect were detected across sensitivity analyses for any subgroup (Appendix I-7 to I-8).

Table 7. BVM vs. SGA: Neurological function by age groups

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size n=patients	Summary of Results RR (95% CI), I^2 Reference: BVM
Adults Low No difference	No RCT	-	-
	5 Observational[18,19,21,25,28]	N=87,003	0.65 (0.40 to 1.14); 85.2%
Pediatrics Insufficient	No RCT	-	-
	1 Observational[23]	n=996	0.16 (0.06 to 0.42); NA
Mixed ages **Moderate** **Favors BVM**	No RCT	-	-
	2 Observational[27,30]	N=628	0.21 (0.05 to 0.96); 16.6%

BVM = bag valve mask; CI = confidence interval; RCT = randomized controlled trial; RR = relative risk; SGA = supraglottic airway
Bold Text = Moderate SOE

BVM was associated with any ROSC compared with SGA in one observational study enrolling mixed ages (SOE: Insufficient) (Table 8). No changes in effect were detected across sensitivity analyses for any subgroup (Appendix I-9).

Table 8: BVM vs. SGA: ROSC by age groups

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size n=patients	Summary of Results RR (95% CI), I^2 Reference: BVM
Adults Low No difference	2 RCT[14,16]	N=158	1.09 (0.45 to 2.60); 0.0%
	7 Observational[17-19,21,25,26,31]	N=42,434	1.19 (0.92 to 1.57); 83.1%
Pediatrics Insufficient	No RCT	-	-
	1 Observational[23]	n=996	1.19 (0.75 to 1.88); NA
Mixed Ages Insufficient	No RCT	-	-
	1 Observational[30]	n=555	0.46 (0.26 to 0.82); NA

BVM = bag valve mask; CI = confidence interval; RCT = randomized controlled trial; RR = relative risk; SGA = supraglottic airway

Qualitative Synthesis: Additional Outcomes

Outcomes for comparisons of BVM to SGA that were not meta-analyzed included length of stay, measures of oxygenation/ventilation, and harms. These results are presented in Table 9 below. Overall, harms were similar between BVM and SGA groups across three studies.[14,16,18] There was no difference between BVM and SGA when comparing blood gases in most studies;[14,15,17-19,31] one study[17] reported lower arterial pH in the BVM group. In one study,[18] providers (regardless of advanced training level) were more likely to establish a successful airway using SGA vs. BVM, while in another there was no difference in successful airway placement.[14] Finally, one study reported significantly fewer hospital and ICU days for BVM groups versus SGA.[24]

Table 9. BVM vs. SGA: Additional outcomes

Outcome Strength of Evidence Conclusion	Number of Studies (n=patients)	Summary of Findings
Length of stay Insufficient	1 observational (n=50)[24]	1 small study, significant difference in hospital- (6 vs. 1) and ICU-free days favoring BVM (7 vs. 1), $p<0.05$
Successful airway Low Favors SGA	1 RCT, 1 observational (N=593)[14,18]	1 study, no difference 1 study, significantly fewer successful airways established in BVM vs. SGA (30% vs. 93%, $p<0.01$)
Blood gas **Moderate** **No difference**	2 RCT, 1 CCT, 2 observational, 1 before/after (N=2,453)[14,15,17-19,31]	5 studies, no difference 1 study, significantly lower median arterial pH in BVM vs. SGA (7.08 vs. 7.12, $p=0.02$)
Harms **Moderate** **No difference**	1 RCT, 1 CCT, 1 observational (N=675)[14,16,18]	No differences between groups across all reported harms

BVM = bag valve mask; CCT = controlled clinical trial; ICU = intensive care unit; RCT = randomized control trial; SGA = supraglottic airway
Bold Text = Moderate SOE

Key Question 2: Bag valve mask compared with endotracheal intubation

Key Results

When BVM was compared with ETI for prehospital airway management across all the included studies:

- Survival in-hospital or at one month post-incident was similar overall based on 15 studies (N=49,454)
    - Favors BVM
        - Low SOE: patients of mixed ages
    - No difference
        - Moderate SOE: adults and OHCA patients
        - Low SOE: pediatrics, trauma and mixed emergency types
- Neurological function at discharge or one month post-incident was similar based on 8 studies (N=77,003)
    - No difference
        - Moderate SOE: adults
        - Low SOE: pediatrics, OHCA and mixed emergency types
    - Insufficient SOE: mixed ages
- ROSC was similar based on 8 studies (N=44,582)
    - Favors ETI
        - Moderate SOE: adults
    - No difference
        - Low SOE: pediatrics and mixed ages
    - Insufficient SOE: patients of mixed ages
- Harms: no differences based on 4 studies (N=3,763; Moderate SOE)

Summary of Results

We identified and analyzed 19 studies reported in 20 articles that compared patient outcomes for BVM and ETI (See Appendix C for the list of included studies). Two studies were reported in a single article,[13] while results from two studies were reported in two articles each.[32,33 and 34,35] These studies included 2 RCTs,[34-36] 1 controlled clinical trial,[32,33] 2 prospective cohorts,[19,20] and 14 retrospective cohorts.[13,21-23,25,27-30,34,35,37-39]

Seven of these studies were rated low ROB,[21-23,28,34-36,39] 6 moderate,[13,26,29,30,38] and one high.[27] Three were rated low ROB for survival and moderate for ROSC or neurological function outcomes.[19,25,32,33] One study was rated moderate ROB for short-term outcomes and high for survival at one month (Appendix G).[20]

The 19 studies included 99,929 patients and the individual study sizes ranged in size from 78[27] to 49,534 patients.[28] Most of the studies (12 of 19) included multiple emergency medical services (EMS) agencies or ambulance services.[13,19,21,23,25,28,29,32-37] However, less than half (8 studies) were conducted in the United States, or the United States and Canada,[13,22,23,32,33,37-39] 8 were conducted in Asia (Japan, South Korea, and Taiwan)[20,21,25-30] two in Europe,[19,34,35] and one in Australia.[36]

Meta Analyses

Fifteen studies contained data on survival for Key Question 2 comparing BVM and ETI, including 2 RCTs,[34,36] one controlled clinical trial (CCT)[32,33] and 12 observational studies.[13,19,21-23,25,27,29,37-39] Across most age groups and emergency types the most frequent finding was of no difference in survival in-hospital or at one month post-incident when comparing BVM to ETI for prehospital airway management (Table 10). For adults and OHCA patients we rated the SOE as moderate for this finding of no difference based on the numbers of studies and patients. Studies of adults included two RCTs[34,36] and four observational studies,[19,21,22,25] and findings for OHCA were based on one RCT,[34] one CCT,[32,33] and seven observational studies.[19,21-23,25,27] Both of these groupings include data from over 40,000 patients and the findings did not change in our sensitivity analyses (Appendix I-10 to I-15). The pooled results of six observational studies in patients of mixed ages[13,27,29,38,39] estimated a lower risk of survival with ETI (favoring BVM), but we rated the strength of evidence supporting this difference as low as the individual and pooled estimates are imprecise and five of the six studies are retrospective designs. Similarly, the pooled results of five observational studies of trauma patients[13,37-39] favored BVM. However, these findings are not consistent with the results of an RCT[36] and study limitations including retrospective designs with moderate to high ROB reduce our confidence that this difference will persist in future studies (SOE: Low).

Table 10. BVM vs. ETI: Survival in-hospital or at one month post-incident by age groups and emergency type

Subgroup Category Strength of Evidence Conclusion	**Number of Studies Study Design**	**Sample Size n=patients**	**Summary of Results RR (95% CI), I^2 Reference: BVM**
Adults **Moderate No difference**	2 RCTs[34,36]	N=2,339	0.99 (0.82, 1.19), 0.0%
	4 Observational[19,21,22,25]	N=40,633	0.84 (0.32, 2.05), 95.6%
Pediatrics Low No difference	1 CCT[32,33]	n=820	0.87 (0.70, 1.08), NA
	2 Observational[23,37]	N=2,086	0.68 (0.23, 1.86), 86.5%
Mixed ages Low Favors BVM	No RCT	-	-
	6 Observational[13,27,29,38,39]	N=3,576	0.44 (0.21, 0.95), 81.2%
OHCA **Moderate No difference**	OHCA: 1 RCT,[34] 1 CCT[32,33]	n=2,631	0.97 (0.68, 1.39), 0.0%
	7 Observational[19,21-23,25,27]	N=42,691	0.80 (0.43, 1.43), 92.2%
Trauma Low No difference	1 RCT[36]	n=299	1.00 (0.85, 1.16), NA
	5 Observational[13,37-39]	N=3,604	0.42 (0.19, 0.89), 90.4%
Mixed emergency types Low No difference	1 CCT[32,33]	n=820	0.87 (0.70, 1.08), NA
	No Observational	-	-

BVM = bag valve mask; CCT = controlled clinical trial; CI = confidence interval; ETI = endotracheal intubation; NA = not applicable; OHCA = out-of-hospital cardiac arrest; RCT = randomized controlled trial; RR = relative risk
Bold Text = Moderate SOE

Data on neurological function were available from eight studies, including two trials (one RCT[34] and one CCT[32,33]) and six observational studies.[19,21,23,25,28,30] The results for neurological function at discharge or one month post-incident are summarized in Table 11. The overall conclusion is of no difference. Two observational studies favored BVM over ETI in terms of functional outcomes, but these did not lead to conclusions favoring BVM for different reasons. In the case of pediatric studies, we made a conservative conclusion based on the fact that the intention to treat analysis of a clinical trial found no difference,[32,33] while a retrospective cohort study favored BVM.[23] The SOE is low as we are not confident in this finding of no difference. When the data were analyzed by the airway actually used in the trial ("as treated" analyses) the results switch to favoring BVM (Appendix I-17). The other study favoring BVM is a single, small retrospective cohort study,[30] which we did not rate as sufficient to support a conclusion. In the case of adults, the one RCT[34] and the pooled results of 4 observational studies[19,21,25,28] provide a moderate level of evidence supporting no difference. The CCT of pediatric patients[32,33] is also in Table 11 as the only included study of mixed emergency types comparing BVM to ETI. We rated this as low SOE because it is a single study with unstable results (i.e, the intention to treat analyses found no difference while the "as treated" favored BVM.

