Comparative Effectiveness Review
Number 243

Prehospital Airway Management: A Systematic Review

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

The information in this report is intended to help healthcare decision makers—patients and clinicians, health system leaders, and policymakers, among others—make well-informed decisions and thereby improve the quality of healthcare services. This report is not intended to be a substitute for the application of clinical judgment. Anyone who makes decisions concerning the provision of clinical care should consider this report in the same way as any medical reference and in conjunction with all other pertinent information, i.e., in the context of available resources and circumstances presented by individual patients.

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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 and funded this report from the EPC Program at AHRQ. AHRQ assigned this report to the following EPC: Pacific Northwest Evidence-based Practice Center (Contract No. 290-2015-00009-I).

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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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.

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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.

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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 do 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 nonfinancial conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential nonfinancial conflicts of interest identified.

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Prehospital Airway Management: A Systematic Review

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 the benefits and harms differ based on patient characteristics, techniques, and devices.

Data sources. We searched electronic citation databases (Ovid® MEDLINE®, CINAHL®, the Cochrane Central Register of Controlled Trials, the Cochrane Database of Systematic Reviews, and Scopus®) from 1990 to September 2020 and reference lists, and posted a Federal Register notice request for data.

Review methods. Review methods followed Agency for Healthcare Research and Quality Evidence-based Practice Center Program methods guidance. Using pre-established criteria, studies were selected and dual reviewed, data were abstracted, and studies were 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 study design, emergency type, and age. We qualitatively synthesized results when meta-analysis was not indicated. Strength of evidence (SOE) was assessed for primary outcomes (survival, neurological function, return of spontaneous circulation [ROSC], and successful advanced airway insertion [for SGA and ETI only]).

Results. We included 99 studies (22 randomized controlled trials and 77 observational studies) involving 630,397 patients. Overall, we found few differences in primary outcomes when airway management approaches were compared.

- For survival, there was moderate SOE for findings of no difference for BVM versus ETI in adult and mixed-age cardiac arrest patients. There was low SOE for no difference in these patients for BVM versus SGA and SGA versus ETI. There was low SOE for all three comparisons in pediatric cardiac arrest patients, and low SOE in adult trauma patients when BVM was compared with ETI.
- For neurological function, there was moderate SOE for no difference for BVM compared with ETI in adults with cardiac arrest. There was low SOE for no difference in pediatric cardiac arrest for BVM versus ETI and SGA versus ETI. In adults with cardiac arrest, neurological function was better for BVM and ETI compared with SGA (both low SOE).
- ROSC was applicable only in cardiac arrest. For adults, there was low SOE that ROSC was more frequent with SGA compared with ETI, and no difference for BVM versus SGA or BVM versus ETI. In pediatric patients there was low SOE of no difference for BVM versus ETI and SGA versus ETI.
- For successful advanced airway insertion, low SOE supported better first-pass success with SGA in adult and pediatric cardiac arrest patients and adult patients in studies that mixed emergency types. Low SOE also supported no difference for first-pass success in

adult medical patients. For overall success, there was moderate SOE of no difference for adults with cardiac arrest, medical, and mixed emergency types.

- While harms were not always measured or reported, moderate SOE supported all available findings. There were no differences in harms for BVM versus SGA or ETI. When SGA was compared with ETI, there were no differences for aspiration, oral/airway trauma, and regurgitation; SGA was better for multiple insertion attempts; and ETI was better for inadequate ventilation.

Conclusions. The most common findings, across emergency types and age groups, were of no differences in primary outcomes when prehospital airway management approaches were compared. As most of the included studies were observational, these findings may reflect study design and methodological limitations. Due to the dynamic nature of the prehospital environment, the results are susceptible to indication and survival biases as well as confounding; however, the current evidence does not favor more invasive airway approaches. No conclusion was supported by high SOE for any comparison and patient group. This supports the need for high-quality randomized controlled trials designed to account for the variability and dynamic nature of prehospital airway management to advance and inform clinical practice as well as emergency medical services education and policy, and to improve patient-centered outcomes.

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Evidence Summary

Main Points

- Four Key Questions addressed the comparative benefits and harms across three airway management approaches by emergency medical services in the prehospital setting: Key Question 1 – bag valve mask [BVM] versus supraglottic airway [SGA]; Key Question 2 – BVM versus endotracheal intubation [ETI]); Key Question 3 – SGA versus ETI; and Key Question 4 – how the benefits and harms differ based on patient characteristics, techniques, and devices.
- The most common finding, across emergency types and age groups, was of no differences in primary outcomes when prehospital airway management approaches were directly compared.
- None of the conclusions were supported by high strength of evidence (SOE); thus, future, more rigorous studies could change the findings.
- The following conclusions for Key Questions 1-3 were supported by low or moderate SOE (see Table A):
    - Survival measured in-hospital or at 1-month post incident:
        - No difference in outcomes for all three comparisons in adult/mixed-age patients with cardiac arrest and pediatric patients with cardiac arrest.
        - No difference when BVM was compared with ETI in adult trauma patients.
    - Neurological function measured by the Cerebral Performance Category (CPC), Pediatric CPC, or modified Rankin Scale (mRS) in-hospital or at 1-month post incident:
        - When BVM was compared with SGA, outcomes favored BVM in adult patients with cardiac arrest.
        - When BVM was compared with ETI, there was no difference in outcomes in adult patients with cardiac arrest.
        - When SGA was compared with ETI, outcomes measured by the CPC favored ETI in adult patients with cardiac arrest; there was no difference in outcomes measured by the mRS in this group.
        - When ETI was compared with BVM or SGA, there was no difference in outcomes in pediatric patients with cardiac arrest.
    - Return of spontaneous circulation (ROSC) (prehospital, sustained, or overall):
        - When BVM was compared with SGA or ETI, there was no difference in outcomes in adult patients.
        - When SGA was compared with ETI, outcomes favored SGA in adult patients.
        - When ETI was compared with BVM or SGA, there was no difference in outcomes in pediatric patients.
    - First-pass successful advanced airway insertion (Key Question 3 only):
        - When SGA was compared with ETI, outcomes favored SGA in adult and pediatric patients with cardiac arrest and adult patients with mixed emergency types.

        - No difference when SGA was compared with ETI in adult patients with medical emergencies.
    - Overall successful advanced airway insertion (Key Question 3 only):
        - No difference when SGA was compared with ETI in adult patients with cardiac arrest, medical, or mixed emergency types.
- For other quantitatively analyzed comparisons and outcomes for Key Questions 1-3, there was insufficient evidence to support conclusions.
- Key findings for comparisons within ETI (Key Question 4):
    - Survival measured in hospital:
        - No difference when rapid sequence intubation (RSI) was compared to ETI with no medication in adult/mixed-age patients with trauma.
    - First-pass successful advanced airway insertion:
        - When RSI was compared to ETI with no medication, RSI was favored in adults/mixed-age patients with mixed emergency types; there was no difference in adults/mixed-age patients with trauma.
        - No difference when video laryngoscopy was compared with direct laryngoscopy in adult/mixed-age patients with cardiac arrest or mixed emergency types.
    - Overall successful advanced airway insertion:
        - When RSI was compared to ETI with no medication, RSI was favored in adults with trauma; there was no difference in adults/mixed-age patients with cardiac arrest or mixed emergency types.
        - No difference when video laryngoscopy was compared with direct laryngoscopy in adult/mixed-age patients with cardiac arrest or mixed emergency types.
- Implications based on the current body of evidence and finding that no one airway management approach was consistently superior:
    - It is possible all three airway management techniques have a role in prehospital care and the preferred airway approach depends on the setting, patient age and type, available provider expertise, and equipment.
    - Future research should:
        - Focus on rigorous studies, preferably randomized controlled trials (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 emergency medical service (EMS) resources including training.

Background and Purpose

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

Three airway management techniques routinely used by EMS include: BVM, SGA, and ETI. Each requires unique training and equipment. Individual research studies, experience with hospitalized patients, and EMS agency resources and personnel experience have led to questions

about which prehospital airway management approach is best for what type of patients in specific situations.

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 currently available research on the comparative effectiveness of these three airway techniques in prehospital care 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 September 8, 2020. We included studies that compared two types of airways or compared variations of one type of airway, such as video and direct laryngoscopy. Details about our search strategies, inclusion criteria, assessment, and synthesis of the evidence are included in the full report text and appendices.

Our approach and results were specific to characteristics of airway management and research on this topic. A key characteristic was that in prehospital care there are fundamental differences in airway management requirements for trauma, cardiac arrest, and other medical needs. Similarly, the needs and challenges of airway management for children differ significantly from those for adults. Given these differences, our results were organized into groups defined by age and emergency type. Studies were not combined across these groups, as such combinations would not be clinically meaningful. Pooled estimates were generated separately for RCTs and observational studies; however, the conclusions and SOE assessments presented include all study designs. When there were conflicting findings, we prioritized those from RCTs with low risk of bias.

Results

Our results synthesized the findings of 99 studies from 101 publications involving 630,397 patients that compared BVM to SGA (Key Question 1, 22 studies), BVM to ETI (Key Question 2, 22 studies), SGA to ETI (Key Question 3, 41 studies), or compared variations of one of the three airway approaches (Key Question 4, 51 studies). The results for Key Questions 1, 2, and 3 for the outcomes of survival in-hospital or at 1-month post incident, neurological function at discharge or at 1-month post incident, ROSC, and first-pass and overall success are presented in Table A.

The overall findings suggested that there are few differences in primary outcomes between the three methods of airway management studied. Similarly, few differences were found in studies that compared variations of one type of airway (e.g., video versus direct laryngoscopy).

Table A. Overview of conclusions: comparisons by emergency types and age groups

Outcome	Emergency Type and Age	KQ1: BVM vs. SGA	KQ2: BVM vs. ETI	KQ3: SGA vs. ETI
Survival	Cardiac arrest: Adults/Mixed	No difference	**No difference**	No difference
	Cardiac arrest: Pediatrics	No difference[a]	No difference	No difference[a]
	Trauma: Adults	*No conclusion*[a]	No difference	*No conclusion*[a]
	Trauma: Pediatrics	No evidence	*No conclusion*[a]	No evidence
Neurological Function	Cardiac arrest: Adults	mRS: No evidence CPC: Favors BVM	mRS: No evidence CPC: **No difference**	mRS: No difference CPC: Favors ETI[a]
	Cardiac arrest: Pediatrics	*No conclusion*[a]	No difference	No difference[a]
	Trauma: Adults	No evidence	No evidence	No evidence
	Trauma: Pediatrics	No evidence	No evidence	No evidence
ROSC[b]	Cardiac arrest: Adults	No difference	No difference	Favors SGA
	Cardiac arrest: Pediatrics	*No conclusion*[a]	No difference[a]	No difference[a]
First-Pass Success[c]	Cardiac arrest: Adults	NA	NA	Favors SGA
	Cardiac arrest: Pediatrics	NA	NA	Favors SGA[a]
	Trauma: Adults	NA	NA	*No conclusion*[a]
	Trauma: Pediatrics	NA	NA	*No conclusion*[a]
	Medical: Adults	NA	NA	No difference
	Medical: Pediatrics	NA	NA	*No conclusion*[a]
	Mixed: Adults	NA	NA	Favors SGA[a]
	Mixed: Pediatrics	NA	NA	No evidence
Overall Success[c]	Cardiac arrest: Adults	NA	NA	**No difference**
	Cardiac arrest: Pediatrics	NA	NA	No evidence
	Trauma: Adults	NA	NA	*No conclusion*[a]
	Trauma: Pediatrics	NA	NA	No evidence
	Medical: Adults	NA	NA	**No difference**
	Medical: Pediatrics	NA	NA	No evidence
	Mixed: Adults	NA	NA	**No difference**[a]
	Mixed: Pediatrics	NA	NA	No evidence
Harms[d]	All groups	**No difference**	**No difference**	**No difference:** Aspiration, Oral/Airway Trauma, Regurgitation **Favors SGA:** Multiple Insertion Attempts **Favors ETI:** Inadequate Ventilation

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

Also included in the full report were 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 was a key strength. It was 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 were weaker observational study designs, rendering them vulnerable to indication and survival biases. Bias, confounding, and incomplete data are difficult to avoid, given the dynamic nature of airway management in the field. Specifically, use of more than one airway approach was common, yet the order, detail, and duration of use was rarely adequately documented and included in analyses. Additionally, the influence of prehospital ventilation was not adequately assessed in the literature, so differences noted in outcomes after various airway management strategies may actually be related to the ventilation provided and not the airway method. Variations within types of airways based on differences in devices and training made generalizations difficult. Finally, there was a lack of evidence focusing on pediatric prehospital airway management.

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 and confounding 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 inconsistencies 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 may be 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 or complexity, as well as 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 simple airway adjuncts (e.g., oropharyngeal airway or nasopharyngeal airway), which are devices inserted orally or nasally to facilitate 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], delayed sequence intubation [DSI], or sedation-facilitated intubation without paralytics), and percutaneous or surgical techniques. (Note: We use the term "supraglottic airway" in this report to describe various "extraglottic airway" methods. While "extraglottic airway" may be more technically correct, we use the term "supraglottic airway" – due to its more common use in the literature – 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 setting, severity of the patient's condition, training and skill level of emergency medical services (EMS) personnel, and available equipment. Field personnel without SGA or ETI training can perform basic maneuvers.

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 different 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 for advanced airway insertion, 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, 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, given the considerations described above. 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 now 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 was 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 was 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 focused on comparing the benefits and harms across three different airway management approaches: BVM, SGA, and ETI. Given the possible variations in the prehospital setting, this review considered 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).

Factors that influenced the scope of this systematic review include:

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

- Uncertainty surrounding the role of recent 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 aggregated 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 followed 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 and submitted to PROSPERO, a 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 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 emphasized and comments suggested review of 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. Revisions were made for clarity of definitions and inclusion of new technology was confirmed.

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

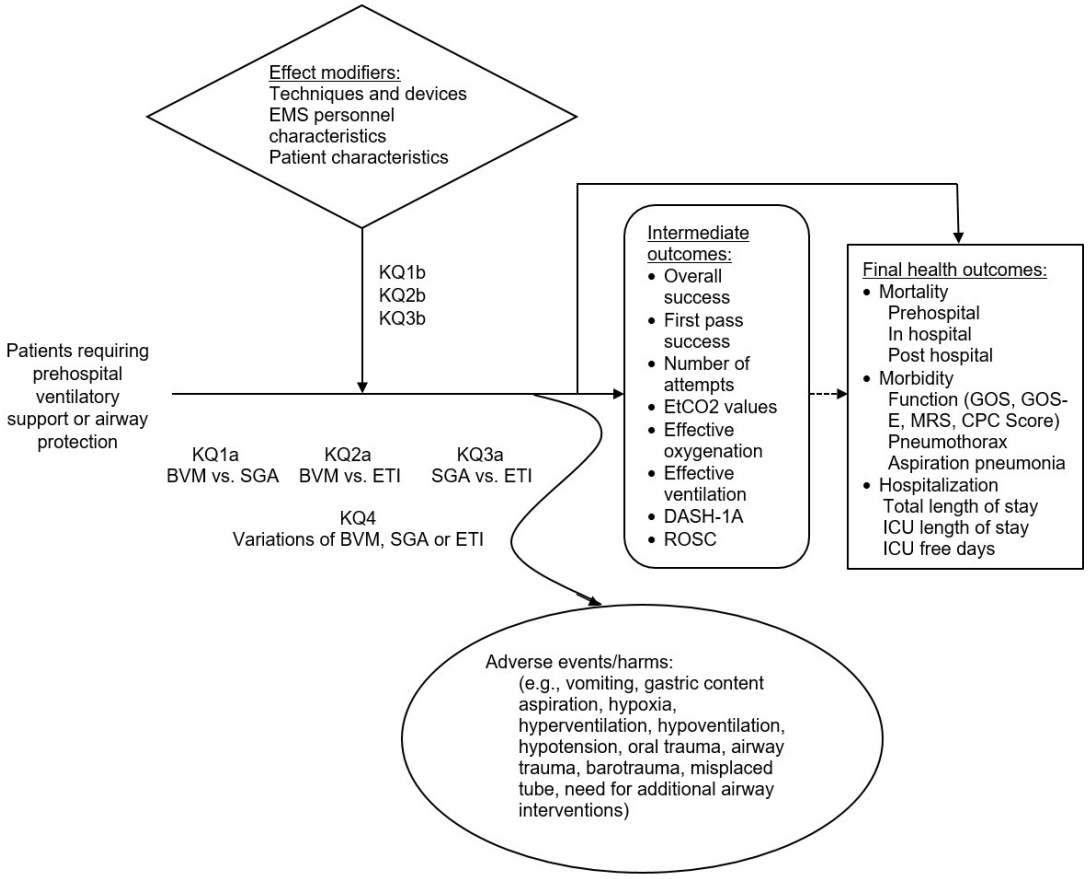
What are the comparative benefits and harms of the following variations of any one of the three included airway interventions (bag valve mask, supraglottic airways, or endotracheal intubation) for patients requiring prehospital ventilatory support or airway protection:

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 presents the 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 population, intervention, comparator, outcome, setting, study design (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 randomized controlled trials (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 to facilitate meta-analyses. 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. Study design-specific criteria were used, 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 (Appendix E and Appendix F), 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.

Definitions and Outcome Measures

Studies in which greater than 85 percent of the participants were cardiac arrest patients were categorized as cardiac arrest at the study level. Studies or subgroups were categorized as pediatric based on each study's age-based definition. Studies in which less than 10 percent of patients were pediatric were categorized as adult at the study level. Studies for which age distribution was not distinguished were categorized as "mixed-age" at the study level.

Results for all outcomes specified in the PICOS were abstracted and analyzed, either quantitatively or qualitatively. We prioritized direct patient centered outcomes for meta-analyses. These included survival to hospital discharge or 30 days, neurological function at hospital discharge or 30 days, return of spontaneous circulation (ROSC), and successful airway placement on the first attempt (first-pass success) and overall (overall success).