Table 11. BVM vs. ETI: Neurological Function by age groups and emergency types

Subgroup Category Strength of Evidence Conclusion	**Number of Studies Study Design**	**Sample Size n=patients**	**Summary of Results RR (95% CI), I^2 Reference: BVM**
Adults **Moderate No difference**	1 RCT[34]	n=2,040	0.97 (0.65, 1.47), NA
	4 Observational[19,21,25,28]	N=72,400	0.79 (0.40, 1.51), 86.3%
Pediatrics Low No difference	1 CCT[32,33]	n=820	0.90 (0.69, 1.17), NA
	1 Observational[23]	n=1,508	0.33 (0.20, 0.53), NA
Mixed ages Insufficient	No RCT	-	-
	1 Observational[30]	n=235	0.12 (0.03, 0.56), NA
OHCA Low No difference	1 RCT,[34] 1 CCT[32,33]	N=2,631	1.06 (0.68 1.92), 0.0%
	6 Observational[19,21,23,25,28,30]	N=74,143	0.58 (0.28, 1.06), 88.4%
Trauma	No studies	-	-
Mixed emergency types Low No difference	1 CCT[32,33]	n=820	0.90 (0.69, 1.17), NA
	No Observational	-	-

BVM = bag valve mask; CI = confidence interval; CCT = controlled clinical trial; ETI = endotracheal intubation; NA = not applicable; OHCA = out-of-hospital cardiac arrest; RCT = randomized controlled trial; RR = relative risk
Bold Text = Moderate SOE

Another subgroup of eight studies reported ROSC for OHCA patients including one RCT[34] and seven observational studies (Table 12).[19,21-23,25,26,30] The six studies of ROSC in adults include an RCT with low ROB conducted in France and Belgium.[34] It is important to note that the providers performing ETI in this study were physicians, which may not be generalizable to other emergency medicine systems. Furthermore, it is unclear what level of provider administered BVM. This RCT and two of the observational studies[21,25] favored ETI, even though the pooled estimate from the observational studies is not statistically significant. Based on this, the evidence favors ETI overall, but the strength of evidence is moderate as it is possible a rigorous study with a different result could change the conclusion. Pooled estimates from observational studies of adults or mixed ages detected no difference in ROSC between BVM and

ETI; however, our assessment of the SOE of these finding is low as only one retrospective study was identified for each.[23,30] Sensitivity analyses resulted in similar findings and the same conclusions (Appendix I-19).

Table 12. BVM vs. ETI: ROSC by age groups

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size n=patients	Summary of Results RR (95% CI), I^2 Reference: BVM
Adults **Moderate** **Favors ETI**	1 RCT[34]	n=2,040	1.14 (1.01, 1.27), NA
	5 Observational[19,21,22,25,26]	N=40,799	1.35 (0.88, 1.94), 83.2%
Pediatrics Low No difference	No RCT	-	-
	1 Observational[23]	n=1,508	1.10 (0.88, 1.39), NA
Mixed ages Insufficient	No RCT	-	-
	1 Observational[30]	n=235	0.67 (0.35, 1.30), NA

BVM = bag valve mask; CI = confidence interval; ETI = endotracheal intubation; NA = not applicable; RCT = randomized controlled trial; RR = relative risk
Bold Text = Moderate SOE

Qualitative Synthesis: Additional Outcomes

Outcomes from studies comparing BVM to ETI that were not meta-analyzed reported length of stay (2 studies[32,33,36]), successful airway insertion (2 studies[32-34]) and measures of adequate ventilation (2 studies[19,36]). Additionally, 4 studies[32-37] reported comparisons of different harms including need for an additional airway, overall complications, aspiration, oral trauma, vomiting/regurgitation, and pneumothorax. Results are presented in Table 13. The SOE was low or insufficient for all of these outcomes except harms. The four studies used different definitions of harms. Three of the four reported differences that were not statistically significant and would not be considered clinically significant even if the studies were larger or rated lower ROB (e.g., 14% vs. 15% for aspiration[32,33]). The one significant finding of note was that regurgitation of gastric contents was 7.7 percentage points lower with ETI in one trial.

Table 13. BVM vs. ETI: Additional outcomes

Outcome Strength of Evidence Conclusion	Number of Studies n=patients	Summary of Results
Length of stay Low No difference	1 RCT, 1 CCT (N=1,142)[32,33,36]	No significant difference in median hospital or ICU length of stay in either study
Successful airway insertion Insufficient	1 RCT, 1 CCT (N=2,873)[32-34]	Inconsistent findings from studies with different analytic approaches
Adequate ventilation Low No difference	1 RCT, 1 observational (N=2,535)[19,36]	No difference • 1 study no statistical difference in SaO_2, pH, PaO_2, $PaCO_2$, at ED arrival or Initial $ETCO_2$ • 1 study no clinical difference in initial SpO_2 in either the total cohort or propensity matched groups.

Outcome Strength of Evidence Conclusion	Number of Studies n=patients	Summary of Results
Harms **Moderate** **No difference**	2 RCTs, 1 CCT, 1 observational (N=3,763)[32-37]	No difference for majority of possible harms • 1 study each finding no difference in o need for additional airway o broadly defined complications o aspiration, oral/airway trauma or vomiting o pneumothorax • 1 study ETI reported expected lower regurgitation of gastric contents 15.2% vs. 7.5%; absolute difference 7.7% (95% CI 4.9 to 10.4), p<0.001

BVM = bag valve mask; CCT = controlled clinical trial; CI = confidence interval; ED = emergency department; ETI = endotracheal intubation; ICU = intensive care unit; RCT = randomized controlled trial
Bold Text = Moderate SOE

Four studies also reported survival to hospital admission, which was not clinically similar enough to be combined with the survival time points in meta-analysis; there was no difference in survival rates between BVM and ETI[19,20,22,23,29,34] (Table 14).

Table 14. BVM vs. ETI: Additional survival outcomes

Outcome Strength of Evidence Conclusion	Number of Studies n=patients	Summary of Results
Survival to hospital admission Low No difference	1 RCT, 3 observational (N=10,339)[22,23,29,34]	No significant difference

RCT = randomized controlled trial

Key Question 3: Supraglottic airway compared with endotracheal intubation

Key Results

When SGA was compared with ETI for prehospital airway management across the included studies:

- Survival in-hospital or at one month post-incident was mostly similar based on 17 studies (n=174,822), with ETI associated with better survival in some subgroups
  - Favors ETI
    - Low SOE: patients of mixed ages and trauma patients
  - No difference
    - Low SOE: adults and OHCA patients
  - Insufficient SOE: pediatric patients
- Neurological function on the modified Rankin Scale showed no difference in outcomes based on 3 studies (N=2,293)
  - No difference
    - Low SOE: adults
- Neurological function on the Cerebral Performance Category/Pediatric Cerebral Performance Category showed no difference in outcomes based on 11 studies (N=177,933)
  - No difference

        - Moderate SOE: adults
    - Insufficient SOE: pediatrics and patients of mixed ages
- ROSC was better with SGA in adults, though inconsistent findings between RCTs and observational studies; pooled analysis included 16 studies (N=180,864)
    - Favors SGA
        - Low SOE: adults
    - Insufficient SOE: pediatrics and patients of mixed ages
- Successful advanced airway insertion at first pass was better with SGA in some subgroups; pooled analysis included 9 studies (N=34,108)
    - Favors SGA
        - Moderate SOE: OHCA patients
        - Low SOE: patients with mixed emergency types
    - No difference
        - Low SOE: adults
    - Insufficient SOE: pediatrics, patients of mixed ages, and in patients with medical and trauma emergencies
- Overall successful advanced airway insertion were similar based on 13 studies (N=25,727)
    - No difference
        - Moderate SOE: adults and patients with medical emergencies
        - Low SOE: patients of mixed ages and patients with OHCA and mixed emergency types
- Harms: Insufficient SOE, based on 5 studies (N=13,232)

Summary of Results

We identified and analyzed 38 studies (in 37 publications; 2 studies were reported in one publication)[13] that compared patient outcomes for SGA and ETI (N=355,625) (See Appendix C for the list of included studies).

These included 4 RCTs,[40-43] 2 controlled clinical trials,[44,45] 8 prospective cohorts,[19,20,46-51] 23 retrospective cohorts,[13,21-23,25-30,52-63] and 1 before-after study.[64]

Ten of these studies were rated low ROB,[21-23,28,40,42,51,61,63,64] 15 moderate,[13,26,29,30,41,45,47,48,50,54,56,57,59,60,62] and seven high.[27,44,46,52,53,55,58] One study was rated low for one outcome and moderate for two other outcomes[25]; one study was rated moderate for one outcome and high for one outcome[20]; two studies were rated low for one outcome and moderate for one outcome[19,43]; and one study was rated low for one outcome and high for one outcome (Appendix G). [49]

Sample sizes in the included studies ranged from 78 to 138,248 participants; 20 studies were conducted in the United States and Canada,[13,22,23,41,43,44,46,48,51-54,58-60,62-64] 10 in Asia,[20,21,25-30,49,61] 7 in Europe,[19,40,42,47,55-57] and 1 in Australia.[50]

Meta-Analysis

Meta-analysis was performed for six outcomes: survival in-hospital or at one month post-incident; neurological function using modified Rankin Scale; neurological function using Cerebral Performance Category or Pediatric Cerebral Performance Category (CPC); ROSC; first-pass success for advanced airway insertion; and, overall success for advanced airway insertion. Thirty-seven studies were included in meta-analysis for one or more of these outcomes. Analyses were stratified by study design and either age group or emergency type. The results for each outcome by subgroup are reported in Tables 15 to 20, and forest plots are provided in Appendix H-10 to H-15.

Survival

Seventeen studies contained data on survival in-hospital or at one month post-incident for Key Question 3 comparing SGA and ETI, including three RCTs[40,42,43] and 14 observational studies.[13,19-23,25,27,29,49,54,59,61] Use of ETI, compared with SGA, resulted in higher rates of survival in most pooled analyses of observational studies, but no difference when data from RCTs was pooled (Table 15).

Studies in adults were limited to patients with OHCA. Pooled analysis of three RCTs found no difference in survival between airway interventions, while ETI was associated with higher rates of survival in eight observational studies. Sensitivity analyses resulted in similar findings (Appendix I-20 to I-25). Of the eight observational studies, three favored ETI, including one very large retrospective cohort study (n=138,248 analyzed for this outcome) conducted in Japan;[61] the other five found no difference in survival. The majority of observational studies (5 of 8) were conducted in Asia, where ETI is used less frequently than SGA, potentially introducing bias from provider skills or preference of airway. The overall conclusion is that there is likely no difference between SGA and ETI on survival in adults (results lean towards no effect; SOE: Low).

There was no difference in survival for SGA compared with ETI in an observational study of pediatric patients (SOE: Insufficient).[23] ETI was associated with survival benefit over SGA in pooled analysis of five observational studies in mixed ages, but SOE is low as studies were all retrospective cohorts with moderate or high ROB.

A total of 14 studies provided data on survival in OHCA patients for pooled analysis – three RCTs and 11 observational studies. Pooled results of the 11 observational studies found higher survival for ETI compared with SGA, but no difference in sensitivity analysis excluding high ROB studies. There was also no difference from pooled analysis of the three RCTs. Overall, the SOE is low due to study limitations (retrospective designs in observational studies and inclusion of studies with moderate or high ROB) and different conclusions based on sensitivity analysis of observational studies.

There was improved survival with ETI in trauma patients. Strength of evidence is low, as all studies were observational and had moderate ROB.

Table 15. SGA vs. ETI: Survival by age groups and emergency types

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size n=patients	Summary of Results RR (95% CI); I^2 Reference: SGA
Adults Low No difference	3 RCT[40,42,43]	N=12,465	0.89 (0.55 to 1.24); 54.4%
	8 Observational[19-22,25,49,59,61]	N=156,846	1.14 (1.06 to 1.44); 0.0%
Pediatrics Insufficient	No RCT	-	-
	1 Observational[23]	n=942	0.69 (0.43 to 1.10); NA
Mixed ages Low Favors ETI	No RCT	-	-
	5 Observational[13,27,29,54]	N=4,569	2.39 (1.35 to 3.88); 32.9%
OHCA	3 RCT[40,42,43]	N=12,465	0.89 (0.55 to 1.24); 54.4%

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size n=patients	Summary of Results RR (95% CI); I^2 Reference: SGA
Low No difference	11 Observational[19-23,25,27,29,49,59,61]	N=158,458	1.13 (1.03 to 1.40); 0.0%
Medical emergencies	No studies	-	-
Trauma	No RCT	-	-
Low Favors ETI	3 Observational[13,54]	N=3,899	3.22 (1.99 to 4.59); 0.0%
Mixed emergency types	No studies	-	-

CI = confidence interval; ETI = endotracheal intubation; NA = not applicable; OHCA = out-of-hospital cardiac arrest; RCT = randomized controlled trial; RR = relative risk; SGA = supraglottic airway

Neurological Function

Fourteen studies (2 RCTs and 12 observational) contained data for pooled analysis of neurological function. Outcomes assessed by the modified Rankin Scale (mRS) were analyzed separately from those assessed using the CPC or Pediatric CPC (mRS in Table 16, CPC/Pediatric CPC in Table 17). All studies were in patients with OHCA.

Modified Rankin Scale

Three studies (2 RCTs[40,43] and 1 observational[63]) assessed neurological function using the modified Rankin Scale (good outcome = mRS score 0-3); all were in adult patients. The pooled results of the two RCTs showed no difference; the observational study favored ETI. One of the RCTs performed sensitivity analyses and found higher rates of good neurological function in patients treated with SGA in analysis grouped by first type of airway received (Appendix I-28).[40] The overall conclusion is that there is likely no difference between SGA and ETI, with low SOE due to inconsistency in findings between studies, and in one RCT between primary results and results of sensitivity analyses.

Table 16. SGA vs. ETI: Neurological function – modified Rankin Scale[a] by age groups

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size (n=patients)	Summary of Results RR (95% CI); I^2 Reference: SGA
Adults	2 RCT[40,43]	N=12,293	0.90 (0.52 to 1.47); 68.6%
Low No difference	1 Observational[63]	n=10,455	1.38 (1.04 to 1.83); NA
Pediatrics	No studies	-	-
Mixed ages	No studies	-	-

CI = confidence interval; CCT = controlled clinical trial; ETI = endotracheal intubation; NA = not applicable; RCT = randomized controlled trial; RR = relative risk; SGA = supraglottic airway
[a] No stratification for emergency type (all studies were out-of-hospital cardiac arrest)

Cerebral Performance Category/Pediatric Cerebral Performance Category

Eleven studies assessed neurological function using the Cerebral Performance Category or Pediatric Cerebral Performance Category (good outcome = CPC or pediatric CPC score 1-2); all studies were observational.[19-21,23,25,28,30,49,56,59,61] Pooled analyses found no difference in neurological function in any age subgroups (Table 17).

Table 17. SGA vs. ETI: Neurological function – Cerebral Performance Category / Pediatric Cerebral Performance Category[a] by age groups

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size (n=patients)	Summary of Results RR (95% CI); I^2 Reference: SGA
Adults	No RCT	-	-
Moderate **No difference**	9 Observational[19-21,25,28,49,56,59,61]	N=176,355	1.11 (0.98 to 1.25); 0.0%
Pediatrics	No RCT	-	-
Insufficient	1 Observational[23]	n=942	0.77 (0.42 to 1.44); NA
Mixed ages	No RCT	-	-
Insufficient	1 Observational[30]	1 n=636	1.01 (0.21 to 4.95); NA

CI = confidence interval; CCT = controlled clinical trial; ETI = endotracheal intubation; NA = not applicable; RCT = randomized controlled trial; RR = relative risk; SGA = supraglottic airway
Bold Text = Moderate SOE
[a] No stratification for emergency type (all studies were out-of-hospital cardiac arrest)

Return of Spontaneous Circulation

Sixteen studies provided data for pooled analysis of ROSC (Table 18). In adults, pooled estimate from combining 3 RCTs favors SGA, but pooling of 11 observational studies found ETI associated with higher rates of ROSC; these findings did not change with sensitivity analyses (Appendix I-28 to I-29). The overall conclusion is that SGA is associated with higher rates of ROSC, based on pooled results from the RCTs, with low SOE due to inconsistency in findings between RCTs and observational studies.

Table 18. SGA vs. ETI: ROSC by age groups

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size (n=patients)	Summary of Results RR (95% CI); I^2 Reference: SGA
Adults	3 RCT[40,42,43]	N=12,460	0.91 (0.83 to 0.97); 0.0%
Low Favors SGA	11 Observational[19-21,25,26,48,49,52,59,61,63]	N=166,826	1.40 (1.27 to 1.54); 69.6%
Pediatrics	No RCT	-	-
Insufficient	1 Observational[23]	n=942	0.75 (0.58 to 0.98); NA
Mixed ages	No RCT	-	-
Insufficient	1 Observational[30]	n=636	1.47 (0.86 to 2.51); NA

CI = confidence interval; ETI = endotracheal intubation; NA = not applicable; RCT = randomized controlled trial; RR = relative risk; SGA = supraglottic airway

Successful Insertion of Advanced Airway

Eight studies provided data for pooled analysis of first pass success rate for insertion of advanced airway (Table 19). In adults, there was no difference in success rate for ETI compared with SGA when two RCTs were pooled;[41,43] observational studies found SGA was inserted successfully on the first attempt more often than ETI.[46,48,50,58,64] The SOE is low, due to majority of studies rated as moderate or high ROB and discrepancy in findings from pooled analyses of RCTs and observational studies. In single observational studies in pediatrics and mixed ages, SGA had higher first-pass success rates (SOE: Insufficient).

In OHCA, trauma, and mixed emergency types, SGA was associated with higher first-pass success rates compared with ETI. In medical emergencies, one small RCT (n=204 analyzed for this outcome) found no difference while a larger observational study reported higher success rate with use of SGA (SOE: Insufficient).

Table 19. SGA vs. ETI: First-pass successful advanced airway insertion by age groups and emergency types

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size (n=patients)	Summary of Results RR (95% CI); I^2 Reference: SGA
Adults	2 RCT[41,43]	(N=3,208)	0.74 (0.39 to 1.45); 92.7%
Low No difference	5 Observational[46,48,50,58,64]	5 (N=30,069)	0.81 (0.79 to 0.84); 0.0%
Pediatrics	No RCT	-	-
Insufficient	1 Observational[58]	(n=522)	0.69 (0.60 to 0.79); NA
Mixed ages	No RCT	-	-
Insufficient	1 Observational[60]	(n=309)	0.55 (0.48 to 0.63); NA
OHCA	1 RCT[43]	(n=3,004)	0.57 (0.54 to 0.60); NA
Moderate **Favors SGA**	4 Observational[46,48,58,64]	(N=20,884)	0.80 (0.78 to 0.86); 0.0%
Medical emergencies	1 RCT[41]	(n=204)	0.99 (0.81 to 1.20); NA
Insufficient	1 Observational[58]	(n=7,397)	0.88 (0.85 to 0.91); NA
Trauma	No RCT	-	-
Insufficient	1 Observational[58]	(n=2,212)	0.79 (0.75 to 0.83); NA
Mixed emergency types	No RCT	-	-
Low Favors SGA	2 Observational[50,60]	(N=407)	0.57 (0.47 to 0.79); 0.0%

CI = confidence interval; ETI = endotracheal intubation; NA = not applicable; OHCA = out-of-hospital cardiac arrest; RCT = randomized controlled trial; RR = relative risk; SGA = supraglottic airway
Bold Text = Moderate SOE

Thirteen studies were pooled for analysis of overall success rates for insertion of advanced airway (Table 20).[40-42,45-48,50,51,53,55,62,64] When ETI and SGA were compared, there were no differences in overall success rates for any subgroups by age or emergency type (SOE: Low and Moderate).

Table 20. SGA vs. ETI: Overall successful advanced airway insertion by age groups and emergency types

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size (n=patients)	Summary of Results RR (95% CI); I^2 Reference: SGA
Adults	3 RCT[40-42]	N=9,641	0.93 (0.88 to 1.01); 39.8%
Moderate **No difference**	8 Observational[45,46,48,50,51,53,55,64]	N=4,905	0.98 (0.91 to 1.05); 72.7%
Pediatrics	No studies	-	-
Mixed ages	No RCT	-	-
Low No difference	2 Observational[47,62]	N=11,181	0.98 (0.77 to 1.26); 94.2%
OHCA	2 RCT[40,42]	N=9,437	0.92 (0.85 to 1.01); 39.9%

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size (n=patients)	Summary of Results RR (95% CI); I^2 Reference: SGA
Low No difference	5 Observational[46-48,55,64]	N=1,901	0.96 (0.85 to 1.08); 81.8%
Medical emergencies	1 RCT[41]	n=204	1.00 (0.87 to 1.15); NA
Moderate **No difference**	1 Observational[45]	n=345	1.07 (0.91 to 1.27); NA
Trauma	No studies	-	-
Mixed emergency types	No RCT	-	-
Low No difference	4 Observational[50,51,53,62]	N=13,840	0.98 (0.89 to 1.08); 91.6%

CI = confidence interval; ETI = endotracheal intubation; NA = not applicable; OHCA = out-of-hospital cardiac arrest; RCT = randomized controlled trial; RR = relative risk; SGA = supraglottic airway
Bold Text = Moderate SOE