Meta-Analyses

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]

The Key Questions were designed to assess the comparative effectiveness and harms by airway intervention, emergency medical services personnel, and patient characteristics. Therefore, stratified analyses were conducted based on study design (i.e., RCTs or observational studies), emergency type (e.g. cardiac arrest, trauma), and population age (adult, pediatric, or mixed-age). Controlled clinical trials were grouped with either RCTs or observational studies in meta-analyses based on the characteristics of the study. If a study provided data for more than one definition of ROSC, we used in order of preference: sustained ROSC, any ROSC, prehospital ROSC. For neurological function, we did not pool across different assessment measures. Studies with mixed-age populations were grouped with the adult studies for stratification in the primary analyses. In primary analyses, we used data from the intent-to-treat 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, unadjusted results), or by excluding studies with outlying results, those rated as high risk of bias, and studies in mixed-age populations, as separate analyses.

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

Qualitative Synthesis

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 chapter and Appendix F).

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 one or more additional investigators prior to assigning a final grade, based 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 (see Appendix J). RCTs 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, based on the totality of evidence across study designs. 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 9,284 abstracts of potentially relevant articles. We reviewed 772 full-text publications. Of those, 99 studies from 101 publications involving 630,397 patients were included for this review (see Appendix B, Literature Flow).

In this section we presented the results of our quantitative and qualitative analyses of the studies included for the review that addressed one or more of the four Key Questions. We began with a summary of the overall findings across Key Questions, and then provided specific results for each individual Key Question. 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 were survival in-hospital or at 1-month post incident for all Key Questions; neurological function at discharge or 1-month post incident, and return of spontaneous circulation (ROSC) for Key Questions 1-3; and successful advanced airway insertion for Key Questions 3 and 4 only (Tables 3-5). Forest plots for the primary analyses are presented in Appendix H. In the sections below that address individual Key Questions, we provided tables with the number of studies and number of patients included in the studies, and the pooled risk ratio with confidence interval and I^2 for randomized controlled trials (RCTs) and observational studies separately. The overall strength of evidence (SOE) was provided for age and emergency type subgroup.

Details on the determinations that contributed to the SOE are in Appendix J. We conducted sensitivity analyses for all outcomes and discussed 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=99[a]	KQ1 N=22[a]	KQ2 N=22[a]	KQ3 N=41[a]	KQ4 N=51
Year of Publication	1990-2000	9 (9.1%)	1 (4.5%)	2 (9.1%)	3 (7.3%)	5 (9.8%)
	2001-2010	22 (22.2%)	5 (22.7%)	7 (31.8%)	9 (22.0%)	10 (19.6%)
	2011-2020	68 (68.7%)	16 (72.7%)	13 (59.1%)	29 (70.7%)	36 (70.6%)
Study Design	RCT	22 (22.2%)	4 (18.2%)	4 (18.2%)	5 (12.2%)	14 (27.5%)
	Prospective observational	20 (20.2%)	5 (22.7%)	3 (13.6%)	10 (24.4%)	9 (17.5%)
	Retrospective observational	50 (50.5%)	12 (54.5%)	15 (68.2%)	25 (61.0%)	23 (45.1%)
	Before/after	7 (7.1%)	1 (4.5%)	0	1 (2.4%)	5 (9.8%)
Geographic Location	United States/Canada	48 (48.5%)	8 (36.4%)	10 (45.5%)	21 (51.2%)	26 (51.0%)
	Europe	26 (26.3%)	4 (18.2%)	2 (9.1%)	8 (19.5%)	14 (27.5%)
	Asia	17 (17.2%)	10 (45.5%)	9 (40.9%)	11 (26.8%)	4 (7.8%)
	Africa	1 (1.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (2.0%)
	Australia	6 (6.1%)	0 (0.0%)	1 (4.5%)	1 (2.4%)	5 (9.8%)
	Multiple countries	1 (1.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (2.0%)
Prehospital Setting	Urban	46 (46.5%)	9 (40.9%)	13 (59.1%)	20 (48.8%)	23 (45.1%)
	Rural	3 (3.0%)	1 (4.5%)	0 (0.0%)	1 (2.4%)	1 (2.0%)
	Mixed	32 (32.3%)	7 (31.8%)	6 (27.3%)	16 (39.0%)	14 (29.4%)

Category	Characteristics	Overall N (%) N=99[a]	KQ1 N=22[a]	KQ2 N=22[a]	KQ3 N=41[a]	KQ4 N=51
	Not reported	18 (18.2%)	5 (22.7%)	3(13.6%)	4 (9.8%)	12 (23.5%)
Number of Agencies/ Institutions	Single	44 (44.4%)	6 (27.3%)	7 (31.8%)	15 (36.6%)	28 (54.9%)
	Multiple	54 (54.5%)	16 (72.7%)	15 (68.2%)	26 (63.4%)	22 (43.1%)
	Not reported	1 (1.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (2.0%)
EMS Provider Level[b]	ETI-capable No	7 (7.1%)	5 (22.7%)	0 (0.0%)	0 (0.0%)	3 (5.9%)
	ETI-capable Yes	40 (40.4%)	7 (31.8%)	11 (50.0%)	15 (36.6%)	24 (47.1%)
	Advanced	15 (15.2%)	1 (4.5%)	1 (4.5%)	1 (2.4%)	12 (23.5%)
	Mixed	36 (36.4%)	9 (40.9%)	10 (45.5%)	25 (61.0%)	11 (21.6%)
	Not reported	1 (1.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (2.0%)
Mode of Transport	Ground	61 (61.6%)	14 (63.6%)	13 (59.1%)	28 (68.3%)	29 (56.9%)
	Air	10 (10.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	10 (19.6%)
	Mixed	17 (17.2%)	3 (13.6%)	3 (13.6%)	7 (17.1%)	8 (15.7%)
	Not reported	11 (11.1%)	5 (22.7%)	6 (27.3%)	6 (14.6%)	4 (7.8%)
Age Group	Pediatric	7 (7.1%)	2 (9.1%)	4 (18.2%)	3 (7.3%)	3 (5.9%)
	Adult	81 (81.8%)	19 (86.4%)	16 (72.7%)	36 (87.8%)	40 (78.4%)
	Mixed	11 (11.1%)	1 (4.5%)	2 (9.1%)	2 (4.9%)	8 (15.7%)
	Not reported	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Emergency Type	Trauma	15 (15.2%)	1 (4.5%)	4 (18.2%)	2 (4.9%)	9 (17.6%)
	Cardiac arrest	49 (49.5%)	21 (95.5%)	17 (77.3%)	31 (75.6%)	13 (25.5%)
	Medical	3 (3.0%)	0 (0.0%)	0 (0.0%)	2 (4.9%)	1 (2.0%)
	Mixed	30 (30.3%)	0 (0.0%)	1 (4.5%)	6 (14.6%)	26 (51.0%)
	Not reported	2 (2.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (3.9%)

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	4	18	22
Key Question 2	4	18	22
Key Question 3	5	36	41
Key Question 4	14	37	51

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 1-month post incident:
  - No difference in outcomes across all three comparisons in adult/mixed-age patients with cardiac arrest and pediatric patients with cardiac arrest.
  - No difference when bag valve mask (BVM) was compared with endotracheal intubation (ETI) in adult trauma patients.
- Neurological function measured by the Cerebral Performance Category (CPC), Pediatric CPC, or modified Rankin Scale (mRS) in-hospital or at 1-month post incident:
  - When BVM was compared with supraglottic airway (SGA), outcomes favored BVM in adult patients with cardiac arrest.
  - When SGA was compared with ETI, outcomes measured by the CPC favored ETI in adult patients with cardiac arrest; there was no difference in outcomes measured by the mRS in this group.

    - When BVM was compared with ETI, there was no difference in outcomes in adult patients with cardiac arrest.
    - When ETI was compared with BVM or SGA, there was no difference in outcomes in pediatric patients with cardiac arrest.
- ROSC (prehospital, sustained, or overall – cardiac arrest patients only):
    - When BVM was compared with SGA or ETI, there was no difference in outcomes in adult cardiac arrest patients.
    - When SGA was compared with ETI, outcomes favored SGA in adult patients with cardiac arrest.
    - When ETI was compared with BVM or SGA, there was no difference in outcomes in pediatric patients with cardiac arrest.
- Successful advanced airway insertion when SGA is compared with ETI:
    - First-pass success favors SGA in adults with cardiac arrest and with mixed emergency types, and in pediatric patients with cardiac arrest; no difference in adults with medical emergencies.
    - No difference in overall success in adults with cardiac arrest, medical emergencies, or mixed emergency types.

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

Outcome	Emergency Type and Age	KQ1: BVM vs. SGA	KQ2: BVM vs. ETI	KQ3: SGA vs. ETI
Survival	Cardiac arrest: Adults/Mixed	No difference	**No difference**	No difference
	Cardiac arrest: Pediatrics	No difference[a]	No difference	No difference[a]
	Trauma: Adults	*No conclusion*[a]	No difference	*No conclusion*[a]
	Trauma: Pediatrics	No evidence	*No conclusion*[a]	No evidence
Neurological Function	Cardiac arrest: Adults	mRS: No evidence CPC: Favors BVM	mRS: No evidence CPC: **No difference**	mRS: No difference CPC: Favors ETI[a]
	Cardiac arrest: Pediatrics	*No conclusion*[a]	No difference	No difference[a]
	Trauma: Adults	No evidence	No evidence	No evidence
	Trauma: Pediatrics	No evidence	No evidence	No evidence
ROSC[b]	Cardiac arrest: Adults	No difference	No difference	Favors SGA
	Cardiac arrest: Pediatrics	*No conclusion*[a]	No difference[a]	No difference[a]
First-Pass Success[c]	Cardiac arrest: Adults	NA	NA	Favors SGA
	Cardiac arrest: Pediatrics	NA	NA	Favors SGA[a]
	Trauma: Adults	NA	NA	*No conclusion*[a]
	Trauma: Pediatrics	NA	NA	*No conclusion*[a]
	Medical: Adults	NA	NA	No difference
	Medical: Pediatrics	NA	NA	*No conclusion*[a]
	Mixed: Adults	NA	NA	Favors SGA[a]
	Mixed: Pediatrics	NA	NA	No evidence
Overall Success[c]	Cardiac arrest: Adults	NA	NA	**No difference**
	Cardiac arrest: Pediatrics	NA	NA	No evidence
	Trauma: Adults	NA	NA	*No conclusion*[a]
	Trauma: Pediatrics	NA	NA	No evidence
	Medical: Adults	NA	NA	**No difference**
	Medical: Pediatrics	NA	NA	No evidence
	Mixed: Adults	NA	NA	**No difference**[a]
	Mixed: Pediatrics	NA	NA	No evidence

Outcome	Emergency Type and Age	KQ1: BVM vs. SGA	KQ2: BVM vs. ETI	KQ3: SGA vs. ETI
Harms[d]	All groups	**No difference**	**No difference**	**No difference:** Aspiration, oral/airway trauma, regurgitation **Favors SGA:** Multiple insertion attempts **Favors ETI:** Inadequate ventilation

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

Table 4. Overview of conclusions: successful advanced airway insertion by emergency type and age—Key Question 3

Outcome	Emergency Type and Age	KQ3: SGA vs. ETI
First-Pass Success	Cardiac arrest: Adults	Favors SGA
	Cardiac arrest: Pediatrics	Favors SGA[a]
	Trauma: Adults	*No conclusion*[a]
	Trauma: Pediatrics	*No conclusion*[a]
	Medical: Adults	No difference
	Medical: Pediatrics	*No conclusion*[a]
	Mixed: Adults	Favors SGA[a]
	Mixed: Pediatrics	No evidence
Overall Success	Cardiac arrest: Adults	**No difference**
	Cardiac arrest: Pediatrics	No evidence
	Trauma: Adults	*No conclusion*[a]
	Trauma: Pediatrics	No evidence
	Medical: Adults	**No difference**
	Medical: Pediatrics	No evidence
	Mixed: Adults	**No difference**[a]
	Mixed: Pediatrics	No evidence

ETI = endotracheal intubation; KQ = Key Question; SGA = supraglottic airway
Bold Text = Moderate SOE, Standard text = Low SOE, Italicized text = Insufficient SOE
[a] Results based only on observational studies

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

Outcome	Emergency Type	Video Versus Direct Laryngoscopy	ETI With Drug-Facilitation Versus Without
Survival	No evidence	No evidence	RSI vs. no medication No difference: • Trauma: Adults/mixed-age
First-Pass Success	Favors medical • Trauma vs. medical: Adults/mixed-age No difference • Medical vs. cardiac arrest: Adults/mixed-age • Trauma vs. cardiac arrest: Adults/mixed-age • Nonarrest vs. cardiac arrest: Adults/mixed-age	No difference • **Cardiac arrest: Adults** • Trauma: Adults • Mixed emergencies: Adults/mixed-age	RSI vs. no medication Favors RSI: • Mixed emergencies: Adults/mixed-age No difference: • Trauma: Adults/mixed-age RSI vs. sedation-facilitated Favors RSI: • Mixed emergencies: Adults/mixed-age Sedation-facilitated vs. no medication No difference: • Mixed emergencies: Adults/mixed-age
Overall Success	No difference • Medical vs. cardiac arrest: Adults/mixed-age • Trauma vs. cardiac arrest: Adults/mixed-age • Nonarrest vs. cardiac arrest: Adults/mixed-age • Trauma vs. medical: Adults/mixed-age	No difference • Cardiac arrest: Adults • Mixed emergencies: Adults/mixed-age	RSI vs. no medication Favored RSI: • Trauma: Adults No difference • Cardiac arrest: Adults • Mixed emergencies: Adults/mixed-age
Harms	No evidence	More often with video: problems advancing the tube	RSI vs. no medication More harms with no medication: recognized esophageal intubation, unrecognized mainstem intubation, hypotension RSI vs. sedation-facilitated No cases in either group for esophageal intubation or aspiration Sedation-facilitated vs. no medication No harms reported in studies

ETI = endotracheal intubation; RSI = rapid sequence intubation; SOE = strength of evidence
Bold Text = Moderate SOE, Standard Text = Low SOE

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 1-month post incident (17 studies; N=49,153) was not significantly different between BVM and SGA for:
    - Adult/mixed-age cardiac arrest patients (SOE: Low)
    - Pediatric cardiac arrest patients (SOE: Low)
- Neurological function, defined as good neurological outcomes at discharge or 1-month post incident measured by the CPC or Pediatric CPC (10 studies; N=92,235), favored BVM versus SGA for:
    - Adult/mixed-age cardiac arrest patients (SOE: Low)
- ROSC, defined as any ROSC (13 studies; N=47,841), was similar between BVM and SGA for:
    - Adult cardiac arrest patients (SOE: Low)
- Harms (4 studies; N=696) were not significantly different between BVM and SGA (SOE: Moderate)

Summary of Results

We included 22 studies that compared patient outcomes for BVM and SGA (N=70,718) (See Appendix C for the list of included studies). These included 4 RCTs (in 5 publications),[13-17] 5 prospective cohorts (in 5 publications),[18-22] 12 retrospective cohorts (in 11 publications),[23-33] and 1 before-after study.[34] The studies included 50 to 45,685 participants, and 8 were conducted in the United States and Canada,[14,16-18,24-27] 6 in Japan,[20,22,29-31,33] 3 in Austria,[13,19,21] 2 each in Taiwan[23,34] and South Korea,[28,32] and 1 in France.[15] Six of these studies were rated low risk of bias (ROB),[19,20,23,25,26,31] 12 moderate (in 11 publications),[13,15,16,18,22,24,27,29,32-34] and one high.[30] Three (in 4 publications) were rated low ROB on certain outcomes and moderate on others (Appendix G).[14,17,21,28]

Meta-Analysis

Twenty-two studies were pooled to obtain estimates for survival, neurological function, and ROSC, stratified by emergency type, age, and study design (Appendix Figures H-1 to H-3).[13-21,23-34] The results for each outcome by emergency type and age groups are reported in Tables 6 to 8.

Survival

There was no difference in survival comparing BVM and SGA in observational studies enrolling pediatric patients with cardiac arrest (SOE: Low) (Table 6). For adult trauma patients, SOE was insufficient, as there was only one eligible study. In studies enrolling adults with cardiac arrest, results were mixed, with observational studies favoring BVM and RCTs showing no difference. When the data were analyzed using unadjusted results, or when studies of mixed-age or those rated high ROB were excluded, results for observational studies with adult cardiac

arrest patients showed no difference between BVM and SGA (Appendix Figures I-1 to I-4). Overall, results for adults with cardiac arrest suggested no difference between BVM and SGA on in-hospital or 30-day survival (SOE: Low).

Table 6. SGA versus BVM: survival by emergency type and age group (BVM referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults/Mixed	No difference (Low)	3 RCT[14-17]	2,046	0.31 (0.15 to 2.98), 0%
			11 OBS[19-25,28,30,32]	45,980	0.65 (0.41 to 0.96), 69.8%
	Pediatrics	No difference (Low)	No RCT	-	-
			2 OBS[18,26]	1078	0.52 (0.17 to 1.98), 0%
Trauma	Adults	No conclusion (Insufficient)	No RCT	-	-
			1 OBS[27]	50	0.76 (0.20 to 2.80), NA
	Pediatrics	-	-	-	-

BVM = bag valve mask; CI = confidence interval; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; RCT = randomized controlled trial; RR = risk ratio; SGA = supraglottic airway; SOE = strength of evidence

Neurological Function

Studies of neurological function at discharge or 1-month post incident were limited to patients with cardiac arrest (Table 7). BVM was associated with good neurological outcome ratings versus SGA in one RCT (2 publications) and eight observational studies enrolling adults (SOE: Low). For pediatric patients, SOE was insufficient, as there was only one eligible observational study (Table 7). Sensitivity analyses of observational studies of adults were conducted with unadjusted results and excluding studies rated high risk of bias. In these, the pooled effect for observational studies changed to no difference between BVM and SGA (Appendix Figures I-5 to I-6). No changes in effect were detected in sensitivity analyses for the RCT or pediatric studies.