Qualitative Synthesis: Additional Outcomes

Included studies reported on outcomes in addition to those synthesized with meta-analyses reported above, and these are summarized and qualitatively synthesized below (Table 21). These outcomes include survival to other time points (24 hours, 72 hours, and to ED, hospital, or ICU admission), neurological function measured by Glasgow Outcome Scale (good outcome = good recovery or moderate disability),[27] various measures of oxygenation or ventilation,[19,44,52,56] and harms, including aspiration, regurgitation, failure of airway insertion (requiring multiple attempts, or inadequate ventilation), dislodgment or unrecognized misplacement, and complications.[40,43,46,51,60] No studies provided results for length of stay (hospital or ICU), or morbidity (pneumothorax or aspiration pneumonia). In general, there were no differences between SGA and ETI for these outcomes (SOE: Insufficient and Low). One RCT found lower rates of inadequate ventilation and multiple insertion attempts for SGA when compared with ETI.[43]

Table 21. SGA vs. ETI: Additional outcomes

Outcome Number of Studies (n=patients)	Summary of Findings	Conclusion	Strength of Evidence
Survival 10 studies (n=35,281)	• 24-hour: 2 studies o 1 study, no difference[52] o 1 study, difference favoring ETI[63]	-	Insufficient
	• 72-hour: 2 studies o 1 study, no difference[52] o 1 study, difference favoring SGA in ITT and per-protocol analyses, but no difference in as-treated or adjusted analyses[43]	No difference	Low
	• Survival to ED, hospital, or ICU admission: 6 studies o 4 studies, no difference[23,29,42,46] o 2 studies, difference favoring ETI[22,59]	No difference	Low
Neurological function: Glasgow Outcome Scale 1 study (n=78)	No difference[27]	-	Insufficient
Length of stay	No studies	-	-
Morbidity	No studies	-	-

Outcome Number of Studies (n=patients)	Summary of Findings	Conclusion	Strength of Evidence
Oxygenation/ ventilation 4 studies (N=2,665)	• ABG: 1 study, no difference[44] • SpO2: 1 study, no difference[19] • ETCO2: 3 studies, no difference[19,52,56]	No difference	Low

Harms
 	
5 studies (N=13,232)
	Findings inconsistent across harms
	• Aspiration: 2 studies, no difference[40,60]
	• Multiple (≥3) insertion attempts: 1 study, significantly lower in SGA compared with ETI[43]
	• Inadequate ventilation: 1 study, significantly lower rate in SGA compared with ETI[43]
	• Dislodged airway or unrecognized misplacement: 3 studies
	  o 2 studies, significantly higher rates in SGA compared with ETI[40,51]
	  o 1 study, significantly higher rate in ETI compared with SGA[43]
	• Regurgitation: 1 study, no difference[40]
	• Any complications: 1 study, no difference[46]
	• Fatal complications: 1 study, occurred in significantly more patients when SGA was used compared with ETI[46] although they evaluated devices that have been phased out of current practice.
		-	Insufficient

CI = confidence interval; ED = emergency department; ETI = endotracheal intubation; ITT = intent to treat; NA = not applicable; OHCA = out-of-hospital cardiac arrest; RCT = randomized controlled trial; RR = relative risk; SGA = supraglottic airway

Key Question 4: Modifiers within airway approaches

There were no studies about modifiers of BVM that met inclusion criteria. We identified four studies reporting on modifiers of SGA, which are qualitatively analyzed. There were 30 studies that compared outcomes across modifiers of ETI; 17 reported on outcomes which are analyzed qualitatively and 22 studies were pooled for one or more outcomes in meta-analysis.

Results for Key Question 4 are organized first by airway intervention (SGA, ETI), then by modifier category (patient characteristics or technique/device), and finally by comparison of interest; results from both meta-analyses (when performed) and qualitative analyses are included. Strength of evidence was not assessed for outcomes that were only analyzed qualitatively.

Supraglottic Airway

The four studies included for modifiers of SGA were RCTs conducted in Canada,[15] United Kingdom,[65] Australia,[66] and Japan.[67] Sample sizes ranged from 51 to 615 patients (N=1,449).

For intermediate outcomes, including steps in airway management and success in securing the airway three studies were rated as moderate ROB[15,65,67] and one was rated as high ROB;[66,67] for primary patient outcomes, including mortality, ROSC and function one study was rated low,[65] two moderate,[15,67] and two high ROB (Appendix G).[66,67]

Technique/Device: Qualitative Analysis

We identified four studies that compared SGA devices.[15,65-67] SGA devices were classified based on the anatomic position of their seal (e.g., pharyngeal or perilaryngeal) and results are grouped by comparisons within or between these classes.

Comparisons of Perilaryngeal Seal SGAs

i-gel vs. laryngeal mask airway (LMA)

- Survival: no difference in survival to discharge[65]
- ROSC: no difference in proportion of patients with ROSC on ED or hospital arrival[65,66]
- Success: no difference in rates of successful insertion on first pass;[65] higher overall success with i-gel compared with LMA[66]

Comparisons of Pharyngeal Seal vs. Perilaryngeal Seal SGAs

Laryngeal tube vs. LMA

- Survival: no difference in 1-month survival rates[67]
- ROSC: no difference in proportions of patients achieving overall ROSC[67]
- Neurological function: no difference in proportion of patients with good neurological function on the CPC at one month[67]
- Success: no difference in rates of successful ventilation at time of hospital arrival[67]

Combitube vs. LMA

- Success: higher rate of successful insertion and ventilation by EMS personnel assessment for Combitube compared with LMA[15]
- Harms: lower rate of inadequate ventilation by ED assessment for LMA compared with Combitube[15]

Comparisons of Pharyngeal Seal SGAs

Combitube vs. PTLA (prehospital pharyngeotracheal lumen airway)

- Success: no difference in rates of successful insertion and ventilation by EMS personnel assessment for Combitube compared with PTLA[15]
- Harms: no difference in rates of inadequate ventilation by ED or EMS personnel assessment for Combitube compared with PTLA[15]

Endotracheal Intubation

Thirty studies were included for ETI; of these, there were 6 RCTs,[68-73] two controlled clinical trials,[32,74] four prospective cohort studies,[48,75-77] 13 retrospective cohort studies,[62,78-89] and five before-after studies.[90-94] The studies included 28 to 32,595 participants (N=56,740). Twenty studies were conducted in the United States or Canada,[32,48,62,69,74,76,77,79,81,83-90,92-94] two in Australia,[78,80] seven in Europe[70-73,75,82,91] and one in Japan.[68] Six studies were rated as low ROB,[70,78,79,83,86,91] 13 were rated moderate,[48,62,68,71,73-75,80,84,88,89,92,94] 10 were rated as high ROB,[69,72,76,77,81,82,85,87,90,93] and one was rated as low ROB for direct outcomes and moderate for indirect outcomes.[32]

Patient Characteristics

The included studies reported on several modifiers of ETI related to patient characteristics. Pooled analysis was possible only for comparisons of emergency type, while comparisons of age, sex and race are summarized qualitatively.

Overall, where there were differences, better outcomes were observed for:

- Adults (compared with children)[81]
- Older children (compared with younger children)[75]
- White participants (compared with non-white participants)[86,88]

- Females (compared with males)[88]

Emergency Type: Meta-Analysis

Results for comparisons of emergency types are presented first with cardiac arrest as the reference group (Tables 22-23), then for trauma versus medical emergencies (Table 24).

Comparisons With Cardiac Arrest

Studies for pooled analysis of comparisons to OHCA were limited to observational studies in mixed age groups (Appendix H-16 to H-18). There were two studies providing data for first-pass success rate (Table 22). The studies did not report for the same comparisons, so data was not pooled, but results are shown in the forest plots.[77,87] Four studies provided data for pooled analysis of overall success rate (Table 23).[62,77,82,87]

Rates of successful insertion on the first attempt were significantly higher for cardiac arrest patients compared with medical or trauma in a single study (Insufficient SOE).[87] There was no difference in overall success rates from pooled analysis.[62,82,87] When compared with non-arrest (medical or trauma), both first-pass and overall success rates were significantly higher in cardiac arrest patients in a single study (Insufficient SOE).[77]

Table 22. First-pass success for comparisons against cardiac arrest for emergency type in observational studies of mixed age groups

Comparison	Number of Studies (n=patients)	Summary of Results RR (95% CI); I^2 Reference: cardiac arrest	Conclusion	Strength of Evidence
Medical vs. cardiac arrest	1 observational (n=432)[87]	0.75 (0.64 to 0.89); NA	-	Insufficient
Trauma vs. cardiac arrest	1 observational (n=352)[87]	0.59 (0.38 to 0.93); NA	-	Insufficient
Non-arrest vs. cardiac arrest	1 observational (n=1,935)[77]	0.79 (0.73 to 0.85); NA	-	Insufficient

CI = confidence interval; NA = not applicable; RR = relative risk

Table 23. Overall success for comparisons against cardiac arrest for emergency type in observational studies of mixed age groups

Comparison	Number of Studies (n=patients)	Summary of Results RR (95% CI); I^2 Reference: cardiac arrest	Conclusion	Strength of Evidence
Medical vs. cardiac arrest	2 observational (N=5,760)[62,87]	0.86 (0.68 to 1.07); 76.6%	No difference	Low
Trauma vs. cardiac arrest	3 observational (N=5,367)[62,82,87]	1.05 (0.74 to 1.42); 0.0%	No difference	Low
Non-arrest vs. cardiac arrest	1 observational (n=1,941)[77]	0.84 (0.80 to 0.88); NA	-	Insufficient

CI = confidence interval; NA = not applicable; RR = relative risk

Comparison of Trauma Versus Medical Emergencies

There were four observational studies comparing success rates in patients with trauma versus medical (non-OHCA) emergencies (Table 24, Appendix H-19).[62,80,81,87] There was no difference in first-pass or overall success rates in pooled analysis of studies in patients of mixed ages.[62,81,87] Studies in adults were limited to a single study that also showed no difference in first-pass or overall success rates (Insufficient SOE).[80]

Table 24. Successful intubation for trauma vs. medical emergency types in observational studies by age group

Outcome	Age Group	Number of Studies (n=patients)	Summary of Results RR (95% CI); I^2 Reference: medical emergency	Conclusion	Strength of Evidence
First-pass success	Adults[80]	1 (n=795)	0.95 (0.91 to 1.00); NA	-	Insufficient
	Mixed ages[81,87]	2 (n=418)	1.01 (0.74 to 1.20); 0.0%	No difference	Low
Overall success	Adults[80]	1 (n=795)	1.00 (0.99 to 1.01); NA	-	Insufficient
	Mixed ages[62,87]	2 (N=1,473)	1.13 (0.97 to 1.22); 0.0%	No difference	Low

CI = confidence interval; NA = not applicable; RR = relative risk

Age: Qualitative Analyses

Pediatrics vs. adults

- Survival: no difference in survival rates for adolescents (11 to 20 years old) compared with younger adults (21 to 40 years old)[84]
- Definitive Airway Sans Hypoxia/Hypotension on First Attempt (DASH-1A): no difference between pediatric (<18 years old) and adult patients (≥18 years old)[86]
- First-pass success: lower first-pass success rates in pediatrics compared with adults[81]
- Overall success: no difference between pediatric (≤19 years old) and adult patients (>19 years old)[62]

Age Within Pediatrics

- Survival: significant difference for both in-hospital and prehospital survival, with lower proportions of infants (<1 year old) surviving compared with toddlers (1 to 5 years old) or school-age children (6 to 14 years old); no difference for toddlers vs. school-age children[75]
- Function (Pediatric Cerebral Performance Category): significantly lower proportion of infants (<1 year old) had good neurological function at discharge compared with toddlers (1 to 5 years old) or school-age children (6 to 14 years old); no difference for toddlers vs. school-age children[75]
- Overall success: no difference between age groups in children[32,62]

Race: Qualitative Analyses

White vs. non-white race

- DASH-1A: achieved significantly more often in white participants than non-white participants[86]
- ROSC: proportion of participants achieving sustained ROSC was significantly higher in white participants than non-white participants[88]

Sex: Qualitative Analyses

Male vs. female

- Survival: among those with prehospital sustained ROSC, significantly higher proportion of female participants survived to hospital discharge compared with male participants[88]
- DASH-1A: no significant difference in proportions of male and female participants experiencing DASH-1A[86]
- ROSC: significantly higher proportion of female participants achieved ROSC (sustained to hospital arrival) compared with male participants[88]
- Success: no significant difference in rates of successful intubation (first-pass or overall) between male and female participants[76,81]

Technique/Device

There were two comparisons for technique/device with data for pooled analysis: RSI vs. no RSI (Tables 25 to 27), and video vs. direct laryngoscopy (Tables 28 and 29). Results from meta-analysis were stratified by study design and age group or emergency type (forest plots in Appendix H-20 to H-25). Additional outcomes for these comparisons are analyzed qualitatively and summarized in each section below. Blade type comparisons are also included and summarized qualitatively.

RSI Versus No RSI

Meta-Analysis

- Survival: no difference for adults[78,79,83] and trauma;[78,79,89] insufficient evidence to draw conclusions for mixed age groups[89] and OHCA patients[83]
- First-pass success: no difference for mixed age groups;[81,89] insufficient evidence for adults,[83] OHCA,[83] trauma,[89] and mixed emergency types[81]
- Overall success: no difference for mixed ages,[62,74,76] adults,[78,83] and mixed emergency types;[62,74,76] insufficient evidence for OHCA[83] and trauma patients[78]

Table 25. RSI vs. No RSI: Survival by subgroup (all observational studies)

Subgroup Category	Subgroup	Number of Studies (n=patients)	Summary of Results RR (95% CI); I^2 Reference: No RSI	Conclusion	Strength of Evidence
Age	Adults[78,79,83]	3 (N=4,207)	1.64 (0.65 to 4.14); 97.9%	No difference	Low
	Mixed ages[89]	1 (n=283)	3.10 (2.25 to 4.25); NA	-	Insufficient
Emergency type	OHCA[83]	1 (n=3,047)	3.69 (3.17 to 4.28); NA	-	Insufficient
	Trauma[78,79,89]	3 (N=1,443)	1.52 (0.71 to 3.36); 95.1%	No difference	Low

CI = confidence interval; OHCA = out-of-hospital cardiac arrest; NA = not applicable; RR = relative risk; RSI = rapid sequence intubation

Table 26. RSI vs. No RSI: First-pass success by subgroup (all observational studies)

Subgroup Category	Subgroup	Number of Studies (n=patients)	Summary of Results RR (95% CI); I^2 Reference: No RSI	Conclusion	Strength of Evidence
Age	Adults[83]	1 (n=2,776)	0.89 (0.82 to 0.96); NA	-	Insufficient
	Mixed ages[81,89]	2 (N=563)	0.90 (0.71 to 1.13); 70.5%	No difference	Low
Emergency type	OHCA[83]	1 (n=2,776)	0.89 (0.82 to 0.96); NA	-	Insufficient
	Trauma[89]	1 (n=267)	0.98 (0.90 to 1.07); NA	-	Insufficient
	Mixed emergency types[81]	1 (n=296)	0.81 (0.72 to 0.91); NA	-	Insufficient

CI = confidence interval; OHCA = out-of-hospital cardiac arrest; NA = not applicable; RR = relative risk; RSI = rapid sequence intubation

Table 27. RSI vs. No RSI: Overall success by subgroup (all observational studies)

Subgroup Category	Subgroup	Number of Studies (n=patients)	Summary of Results RR (95% CI); I^2 Reference: No RSI	Conclusion	Strength of Evidence
Age	Adults[78,83]	2 (N=3,059)	1.91 (0.38 to 10.16); 97.9%	No difference	Low
	Mixed ages[62,74,76]	3 (N=8,971)	1.06 (0.98 to 1.20); 0.0%	No difference	Low
Emergency type	OHCA[83]	1 (n=2,776)	0.99 (0.98 to 1.01); NA	-	Insufficient
	Trauma[78]	1 (n=283)	3.89 (2.63 to 5.75); NA	-	Insufficient
	Mixed emergency types[62,74,76]	3 (N=8,971)	1.06 (0.98 to 1.20); 0.0%	No difference	Low

CI = confidence interval; OHCA = out-of-hospital cardiac arrest; NA = not applicable; RR = relative risk; RSI = rapid sequence intubation

Qualitative Analysis

- ICU length of stay: significantly longer length of stay for RSI compared with no paralyzing agents[78]
- Harms: lower rates of vomiting, oral trauma, and misplaced tubes for RSI compared with no RSI; no difference in rates of tracheal perforation or pneumothorax[89]

Video Versus Direct Laryngoscopy

Meta-Analysis

- No difference in first-pass or overall success rates in adults, mixed ages, cardiac arrest, and mixed emergency types.[48,68,69,71-73,81,9285,92-94]

Table 28. First-pass success for video versus direct laryngoscopy by subgroup

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size (n=patients)	Summary of Results RR (95% CI); I^2 Reference: Direct laryngoscopy
Adults Low No difference	3 RCTs[68,69,71]	N=705	0.93 (0.61 to 1.12); 0.0%
	3 Observational[48,81,92]	N=1,073	1.30 (0.83 to 2.06); 91.8%

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size (n=patients)	Summary of Results RR (95% CI); I^2 Reference: Direct laryngoscopy
Pediatrics Insufficient	No RCT	-	-
	1 Observational[81]	n=10	3.67 (0.28 to 48.56); NA
Mixed ages Low No difference	No RCT	-	-
	2 Observational[85,93]	N=4,761	1.00 (0.95 to 1.24); 0.0%
OHCA Low No difference	2 RCTs[68,69]	N=191	0.76 (0.46 to 1.26); 39.6%
	1 Observational[48]	n=273	0.99 (0.84 to 1.17); NA
Medical emergencies Insufficient	No RCT	-	-
	1 Observational[81]	n=249	1.18 (1.02 to 1.36); NA
Trauma Insufficient	No RCT	-	-
	1 Observational[81]	n=47	1.16 (0.88 to 1.53); NA
Mixed emergency types Low No difference	1 RCT[71]	n=514	0.95 (0.88 to 1.04); NA
	3 Observational[85,92,93]	N=5,275	1.31 (0.84 to 2.08); 94.0%

CI = confidence interval; OHCA = out-of-hospital cardiac arrest; NA = not applicable; RR = relative risk; RCT = randomized controlled trial

Table 29. Overall success for video versus direct laryngoscopy by subgroup

Subgroup Category Strength of Evidence Conclusion	Number of Studies Study Design	Sample Size (n=patients)	Summary of Results RR (95% CI); I^2 Reference: Direct laryngoscopy
Adults Low No difference	5 RCTs[68,69,71-73]	(N=1,244)	0.77 (0.57 to 1.03); 97.3%
	2 Observational[48,92]	(N=787)	1.28 (0.79 to 2.05); 89.7%
Mixed ages Low No difference	No RCT	-	-
	2 Observational[93,94]	(N=713)	1.02 (0.99 to 1.06); 0.0%
OHCA Low No difference	2 RCTs[68,69]	(N=191)	0.96 (0.86 to 1.04); 0.0%
	1 Observational[48]	(n=273)	1.05 (0.92 to 1.19); NA
Mixed emergency types Low No difference	3 RCTs[71-73]	(N=1,053)	0.68 (0.42 to 1.09); 96.3%
	3 Observational[92-94]	(N=1,227)	1.17 (0.86 to 1.60); 97.2%

CI = confidence interval; OHCA = out-of-hospital cardiac arrest; NA = not applicable; RR = relative risk; RCT = randomized controlled trial

Qualitative Analysis

- ROSC: no difference in proportion of patients with prehospital ROSC[48]
- Harms: no difference in proportion of patients experiencing oral trauma, regurgitation, or esophageal intubation;[73,94] higher rates of failure to advance the tube into the larynx and trachea in video ETI[73]

Blade Types: Qualitative Analysis

Metal reusable vs. plastic disposable

- Success: higher rate of first-pass success with use of metal blades compared with plastic disposable blades[90,91]

Reusable metal vs. single-use metal

- Success: no difference in rates of successful intubation on first pass for reusable compared with single-use metal blades[70]
- Harms: no difference in rates of vomiting, dental trauma, or hypotension, or overall complication rates between metal reusable and single-use blades[70]

Discussion

Findings in Relation to the Decisional Dilemmas

Introduction

An essential part of prehospital care is airway management, which ensures that patients receive adequate oxygenation and ventilation. There are currently three main approaches to airway management: bag valve mask (BVM) (usually with airway adjuncts such as oropharyngeal airway [OPA] and nasopharyngeal airway [NPA]), supraglottic airway (SGA), and endotracheal intubation (ETI). While guidelines and best practices exist, individual experiences, policies, and research do not definitively support one airway approach over another.

Determining individual patient needs in the prehospital environment is challenging, and the actions first responders take are influenced by myriad factors that can vary significantly across patient and clinical scenarios. An essential factor is the variation in resources available for prehospital care, including modes of transport (e.g., ground vs. air), level of training and expertise of the prehospital clinician, and available equipment on scene. Additional factors influencing emergency personnel actions include the specific clinical patient scenario, and estimated transport time to an emergency department and hospital. These can also change dynamically in EMS calls. In this review, our objective was to interpret findings regarding these factors in order to facilitate application in local environments.