Table 7. SGA versus BVM: neurological function by emergency type and age group (BVM referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults/Mixed	Favors BVM (Low)	1 RCT[14,17]	1,499	0.21 (0.15 to 0.29), NA
			8 OBS[19,21-23,28,30,31,33]	89,830	0.52 (0.32 to 0.83), 84.2%
	Pediatrics	No conclusion (Insufficient)	No RCT	-	-
			1 OBS[26]	996	0.16 (0.06 to 0.42), NA

BVM = bag valve mask; CI = confidence interval; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; RCT = randomized controlled trial; RR = risk ratio; SGA = supraglottic airway; SOE = strength of evidence

Return of Spontaneous Circulation

Studies of ROSC were restricted to patients with cardiac arrest (Table 8). There was no difference in achieving any ROSC when comparing BVM versus SGA in RCTs and observational studies of adult patients (SOE: Low). For pediatric patients, SOE was insufficient, as there was only one eligible study. When the data were analyzed using unadjusted results, results for an observational study enrolling pediatrics favored SGA (Appendix Figure I-7); no other changes in effect were detected across sensitivity analyses.

Table 8. SGA versus BVM: ROSC by emergency type and age group (BVM referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults	No difference (Low)	3 RCT[13-15,17]	1,657	0.94 (0.76 to 1.27), 0%
			9 OBS[19-23,28,29,33,34]	45,188	1.07 (0.82 to 1.40), 87.2%
	Pediatrics	No conclusion (Insufficient)	No RCT	-	-
			1 OBS[26]	996	1.19 (0.75 to 1.88), NA

BVM = bag valve mask; CI = confidence interval; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; RCT = randomized controlled trial; ROSC = return of spontaneous circulation; RR = risk ratio; SGA = supraglottic airway; SOE = strength of evidence

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. Overall, harms were similar between BVM and SGA groups across four studies (SOE: Moderate).[13,15,18,19] There was no difference between BVM and SGA when comparing oxygenation and ventilation on emergency department (ED) arrival in five studies (SOE: Moderate);[13,16,20,21,34] but one study[20] reported lower arterial pH in the BVM group. For successful airway placement, results were inconsistent between studies with insufficient evidence to support a conclusion. Finally, for length of stay, only one observational study reported data (SOE: Insufficient).[27]

Table 9. BVM versus SGA: additional outcomes

Outcome	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Findings
Length of Stay	No conclusion (Insufficient)	1 OBS[27]	50	Significant difference in hospital- (6 vs. 1) and ICU-free days favoring BVM (7 vs. 1), p<0.05
Successful Airway	No conclusion (Insufficient)	1 RCT[13]	76	No difference
		1 OBS[19]	517	Significantly fewer successful airways established in BVM vs. SGA (30% vs. 93%, p<0.01)
Oxygenation / Ventilation	No difference (Moderate)	2 RCT[13,16]	145	No difference
		3 OBS[20,21,34]	2,380	In 1 study,[20] significantly lower median arterial pH in BVM vs. SGA (7.08 mm Hg vs. 7.12 mm Hg, p=0.02)
Harms	No difference (Moderate)	2 RCT[13,15]	116	No differences between groups across all reported harms
		2 OBS[18,19]	580	In 1 study,[18] lower rates of aspiration pneumonitis within 72 hours for BVM vs. SGA (5% vs. 33%)

BVM = bag valve mask; ICU = intensive care unit; OBS = observational study; RCT = randomized controlled trial; SGA = supraglottic airway; SOE = strength of evidence

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 1 month (18 studies; N=52,770) was not significantly different for:
  - Adult/mixed-age cardiac arrest patients (SOE: Moderate)
  - Adult/mixed-age trauma patients (SOE: Low)
  - Pediatric cardiac arrest patients (SOE: Low)
- Neurological function at discharge or 1-month post incident was not significantly different (9 studies; N=78,576) for:
  - Adult cardiac arrest patients (SOE: Moderate)
  - Pediatric cardiac arrest patients (SOE: Low)
- ROSC rates were not significantly different (11 studies; N=48,802) for:
  - Adult cardiac arrest patients (SOE: Low)
  - Pediatric cardiac arrest patients (SOE: Low)
- Harms: no differences (5 studies; N=3,918; SOE: Moderate)

Summary of Results

We identified and analyzed 22 studies reported in 24 publications that compared patient outcomes for BVM and ETI (See Appendix C for the list of included studies). Two studies were reported in a single publication,[24] while results from three studies were reported in two publications each.[35,36 and 37,38 and 14,17] These studies included three RCTs,[14,17,37-39] one controlled clinical trial (CCT) which was included with the RCTs in the meta analyses,[35,36] three prospective cohorts,[18,21,22] and 15 retrospective cohorts.[23-26,28-33,40-43]

Seven of these studies were rated low ROB,[23,25,26,31,37-39,42] six moderate,[24,29,32,33,41] and three high.[30,40,43] Three were rated low ROB for survival and moderate for ROSC or neurological function outcomes.[21,28,35,36] One study was rated moderate ROB for short-term outcomes and high ROB for survival at 1 month).[22] (See Appendix G for ROB details).

The 22 studies included 106,325 patients and the individual studies ranged in size from 78[30] to 49,534 patients.[31] Most of the studies (15 of 22) included multiple emergency medical services (EMS) agencies or ambulance services.[14,17,18,21,23,24,26,28,31,32,35-40,43] However, less than half (10 studies) were conducted in the United States, or the United States and Canada;[14,17,18,24-26,35,36,40-43] nine were conducted in Asia (Japan, South Korea, Taiwan, Thailand);[22,23,28-33,43] two in Europe;[21,37,38] and one in Australia.[39]

Meta-Analysis

Meta analyses were conducted of studies that compared BVM to ETI for prehospital airway management for outcomes of survival, neurological function, and ROSC. Analyses were stratified by study design, age group and emergency type. For Key Question 2, sensitivity analyses did not change any conclusions. Therefore, only the primary analyses were summarized in this section.

Survival

Eighteen studies contained data on survival for Key Question 2 comparing BVM and ETI, including 4 RCTs[14,17,35-37,39] and 14 observational studies.[18,21-26,28,30,32,40-42]

Across age groups and emergency types, the findings showed no difference in survival in-hospital or at 1-month post incident when comparing BVM to ETI for prehospital airway management (Table 10; Appendix Figure H-4). For adult/mixed age cardiac arrest patients, we rated the SOE as moderate for this finding of no difference because the pooled estimates are based on several studies that included a large number of patients. The SOE was moderate rather than high because the findings were inconsistent across studies and the pooled estimates were not precise. We assessed the SOE as low for the conclusion of no difference for pediatric cardiac arrest patients and adult/mixed age trauma patients because each of these strata contained three studies with inconsistent results, and their pooled estimates were also imprecise. In both of these patient groups an RCT or CCT found no difference. The findings from the larger observational studies that favored BVM are likely affected by the fact that patients requiring ETI outside of controlled trials are less likely to survive. This suggests that future research could change the conclusion for these two groups.

For pediatric cardiac arrest patients, a moderate sized CCT (n=591)[35,36] and a small observational study of 136 patients found no difference,[18] while a larger observational study (n=1,508) found that survival was better with BVM.[26] In the case of adult trauma patients, an RCT with 299 patients reported no difference[39] while two observational studies involving 1,029 patients when combined favored BVM, reporting lower rates of survival with ETI.[41,42] As only one retrospective cohort study of pediatric trauma patients was identified that reported survival, and it was rated as high risk of bias,[40] the evidence was insufficient to support a conclusion.

Table 10. ETI versus BVM: survival by emergency type and age groups (BVM referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults/Mixed	No difference (Moderate)	2 RCT[14,17,37,38]	3,388	0.45 (0.07 to 2.89), 97.5%
			9 OBS[21-25,28,30,32]	45,241	0.84 (0.52 to 1.32), 85.4%
	Pediatrics	No difference (Low)	1 CCT[35,36]	591	0.96 (0.56 to 1.66), NA
			2 OBS[18,26]	1,644	0.44 (0.28 to 0.74), 0%
Trauma	Adults/Mixed	No difference (Low)	1 RCT[39]	299	1.00 (0.85 to 1.16), NA
			2 OBS[41,42]	1029	0.17 (0.12 to 0.32), 10.7%
	Pediatrics	No conclusion (Insufficient)	No RCT	-	-
			1 OBS[40]	578	1.01 (0.82 to 1.24), NA

BVM = bag valve mask; CCT = controlled clinical trial; CI = confidence interval; ETI = endotracheal intubation; NA = not applicable; OBS = observational study; RCT = randomized controlled trial; RR = risk ratio; SOE = strength of evidence

Neurological Function

Data on neurological function were available from nine studies, including one RCT,[37] one CCT,[35,36] and seven observational studies.[21-23,26,28,31,33] All of these studies involved cardiac arrest patients; none of the included studies of trauma patients included data on neurological function. The results for neurological function at discharge or 1-month post incident are presented in Table 11 and the forest plot in Appendix Figure H-5.

The overall conclusion was of no difference when BVM was compared to ETI. For adults the evidence consisted of 7 studies with 76,477 patients. The SOE was moderate, not high, despite the large number of patients, because the findings were inconsistent across studies. One RCT[37] and three observational studies[22,23,28] reported no difference, while three other observational studies found that function was better with BVM when compared to ETI.[21,31,33]

For pediatric cardiac arrest patients, we made a conservative conclusion based on the fact that the intention-to-treat analysis of a clinical trial found no difference,[35,36] while a single retrospective cohort study favored BVM,[26] therefore there was some inconsistency. The SOE for the conclusion of no difference was low as we expect future studies could change this conclusion.

Table 11. ETI versus BVM: neurological function by emergency types and age groups (BVM referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults	**No difference (Moderate)**	1 RCT[37,38]	2,040	0.97 (0.65 to 1.47), NA
			6 OBS[21-23,28,31,33]	74,437	0.65 (0.32 to 1.13), 84.1%
	Pediatrics	No difference (Low)	1 CCT[35,36]	591	1.45 (0.66 to 3.16), NA
			1 OBS[26]	1,508	0.33 (0.20 to 0.53), NA

BVM = bag valve mask; CCT = controlled clinical trial; CI = confidence interval; ETI = endotracheal intubation; NA = not applicable; OBS = observational study; RCT = randomized controlled trial; RR = risk ratio; SOE = strength of evidence
Bold Text = Moderate SOE

Return of Spontaneous Circulation

A total of 11 studies compared BVM and ETI in terms of ROSC for out-of-hospital cardiac arrest patients. The pooled results are summarized in Table 12 and the forest plot provided in Appendix Figure H-6. These studies include two RCTs[14,17,37] and nine observational studies.[21-23,25,26,28,29,33,43] One study consisted of pediatric patients[26] and the rest are of adults.

The studies comparing ROSC in adults include a RCT with low ROB conducted in France and Belgium.[37] It is important to note that the providers performing ETI in this study were physicians, which limits generalizability to EMS systems in which nonphysicians perform ETI. Furthermore, it is unclear what level of provider provided BVM. This RCT and three of the observational studies[22,23,28] favored ETI while one RCT[14,17] and the other observational studies found no significant difference in ROSC for BVM versus ETI. The SOE was low.

Table 12. ETI versus BVM: ROSC by emergency type and age groups (BVM referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults	No difference (Low)	2 RCT[14,17,37,38]	3,338	1.01 (0.72 to 1,38), 68.9%
			8 OBS[21-23,25,28,29,33,43]	43,906	1.18 (0.85 to 1.56), 86.4%
	Pediatrics	No difference (Low)	No RCT	-	-
			1 OBS[26]	1,508	1.10 (0.88 to 1.39), NA

BVM = bag valve mask; CI = confidence interval; ETI = endotracheal intubation; NA = not applicable; OBS = observational study; RCT = randomized controlled trial; ROSC = return of spontaneous circulation; RR = risk ratio; SOE = strength of evidence

Qualitative Synthesis: Additional Outcomes

Outcomes from studies comparing BVM to ETI that were not meta-analyzed included length of stay (2 studies[35,36,39]), successful airway insertion (2 studies[35-37]), and measures of adequate ventilation (2 studies[21,39]). Additionally, four studies[35-40] reported comparisons of several harms including the need for an additional airway, aspiration, oral trauma, vomiting/ regurgitation, and pneumothorax, as well as overall complications. Results are presented in Table 13. The SOE was low or insufficient for all of these additional outcomes except for harms. The four studies used different definitions of harms. Three of the four reported differences that were not statistically significant. The one significant finding was that regurgitation of gastric contents was 7.7 percentage points lower with ETI in one RCT.

Table 13. BVM versus ETI: additional outcomes

Outcome	Conclusion (SOE)	Number of Studies	Number of Patients	Summary of Findings
Length of Stay	No difference (Low)	1 RCT[39] 1 CCT[35,36]	1,142	• No significant difference in median total days in hospital in both studies • No significant different in time in ICU in both studies
Successful Airway	No conclusion (Insufficient)	1 RCT[37] 1 CCT[35,36]	2,873	Inconsistent findings from studies with different analytic approaches
Oxygenation / Ventilation	No difference (Low)	1 RCT[39]	160	• No statistical difference in SaO_2, pH, PaO_2, $PaCO_2$, at ED arrival or Initial $ETCO_2$
		1 OBS[21]	793	• No clinical difference in initial $ETCO_2$ or SpO_2 in propensity matched groups and no difference in SpO_2 in the total cohort

Harms	No difference (Moderate)	2 RCTs[37-39]
		1 CCT[35,36]
			3,062	• No difference in
				  ○ need for additional airway
				  ○ aspiration, oral/airway trauma or vomiting
				  ○ pneumothorax
				• ETI resulted in 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

		2 OBS[18,40]	714	• No difference in broadly defined complications • No different in blood in airway, swelling, or pharyngeal injury

BVM = bag valve mask; ETI = endotracheal intubation; ICU = intensive care unit; OBS = observational study; RCT = randomized controlled trial; SGA = supraglottic airway; SOE = strength of evidence

Studies that reported results for survival and neurological function that could not be included in the meta-analyses are summarized in Table 14. Five studies reported survival to hospital admission, which was not clinically similar enough to be combined with the other time points of survival to discharge or 1-month post injury in meta-analysis. However, the conclusion remains the same as all reported no difference in survival rates between BVM and ETI.[14,17,25,26,32,37] Three studies reported neurological function using three different measures (Glasgow Outcome Scale [GOS],[30] Functional Independence Measure [FIM],[40] and mRS).[14,17] The study results were not

pooled due to this difference in assessment method. Given the inconsistent results across studies, we assessed this evidence as insufficient to support a conclusion.

Table 14. BVM versus ETI: additional studies of survival and neurological function

Outcome	Conclusion (SOE)	Number of Studies	Number of Patients	Summary of Findings
Survival to Hospital Admission	No difference (Low)	2 RCT[14,17,37]	3,978	• No significant difference
		3 OBS[25,26,32]	3,162	• No significant difference
Neurological Function	No conclusion (Insufficient)	1 RCT[14,17]	1,348	Inconsistent finding from 3 studies using different measures of function (GOS, FIM, mRS)
		2 OBS[30,40]	211	

BVM = bag valve mask; ETI = endotracheal intubation; FIM = Functional Independence Measure; GOS = Glasgow Outcome Scale; OBS = observational study; mRS = modified Rankin Scale; RCT = randomized controlled trial; SOE = strength of evidence

Key Question 3: Supraglottic Airway Compared With Endotracheal Intubation

Key Results

When SGA was compared with ETI for prehospital airway management:

- Survival in-hospital or at 1-month post incident (20 studies; N=180,692) was not significantly different between SGA and ETI for:
  - Adult/mixed-age cardiac arrest patients (SOE: Low)
  - Pediatric cardiac arrest patients (SOE: Low)
- Neurological function, defined as good neurological outcomes at discharge or 1-month post incident (16 studies; N=203,246):
  - Favored ETI versus SGA for adult cardiac arrest patients when measured by the CPC (SOE: Low)
  - Was not significantly different between SGA and ETI for adult cardiac arrest patients when measured by the mRS (SOE: Low)
  - Was not significantly different between SGA and ETI for pediatric cardiac arrest patients when measured by the Pediatric Cerebral Performance Category (PCPC) (SOE: Low)
- Return of spontaneous circulation, defined as any ROSC (18 studies; N=186,642):
  - Favored SGA over ETI for adult cardiac arrest patients (SOE: Low)
  - Was not significantly different between SGA and ETI for Pediatric cardiac arrest patients (SOE: Low)
- First-pass success (9 studies; N=34,200):
  - Favored SGA versus ETI for adult cardiac arrest patients, pediatric cardiac arrest patients, and adult patients with mixed emergency types (SOE: Low)
  - Was not significantly different between SGA and ETI for adult medical emergency patients (SOE: Low)
- Overall success (14 studies; N=71,660) was not significantly different between SGA and ETI for:
  - Adult cardiac arrest patients (SOE: Moderate)
  - Adult medical emergency patients (SOE: Moderate)
  - Adult patients with mixed emergency types (SOE: Moderate)

- Harms (7 studies; N=13,687)
    - No difference between SGA and ETI for aspiration (2 studies; SOE: Moderate)
    - No difference between SGA and ETI for oral/airway trauma (2 studies; SOE: Moderate)
    - No difference between SGA and ETI for regurgitation (single RCT; SOE: Moderate)
    - Favored SGA for multiple insertion attempts (single RCT; SOE: Moderate)
    - Favored ETI for inadequate ventilation (single RCT; SOE: Moderate)

Summary of Results

We identified and analyzed 41 studies that compared patient outcomes for SGA and ETI (N=383,953). One publication[24] included two studies and two publications[14,17] were reported as one study because the latter was a secondary analysis (See Appendix C for the list of included studies). These included 4 RCTs,[14,17,44-46] 2 CCTs,[47,48] 9 prospective cohorts,[18,21,22,49-54] 25 retrospective cohorts,[23-26,28-33,55-68] and 1 before-after study.[69]

Ten of these studies were rated low ROB,[23,25,26,31,44,46,54,64,68,69] fifteen moderate,[18,24,29,32,33,45,48,50,51,53,57,59,60,62,63] and eight high.[30,47,49,55,56,58,61,67] One study was rated low for one outcome and moderate for two other outcomes;[28] one study was rated moderate for one outcome and high for one outcome;[22] two studies were rated low for one outcome and moderate for one outcome;[17,21] two studies were rated low for two outcomes and moderate for one,[65,66] and one study was rated low for one outcome and high for one outcome (Appendix G).[52]

Sample sizes in the included studies ranged from 78 to 138,248 participants; 21 studies were conducted in the United States and Canada,[17,18,24-26,45,47-49,51,54-57,61-63,67-69] 11 in Asia,[22,23,28-33,52,64,66] 8 in Europe,[21,44,46,50,58-60,65] and 1 in Australia.[53]

Meta-Analysis

Meta-analysis was performed for six outcomes: survival in-hospital or at 1-month post incident; neurological function using modified Rankin Scale; neurological function using CPC or Pediatric Cerebral Performance Category (PCPC); ROSC; first-pass success; and overall success. Thirty-seven studies were included in meta-analysis for one or more of these outcomes. The results for each outcome by subgroup are reported in Tables 15 to 20, and forest plots are provided in Appendix Figures H-7 to H-11.

Survival

Twenty studies contained data on survival in-hospital or at 1-month post incident for Key Question 3 comparing SGA and ETI, including three RCTs[14,17,44,46] and 17 observational studies[18,21-26,28,30,32,52,57,62,64-66] (Table 15). Of the 20 studies, 19 included patients with cardiac arrest, and 1[57] included trauma patients.

For studies of adult/mixed-age cardiac arrest patients, pooled analysis of 3 RCTs found no difference in survival between airway interventions, while ETI was associated with higher rates of survival in 13 observational studies. Sensitivity analyses resulted in similar findings (Appendix Figures I-8 to I-9). Of the 13 observational studies, four favored ETI, including one very large retrospective cohort study (n=138,248 analyzed for this outcome) conducted in Japan;[64] the other nine found no difference in survival. Seven of the 13 studies were conducted in Asia, where ETI is used less frequently than SGA in the prehospital setting, potentially introducing bias from provider skills or preference of airway. The overall conclusion was that

there is no difference between SGA and ETI on survival in adult/mixed-age cardiac patients (SOE: Low).

In three observational studies of pediatric patients (SOE: Low).[18,26,66] There was no difference in survival for SGA compared with ETI.

Table 15. ETI versus SGA: survival by emergency type and age group (SGA referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults/Mixed	No difference (Low)	3 RCT[14,17,44,46]	12,465	0.89 (0.55 to 1.24), 54.4%
			13 OBS[21-25,28,30,32,52,62,64,65]	164,623	1.24 (1.12 to 1.45), 40.0%
	Pediatrics	No difference (Low)	No RCT	-	-
			3 OBS[18,26,66]	1,260	0.76 (0.48 to 1.23), 0%
Trauma	Adults/Mixed	No conclusion (Insufficient)	No RCT	-	-
			1 OBS[57]	2,344	3.35 (2.40 to 4.68), NA
	Pediatrics	-	-	-	-

CI = confidence interval; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; RCT = randomized controlled trial; RR = risk ratio; SGA = supraglottic airway; SOE = strength of evidence

Neurological Function

Sixteen studies (2 RCTs and 14 observational) contained data for pooled analysis of neurological function measured at discharge or 1-month post incident. Outcomes assessed by the mRS were analyzed separately from those assessed using the CPC or PCPC (mRS in Table 16, CPC/PCPC in Table 17). All studies were in cardiac arrest patients.

Modified Rankin Scale

Three studies (2 RCTs[17,44] and 1 observational[68]) assessed neurological function using the mRS (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. We 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 Figures I-8 to I-9),[44] rendering the findings from that study susceptible to indication bias. The overall conclusion was that there is likely no difference in neurological function between SGA and ETI, with low SOE due to inconsistency in findings between studies, and inconsistency in one RCT between primary and sensitivity analyses results.

Table 16. ETI versus SGA: neurological function – modified Rankin Scale by emergency type and age group (SGA referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults	No difference (Low)	2 RCT[17,44]	12,293	0.90 (0.52 to 1.47), 68.6%
			1 OBS[68]	10,455	1.38 (1.04 to 1.83), NA
	Pediatrics	-	-	-	-

CI = confidence interval; CCT = controlled clinical trial; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; RCT = randomized controlled trial; RR = risk ratio; SGA = supraglottic airway; SOE = strength of evidence

Cerebral Performance Category/Pediatric Cerebral Performance Category

Thirteen studies assessed neurological function using the CPC or PCPC (good outcome = CPC or PCPC score 1-2).[21-23,26,28,31,33,52,59,62,64-66] All studies were observational. Pooled results slightly favored ETI over SGA in adults. However, of the 11 adult studies, only 2 favored ETI, and the remaining 9 showed no difference. There was no difference in pediatric patients (SOE: Low) (Table 17).

Table 17. ETI versus SGA: neurological function—Cerebral Performance Category/Pediatric Cerebral Performance Category by emergency type and age group (SGA referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults CPC	Favors ETI (Low)	No RCT	-	-
			11 OBS[21-23,28,31,33,52,59,62,64,65]	182,543	1.15 (1.02 to 1.28), 0%
	Pediatrics PCPC	No difference (Low)	No RCT	-	-
			2 OBS[26,66]	1,168	0.82 (0.37 to 2.75), 0%

CI = confidence interval; CCT = controlled clinical trial; CPC = Cerebral Performance Category; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; PCPC = Pediatric Cerebral Performance Category; RCT = randomized controlled trial; RR = risk ratio; SGA = supraglottic airway; SOE = strength of evidence

Return of Spontaneous Circulation

Eighteen studies provided data for pooled analysis of ROSC (Table 18). In adults, pooled estimates from combining three RCTs favored SGA. Pooling of 13 observational studies found ETI associated with higher rates of ROSC. The overall conclusion was that SGA was associated with higher rates of ROSC in adults, based on pooled results from the RCTs, with low SOE due to inconsistency in findings between RCTs and observational studies. There was no difference found in pediatric studies (SOE: Low).

Table 18. ETI versus SGA: ROSC by age group (SGA referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults	Favors SGA (Low)	3 RCT[17,44,46]	12,460	0.91 (0.83 to 0.97), 0%
			13 OBS[21-23,28,29,33,51,52,55,62,64,65,68]	173,014	1.41 (1.29 to 1.53), 66.7%
	Pediatrics	No difference (Low)	No RCT	-	-
			2 OBS[26,66]	1,168	0.81 (0.56 to 1.70), 0%

CI = confidence interval; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; RCT = randomized controlled trial; ROSC = return of spontaneous circulation; RR = risk ratio; SGA = supraglottic airway; SOE = strength of evidence

Successful Insertion of Advanced Airway

Nine studies provided data for pooled analysis of first-pass success (Table 19). In adults with cardiac arrest, results favored SGA over ETI in the single RCT[17] and the four pooled observational studies[49,51,61,69] (SOE: Low). In pediatric patients with cardiac arrest, results from two observational studies[18,61] favored SGA (SOE: Low). In adults with medical emergencies, results of a single RCT[45] indicated no difference, and results of one observational study[61] favored SGA (SOE: Low). In adults with mixed emergency types, results of two observational studies[53,63] favored SGA (SOE: Low).

Table 19. ETI versus SGA: first-pass successful advanced airway insertion by emergency type and age group (SGA referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults	Favors SGA (Low)	1 RCT[17]	3,004	0.57 (0.54 to 0.60), NA
			4 OBS[49,51,61,69]	20,531	0.80 (0.78 to 0.86), 0%
	Pediatrics	Favors SGA (Low)	No RCT	-	-
			2 OBS[18,61]	445	0.67 (0.56 to 0.78), 0%
Trauma	Adults	No conclusion (Insufficient)	No RCT	-	-
			1 OBS[61]	2,143	0.79 (0.75 to 0.83), NA
	Pediatrics	No conclusion (Insufficient)	No RCT	-	-
			1 OBS[61]	69	0.67 (0.48 to 0.94), NA
Medical	Adults	No difference (Low)	1 RCT[45]	204	0.99 (0.81 to 1.20), NA
			1 OBS[61]	7,297	0.88 (0.85 to 0.91), NA
	Pediatrics	No conclusion (Insufficient)	1 OBS[61]	100	0.76 (0.42 to 1.38), NA
Mixed Emergency Types	Adults	Favors SGA (Low)	No RCT	-	-
			2 OBS[53,63]	407	0.57 (0.47 to 0.79), 0%
	Pediatrics	-	-	-	-

CI = confidence interval; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; RCT = randomized controlled trial; RR = risk ratio; SGA = supraglottic airway; SOE = strength of evidence

Fourteen studies were pooled for analysis of overall success rates for insertion of advanced airway (Table 20).[14,17,44-46,48-51,53,54,56,58,67,69] When ETI and SGA were compared, there were no differences in overall success rates for any subgroups (SOE: Moderate).

Table 20. ETI versus SGA: overall successful advanced airway insertion by emergency type and age group (SGA referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults	No difference (Moderate)	3 RCT[14,17,44,46]	11,720	0.94 (0.89 to 1.00), 77.9%
			6 OBS[49-51,58,67,69]	36,983	0.94 (0.85 to 1.04), 90.0%
	Pediatrics	-	-	-	-
Trauma	Adults	No conclusion (Insufficient)	No RCT	-	-
			1 OBS[67]	3,842	0.93 (0.88 to 0.98), NA
	Pediatrics	-	-	-	-

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Medical	Adults	No difference (Moderate)	1 RCT[45]	204	1.00 (0.87 to 1.15), NA
			2 OBS[48,67]	15,644	0.90 (0.86 to 1.08), 0%
	Pediatrics	-	-	-	-
Mixed Emergency Types	Adults	No difference (Moderate)	No RCT	-	-
			3 OBS[53,54,56]	3,267	1.02 (0.99 to 1.06), 0%
	Pediatrics	-	-	-	-

CI = confidence interval; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; RCT = randomized controlled trial; RR = risk ratio; SGA = supraglottic airway; SOE = strength of evidence

Qualitative Synthesis: Additional Outcomes

Included studies reported on other 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 intensive care unit [ICU] admission);[14,25,26,32,44,46,49,55,62,65,68] neurological function measured by the GOS;[30] various measures of oxygenation or ventilation efficacy;[21,47,55,59] and harms, including aspiration, regurgitation, failure of airway insertion (requiring multiple attempts), inadequate ventilation, oral/airway trauma, dislodgment or unrecognized misplacement, and other complications.[17,18,44,49,54,63,69] No studies provided results for length of stay (hospital or ICU), or morbidity (pneumothorax or aspiration pneumonia).

No difference between SGA and ETI was found for 72-hour survival; survival to ED, hospital, or ICU admission; and oxygenation/ventilation. For harms, no difference between SGA and ETI was found for aspiration, oral/airway trauma, and regurgitation (SOE: Moderate). With regard to the need for multiple insertion attempts, SGA was favored over ETI; for inadequate ventilation, ETI was favored over SGA (for both, SOE: Moderate). While these findings were based on a single study, it was an RCT with low ROB.[17]

Table 21. SGA versus ETI: additional outcomes

Outcome	Conclusion (SOE)	Number of Studies	Number of Patients	Summary of Findings
Survival 24-hour	No conclusion (Insufficient)	3 OBS[55,65,68]	29,777	Inconsistent findings
Survival 72-hour	No difference (Moderate)	2 RCT[14,17,44]	12,300	For one study, difference favoring SGA in ITT and per-protocol analyses, but no difference in as-treated or adjusted analyses. Second study no difference.
Survival To ED, Hospital, or ICU Admission	No difference (Low)	2 RCT[14,17,46]	3,176	No difference
		5 OBS[25,26,32,49,62]	17,506	Inconsistent findings
Neurological Function GOS	No conclusion (Insufficient)	1 OBS[30]	78	-
Oxygenation/ Ventilation	No difference (Low)	4 OBS[21,47,55,59]	2,665	No difference ABG (1 study); Sp02 (1 study); ETC02 (3 studies)
Harms: Aspiration	No difference (Moderate)	1 RCT[44]	9,296	No difference
		1 OBS[63]	256	No difference

Outcome	Conclusion (SOE)	Number of Studies	Number of Patients	Summary of Findings
Harms: Oral/Airway Trauma	No difference (Moderate)	1 RCT[17]	3,004	No difference
		1 OBS[18]	155	No difference
Harms: Multiple (≥3) Insertions	Favors SGA (Moderate)	1 RCT[17]	3,004	Single study with low ROB ETI 1.3%, SGA 0.4% Difference -0.9; (95% CI -1.7 to -0.2) p=0.01
Harms: Inadequate Ventilation	Favors ETI (Moderate)	1 RCT[17]	3,004	Single study with low ROB ETI 0.6%, SGA 1.8% Difference 1.2 (95% CI 0.3 to 2.1) p=0.01
Harms: Regurgitation	No difference (Moderate)	1 RCT[44]	9,296	Single study with low ROB
Harms: Dislodged/Misplaced Intubation Any Complication Fatal Complication Need for Additional Airway Blood in Airway	No conclusion (Insufficient)	2 RCT[17,44]	12,300	Inconsistent findings
		4 OBS[18,49,54,69]	1131	Inconsistent findings; single OBS studies

ABG = arterial blood gas; CI = confidence interval; ED = emergency department; ETI = endotracheal intubation; GOS = Glasgow Outcome Scale; ICU = intensive care unit; ITT = intent to treat; NA = not applicable; OBS = observational study; RCT = randomized controlled trial; ROB = risk of bias; RR = risk ratio; SGA = supraglottic airway; SOE = strength of evidence

Key Question 4: Modifiers Within Airway Approaches

Key Results

Key Results: Endotracheal Intubation

In studies reporting on modifiers of ETI for prehospital airway management:

- ETI: Technique/device modifiers
    - ETI with drug-facilitation versus without: rapid sequence intubation (RSI) versus no medication
        - Survival to hospital discharge (6 studies; N=3,947) was not significantly different for:
            - Adult/mixed-age with trauma (Low SOE)
        - First-pass success (8 studies; N=33,887):
            - Favored RSI for adult/mixed-age with mixed emergency types (Low SOE)
            - Was not significantly different for adult/mixed-age with trauma (Low SOE)
        - Overall success rate (6 studies; N=56,046):
            - Favored RSI for adults with trauma (Low SOE)
            - Was not significantly different for:
                - Adult cardiac arrest patients (Low SOE)
                - Adults/mixed-age with mixed emergency types (Low SOE)
        - Harms
            - Occurred more often in the no medication group: recognized esophageal intubation and unrecognized mainstem intubation

            - No difference or inconsistent findings for other reported harms
    - ETI with drug-facilitation versus without: RSI versus sedation-facilitated
        - First-pass success (3 studies; N=5,842) favored RSI for:
            - Adults/mixed-age with mixed emergency types (Low SOE)
        - Harms
            - No cases of esophageal intubation or aspiration observed
    - ETI with drug-facilitation versus without: sedation-facilitated versus no medication
        - First-pass success (3 studies; N=19,262) was not significantly different for:
            - Adults/mixed-age with mixed emergency types (Low SOE)
    - Video versus direct laryngoscopy
        - First-pass success rate (12 studies; N=7,280) was not significantly different for:
            - Adult cardiac arrest patients (Low SOE)
            - Adult/mixed-age with mixed emergency types (Moderate SOE)
        - Overall success rate (11 studies; N=3,060) was not significantly different for:
            - Adult cardiac arrest patients (Moderate SOE)
            - Adult/mixed-age with mixed emergency types (Low SOE)
        - Harms
            - Problem with advancing the endotracheal tube reported more often with video laryngoscopy
            - No difference for all other reported harms
    - Laryngoscope blade material
        - Favored metal blades for:
            - First-pass success: disposable plastic versus reusable or disposable metal
        - No difference for:
            - First-pass success: reusable versus single-use metal blades
            - All reported harms
    - Gum elastic bougie
        - First-pass success and Definitive Airway Sans Hypoxia/Hypotension on First Attempt (DASH-1A): favored use of bougie
        - No difference for overall success
- ETI: Patient characteristics modifiers
    - Emergency type
        - First-pass success rate (9 studies; N=38,211)
            - Favored medical for:
                - Trauma versus medical: adult/mixed-age (Low SOE)
            - No significant differences for:
                - Nonarrest versus cardiac arrest: adult/mixed-age (Low SOE)
        - Overall success rate (9 studies; N=60,307) was not significantly different for:

                - Medical versus cardiac arrest: adult/mixed-age (Low SOE)
                - Trauma versus cardiac arrest: adult/mixed-age (Low SOE)
                - Nonarrest versus cardiac arrest: adult/mixed-age (Low SOE)
                - Trauma versus medical: adult/mixed-age (Low SOE)
        - Age: age within pediatrics
            - Poorer outcomes for infants versus toddlers or school-age children: survival, neurological function, first-pass success
            - Better outcome for infants, versus toddlers or school-age children: aspiration pneumonia
            - No differences for:
                - Overall success across pediatric age groups
                - Toddlers versus school-age children for any outcome
            - Harms
                - No differences across age groups within pediatrics for any reported harms
        - Age: pediatric versus adult
            - Favored adult for: overall success
            - Was not different for: survival, DASH-1A
        - Age: elderly versus adult
            - Was not different for: neurological function
        - Sex: female versus male
            - Favored female for: survival, ROSC
            - Was not different for: overall success, DASH-1A
        - Race: white versus nonwhite
            - Poorer outcomes for nonwhite participants: ROSC, DASH-1A

Key Results: Supraglottic Airway

In studies reporting on modifiers of SGA for prehospital airway management:

- SGA: Technique/device modifiers
    - Perilaryngeal seal SGAs (i-gel vs. laryngeal mask airway [LMA]):
        - Favored i-gel for: overall success
        - Was not different for: survival, ROSC, first-pass success
    - Pharyngeal versus perilaryngeal seal SGAs (laryngeal tube [LT], esophageal obturator, Combitube, or pharyngeotracheal lumen airway [PTLA] versus LMA)
        - Was not different for: survival, neurological function, ventilation, arterial blood gases
        - Harms
            - Occurred more often with pharyngeal seal SGAs: inadequate ventilation, dislodgement, and total complications
            - No difference for: tongue/pharyngeal swelling, bleeding, air leak, and incorrect placement
    - Pharyngeal seal SGAs (Combitube versus PTLA):
        - No difference: success, arterial blood gases
        - Harms
            - No difference for: inadequate ventilation
- SGA: Patient characteristics modifier

- Age: pediatric versus adult
  - Was not different for: first-pass success and overall success

There were 45 studies that compared outcomes across potential modifiers of ETI; 28 reported on outcomes which are analyzed qualitatively while 32 studies were pooled for one or more outcomes in meta-analysis. We identified eight studies reporting on potential modifiers of SGA, which were qualitatively analyzed. No studies about modifiers of BVM met inclusion criteria.