Our quantitative and qualitative syntheses are based on 81 studies comparing BVM to SGA (Key Question 1), BVM to ETI (Key Question 2), SGA to ETI (Key Question 3), and selected modifiers within BVM, SGA, or ETI (Key Question 4). The aim of the quantitative synthesis was to identify any differences in survival in-hospital or at one month post-incident, neurological function at discharge or one month post-incident, return of spontaneous circulation (ROSC), or successful advanced airway insertion. Results were stratified by emergency type and age, as patient needs and clinical presentation across emergency types and age differ to the degree that it was not clinically reasonable to combine them. Key results are reported in Tables 30 and 31, with separate tables for the primary outcomes for each of the four key questions (Tables 32 to 36).

Most strength of evidence (SOE) assessments were "low," primarily due to the limited number of studies and inconsistencies in outcomes. Those outcomes rated "moderate" included more studies, more rigorous study designs, consistent results, or more precise estimates. There were no "high" SOE ratings. Therefore, additional well-designed studies could change our conclusions.

Key Results

Key Questions 1, 2, and 3

Results for Key Questions 1, 2, and 3 were pooled by age for survival, neurological function, and ROSC (Table 30); for Key Question 3 by age for successful advanced airway insertion (Table 31); for Key Questions 1, 2, and 3 by emergency type for survival and neurological function (Table 32); and for Key Question 3 by emergency type for successful advanced airway insertion (Table 33).

Table 30. Outcome comparisons by age group and study design (Key Question 1, 2, and 3)

Outcome	Age Group: Study Design	KQ1: BVM vs. SGA	KQ2: BVM vs. ETI	KQ3: SGA vs. ETI
Survival	Adults: RCT	**No difference**	**No difference**	No difference
	Adults: Observational	**No difference**	**No difference**	Favors ETI
	Pediatrics: RCT	-	No difference	-
	Pediatrics: Observational	*Insufficient*	No difference	*Insufficient*
	Mixed ages: RCT	No difference	-	-
	Mixed ages: Observational	Favors BVM	Favors BVM	Favors ETI
Neurological function	Adults: RCT	-	**No difference**	mRS: No difference CPC: -
	Adults: Observational	No difference	**No difference**	mRS: Favors ETI **CPC: No difference**
	Pediatrics: RCT	-	No difference	-
	Pediatrics: Observational	*Insufficient*	Favors BVM	*Insufficient*
	Mixed ages: RCT	-	-	-
	Mixed ages: Observational	**Favors BVM**	*Insufficient*	*Insufficient*
ROSC	Adults: RCT	No difference	**Favors ETI**	Favors SGA
	Adults: Observational	No difference	**No difference**	Favors ETI
	Pediatrics: RCT	-	-	-
	Pediatrics: Observational	*Insufficient*	No difference	*Insufficient*
	Mixed ages: RCT	-	-	-
	Mixed ages: Observational	*Insufficient*	No difference	*Insufficient*

BVM = bag valve mask; ETI = endotracheal intubation; KQ = Key Question; mRS = modified Rankin Scale; RCT = randomized controlled trial; ROSC = return of spontaneous circulation; SGA = supraglottic airway
Bold Text = Moderate SOE, Standard Text = Low SOE, Italicized Text = Insufficient SOE

Table 31. Successful advanced airway insertion by age group and study design (Key Question 3)

Outcome	Age Group: Study Design	Key Question 3. SGA vs. ETI
First-pass success	Adults: RCT	No difference
	Adults: Observational	Favors SGA
	Pediatrics: RCT	-
	Pediatrics: Observational	*Insufficient*
	Mixed ages: RCT	-
	Mixed ages: Observational	*Insufficient*
Overall success	Adults: RCT	**No difference**
	Adults: Observational	**No difference**
	Pediatrics: RCT	-
	Pediatrics: Observational	-
	Mixed: RCT	-
	Mixed: Observational	No difference

ETI = endotracheal intubation; RCT = randomized controlled trial; SGA = supraglottic airway
Bold Text= Moderate SOE, Standard Text = Low SOE, Italicized Text = Insufficient SOE

Table 32. Outcomes for comparisons by emergency type and study design

Outcome	Emergency Type: Study Design	KQ1: BVM vs. SGA	KQ2: BVM vs. ETI	KQ3: SGA vs. ETI
Survival	OHCA: RCT	**No difference**	**No difference**	No difference
	OHCA: Observational	**No difference**	**No difference**	Favors ETI
	Trauma: RCT	-	No difference	-
	Trauma: Observational	**Favors BVM**	Favors BVM	Favors ETI
	Mixed emergency types: RCT	-	No difference	-
	Mixed emergency types: Observational	-	-	-
Neurological function	OHCA: RCT	-	No difference	-
	OHCA: Observational	-	No difference	-
	Trauma: RCT	-	-	-
	Trauma: Observational	-	-	-
	Mixed emergency types: RCT	-	No difference	-
	Mixed emergency types: Observational	-	-	-

BVM = bag valve mask; ETI = endotracheal intubation; KQ = Key Question; mRS = modified Rankin Scale; OHCA = out-of-hospital cardiac arrest; RCT = randomized controlled trial; SGA = supraglottic airway
Bold Text= Moderate SOE, Standard Text = Low SOE

Table 33. Successful advanced airway insertion outcomes by emergency type and study design (Key Question 3)

Outcome	Emergency Type: Study Design	Key Question 3: SGA vs. ETI
First-pass success	OHCA: RCT	**Favors SGA**
	OHCA: Observational	**Favors SGA**
	Medical: RCT	*Insufficient*
	Medical: Observational	*Insufficient*
	Trauma: RCT	-
	Trauma: Observational	*Insufficient*
	Mixed emergency types: RCT	-
	Mixed emergency types: Observational	Favors SGA
Overall success	OHCA: RCT	No difference
	OHCA: Observational	No difference
	Medical: RCT	**No difference**
	Medical: Observational	**No difference**
	Trauma: RCT	-
	Trauma: Observational	-
	Mixed emergency types: RCT	-
	Mixed emergency types: Observational	No difference

ETI = endotracheal intubation; OHCA = out-of-hospital cardiac arrest; RCT = randomized controlled trial; SGA = supraglottic airway
Bold Text= Moderate SOE, Standard Text = Low SOE, Italicized Text = Insufficient SOE

Our pooled estimates found no statistically significant differences in outcomes from head-to-head comparisons of airway management across most subgroups of emergency types and ages. The included studies were primarily observational and limited by selection bias; very few RCTs were available.

For Key Question 1 (BVM vs. SGA), most comparisons showed no difference; a minority favored BVM in survival, neurological function, and ROSC. However, there is limited confidence in the findings, as it often was not clear whether the comparison was BVM versus SGA directly, or BVM versus BVM initially, followed by SGA. Studies did not always clearly identify whether other devices (e.g., OPA and NPA) were used in conjunction with BVM, nor 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 field setting.

There is a strong possibility that resuscitation time bias influenced results favoring BVM.[95] Resuscitation time bias refers to interventions that are applied at varying times; those applied later are less effective in part due to the delayed application. As BVM typically is the first airway used in the field, if it is successful as a first approach, then BVM success would be inflated by (a) patients in better condition who may recover more quickly, or (b) shorter time between EMS arrival and airway intervention. 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.[96-100]

For Key Question 2 (BVM vs. ETI), the same caveats apply as identified for Key Question 1. The single RCT favoring ETI over BVM in ROSC outcomes was conducted in Europe, which may reflect the prehospital setting and EMS expertise unique to that environment in which physicians assume responsibility for ETI.[34] Additionally, the higher occurrence of regurgitation observed with BVM in the trial suggests BVM may not be an ideal airway and ventilation technique for a prolonged period of time.

For Key Question 3 (SGA vs. ETI), observational studies reported no difference in neurological function in adults. Studies indicating a survival benefit for patients receiving ETI were limited by indication bias, as the airway approach was not chosen at random. Some studies used propensity matching and logistic regression analysis, but neither statistical method can completely correct for this limitation.[101,102] When pooled, the two RCTs comparing SGA vs. ETI found no survival differences in favor of ETI. Moreover, survival benefit in the smaller RCT favored SGA but this effect was overshadowed by the no difference noted in the other RCT which was three times larger.[40,43] While the two RCTs were combined for the meta-analysis, it is important to note that they studied different SGAs, and had different randomization schemes (cluster vs. paramedic). Compared with ETI, SGAs are faster to insert, and had higher first pass success in specific subgroups. However, no difference was noted in rates of overall success. It is thought that SGAs may not protect against aspiration and thus may not work well for patients with vomiting, or 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 to hyperventilate with the SGA than the ETI. This is a topic for future research.

From an EMS perspective, ROSC is the primary field resuscitation endpoint and therefore a meaningful outcome for first responders. Most studies report ROSC outcomes were improved with SGA versus ETI (Table 18). However, survival and neurological function are considerably influenced by post-ROSC care, including hospital procedures (e.g., targeted temperature management, cardiac catheterization, and critical care expertise) and shared decision-making with family regarding prognosis. Best practices regarding neuroprognostication are evolving, and consequently patients may be moved too rapidly to comfort care, especially following OHCA.[103]

Key Question 4

We analyzed SGA results qualitatively. For ETI, we pooled results for comparisons of two technique/device categories, video versus direct laryngoscopy and rapid sequence intubation

(RSI) versus no RSI, with stratification by age (Table 34) and emergency type (Table 35) for both survival and successful advanced airway insertion (first pass and overall). Also for ETI, results were pooled for comparisons of emergency types, with stratification by age group, for first pass and overall successful advanced airway insertion (Table 36).