Results for Key Question 4 are organized first by airway intervention (ETI, SGA), then by modifier category (technique/device, patient characteristics). Results from meta-analyses and qualitative analyses are included, where applicable. Strength of evidence was not assessed for outcomes only analyzed qualitatively.

Endotracheal Intubation

Endotracheal Intubation: Technique/Device

There were four sets of comparisons for technique/device modifiers of ETI: ETI with drug-facilitation versus without; video versus direct laryngoscopy; laryngoscope blade material; and gum elastic bougie use.

There was enough data for pooled analysis of two sets of these comparisons: ETI with drug-facilitation versus without, and video versus direct laryngoscopy. Additional outcomes for these comparisons were analyzed qualitatively. We also qualitatively analyzed outcomes for comparisons of laryngoscope blade material and gum elastic bougie use.

Technique/Device: Endotracheal Intubation With Drug Facilitation Versus Without

To assess outcomes from variations in drug facilitation for ETI, we categorized interventions as RSI, sedation-facilitated, or no medication, resulting in three comparisons: RSI versus no medication; RSI versus sedation-facilitated; and sedation-facilitated versus no medication.

For first-pass success, meta-analysis was performed for all three comparisons. For survival and overall success outcomes, sufficient data for pooled analysis was only available for RSI versus no medication. For the other two comparisons, these outcomes are analyzed and summarized qualitatively. For all comparisons, additional outcomes and harms are also analyzed qualitatively.

Rapid Sequence Intubation Versus No Medication

We identified and analyzed 17 studies (16 observational studies and one CCT; N=165,621) comparing RSI and ETI with no medication.[61,67,70-84] Fourteen observational studies (N=144,206) provided data for pooled analysis of one or more outcomes.[61,67,70,72-75,77-80,82-84]

There were six studies (N=3,947) included for pooled analysis of survival to hospital discharge (Table 22, Appendix Figure H-12)**.** Study populations were all adults or mixed-age; there were no studies in children. For patients with trauma in adult/mixed-age group, there was no difference in survival (SOE: Low).[70,72,73,83] No changes in effects were detected in sensitivity analyses. For adults with cardiac arrest[77] and adults with medical emergencies,[75] SOE was insufficient, as there was only one observational study for each subgroup.

Table 22. Survival for RSI versus no medication as modifier of ETI by subgroup (no medication referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults	No conclusion (Insufficient)	1 OBS[77]	3,047	3.69 (3.17 to 4.28), NA
Trauma	Adults/mixed-age	No difference (Low)	4 OBS[70,72,73,83]	2,520	1.41 (0.83 to 2.46), 95.5%
Medical	Adults	No conclusion (Insufficient)	1 OBS[75]	1,454	0.89 (0.82 to 0.97), NA

CI = confidence interval; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; RR = risk ratio; RSI = rapid sequence intubation; SOE = strength of evidence

We included eight studies (N=33,887) for pooled analysis of first-pass success (Table 23, Appendix Figure H-13).[61,74,77,79,80,82-84] Higher rates of first-pass success were observed with RSI in adults/mixed-age with mixed emergency types (SOE: Low).[61,74,80,82,84] When high ROB studies were excluded from analysis, there was no difference for RSI compared to no medication, based on two remaining studies (Appendix Figure I-9).[80,82] There was no difference among adults/mixed-age with trauma emergencies (SOE: Low).[79,83] For adults with cardiac arrest[77] and pediatrics with mixed emergency types,[61] SOE was insufficient, as there was only one observational study for each subgroup.

Table 23. First-pass success for RSI versus no medication as modifier of ETI by subgroup (no medication referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults	No conclusion (Insufficient)	1 OBS[77]	2,776	0.89 (0.82 to 0.96), NA
Trauma	Adults/mixed-age	No difference (Low)	2 OBS[79,83]	530	1.00 (0.88 to 1.14), 11.9%
Mixed Emergency Types	Adults/mixed-age	Favors RSI (Low)	5 OBS[61,74,80,82,84]	30,126	1.13 (1.09 to 1.17), 62.2%
	Pediatrics	No conclusion (Insufficient)	1 OBS[61]	455	1.37 (1.16 to 1.63), NA

CI = confidence interval; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; RR = risk ratio; RSI = rapid sequence intubation; SOE = strength of evidence

Six studies (N=56,046) were included for pooled analysis of overall success (Table 24, Appendix Figure H-13).[67,70,77,78,80,84] All of the studies were in adults or mixed age group; none provided data separately for pediatric patients.

For adults with trauma emergencies, the two studies individually found higher overall success rates with RSI although the pooled results showed no difference. This is because the two studies differed in magnitude and precision of effect estimates, resulting in a wide confidence interval for the pooled result. The pooled confidence interval reflects study heterogeneity; thus our conclusion is that the comparison favors RSI (SOE: Low). Overall success rates were not different with RSI compared to no medication for three other subgroups: adults with cardiac arrest;[67,77] adults with trauma;[67,70] and adults/mixed age with mixed emergency types[78,80,84] (for all, SOE: Low). For adults with medical emergencies, SOE was insufficient, as there was only one observational study.[67]

Table 24. Overall success for RSI versus no medication as modifier of ETI by subgroup (no medication referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults	No difference (Low)	2 OBS[67,77]	30,496	1.04 (0.94 to 1.14), 97.2%
Trauma	Adults	Favors RSI[a] (Low)	2 OBS[67,70]	3,769	2.16 (0.59 to 8.40), 96.7%
Medical	Adults	No conclusion (Insufficient)	1 OBS[67]	13,566	1.27 (1.25 to 1.29), NA
Mixed Emergency Types	Adults/mixed-age	No difference (Low)	3 OBS[78,80,84]	8,215	1.10 (0.87 to 1.36), 96.2%

CI = confidence interval; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; RR = risk ratio; RSI = rapid sequence intubation; SOE = strength of evidence

[a] Pooled result shows no difference with wide CI due to study heterogeneity for effect estimates. Both studies favored RSI and our conclusion is that the comparison favors RSI.

Results from qualitative analysis of additional outcomes are summarized in Table 25**.** Length of stay in the ICU was reported in two studies. One study found that for survivors, the ICU stay was longer for the RSI group.[70] However, the other study did not detect any difference for either ICU or hospital length of stay.[75] All other outcomes were evaluated in only one study.

Table 25. Additional outcomes for RSI versus no medication as modifier of ETI

Outcome	Study Number and Design	Number of Patients	Summary of Findings
DASH-1A	1 OBS[79]	257	Higher rates with RSI; OR 2.93 (95% CI 0.88 to 9.77), p=0.08
Neurological Function	1 OBS[81]	21	GOS scale of 4 or 5 at hospital discharge: • No difference
ICU Length of Stay	2 OBS[70,75]	38,550	Inconsistent • Longer with RSI; mean days, AOR 1.58 (95% CI 1.30 to 1.92), p<0.0001[70] • No difference, median days[75]
Hospital Length of Stay	1 OBS[75]	38,352	No difference in mean length of stay
Oxygenation/ Ventilation	1 OBS[75]	38,352	Larger increase in SpO2 in RSI group • SpO_2 difference, final prehospital minus initial: 4.9 vs. 3.6; difference −1.3 (95% CI -2.5 to -0.06), p=0.04

AOR = adjusted odds ratio; CI = confidence interval; DASH-1A = Definitive Airway Sans Hypoxia/Hypotension on First Attempt; ETI = endotracheal intubation; GOS = Glasgow Outcome Scale; ICU = intensive care unit; OR = odds ratio; OBS = observational study; RSI = rapid sequence intubation

Two studies provided data on comparative harms. Results for each harm are summarized by individual study (Table 26). The no medication group had higher rates of recognized esophageal intubation and unrecognized mainstem intubation. Hypotension was reported in two studies; one[72] found higher rates with no medication while the other study[70] found no difference. There was no difference for RSI versus no medication for recognized mainstem intubation, hypoxia, or oral trauma. No cases of unrecognized esophageal intubation, tracheal perforation, or barotrauma were observed in either group.

Table 26. Harms for RSI versus no medication as modifier of ETI

Harm Description	Study Design	Number of Patients	Proportion Experienced Harm: RSI	Proportion Experienced Harm: No Medication	Summary of Findings
Esophageal Intubation	OBS[83]	283	0% (0/140)	0% (0/143)	Unrecognized: none observed in either group
			4% (5/140)	20% (28/143)	Recognized: occurred more often in no medication group
Mainstem Intubation	OBS[83]	283	0% (0/140)	8% (11/143)	Unrecognized: occurred more often in no medication group
			1% (1/140)	1% (2/143)	Recognized: no difference
Hypotension[a]	OBS[70]	272	15.4% (27/175)	11.7% (10/85)	No difference; prehospital
			11.7% (20/171)	9.0% (8/89)	No difference; on ED arrival
	OBS[72]	1,077	23% (117/774)	37% (76/303)	Occurred more often in no medication group, p<0.001
Hypoxia[b]	OBS[70]	283	14.6% (28/192)	17.5% (16/91)	No difference; prehospital
			11.2% (21/187)	8.2% (7/85)	No difference; on ED arrival
Oral Trauma	OBS[83]	283	0% (0/140)	1% (2/143)	No difference
Tracheal Perforation	OBS[83]	283	0% (0/140)	0% (0/143)	None observed in either group
Barotrauma	OBS[83]	283	0% (0/140)	0% (0/143)	None observed in either group

ED = emergency department; ETI = endotracheal intubation; OBS = observational study; RSI = rapid sequence intubation
[a] Hypotension = SBP <90 mmHg
[b] Hypoxia = SaO_2 <90%

Rapid Sequence Intubation Versus Sedation-Facilitated

Five studies (4 observational and 1 CCT; N=31,778) were included for the comparison of RSI and ETI with sedation facilitation.[61,71,74,81,84]

Three observational studies (N=5,842) provided data for pooled analysis of first-pass success (Table 27, Appendix Figure H-14).[61,74,84] For adult/mixed age patients with mixed emergency types, there were higher rates of first-pass success with RSI (SOE: Low).[61,74,84] SOE was insufficient for children with mixed emergency types, as there was only one observational study.[61]

Table 27. First-pass success for RSI versus sedation-facilitated as modifier of ETI by subgroup (sedation-facilitated referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Mixed Emergency Types	Adults/mixed-age	Favors RSI (Low)	3 OBS[61,74,84]	5,778	1.11 (1.05 to 1.18), 0.0%
	Pediatrics	No conclusion (Insufficient)	1 OBS[61]	64	1.45 (0.88 to 2.39), NA

CI = confidence interval; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; RSI = rapid sequence intubation; SOE = strength of evidence

Additional outcomes and harms were qualitatively analyzed and are summarized in Tables 28 and 29, respectively. Overall success rates were higher with RSI compared to sedation-facilitated ETI.[71,84] There was no statistically significant difference between groups for neurological function at hospital discharge.[81] There was limited reporting of harms in the included studies, with only one study providing comparative data.[71] In that study, no cases of esophageal intubation or aspiration were observed in either group.

Table 28. Additional outcomes for RSI versus sedation-facilitated as modifier of ETI

Outcome	Study Number and Design	Number of Patients	Summary of Findings
Overall Success	1 CCT[71], 1 OBS[84]	255	Higher rates with RSI • 96% vs. 71%, p<0.03[71] • 96.3% vs. 77.0%, p<0.01[84]
Neurological Function	1 OBS[81]	68	GOS scale of 4 or 5 at hospital discharge: • No difference

CCT = controlled clinical trial; ETI = endotracheal intubation; GOS = Glasgow Outcome Scale; OBS = observational study; RSI = rapid sequence intubation

Table 29. Harms for RSI versus sedation-facilitated as modifier of ETI

Harm Description	Study Design	Number of Patients	Proportion Experienced Harm: RSI	Proportion Experienced Harm: Sedation-Facilitated	Summary of Findings
Esophageal Intubation	CCT[71]	49	0% (0/25)	0% (0/24)	No cases observed for either group; not specified if recognized or unrecognized
Aspiration	CCT[71]	49	0% (0/25)	0% (0/24)	No cases observed for either group

CCT = controlled clinical trial; ETI = endotracheal intubation; RSI = rapid sequence intubation

Sedation-Facilitated Versus No Medication

Four observational studies (N=19,325) were included for comparison of ETI with sedation facilitation versus ETI with no medication.[61,74,81,84]

Three studies (N=19,262) provided data for pooled analysis of first-pass success (Table 30, Appendix Figure H-15).[61,74,84] There was no difference for adults/mixed-age with mixed emergency types (SOE: Low).[61,74,84] For children with mixed emergency types, SOE was insufficient, as there was only one observational study.[61]

Additional outcomes were qualitatively analyzed and are summarized in Table 31. There were better outcomes with sedation-facilitated ETI for neurological function.[81] Overall success rates were similar between groups.[84]

None of the included studies reported on comparative harms outcomes for sedation-facilitated ETI versus ETI without medication.

Table 30. First-pass success for sedation-facilitated versus no medication as modifier of ETI by subgroup (no medication referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Mixed Emergency Types	Adults/mixed-age	No difference (Low)	3 OBS[61,74,84]	18,841	1.02 (0.77 to 1.27), 0.0%
	Pediatrics	No conclusion (Insufficient)	1 OBS[61]	421	0.95 (0.58 to 1.53), NA

CI = confidence interval; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; RR = risk ratio; SOE = strength of evidence

Table 31. Additional outcomes for sedation-facilitated versus no medication as modifier of ETI

Outcome	Study Number and Design	Number of Patients	Summary of Findings
Overall Success	1 OBS[84]	589	No difference
Neurological Function	1 OBS[81]	63	GOS scale of 4 or 5 at hospital discharge: • Higher proportion with sedation-facilitated; 62% vs. 13%, p=0.0176

ETI = endotracheal intubation; GOS = Glasgow Outcome Scale; OBS = observational study

Technique/Device: Video Versus Direct Laryngoscopy

We identified and analyzed 15 studies (6 RCTs, 9 observational; N=8,968) that compared outcomes of first-pass success and overall success for video and direct laryngoscopy.[51,74,79,85-96] Fourteen studies enrolled adults only, and one study[90] included patients of all ages (mixed-age).

Twelve studies were pooled to obtain estimates for first-pass success (Table 32, Appendix Figure H-16).[51,74,79,85-93] There was no difference in rates of first-pass success for video versus direct laryngoscopy in RCTs and observational studies of adult patients with cardiac arrest (SOE: Low).[51,85,87,88,93] There was also no difference for video versus direct laryngoscopy in RCTs and observational studies of adults or mixed-age with mixed emergency types (SOE: Moderate).[86,88-92] SOE was insufficient for adults with medical emergencies and adults with trauma emergencies. No changes in effects were detected in sensitivity analyses.

Table 32. First-pass success for video versus direct laryngoscopy as modifier of ETI by subgroup (direct laryngoscopy referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults	No difference (Low)	2 RCT[85,87]	191	0.76 (0.46 to 1.26), 69.8%
			3 OBS[51,88,93]	714	1.19 (0.74 to 1.87), 87.6%
Trauma	Adults	No conclusion (Insufficient)	No RCT	-	-
			2 OBS[74,79]	310	1.01 (0.30 to 1.93), 74.9%
Medical	Adults	No conclusion (Insufficient)	No RCT	-	-
			1 OBS[74]	249	1.18 (1.02 to 1.36), NA
Mixed Emergency	Adults/mixed-age	No difference (Moderate)	2 RCT[89,91]	666	1.06 (0.81 to 1.41), 88.7%
			4 OBS[86,88,90,92]	5,150	1.22 (0.96 to 1.63), 85.8%

CI = confidence interval; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; RCT = randomized control trial; RR = risk ratio; SOE = strength of evidence

Eleven studies were pooled to obtain estimates for overall success (Table 33, Appendix Figure H-16).[51,85-90,93-96] There was no difference in rates of overall success for video versus direct laryngoscopy in RCTs and observational studies of adult patients with cardiac arrest (SOE: Moderate).[51,85,87,88,93] For adults or mixed-age with mixed emergency types there was no difference in RCTs and observational studies (SOE: Low).[86,88-90,94-96] No changes in effect were detected in sensitivity analyses for either subgroup.

In qualitative analysis, there was no difference in video versus direct laryngoscopy for DASH-1A[79] or ROSC[51,86] in observational studies (Table 34).

Table 33. Overall success for video versus direct laryngoscopy as modifier of ETI by subgroup (direct laryngoscopy referent)

Emergency Type	Age Group	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Cardiac Arrest	Adults	No difference (Moderate)	2 RCT[85,87]	191	0.96 (0.86 to 1.04), 0%
			3 OBS[51,88 93]	714	1.19 (0.94 to 1.49), 78.5%
Mixed Emergency	Adults/mixed-age	No difference (Low)	3 RCT[89,94,95]	1,053	0.68 (0.42 to 1.09), 97.6%
			4 OBS[86,88,90,96]	1,102	1.15 (0.98 to 1.40); 85.7%

CI = confidence interval; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; OBS = observational study; RCT = randomized control trial; SOE = strength of evidence

Table 34. Additional outcomes for video versus direct laryngoscopy as modifier of ETI

Outcome	Study Number and Design	Number of Patients	Summary of Findings
DASH-1A	1 OBS[79]	256	No difference
ROSC	2 OBS[51,86]	489	No difference • Prehospital ROSC[51] • ROSC timing not specified[86]

ETI = endotracheal intubation; DASH-1A = Definitive Airway Sans Hypoxia/Hypotension on First Attempt; OBS = observational study; ROSC = return of spontaneous circulation

Five studies provided data for qualitative analysis of comparative harms for video and direct laryngoscopy.[74,86,89,95,96] Results for each harm are summarized by individual study in Table 35. Similar proportions of patients experienced reported harms in both groups (peri-intubation cardiac arrest, esophageal intubations, oral or airway trauma, regurgitation, and total complications).

Table 35. Harms for video versus direct laryngoscopy as modifier of ETI

Harm Description	Study Design	Number of Patients	Proportion Experienced Harm: Video	Proportion Experienced Harm: Direct	Summary of Findings
Peri-Intubation Cardiac Arrest	OBS[74]	296	2.8% (5/181)	2.6% (3/151)	No difference
Esophageal Intubation	RCT[95]	326	1.8% (3/168)	2.5% (4/158)	No difference; not specified if recognized or unrecognized
	RCT[89]	579	4.8% (14/294)	3.2% (9/285)	No difference; not specified if recognized or unrecognized
	OBS[96]	615	0% (0/300)	0% (0/315)	None occurred in either group; unrecognized esophageal intubations
Oral/Airway Trauma	RCT[89]	579	2.7% (8/294)	2.1% (6/285)	No difference
	OBS[96]	615	0.6% (2/315)	1.0% (3/300)	No difference
Regurgitation	OBS[96]	615	4.8% (15/315)	4.3% (13/300)	No difference
Problems Advancing the Endotracheal Tube	RCT[95]	326	18.4% (31/168)	1.9% (3/158)	To larynx: higher rate with video laryngoscopy, p<0.0001
			9.5% (16/168)	1.9% (3/158)	To trachea: higher rate with video laryngoscopy, p=0.0036
Complications	OBS[86]	212	1% (1/89)	2% (3/123)	No difference

ETI = endotracheal intubation; OBS = observational study; RCT = randomized control trial

Technique/Device: Laryngoscope Blades and Gum Elastic Bougie

Additional technique/device comparisons for ETI included laryngoscope blade material (1 RCT,[97] 2 observational studies;[98,99] N=4,466) and gum elastic bougie use (2 observational studies,[78,79] N=410). Results for outcomes were analyzed qualitatively and these are summarized in Table 36. Reusable metal blades were associated with higher rates of first-pass success compared with plastic disposable blades,[98,99] and similar rates versus single-use metal blades.[97] Use of gum elastic bougie was associated with successful DASH-1A and first-pass success in a study involving helicopter EMS providers (flight registered nurse, nurse practitioner, or emergency physician).[79] For overall success, there was no difference in rates with bougie use versus without, in a study with paramedic and emergency medical technician providers.[78]

Two studies provided data on harms outcomes for comparisons of laryngoscope blade material.[97,98] Results for each harm are summarized by individual study in Table 37. Across

reported harms, there was no difference in proportions of patients experiencing harm for both metal versus plastic blades and for reusable versus disposable metal blades.

No eligible studies reported on comparative harms for gum elastic bougie use.

Table 36. Outcomes for comparisons of laryngoscope blades and use of gum elastic bougie as modifiers of ETI

Comparison	Outcome	Study Number and Design	Number of Patients	Summary of Findings
Reusable vs. Single-Use Metal Blades	First-pass success	1 RCT[97]	817	No difference
Metal vs. Plastic Blades	First-pass success	2 OBS[98,99]	3,649	Higher rates of first-pass success with metal blades than plastic blades • Reusable metal vs. disposable plastic: OR 1.94 (95% CI 1.17 to 3.41), p<0.001[99] • Disposable metal vs. disposable plastic: 84% vs. 76%, p<0.002[98]
Gum Elastic Bougie	DASH-1A	1 OBS[79]	263	Use of gum elastic bougie associated with successful DASH-1A; AOR 5.38 (95% CI 1.83 to 15.8), p=0.002
	First-pass success	1 OBS[79]	263	Use of gum elastic bougie associated with first-pass success; AOR 7.79 (95% CI 2.31 to 26.3), p<0.001
	Overall success	1 OBS[78]	147	No difference

AOR = adjusted odds ratio; CI = confidence interval; ETI = endotracheal intubation; DASH-1A = Definitive Airway Sans Hypoxia/Hypotension on First Attempt; OBS = observational study; OR = odds ratio; RCT = randomized control trial

Table 37. Harms for comparisons of laryngoscope blades as modifier of ETI

Harm Description	Study Design	Number of Patients	Proportion Experienced Harm for:	Versus Proportion Experienced Harm for:	Summary of Findings
Unrecognized Esophageal Intubation	OBS[98]	2,472	Metal blades: 0% (0/1,395)	Plastic blades: 0% (0/1,077)	None occurred in either group
Hypotension	RCT[97]	817	Reusable metal blades: 7% (29/408)	Disposable metal blades: 10% (39/409)	No difference
Dental Trauma	RCT[97]	817	Reusable metal blades: 0.2% (1/408)	Disposable metal blades: 0.2% (1/409)	No difference
Vomiting	RCT[97]	817	Reusable metal blades: 2% (6/408)	Disposable metal blades: 2% (7/409)	No difference
Any Complication	RCT[97]	817	Reusable metal blades: 19% (76/408)	Disposable metal blades: 21% (87/409)	No difference

ETI = endotracheal intubation; OBS = observational study; RCT = randomized control trial

Endotracheal Intubation: 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 were summarized qualitatively.

Patient Characteristics: Emergency Type

Ten studies (N=101,799) provided data for pooled analysis of emergency type comparisons for first-pass success or overall success outcomes (Tables 38 and 39, Appendix Figures 17 to 20).[61,67,74,80,84,100-104] No eligible studies provided data on comparative harms for emergency types.

First-pass success rates were higher in medical emergencies than trauma emergencies among adults/mixed age patients (SOE: Low).[61,74,101,104] In adults/mixed age patients, rates were similar for nonarrest versus cardiac arrest emergencies (SOE: Low).[80,84,88,100,103] SOE was insufficient for first-pass success rates in adults/mixed age patients for medical versus cardiac arrest and for trauma versus cardiac arrest, due to study limitations and inconsistent findings. In pediatric patients, SOE was insufficient for all emergency type comparisons, as there was only one observational study.[61]

There was no difference in overall success rates for all comparisons of emergency types in studies of adults/mixed-age (for all, SOE: Low).

Table 38. First-pass success for comparisons of emergency type as modifier of ETI

Comparison	Subgroup	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Medical vs. Cardiac Arrest[a]	Adults/mixed-age	No conclusion (Insufficient)	2 OBS[61,104]	20,644	0.90 (0.61 to 1.26), 0%
	Pediatrics	No conclusion (Insufficient)	1 OBS[61]	409	0.97 (0.80 to 1.19), NA
Trauma vs. Cardiac Arrest[a]	Adults/mixed-age	No conclusion (Insufficient)	2 OBS[61,104]	15,924	0.97 (0.71 to 1.02), 0%
	Pediatrics	No conclusion (Insufficient)	1 OBS[61]	374	1.00 (0.80 to 1.26), NA
Nonarrest vs. Cardiac Arrest[a]	Adults/mixed-age	No difference (Low)	5 OBS[80,84,88,100,103]	14,148	1.00 (0.87 to 1.15), 96.1%
Trauma vs. Medical[b]	Adults/mixed-age	Favors medical (Low)	4 OBS[61,74,101,104]	9,527	0.96 (0.93 to 0.99), 0%
	Pediatrics	No conclusion (Insufficient)	1 OBS[61]	157	1.03 (0.79 to 1.35), NA

CI = confidence interval; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; NA = not applicable; OBS = observational study; SOE = strength of evidence; RR = risk ratio

[a] Referent group = cardiac arrest

[b] Referent group = medical

Table 39. Overall success for comparisons of emergency type as modifier of ETI

Comparison	Subgroup	Conclusion (SOE)	Study Number and Design	Number of Patients	Summary of Results RR (95% CI), I^2
Medical vs. Cardiac Arrest[a]	Adults/mixed-age	No difference (Low)	2 OBS[67,104]	41,718	0.88 (0.66 to 1.15), 93.4%
Trauma vs. Cardiac Arrest[a]	Adults/mixed-age	No difference (Low)	3 OBS[67,102,104]	31,586	0.97 (0.89 to 1.07), 0%
Nonarrest vs. Cardiac Arrest[a]	Adults/mixed-age	No difference (Low)	5 OBS[80,84,88,100,103]	14,259	0.98 (0.90 to 1.07), 99.2%
Trauma vs. Medical[b]	Adults/mixed-age	No difference (Low)	3 OBS[67,101,104]	17,969	1.00 (0.99 to 1.01), 0%

CI = confidence interval; ETI = endotracheal intubation; I^2 = statistical test of heterogeneity; OBS = observational study; RR = risk ratio; SOE = strength of evidence

[a] Referent group = cardiac arrest

[b] Referent group = medical

Patient Characteristics: Age, Sex, and Race

Age

Results for comparisons of age as a modifier of ETI are summarized in Tables 40 and 41**.** We included three categories for comparisons of age: age within pediatrics, pediatric versus adult, and elderly versus adult. We used the age categories as defined in each study; these thresholds varied across studies and are listed in the paragraphs below for the respective comparisons.

Three studies (in four publications; N=1,211) provided data on comparative outcomes, including harms, for different ages within pediatric samples.[35,36,105,106] Age cutoffs for the categories varied for the three studies. The thresholds in Eich, 2009[105] were: infants less than 1 year old, toddlers age 1 to 5 years, and school-age children 6 to 14 years old. Prekker, 2016[106] used these same cutoffs for infants and toddlers, with school age defined as 6 to 12 years old. Gausche, 2000[35,36] also had three age groups: age less than 3 years, 3 to 8 years old, and greater than 8 years old. Compared to toddlers or school-age children, infants had poorer outcomes for survival, neurological function and first-pass success.[105,106] However, aspiration pneumonia occurred less frequently in infants than in children of other ages.[106] For overall success, there were no differences across all pediatric age groups.[35,36] There were no differences for toddlers versus school-age children for any outcome.[105,106] Harms were experienced at similar rates for all age groups within pediatrics (Table 41).[105,106]

There were six studies (N=90,657) reporting on outcomes for pediatric versus adult patients.[61,67,74,79,107,108] In Murray, 2000,[108] adolescents were 11 to 20 years old and younger adults were age 21 to 40 years. Powell, 2019[79] defined pediatrics as less than 18 years old; pediatric was defined as 14 years and younger in Jarvis, 2019,[61] and Eberlein, 2019[74] did not provide age cutoffs. Rates of survival to hospital discharge were similar for adolescents and young adults.[108] In two studies of patients with mixed emergency types and prehospital providers of varying levels, first-pass success rates were higher for adults than children.[61,74] However, one study of trauma patients treated by advanced prehospital providers in a helicopter EMS system found no difference in first-pass or overall success rates for children versus adults.[79]

One RCT (n=156) compared elderly (age >60 years) versus adult patients, finding significantly lower rates of favorable neurological outcomes in the elderly.[39]

Table 40. Outcomes for comparisons of age as modifier of ETI

Comparison	Outcome	Study Number and Design	Number of Patients	Summary of Findings
Age Within Pediatrics	Survival	1 OBS[105]	82	Prehospital and in-hospital survival: • Lower rates in infants vs. toddlers or school-age children; prehospital: 47.1% vs. 96.4% vs. 97.3%, p<0.001; in-hospital: 41.2% vs. 89.3% vs. 83.8%, p<0.001 • No difference in toddlers vs. school-age children
	Neurological function	1 OBS[105]	63	Pediatric CPC score 1-3 at hospital discharge: • Smaller proportion of infants vs. toddlers or school-age children; 42.9% vs. 88% vs 93.5%, p<0.001 • No difference for toddlers vs. school-age children
	First-pass success	1 OBS[106]	299	• Lower rates in infants than toddlers or school-age children; 52.6% vs. 74.1% vs. 73.9% • Similar rates in toddlers and school-age children
	Overall success	1 CCT[35,36]	310	No difference among children of different ages

Comparison	Outcome	Study Number and Design	Number of Patients	Summary of Findings
	Morbidity	1 OBS[106]	219	Aspiration pneumonia: • Lower rates in infants than toddlers or school-age children; 5% vs. 24% • Similar rates in toddlers and school-age children
Pediatric vs. Adult	Survival	1 OBS[108]	57	Survival to hospital discharge: • No difference between adolescents vs. younger adults
	First-pass success	3 OBS[61,74,79]	23,078	Inconsistent • Lower rates in pediatrics vs. adults; 50.0% vs. 81.8%, p=0.026;[74] 58.5% vs. 72.7%, AOR 0.56 (95% CI 0.46 to 0.67), p<0.05[61] • No difference[79]
	Overall success	2 OBS[67,107]	47,441	Lower rates in pediatrics vs. adults • 55.8% vs. 84.2%, p<0.05[107] • 71.8% vs. 79.0%, p<0.05[67]
	DASH-1A	1 OBS[79]	257	No difference between pediatric and adult patients
Elderly vs. Adult	Neurological function	1 RCT[39]	156	GOSe 5-8 at 6 months: • Smaller proportion of elderly vs. adult; 14% vs. 62%, p<0.001

AOR = adjusted odds ratio; CCT = controlled clinical trial; CI = confidence interval; ETI = endotracheal intubation; CPC = Cerebral Performance Score; DASH-1A = Definitive Airway Sans Hypoxia/Hypotension on First Attempt; GOSe = Glasgow Outcome Scale extended; OBS = observational study; RCT = randomized control trial

Table 41. Harms for comparisons of age within pediatrics as modifier of ETI

Harm Description	Study Design	Number of Patients	Age Range: Proportion Experienced Harm	Summary of Findings
Peri-Intubation Cardiac Arrest	OBS[106]	299	<1 year: 2% (2/114) 1 to 5 years: 1% (1/116) 6 to 12 years: 4% (3/69)	No difference across age groups
Unrecognized Bronchial Intubation	OBS[106]	241	<1 year: 16% (12/75) 1 to 5 years: 24% (26/108) 6 to 12 years: 14% (9/64)	No difference across age groups
	OBS[105]	58	<1 year: 0% (0/13) 1 to 5 years: 4.5% (1/22) 6 to 14 years: 4.3% (1/23)	No difference between any age groups
Respiratory Tract Injury	OBS[106]	295	<1 year: 0% (0/NR) 1 to 5 years: 1% (1/NR) 6 to 12 years: 0% (0/NR)	Single case observed

ETI = endotracheal intubation; NR = not reported; OBS = observational study

Sex

Five observational studies (N=31,219) were included for comparative outcomes by patient sex (female vs. male) as a modifier of ETI (Table 42).[61,74,79,109] Better outcomes were observed for females for survival and sustained ROSC.[78,109] There were higher rates of first-pass success in females,[61,74,79] however these differences were only statistically significant in one of three studies.[61] There was no difference in rates of overall success or DASH-1A for females and males.[78,79] No eligible studies provided data on comparative harms for sex.

Table 42. Outcomes for comparisons of sex as modifier of ETI

Comparison	Outcome	Study Number and Design	Number of Patients	Summary of Findings
Female vs. Male	Survival	1 OBS[109]	299	Survival to hospital discharge: • Higher rates in female vs. male participants; AOR 1.69 (95% CI 1.10 to 2.63), p<0.05
	ROSC	1 OBS[109]	1,142	Sustained ROSC to hospital arrival: • Larger proportion of female vs. male participants; AOR 1.52 (95% CI 1.12 to 2.04), p<0.05
	DASH-1A	1 OBS[79]	257	No difference
	First-pass success	3 OBS[61,74,79]	23,078	Inconsistent • No difference[74,79] • Higher rates in female vs. male participants; 74.7% vs. 70.8%, p<0.001[61]
	Overall success	1 OBS[78]	150	No difference

AOR = adjusted odd ratio; CI = confidence interval; DASH-1A = Definitive Airway Sans Hypoxia/Hypotension on First Attempt; ETI = endotracheal intubation; OBS = observational study; ROSC = return of spontaneous circulation

Race

Three studies (N=30,773) conducted in the United States provided data for outcomes by patient race as a modifier of ETI, but were limited to comparisons of white versus nonwhite race (Table 43).[61,79,109] White participants had higher rates of sustained ROSC when compared to participants of nonwhite race.[109] One large observational study found a statistically significant association between white race and first-pass success.[61] A separate study found no difference in first-pass success rates, but reported higher rates of DASH-1A in white participants; of note, more than 95 percent of the participants in this study identified as white.[79] No eligible studies provided data on comparative harms by race.