Table 34. Outcomes for comparisons of technique/device by age subgroups

Outcome	Age Group: Study Design	Video vs. Direct	RSI vs. no RSI
Survival (in-hospital or at one month post-incident)	Adults: Observational	-	No difference
	Mixed ages: Observational	-	*Insufficient*
First-pass success	Adults: RCT	No difference	-
	Adults: Observational	No difference	*Insufficient*
	Pediatrics: Observational	*Insufficient*	-
	Mixed ages: Observational	No difference	No difference
Overall success	Adults: RCT	No difference	-
	Adults: Observational	No difference	No difference
	Mixed ages: Observational	No difference	No difference

RCT = randomized controlled trial; RSI = rapid sequence intubation

Table 35. Outcomes for comparisons of technique/device by emergency type subgroups

Outcome	Emergency Type: Study design	Video vs. Direct	RSI vs. no RSI
Survival (in-hospital or at one month post-incident)	OHCA: Observational	-	*Insufficient*
	Trauma: Observational	-	No difference
First-pass success	OHCA: RCT	No difference	-
	OHCA: Observational	No difference	*Insufficient*
	Medical: Observational	*Insufficient*	-
	Trauma: Observational	*Insufficient*	*Insufficient*
	Mixed emergency types: RCT	No difference	-
	Mixed emergency types: Observational	No difference	*Insufficient*
Overall success	OHCA: RCT	No difference	-
	OHCA: Observational	No difference	*Insufficient*
	Trauma: Observational	-	*Insufficient*
	Mixed emergency types: RCT	No difference	-
	Mixed emergency types: Observational	No difference	No difference

OHCA = out-of-hospital cardiac arrest; RCT = randomized controlled trial; RSI = rapid sequence intubation

Table 36. Successful intubation for comparisons of emergency type by age subgroups

Outcome	Subgroup	Medical vs. Cardiac Arrest	Trauma vs. Cardiac Arrest	Non-Arrest vs. Cardiac Arrest	Medical vs. Trauma
First-pass success	Adults	-	-	-	*Insufficient*
	Mixed ages	*Insufficient*	*Insufficient*	*Insufficient*	No difference
Overall success	Adults	-	-	-	*Insufficient*
	Mixed ages	No difference	No difference	*Insufficient*	No difference

Supraglottic Airway

Studies of SGA were included that compared different devices. Key findings were:

- Higher overall success with i-gel compared with Soft Seal Laryngeal Mask[66]
- Higher rate of successful insertion and ventilation by emergency medical services (EMS) personnel assessment for Combitube compared with laryngeal mask (LMA)[15]
- Lower rate of inadequate ventilation by emergency department (ED) assessment for LMA compared with Combitube[15]

Overall, these findings suggest that LMA may not be the ideal device for EMS. The i-gel (with a similar shape as LMA) is technically less challenging to deploy given its cuffless design and is more effective in the prehospital environment. It appears to have higher leak pressures provides a better seal, and has an intrinsic bite block, all of which may facilitate better ventilation during continuous chest compressions.

Endotracheal Intubation

Patient Characteristics

Video Versus Direct Laryngoscopy

- No difference in first-pass or overall success rates in adults, mixed ages, cardiac arrest, and mixed emergency types (SOE: Low).[48,68,69,71-73,81,85,92-94]

Rapid Sequence Intubation Versus No Rapid Sequence Intubation

- No differences in survival in adults and trauma patients (SOE: Low).[78,79,83,89]
- No difference in first pass successful advanced airway insertion in mixed ages (SOE: Low).[81,89]
- No difference in overall successful advanced airway insertion in adults,[78,83] mixed ages,[62,74,76] and mixed emergency types[62,74,76] (SOE: Low).

Emergency Type

- No difference in overall successful advanced airway insertion in medical or trauma vs. OHCA patients (SOE: Low).[62,82,87]

We found no difference in successful advanced airway insertion among emergency types. In many of these studies, it is not always clear how success was measured. If intubation success in a cardiac arrest patient is based on paramedic documentation without waveform capnography/video/independent confirmation, and the patient does not survive to hospital admission, the intubation success cannot be confirmed. On the other hand, if the patient survives to hospital admission, then it is more likely that the airway success will be confirmed.

We also found no difference in RSI versus no RSI among trauma patients. A single retrospective study rated as low ROB reported better survival with RSI use in OHCA patients (Insufficient SOE).[83] In this study, RSI was used in one of seven patients and the baseline characteristics of these patients were different than those intubated without RSI. Although these findings persisted after adjustment for differences in Utstein variables, it is likely that other confounders were present but not accounted for in this study. Confounding by indication bias remains a problematic issue in OHCA studies and the only way to address this bias is through a RCT. The recent dispersion of high performance CPR into EMS has resulted in more patients showing evidence of consciousness and retained upper airway reflexes during resuscitation. Perhaps the key message is that for ETI, the method used will need to be flexible based on the patient characteristics. RSI may be appropriate in a smaller portion of patients with OHCA. This is important for systems that move towards ETI for prehospital airway management.

Conclusions

The overall findings suggest that there are limited differences in patient-oriented outcomes between the three methods of airway management studied (BVM, SGA, and ETI), in particular survival to hospital discharge and survival with good neurological function. This is important and reassuring in that the skill level for acquisition and retention of these skills is different and allows effective airway management with oxygenation and ventilation to be provided for the majority of patients who need it.

The evidence does not suggest that, in general, outcomes improve using any one particular airway approach in any specific patient scenario. It is possible that having different methods available may be important since sometimes the circumstance calls for a particular strategy, even when all options are available to the provider. For example, a patient that has active vomiting or airway secretions is hard to manage with a BVM (increases aspiration) or SGA (does not protect against aspiration) so ETI may be most appropriate.

In pediatric populations, experience with airway management in children is very limited in most EMS systems and so skill maintenance is a challenge. This is also now increasingly true for adults since opportunities for training have become more limited over the past 20 years. In the past prehospital providers could acquire initial and refresher training in the operating room, which is no longer allowed in many hospitals.

Strengths and Limitations

The results and conclusions detailed in this report have been shaped by the strengths and limitations of both the evidence available and our approach to the review. What questions researchers asked, how studies were designed, and what data were collected and reported establish the boundaries of what this systematic review can and cannot answer and our confidence in our conclusions. We made methodological choices and decisions about how to search for, analyze, and present this body of evidence that also impacted the report.

Strengths and Limitations of the Evidence

The primary strengths of the evidence base include the availability of prehospital studies that assess important outcomes, the variety of interventions and indications, and that some, though not all, studies employed more rigorous designs.

We were able to identify 81 studies of prehospital airway management that compared the three types of airway approaches currently available (i.e., BVM, SGA, and ETI) or evaluated variations of a single approach. Responding to questions about prehospital care is often hindered by the fact that conducting research in the prehospital environment is challenging. When studying some elements of prehospital care, extrapolations have been made from evidence from emergency departments or simulations. Another challenge is that the prehospital period is short and as a result the opportunities for data collection can be limited, so only short-term or intermediate outcomes, such as survival to hospital admission, are reported in studies. For this review, we were fortunate to have direct evidence consisting of prehospital studies that reported the key patient-centered outcomes of survival, neurological function and return of spontaneous circulation (ROSC).

It was an advantage that the included studies were conducted in several different countries and that the research mirrors other variations in prehospital care, such as different types of emergencies, modes of transport available, and EMS system structure and personnel training.

This review seeks to inform broad policies and guidelines for emergency prehospital care. If the body of evidence was limited to only a subset of the options, such as only air transport, only cardiac arrest patients, or only care in urban areas, applicability would be more limited.

This review includes the results of 17 RCTs, six controlled clinical trials, and 12 prospective cohort studies. Combined, these represent 43% of the evidence in the report. The remaining studies are retrospective cohort studies and before/after comparisons. While there is no guarantee that trials and prospective studies will provide better evidence, the ability to control or at least influence data collection and the delivery of care to some degree may reduce bias and increase the likelihood studies will include variables and outcomes needed to address the proposed research questions. Some of the included studies employed advanced techniques designed to reduce or adjust for bias such as randomizing clusters (prehospital personnel, teams or agencies) rather than patients or using propensity scoring to create more similar groups.

There are several important limitations to the available evidence assessing the impact of different airway devices in prehospital care. The most serious limitations of the evidence on prehospital airway management result from the intersection of the weaknesses of study designs and the risk of biases that are common challenges in prehospital and emergency care research. While the body of evidence does include trials, the majority of the studies are retrospective observational studies based on analyses of data from national or regional registries or administrative data from a single health system or EMS agency. This is not surprising as prospective studies and trials are more difficult, more costly, and subject to strict regulation, particularly as prehospital patients are unlikely to be able to consent to participate in the research. Bias may be more likely in observational studies, and this may explain why the results from trials and observational study differ in this review. Indication bias, classifying patients by the treatment received, and survival bias, including only patients who survive for treatment to be initiated, are variants of selection bias that are likely to occur in observational studies of prehospital care. Furthermore, confounding variables can influence the observed outcomes. Measurement of confounders is often limited in large administrative databases, and analyses may not account for all relevant potential confounders. Other characteristics may introduce bias in both observational studies and trials in prehospital research. Specifically, prehospital care is provided in different patterns over the prehospital care time period with patients rarely receiving the exact same treatment even within trial arms or treatment groups. Additionally, the impact of specific prehospital interventions may vary at different care time points, particularly when a patient's status is changing rapidly.[104]

Of importance, first responders 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 included studies for this review. It is likely that providers have greater skill with one technique more than others, 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 often the norm with a progression through different approaches as the patient is assessed. The use of multiple airways, the order, and the duration of each may affect outcomes, but are rarely documented precisely and included in analyses. While some studies clearly define which airways were used first and when an airway was used as rescue when another airway failed, this is not explicit in all studies. 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 may influence both the intervention received and outcomes.[95] The preparation time needed for different airways and the differences in skill and experience may be confounders, and the impact is often difficult to separate from the airway itself. An additional consideration is that there is variation in device designs within each class of airway. For example, SGA includes devices that seal in different locations and may or may not incorporate balloons in their design (e.g., LMA, King LT, and i-gel). In some studies, this is specified, but even so the variation in techniques and skill needed could contribute to variation in outcomes, and all possible comparisons within and across types of devices have not been studied.

Finally, there is a paucity of data regarding prehospital ventilation because we do not have a way to accurately measure it. When available we use capnography, but this does not provide a complete picture and can be affected by other factors such as medications and blood flow to the lungs. The challenge with most airway trials to date is that they have not addressed what happens after the airway is secured. Ventilation has not been assessed, so the differences noted in outcomes after various airway strategies may be related to the ventilation provided and not the airway method. Better tools are needed to measure ventilation parameters like rate, volume, and pressures.

Strengths and Limitations of the Review

The methods for this review are based on the AHRQ methods guidance [105] and the IOM standards for systematic reviews.[106] We searched multiple databases, asked TEP members, clinical experts, and reviewers to suggest known studies, and we solicited unpublished data and additional studies through the AHRQ public call for information. We identified a sizable body of literature, suggesting our search was comprehensive, though it is not impossible that we missed studies. The setting of care is often not indexed in citation databases such as MEDLINE. However, the phrase 'Emergency Medical Services' is a MeSH/indexing term, increasing the likelihood that this was assigned to appropriate studies, and we also searched titles and abstracts for other terms such as "prehospital" and "field" to increase our yield.

We limited our inclusion to studies in English, which may introduce bias, though we did not locate any English language abstracts of studies published in other languages that met our inclusion criteria. As we included observational studies, we were not able to assess some types of reporting bias, as most studies were not registered prior to their conduct in ClinicalTrials.gov or a similar registry. Additionally, some of the retrospective cohort studies were analyses of large trauma or emergency care registries. These registries contain data from multiple trauma centers or health systems. While we looked for potential overlap in the populations used in these studies and also for overlap between registry or multi-site studies and single site studies, we cannot be sure the populations are all mutually exclusive and it is possible that some patients were included more than once.