Table 43. Outcomes for comparisons of race as modifier of ETI

Comparison	Outcome	Study Number and Design	Number of Patients	Summary of Findings
White vs. Nonwhite	ROSC	1 OBS[109]	1,142	Sustained ROSC: • Larger proportion of white participants than nonwhite participants; AOR 1.39 (95% CI 1.04 to 1.86), p<0.05
	DASH-1A	1 OBS[79]	257	Higher rates in white participants than nonwhite participants; AOR 4.62 (95% CI 1.13 to 19.0), p=0.034
	First-pass success	2 OBS[61,79]	29,631	Inconsistent • Similar rates for white and nonwhite participants[79] • White race associated with higher rates of first-pass success[61]

AOR = adjusted odds ratio; CI = confidence interval; ETI = endotracheal intubation; DASH-1A = Definitive Airway Sans Hypoxia/Hypotension on First Attempt; OBS = observational study; ROSC = return of spontaneous circulation

Supraglottic Airway

Supraglottic Airway: Technique/Device

Technique/Device: Supraglottic Airway Devices

We identified six studies that compared SGA devices.[16,64,110-113] SGA devices were classified based on the anatomic position of their seal (e.g., pharyngeal or perilaryngeal) and results were grouped by comparisons within or between these classes.

Perilaryngeal Seal Supraglottic Airways

Two RCTs (N=454) were included for the comparison of perilaryngeal seal SGAs (Table 44).[110,111] Both studies compared i-gel to LMA in adult cardiac arrest patients. There were higher rates of overall success with i-gel in the smaller RCT.[111] No differences were found for survival to hospital discharge, ROSC on hospital arrival, or first-pass success.

Table 44. Outcomes for comparisons of perilaryngeal seal SGAs

Comparison	Outcome	Study Number and Design	Number of Patients	Summary of Findings
i-gel vs. LMA	Survival	1 RCT[110]	406	Survival to hospital discharge: • No difference
	ROSC	2 RCT[110,111]	454	ROSC on ED or hospital arrival • No difference
	First-pass success	1 RCT[110]	406	No difference
	Overall success	1 RCT[111]	48	Higher rates with i-gel; 90% vs. 57%, RR 1.58 (95% CI 1.11 to 2.24), p=0.023

CI = confidence interval; ED = emergency department; LMA = laryngeal mask airway; RCT = randomized control trial; RR = risk ratio; ROSC = return of spontaneous circulation; SGA = supraglottic airway

Pharyngeal Versus Perilaryngeal Seal Supraglottic Airways

Four studies (3 RCTs,[16,112,113] 1 observational;[64] N=123,692) provided data for comparisons of pharyngeal versus perilaryngeal seal SGAs (Tables 45 and 46). All studies were in adult patients. Pharyngeal seal SGAs included LT, esophageal obturators, Combitube, and PTLA. The perilaryngeal seal SGA in all studies was the LMA.

For ROSC, findings were inconsistent between studies. In one observational study, there was a statistically significant difference in rates of prehospital ROSC, favoring the pharyngeal seal SGA; however, the difference is not clinically meaningful (4.41% using esophageal obturator airway vs. 4.90% using LMA).[64] In RCTs, there was no difference between device types (LT vs. LMA) for either prehospital ROSC[113] or overall ROSC.[112] There were also inconsistent findings for successful airway insertion. First-pass and overall success rates were higher with perilaryngeal seal SGA in one RCT,[113] while another RCT[16] found higher rates of successful insertion and ventilation by EMS personnel assessment with pharyngeal seal SGAs. No differences were found for survival,[64,112] neurological function,[64,112] or oxygenation/ventilation[16,112] outcomes.

Comparative harms for pharyngeal versus perilaryngeal seal SGAs were reported in two RCTs (Table 46).[16,113] Where there were differences, higher rates of harms were experienced with use of pharyngeal seal SGAs (total complications, inadequate ventilation, and dislodgement).

Table 45. Outcomes for comparisons of pharyngeal versus perilaryngeal seal SGAs

Outcome	Comparison	Study Number and Design	Number of Patients	Summary of Findings
Survival	LT vs. LMA	1 RCT[112]	313	Survival at 1 month • No difference
	Esophageal obturator[a] vs. LMA	1 OBS[64]	122,194	Survival at 1 month: • No difference
Neurological Function	LT vs. LMA	1 RCT[112]	313	CPC score 1 or 2 at 1 month: • No difference
	Esophageal obturator[a] vs. LMA	1 OBS[64]	122,194	CPC score 1 or 2 at 1 month: • No difference
ROSC	LT vs. LMA	2 RCT[112,113]	1,213	Prehospital ROSC:[113] • No difference Overall ROSC:[112] • No difference
	Esophageal obturator[a] vs. LMA	1 OBS[64]	122,194	Prehospital ROSC • Favors esophageal obturator; 4.41% vs. 4.90%, p=0.0002
Success	LT vs. LMA	1 RCT[113]	900	First-pass and overall success: • Higher rates with LMA, p<0.02
	Combitube vs. LMA	1 RCT[16]	185	Successful insertion and ventilation: • Higher rate with Combitube, p=0.048
Oxygenation/ Ventilation	LT vs. LMA	1 RCT[112]	313	Successful ventilation at time of hospital arrival: • No difference
	PTLA vs. LMA	1 RCT[16]	100	ABG at hospital arrival, mean PCO_2 and mean PO_2: • No difference

ABG = arterial blood gas; CPC = Cerebral Performance Category; LMA = laryngeal mask airway; LT = laryngeal tube; OBS = observational study; PTLA = pharyngeotracheal lumen airway; RCT = randomized control trial; ROSC = return of spontaneous circulation; SGA = supraglottic airway

[a] Esophageal obturator included LT, Combitube, or esophageal gastric tracheal airway

Table 46. Harms for comparisons of pharyngeal versus perilaryngeal seal SGAs

Harm Description	Comparison	Study Design	Number of Patients	Proportion Experienced Harm for:	Versus Proportion Experienced Harm for:	Summary of Findings
Complications	LT vs. LMA	RCT[113]	571	LT: 19.0% (33/174)	LMA: 8.6% (34/397)	Higher rate with LT; AOR 2.71 (95% CI 1.69 to 4.35), p<0.001
Tongue/ Pharyngeal Swelling	LT vs. LMA	RCT[113]	571	LT: 1.1% (2/174)	LMA: 1.0% (4/397)	No difference
Bleeding	LT vs. LMA	RCT[113]	571	LT: 2.3% (4/174)	LMA: 1.5% (6/397)	No difference
Air Leak	LT vs. LMA	RCT[113]	571	LT: 1.7% (3/174)	LMA: 0.5% (2/397)	No difference
Incorrect Placement	LT vs. LMA	RCT[113]	571	LT: 2.3% (4/174)	LMA: 1.3% (5/397)	No difference
Inadequate Ventilation	Combitube vs. LMA	RCT[16]	185	Combitube: 23% (18/77)	LMA: 7% (8/108)	Higher rate with Combitube, p=0.01
Dislodgement	LT vs. LMA	RCT[113]	571	LT: 12.6% (22/174)	LMA: 4.5% (18/397)	Higher rate with LT, p=0.001

AOR = adjusted odds ratio; CI = confidence interval; LMA = laryngeal mask airway; LT = laryngeal tube; PTLA = pharyngeotracheal lumen airway; RCT = randomized control trial; SGA = supraglottic airway

Pharyngeal Seal Supraglottic Airways

A single RCT (n=194) compared pharyngeal seal SGAs (Combitube versus PTLA).[16] There were no differences between devices for successful insertion and ventilation or arterial blood gases (Table 47). For harms, similar rates were observed for inadequate ventilation on hospital arrival (Table 48).

Table 47. Outcomes for comparisons of pharyngeal seal SGAs

Comparison	Outcome	Study Number and Design	Number of Patients	Summary of Findings
Combitube vs. PTLA	Success	1 RCT[16]	194	Successful insertion and ventilation: • No difference
	Oxygenation/ ventilation	1 RCT[16]	66	ABG at hospital arrival, mean PCO_2 and mean PO_2: • No difference

ABG = arterial blood gas; PTLA = pharyngeotracheal lumen airway; RCT = randomized control trial; SGA = supraglottic airway

Table 48. Harms for Combitube versus PTLA as modifier of SGA

Harm Description	Study Design	Number of Patients	Proportion Experienced Harm: Combitube	Proportion Experienced Harm: PTLA	Summary of Findings
Inadequate Ventilation	RCT[16]	194	23% (18/77)	20% (23/117)	No difference

PTLA = pharyngeotracheal lumen airway; RCT = randomized control trial; SGA = supraglottic airway

Supraglottic Airway: Patient Characteristics

Patient Characteristics: Age

Two large observational studies were included for age (pediatric versus adult) as a modifier of SGA outcomes (Table 49).[61,67] Studies utilized multiple devices including both pharyngeal and perilaryngeal seal SGAs. The rates of first-pass success and overall success were not different for children compared to adults. No eligible studies provided data on comparative harms for age as a modifier of SGA.

Table 49. Outcomes for comparisons of age as modifier of SGA: pediatric versus adult

Outcome	Study Number and Design	Number of Patients	Summary of Findings
First-Pass Success	1 OBS[61]	6,849	No difference
Overall Success	1 OBS[67]	9,461	No difference

OBS = observational study; SGA = supraglottic airway

Discussion

Findings in Relation to the Decisional Dilemmas

Introduction

An essential part of prehospital care is airway management, which enables patients to receive adequate oxygenation and ventilation. There are currently three main approaches to airway management: bag valve mask (BVM) (usually with airway adjuncts such as oropharyngeal airway and nasopharyngeal airway), 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. Furthermore, these approaches are often used in a complementary fashion so that one serves as a backup when the other is deemed ineffective.

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 practitioner actions include the specific clinical patient scenario, and estimated transport time to an emergency department and hospital. These can also change dynamically throughout emergency medical services (EMS) calls. In this review, our objective was to aggregate and summarize findings regarding these factors to facilitate application in local environments.

Our quantitative and qualitative syntheses were based on 99 studies from 101 publications. Studies compared 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 syntheses was to identify any differences in survival in-hospital or at 1-month post incident, neurological function at discharge or 1-month post incident, return of spontaneous circulation (ROSC), or successful advanced airway insertion. Results were stratified by emergency type and age, since 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 3, 4, and 5.

The included studies were primarily observational and limited by indication and survival bias; very few randomized controlled trials (RCTs) were available. Most strength of evidence (SOE) assessments were “low,” mainly due to the limited number of studies and inconsistencies in outcomes. Those outcomes rated “moderate” included more studies, more rigorous study designs, consistent findings, or more precise estimates. There were no “high” SOE ratings. Therefore, additional well-designed future studies could change our conclusions.

Key Results

Key Questions 1, 2, and 3

Results for Key Questions 1, 2, and 3 were quantitatively analyzed for survival, neurological function, and ROSC (Table 3); and for successful advanced airway insertion for Key Question 3 (Table 4). Overall, evidence indicated few differences between airway approaches; when

statistically significant differences occurred, they were for specific outcomes/comparisons and didn't indicate a pattern clearly favoring one airway over another across multiple outcomes.

Our pooled estimates found few statistically significant differences in outcomes from head-to-head comparisons of airway management methods across most subgroups of emergency types and ages.

For Key Question 1 (BVM vs. SGA), there was no difference in survival for adult/mixed-age patients with cardiac arrest, and pediatric patients with cardiac arrest; and no difference in ROSC for adult patients with cardiac arrest. For neurological function measured by the Cerebral Performance Category (CPC), there were better outcomes with BVM for adult/mixed-age patients with cardiac arrest. No differences in harms were noted.[13,15,18,19]

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

There was a strong possibility that resuscitation time bias influenced results favoring BVM.[114] Resuscitation time bias refers to interventions that are applied at varying times; those applied later are less effective in part due to their delayed application. As BVM typically is the first airway management technique used in the field, effects of successful BVM would be favorably confounded by the shorter time between EMS arrival and airway intervention. This is particularly true for patients presenting with cardiac arrest with favorable features such as being witnessed, receiving bystander CPR, and a shockable initial rhythm. Another contributing factor is hyperventilation, which may occur more frequently with advanced airways (SGA or ETI) than with BVM. Hyperventilation has been shown to adversely impact patient outcomes in part by increasing intrathoracic pressure and decreasing venous return, ultimately leading to decreased cerebral and coronary perfusion pressures.[115-119]

For Key Question 2 (BVM vs. ETI), results indicated no difference in survival, neurological function measured by the CPC, or ROSC across the subgroups identified in Table 3. No differences in harms were noted.[18,35-40] The same caveats apply as identified for Key Question 1 with respect to study limitations. For example, whether ETI was preceded by BVM or not, lack of precise details on BVM use and subjective measurement of its effectiveness, resuscitation time bias, and potential hyperventilation all limit firm conclusions for this question.

For Key Question 3 (SGA vs. ETI), outcomes favored SGA for ROSC in adults with cardiac arrest,[17,21-23,28,29,33 ,44,46,51,52,55,62,64,65,68] and for first-pass success in adults with cardiac arrest,[17,49,51,61,69] pediatric patients with cardiac arrest,[18,61] and adults with mixed emergency types.[53,63] Outcomes favored ETI for neurological function in adults with cardiac arrest (measured by the CPC).[21-23,28,31,33,52,59,62,64,65] There was no difference between approaches for survival in adult/mixed-age patients with cardiac arrest[14,17,21-25,28,30,32,44,46,52,62,64,65] and pediatric patients with cardiac arrest;[18,26,66] for neurological function in adults with cardiac arrest (measured by the Modified Rankin Sore [mRS])[17,44] and pediatric patients with cardiac arrest (measured by the Pediatric Cerebral Performance Category [PCPC]);[26,66] for ROSC in pediatric patients with cardiac arrest;[26,66] for first-pass success in adults with medical emergencies;[45,61] and

for overall successful advanced airway insertion in adults with cardiac arrest,[17,44,46,49-51,58,67,69] adults with medical emergencies,[45,48,67] and adults with mixed emergency types.[53,54,56]

For harms, better outcomes were observed with SGA for multiple insertion attempts,[17] and with ETI for inadequate ventilation.[17] No differences were noted for aspiration,[44,63] oral/airway trauma,[17,18] and regurgitation.[44]

Compared with ETI, SGAs were faster to insert, and had higher first-pass success in specific subgroups. However, no difference was noted in rates of overall insertion success. It is thought that SGAs may not protect against aspiration and thus may not work well for patients with 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 for EMS clinicians to hyperventilate with the SGA than with ETI. This is a topic for future research. From an EMS perspective, ROSC is the primary field resuscitation endpoint in cardiac arrest and therefore a meaningful outcome for first responders. Most studies report ROSC outcomes were improved with SGA versus ETI (Table 18). Survival and neurological function are influenced by postresuscitation care, including hospital procedures (e.g., targeted temperature management, cardiac catheterization, and critical care expertise) and shared decision making with family regarding prognosis and withdrawal of life sustaining treatments. Best practices regarding neuroprognostication are evolving, and unfortunately, at present patients may be moved too quickly to comfort care, especially following cardiac arrest.[120]

Key Question 4

No studies met inclusion criteria about modifiers for BVM. Studies addressing modifiers for SGA were analyzed qualitatively. For ETI, results were both pooled in meta-analyses and analyzed qualitatively (Table 5). For both SGA and ETI, modifiers included technique/device and patient characteristics.

Endotracheal Intubation

Technique/Device

There were four sets of comparisons for technique/device modifiers of ETI: ETI with drug-facilitation versus without; video versus direct laryngoscopy; laryngoscope blade material; and use of the gum elastic bougie as an adjunct.

For the drug-facilitation category, we compared rapid sequence intubation (RSI) versus no medication, RSI versus sedation-facilitated, and sedation-facilitated versus no medication. For RSI versus no medication, there was no difference for survival in adult/mixed-age patients with trauma;[70,72,73,83] for first-pass success in adult/mixed-age patients trauma;[79,83] for overall success in adults with cardiac arrest;[67,77] and overall success in adult/mixed-age patients with mixed emergency types.[78,80,84] RSI was favored for first-pass success in adult/mixed-age patients with mixed emergency types,[61,74,80,82,84] and for overall success in adults with trauma.[67,70] For RSI versus sedation-facilitated ETI, RSI was favored for first-pass success in adult/mixed-age patients with mixed emergency types.[61,74,84] For sedation-facilitated ETI versus no medication, there was no difference for first-pass success in adult/mixed age patients with mixed emergency types.[61,74,84]

For video versus direct laryngoscopy, there was no difference for first-pass success for adults with cardiac arrest[51,85,87,88,93] and adult/mixed age patients with mixed emergency types,[86,88-92]

and for overall success in adults with cardiac arrest[51,85,87,88,93] and adult/mixed age patients with mixed emergency types.[86,88-90,94-96]

For laryngoscope blade materials, there was no difference between reusable versus single-use blades for first-pass success.[97] Metal blades were favored over plastic blades for first-pass successful advanced airway insertion.[98,99]

For gum elastic bougie, there was no difference for overall success.[78] Use of bougie was favored for first-pass success[79] and Definitive Airway Sans Hypoxia/Hypotension on First Attempt (DASH-1A).[79]

Patient Characteristics

We analyzed how outcomes of ETI varied by emergency type, age, sex, and race. For emergency type, in adults/mixed age patients there was better first-pass success for medical emergencies when compared to trauma[61,74,101,104] and there was no significant difference for nonarrest versus cardiac arrest.[80,84,88,100,103] Overall success was not significantly different between any emergency types in adults/mixed age patients.[64,67,80,84,88,100-104]

In many of these studies, it was 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 arrival, the intubation success cannot be confirmed. On the other hand, if the patient survives to hospital arrival, then it is more likely that the airway success will be confirmed.