Using meta-analysis to pool the results requires judgements about what populations, interventions and outcomes are similar enough to combine and what subgroups are important. We established criteria a priori and have described this in our methods detail (see Appendix A). These decisions have an important impact on the results, and the results could differ if other criteria were used. A key decision we made was that all our results would be stratified by age group or by emergency type. As a result, there is no single pooled value giving overall results that combine all studies across adults, pediatrics, trauma, and cardiac arrest for each Key Question. We did this based on our belief that combining these would be clinically inappropriate, although this limits the ability to make global statements about effectiveness. We also did not combine age and emergency types. For example, we report a pooled estimate of the relative risk of survival for studies of adults and a separate result for survival for trauma patients. We made this decision because creating subgroups by combining age and type of emergency often resulted in strata with too few studies for meta-analysis; however, the result, following that example above, is that adult trauma patients are included in both of these pooled estimates.

Applicability

The applicability of the evidence we identified and synthesized is operationalized in terms of how similar or different key aspects of the included studies correspond to the current practice and policy decisional dilemmas that inspired this review. Using the PICOS framework, we can identify what elements affect applicability and the extent to which the evidence available and the ideal research match.

Our assessment of the applicability of the identified and synthesized evidence varies across PICOS elements. Some elements, such as the Population, Comparators, and Setting, mirror current practice and policy questions. Other elements of the research evidence, including details of interventions and the reported outcomes, are not sufficient to directly respond to the decisional dilemmas surrounding prehospital airway management, underscoring the needs for additional research as outlined later in this discussion.

The population of interest is all patients treated by emergency medical services for trauma, cardiac arrest or other urgent causes of respiratory failure. All these types of patients as well as broad age categories of adults and pediatrics are represented in the included studies. This is important as prior evidence and clinical indications are that airway management is significantly different across these groups. There are, however, other subgroups where variation is possible, but not documented to date, and are not represented. For example, the race of patients is rarely reported in these studies, making it difficult to determine if there are differences in needs, treatment, or outcomes and whether the results apply across racial groups. Unfortunately the studies included for this review only provided two categories – white and non-white. The findings are consistent with what is seen in other OHCA studies related to race and ethnicity and likely not related to airway interventions. Non-white patients have poorer survival, possibly due to not having bystander actions, in delays in calling 911, or other factors not yet addressed in the literature.[107]

While age was always reported, some studies did not report results by age groups. Other results suggest that patients may need to be further divided by age into finer groups as results differ for infants versus older children or for middle-aged adults versus older adults. Another characteristic of these patient populations that might be important in some cases, but is rarely reported, is pre-existing conditions. While many conditions may not be germane to airway decisions or the information may not be available, some such as obesity, can be observed, or others such as anticoagulant use could be communicated by medic alert bracelets or tags.

The comparators and setting of the studies also closely correspond to the key questions. The studies included direct comparisons of different types of airways or variations on a type of airway, corresponding to the decisional dilemma of what to recommend in practice. The studies were also all conducted in the field with actual patients, providing direct evidence. This eliminated the need to include studies conducted in the ED or simulations.

Most problematic for applicability are known and unknown variations in key aspects of the airway interventions. As documented in Table 1, the included studies were conducted in several countries with different emergency medical systems. Key differences include the provision of prehospital care by physicians and the levels of training, scope of practice and supervision of nonphysician providers. For example, one of the more rigorous studies in this field is an RCT conducted in France and Belgium in which physicians were responsible for field ETI.[34] Similarly, in Asian countries such as Japan, South Korea and Taiwan, prehospital providers are not permitted to place advanced airways without extra training and even then still require on-line medical control approval to place advanced airways. These differences reduce the applicability of results across systems. While we created functional categories for the level of emergency provider in each study, included this in our data abstraction (Appendix E), and listed the category on the meta-analysis forest plots next to each study (Appendix H and I), we did pool studies despite these variations and chose not to limit inclusion to studies conducted in the United States.

Applicability is also potentially impacted by differences in the outcomes measured and compared in the included studies. What is important continually changes as our understanding of physiology, physiologic reserve, and how the body responds evolves. We were encouraged to find studies that included outcomes that are patient-centered and not focused only on steps in prehospital care process. We believe survival, neurological function and ROSC are important as reflected in our focus on these outcomes for quantitative synthesis. However, there is an increasing emphasis on appropriate ventilation as a necessary precursor to better outcomes, and most studies did not provide data on ventilation. Specifically, leaders in emergency care are suggesting that the focus should be more on breathing than airway. This is in part due to the detrimental impact of hyperventilation for trauma and cardiac arrest patients and the higher probability that hyperventilation will occur when more attention is given to securing an airway then to ventilation and oxygenation.[96-100] While a few studies did include blood gases on ED arrival and found no significant differences, these outcomes were not common. This sparsity of data means the current body of evidence cannot be easily applied to decisions about how to maximize these outcomes.

COVID-19. It is important to recognize that the systematic review and meta-analyses presented above were initiated prior to the COVID-19 pandemic, which has impacted airway management. As prehospital airway management is considered an aerosol-generating procedure, EMS providers must ensure they have appropriate respiratory, skin, and eye protection equipment to decrease potential exposures. Interim American Heart Association (AHA) guidelines recommend that prehospital providers prioritize oxygenation and ventilation strategies with lower aerosolization risk, such as an endotracheal tube connected to a ventilator with a high-efficiency particle air (HEPA) filter in the path of the exhaled gas. If available, video laryngoscopy may also help reduce intubation exposure to aerosolized particles. If endotracheal intubation is not feasible or delayed, manual ventilation with a BVM or SGA device should be performed with a HEPA filter in place.

Implications for Clinical Practice, Education, Research, or Health Policy

Based on the findings from this systematic review and meta-analysis, all three methods for airway management appear to be effective options for patients in the prehospital environment. The preferred airway depends on setting, patient age and type, and available provider expertise and equipment. As no method is universally successful, having all three available to support initial airway management attempts may optimize patient outcomes.

Airway management provides oxygenation and ventilation. BVM and SGA, which are faster to insert, should be the mainstay management, as they facilitate prompt ventilation of the patient compared with ETI. Any device that is used needs to be closely monitored (e.g., pulse oximetry, waveform capnography, future ventilation measuring devices) to ensure appropriate overall resuscitation.

Provider Training, Expertise, and Skills Maintenance

The quality of EMS performance in securing an airway will influence patient outcomes. Airway skill maintenance, especially with advanced techniques, has been a challenge, and some systems are restricting advanced skills like ETI to a smaller number of providers. ETI should be available, but requirements for continued skills maintenance and cost of equipment may necessitate limiting ETI to higher-level providers, especially in tiered systems where a more complex set of resources are sent to a smaller number of calls.

Future Research

Although airway management remains a key intervention in the prehospital setting, this systematic review and meta-analysis highlights several gaps in the literature, first being the need for more high quality research from RCTs to minimize indication bias. While observational studies tend to be easier to conduct, they primarily are hypothesis generating and provide the foundation for RCTs. Future airway studies need to clearly identify what is being measured so the different airway methods used can be compared more accurately (e.g., whether adjuncts were used with BVM [OPA, NPA]). Future research needs to incorporate objective measures of success in oxygenation and ventilation (e.g., capnography, video, etc.); newer monitors and developing technology will hopefully assist in more precise measurement of these outcomes. The ability to record procedures in real time is one of the key challenges faced by providers in the ED setting, and consideration should be given to extending this into the field setting. Resuscitation time bias remains an important issue in OHCA studies, and efforts should be made to accurately capture airway intervention timing to mitigate this issue. Research is also needed to identify optimal methods to acquire and maintain airway management skills in the prehospital setting.

Specific recommendations include:

- Conduct RCTs that compare all three airway approaches in the same trial.
- Include data on ventilation, and assess effectiveness of the method of airway management to ventilate.
- Identify the impact of ventilation volume, ventilation rate, and airway pressure on outcomes across different airway methods to better understand the importance of airway vs. breathing during resuscitation.
- Clarify technique used in BVM studies (one person or two person).
- Assess effects of experience as well as frequency of skill utilization with regards to ETI.
- Incorporate more objective outcome reporting methods, as observational studies often rely on self-reported success.
- Conduct more research about pediatric airway management.
- Improve data collection for and integration into national and international databases.
- Increase the use of video or passive monitoring / data collection technology that can more accurately document timing and care processes.
- Conduct more research on waveform capnography to confirm successful ventilation with each device.
- Conduct mechanistic studies in humans to advance understanding of underlying mechanisms by which differences may be occurring.

Conclusion

Overall, there is limited evidence to suggest differences in patient-oriented outcomes between use of BVM, SGA, and ETI in the management of prehospital airway. The objective of this systematic review and meta-analysis was to identify and synthesize the available evidence to support the development of evidence-based recommendations and guidelines for prehospital airway management. From the beginning, all participants, contributors, and stakeholders involved in this process were aware that the outcome would not be a simple set of algorithmic protocols. This topic converges vast variation in multiple factors influencing prehospital airway management (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 are presented for clinically meaningful patient populations and are not summarized across groups because that would not be clinically appropriate. While the findings from this effort are detailed and comprehensive, it is important to use them to inform policy, practice, education, and research to improve prehospital airway management and patient outcomes.

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Abbreviations and Acronyms

Abbreviation	Definition
AHRQ	Agency for Healthcare Research and Quality
BiPAP	Bi-level positive airway pressure
BVM	bag valve mask
CCT	controlled clinical trial
CDC	Centers for Disease Control and Prevention
CPAP	continuous positive airway pressure
CPC Score	Cerebral Performance Category Score
DASH-1A	Definitive Airway Sans Hypoxia/Hypotension on First Attempt
DSI	delayed sequence intubation
ED	emergency department
EMS	emergency medical service
EPC	Evidence-based Practice Center
ETI	endotracheal intubation
ICU	intensive care unit
ITT	intent to treat
KQ	Key Question
LMA	laryngeal mask airway
mRS	modified Rankin Scale
NPA	nasopharyngeal airway
OBS	observational
OHCA	out-of-hospital cardiac arrest
OHSU	Oregon Health & Science University
OPA	oropharyngeal airway
PICOS	Population, Intervention, Comparator, Outcome, Setting, Study Design
RCT	randomized controlled trial
ROB	risk of bias
ROSC	return of spontaneous circulation
RSI	rapid sequence intubation
SGA	supraglottic airway
SIDS	Sudden Infant Death Syndrome
SOE	strength of evidence
TEP	Technical Expert Panel
TOO	Task Order Officer
USPSTF	U.S. Preventive Services Task Force