For age, within pediatrics there were poorer outcomes for infants versus toddlers or school-age children for survival,[105] neurological function,[105] and first-pass success;[106] whereas there were better outcomes for infants versus toddlers or school-age children for aspiration pneumonia.[106] There was no difference for overall success across pediatric groups,[106] and no difference between toddlers versus school-age children for any outcome.[105,106] When pediatric patients were compared with adults, there was no difference for survival[108] or DASH-1A.[79] When adults were compared with elderly patients, no difference was found for neurological function.[39]

For sex, outcomes favored females for survival,[109] ROSC,[109] and overall success.[78] There was no difference for DASH-1A.[79]

For race, outcomes were poorer for nonwhite compared to white patients for ROSC[109] and DASH-1A.[109]

Supraglottic Airway

Technique/Device

Within the category of technique/device, we compared within and between categories of perilaryngeal seal SGAs and pharyngeal seal SGAs. In the perilaryngeal seal SGA comparisons (i-gel versus laryngeal mask airway [LMA]), results favored i-gel over LMA for overall successful advanced airway insertion,[111] but there was no difference for survival, ROSC, or first-pass success.[110,111] In the pharyngeal versus perilaryngeal seal SGA comparisons (laryngeal tube [LT], esophageal obturator, Combitube, or pharyngeotracheal lumen airway [PTLA] vs. LMA), no difference was found for survival,[64,112] neurological function,[64,112] and ventilation and arterial blood gases.[16,112] In the pharyngeal seal SGA comparisons (Combitube versus PTLA), no difference was found for successful advanced airway insertion and arterial blood gases.[16]

Overall, these findings suggested that LMA may not be an ideal SGA 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.

Patient Characteristics

Within the category of patient characteristics, there was no difference between adults and pediatric patients for successful SGA insertion (first-pass or overall).[61,67]

Summary of the Evidence

The overall findings suggested 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 because the level and extent of training required for the acquisition and retention of ETI skills is different than for the other techniques. The comparable performance of BVM and SGA, which have less training requirements, allows for effective airway management with oxygenation and ventilation to be provided for the majority of patients who need it.

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

Experience with airway management in the pediatric population is very limited across most EMS systems and skill maintenance is a constant 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, but this is no longer allowed in many hospitals. Given these challenges and similar patient orientated outcomes across airway management methods, EMS agencies need to reassess the importance and role of ETI in their approach to advanced airway management.

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 included the availability of prehospital studies that assessed important outcomes and the variety of interventions and indications. Additionally some, though not all, studies employed more rigorous designs.

We were able to identify 99 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 other elements of prehospital care, extrapolations have been made with evidence from emergency departments or simulations. A challenge was 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, were 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 ROSC.

It was an advantage that the included studies were conducted in several different countries and that the research had wide variation in prehospital care situations, 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 included the results of 19 RCTs, 6 controlled clinical trials (CCTs), and 17 prospective cohort studies. The remaining studies were retrospective cohort studies and before/after comparisons. While there is no guarantee that trials and prospective studies provide better evidence, their ability to control or at least influence data collection and the delivery of care to some degree may reduce bias and confounding and increase the likelihood of including variables and outcomes needed to address the proposed research questions.

There were several important limitations to the available evidence assessing the impact of different airway devices in prehospital care. The most serious limitations resulted from 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 did include trials, the majority 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 may be unable 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 studies occasionally differ in this review. Indication bias, classifying patients by the treatment received, and survival bias, including only patients who survive a treatment are variants of selection bias that are likely to occur in observational studies of prehospital care. Furthermore, 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 challenges may also 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 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.[121]

Importantly, EMS clinicians acquire skill in all airway procedures over time and with practice. The skillset of the provider with each technique was rarely controlled for in the 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 typical 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 this information is 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.[114] The preparation time needed for different airway management techniques and the differences in skill and experience may be confounders, and the impact is often difficult to separate from the airway 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). The particular device used is specified in some studies, 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 presently have a way to accurately measure it. When available we use waveform capnography, but this does not provide a complete picture and can be affected by other factors such as medications, tissue metabolism 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 consistently, so the differences noted in outcomes may be related to the ventilation provided and not the airway method. Better tools are needed to measure ventilation parameters in particular rate, tidal volume, and airway pressures.

Strengths and Limitations of the Review

The methods for this review were based on the Agency for Healthcare Research and Quality (AHRQ) methods guidance[122] and the Institute of Medicine standards for systematic reviews.[123] We searched multiple databases, requested Technical Expert Panel members, clinical experts, and reviewers to suggest known studies. We reviewed reference lists, and we solicited unpublished data and additional studies through the AHRQ public call for information. We utilized broad search strategies 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, since 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 and emergency type. 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.

Applicability

The applicability of the evidence we synthesized was 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 (Population, Intervention, Comparison, Outcome, Setting), 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 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 was 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 indicates that airway management is significantly different across these age groups. Other subgroup variation is not explicitly documented nor represented. For example, the race of patients is rarely reported in 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 nonwhite. The findings were consistent with what is seen in other cardiac arrest studies related to race and ethnicity and are likely not related to airway interventions. Nonwhite patients have poorer survival, possibly due to not having bystander actions, delays in calling 911, or other factors not yet addressed in the literature.[124] Another influencing factor we do not have much information about is the race of the EMS clinician. Implicit bias may also affect how care is rendered in EMS but has not been studied in airway management.

While age was always reported, some studies did not report results by age groups. Other results suggested 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 emergency department (ED) or simulations.

Most problematic for applicability are the 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 EMS systems. Key differences included 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.[37] 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 are required to seek online medical control approval to place advanced airways. These differences reduced 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 was 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 responses evolve. We were encouraged to find studies that included outcomes that are patient-centered and not simply focused only on prehospital care processes. 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.[115-119] 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 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 appeared to be effective options for patients in the prehospital environment. The preferred airway depends on setting, patient age and emergency 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.

Effective airway management allows a means for oxygenation and ventilation. BVM and SGA, which are quicker to deploy, should be the mainstay management, as they facilitate prompt

oxygenation and ventilation of the patient compared with ETI. Any device or technique 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 also influence patient outcomes. Paramedic training programs vary considerably in the United States in terms of number of hours, patient contact time, and live procedures. The opportunity for live training has diminished, as has the need for use of advanced airways since non-invasive ventilation is now an option for patients with hypoxemic and hypercarbic respiratory failure. This is an unfortunate reality faced by many training programs who have turned to other options such as cadaver and simulation settings to teach and verify skills prior to graduation. Our findings highlight the fact that good training programs need to teach a variety of skills related to airway management with the ultimate goal being oxygenation and ventilation. Skill maintenance, especially with advanced airway techniques, has also 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 are often primarily hypothesis generating and provide a foundational basis for RCTs. Future airway studies need to clearly identify devices utilized and airway management methods (e.g., whether adjuncts were used with BVM [oropharyngeal and nasopharyngeal airway]) to allow for more accurate comparisons of the different airway methods). Future research needs to incorporate objective measures of success in oxygenation and ventilation (e.g., waveform capnography, video monitoring, in-line ventilation rate, flow, tidal volume, and pressure, etc.); 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 data collection techniques and technologies have been developed. Consideration should be given to extending this into the prehospital setting. Resuscitation time bias remains an important issue in cardiac arrest studies, and efforts should be made to accurately capture airway intervention timing to mitigate this concern. 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 oxygenation and 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 versus breathing during resuscitation.

- Clarify technique used in BVM studies (one person or two person, proper mask seal, airway adjuncts).
- 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 and failure.
- Conduct more research dedicated to pediatric airway management and ventilation.
- Improve data collection for 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 type of airway and ventilation device.
- Conduct mechanistic studies in humans to advance understanding of underlying pathophysiologies by which differences may be occurring.
- Further assess the impact race and sex have on different airway management strategies.

Conclusion

Overall, there is limited evidence to suggest differences in patient-oriented outcomes between use of bag valve mask (BVM), supraglottic airway (SGA), and endotracheal intubation (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. The findings from this effort are detailed and comprehensive and it is important to use them to inform policy, practice, education, and research to improve prehospital airway management and ventilation support to optimize 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
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 services
EPC	Evidence-based Practice Center
ETI	endotracheal intubation
GOS	Glasgow Outcome Scale
ICU	intensive care unit
ITT	intent to treat
KQ	Key Question
LMA	laryngeal mask airway
LT	Laryngeal tube
mRS	modified Rankin Scale
OBS	observational
PICOS	population, intervention, comparator, outcome, setting, study design
PTLA	Pharyngeotracheal lumen airway
RCT	randomized controlled trial
ROB	risk of bias
ROSC	return of spontaneous circulation
RSI	rapid sequence intubation
SGA	supraglottic airway
SOE	strength of evidence
TEP	Technical Expert Panel
TOO	Task Order Officer

Appendix A. Methods

Details of Study Selection

Publication date range. Studies were included that were published from January 1990 to September 2020. The beginning of the date range was selected based on the recommendation of the Key Informants and Technical Expert panels. Electronic searches will be updated to identify new publications while the draft report is subject to public and peer review. Literature identified during the updated search will be assessed following the same process of dual review as other studies considered for inclusion in the report.

Literature databases. MEDLINE®, CINAHL®, the Cochrane Central Register of Controlled Trials, the Cochrane Database of Systematic Reviews, and Scopus® were searched to capture published literature.

Supplementing searches. A Supplemental Evidence and Data for Systematic review (SEADS) portal was available to facilitate submission of published and unpublished studies. Notice was posted in the *Federal Register* requesting published and unpublished evidence relevant to the review; no relevant submissions were received.

Hand searching. Reference lists of systematic reviews and included articles were reviewed to identify additional literature for inclusion.

The search was developed and executed by a research librarian with extensive systematic review experience and peer reviewed by a second librarian. The search strategies for each citation database are included below.

Search Strategies

Database: Ovid MEDLINE(R) ALL 1946 to September, 2020
1. exp emergency medical services/ or exp "transportation of patients"/ or triage/
2. ("emt" or "ems" or "emergency medical" or field or "paramedic*" or "prehospital" or "pre-hospital" or transport* or trauma or traumatic).ti,ab,kf.
3. 1 or 2
4. exp Airway Management/
5. (intubate or intubation or airway or ventilation or ventilatory).ti,ab,kf.
6. (endotracheal or supraglottic or tracheal or prehospital or "pre-hospital" or field).ti,ab,kf.
7. 5 and 6
8. "bag valve mask".ti,ab,kf.
9. (airway adj5 manage*).ti,ab,kf.
10. 4 or 7 or 8 or 9
11. 3 and 10
12. limit 11 to yr="1990 - 2020"
13. (random or control or trial or cohort or case* or prospective or retrospective).ti,ab,kf,tw.
14. 12 and 13
15. exp cohort studies/
16. cohort$.tw.
17. controlled clinical trial.pt.
18. exp case-control studies/
19. (case$ and control$).tw.
20. or/15-19

21. randomized controlled trial.pt.
22. (random* or placebo* or control* or trial or blind*).ti,ab.
23. (animals not humans).sh.
24. (comment or editorial or meta-analysis or practice-guideline or review or letter).pt.
25. (21 or 22) not (23 or 24)
26. 20 or 25
27. 12 and 26
28. 14 or 27
29. limit 28 to english language
30. "prehospital emergency care".jn.
31. "prehospital & disaster medicine".jn.
32. "resuscitation".jn.
33. "military medicine".jn.
34. or/30-33
35. 10 and 34
36. limit 35 to yr="1990 - 2020"
37. 29 or 36

Database: EBM Reviews - Cochrane Central Register of Controlled Trials <September 2020>
Search Strategy:

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1 exp emergency medical services/ or exp "transportation of patients"/ or triage/
2 ("emt" or "ems" or "emergency medical" or field or "paramedic*" or "prehospital" or "pre- hospital" or transport* or trauma or traumatic).ti,ab,hw.
3 1 or 2
4 exp Airway Management/
5 (intubate or intubation or airway or ventilation or ventilatory).ti,ab,hw.
6 (endotracheal or supraglottic or tracheal or prehospital or "pre-hospital" or field).ti,ab,hw.
7 5 and 6
8 "bag valve mask".ti,ab,hw.
9 (airway adj5 manage*).ti,ab,hw.
10 4 or 7 or 8 or 9
11 3 and 10
12 limit 11 to yr="1990 - 2020"
13 conference abstract.pt.
14 "journal: conference abstract".pt.
15 "journal: conference review".pt.
16 "http://.www.who.int/trialsearch*".so.
17 "https://clinicaltrials.gov*".so.
18 13 or 14 or 15 or 16 or 17
19 11 not 18
20 limit 19 to medline records
21 19 not 20

Database: EBM Reviews - Cochrane Database of Systematic Reviews <2005 to September 8, 2020>

Search Strategy:

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1 ("emt" or "ems" or "emergency medical" or field or "paramedic*" or "prehospital" or "pre-hospital" or transport* or trauma or traumatic).ti,ab.
2 (intubate or intubation or airway or ventilation or ventilatory).ti,ab.
3 (endotracheal or supraglottic or tracheal or prehospital or "pre-hospital" or field).ti,ab.
4 2 and 3
5 "bag valve mask".ti,ab.
6 (airway adj5 manage*).ti,ab.
7 4 or 5 or 6
8 1 and 7

Database: EBSCOHost CINAHL PLUS September 8, 2020
S1 "emt" or "ems" or "emergency medical" or field or "paramedic*" or "prehospital" or "pre- hospital" or transport* or trauma or traumatic
S2 intubate or intubation or airway or ventilation or ventilatory
S3 endotracheal or supraglottic or tracheal or prehospital or "pre-hospital" or field
S4 bag valve mask
S5 "airway management"
S6 (MH "Airway Management+")
S7 (MH "Prehospital Care")
S8 S6 AND S7
S9 S2 AND S3
S10 S4 OR S9
S11 S1 AND S10
S12 S8 OR S11
S13 (MH "Experimental Studies+") OR (MH "Retrospective Design")
S14 random* or control* or trial or cohort or case* or prospective or retrospective
S15 S13 OR S14
S16 S12 AND S15
S17 Limiters - Published Date: 19900101-20201231; English Language; Exclude MEDLINE records

Database: Elsevier Scopus September 8, 2020
PUBYEAR > 1990 ((TITLE ("emt" OR "ems" OR "emergency medical" OR field OR "paramedic*" OR "prehospital" OR "pre-hospital" OR transport* OR trauma OR traumatic)) AND (((TITLE (intubate OR intubation OR airway OR ventilation OR ventilatory) AND TITLE (endotracheal OR supraglottic OR tracheal OR prehospital OR "pre-hospital" OR field))) OR (TITLE ("bag valve mask" OR "airway management")))) AND (TITLE (random* OR control OR trial OR cohort OR case* OR prospective OR retrospective))

Inclusion and Exclusion Criteria

The criteria for inclusion and exclusion of studies are based on the Key Questions and organized using the PICOS framework below (Table A-1).

Table A-1. PICOS

PICOS	Inclusion Criteria	Exclusion Criteria
Populations	Patients requiring prehospital ventilatory support or airway protection who are treated in the prehospital setting by emergency medical services personnel (paramedic, advanced emergency medical technician, emergency medical technician, emergency medical responder, etc.)	• Patients treated with naloxone to reverse opioid-related respiratory failure • Patients cared for in other than the prehospital setting

Interventions	• Bag valve mask ventilation
	• Supraglottic airway insertion, including dual-lumen airways
	• Endotracheal intubation
	  ○ Via direct laryngoscopy with or without RSI or DSI
	  ○ Via video laryngoscopy with or without RSI or DSI
		• Nasotracheal intubation
		• Percutaneous devices
		• Surgical airway procedures
		• CPAP and BiPAP

Comparators	KQ1: bag valve mask vs. supraglottic airway KQ2: bag valve mask vs. endotracheal intubation KQ3: supraglottic airway vs. endotracheal intubation KQ4: different techniques for any one of the three included types of airways	• No airway management • Prehospital vs. in-hospital

Outcomes	<u>Patient Health Outcomes (highest priority)</u>
	• Mortality/survival
	  ○ To arrival at hospital
	  ○ To hospital discharge
	  ○ Any period less than or equal to 30 days post-injury
	• Morbidity
	  ○ Glasgow Outcome Scale, Glasgow Outcome Scale Extended, Modified Rankin Scale, Cerebral Performance Category
	  ○ Pneumothorax
	  ○ Aspiration pneumonia
	• Length of stay
	  ○ Hospital length of stay (days)
	  ○ ICU length of stay (days)
	  ○ ICU-free days
	<u>Intermediate outcomes (secondary priority)</u>
	• Overall success rate[1]
	• First-pass success rate
	• Number of prehospital attempts to secure an airway
	• $EtCO_2$ values
	• Effective oxygenation
	• Effective ventilation
	• Definitive Airway Sans Hypoxia/Hypotension on First Attempt (DASH-1A)
	• ROSC
	<u>Adverse events/harms</u>
	• Vomiting
	• Gastric content aspiration
	• Hypoxia (SpO_2<90%)
	• Hyperventilation ($EtCO_2$<35)
	• Hypoventilation ($EtCO_2$>45)
	• Hypotension (low SBP or MAP)
	• Oral trauma, airway trauma
	• Barotrauma
	• Misplaced tube
	• Need for additional airway interventions
		• Long-term outcomes (more than 30 days post-injury)
		• Adrenal inhibition
		• Time in field
		• Time to resuscitation
		• Ventilator associated pneumonia
		• $HC0_3$
		• Tracheal stenosis

PICOS	Inclusion Criteria	Exclusion Criteria
Setting	• Prehospital • ED only if needed to fill important gaps where there are no prehospital studies • International studies in English language	• Airway studies conducted in cadaver labs, or simulated environments; operating rooms, or inpatient. • ED studies if prehospital studies of the topic are available.
Study Design	• RCTs • Prospective comparative studies • Retrospective comparative studies • Case control studies	• Systematic reviews (we will use reference lists to identify studies for possible inclusion) • Case series • Descriptive studies • Letters to the editor • Opinion papers • Studies published prior to 1990

BiPAP = bilevel positive airway pressure; CPAP = continuous positive airway pressure; DSI = delayed sequence intubation; ED = emergency department; ICU = intensive care unit; KQ = Key Question; MAP = mean arterial pressure; PICOS = population, interventions, comparaters, outcomes, setting, study design; RCT = randomized controlled trial; RSI = rapid sequence intubation; SBP = systolic blood pressure

[l]Included studies reported successful airway management with BVM in different ways. Although the BVM approach does not require airway insertion, BVM success was compared to that of SGA and ETI. These comparisons are reported in the Results sections.

Study design. For all Key Questions, we included randomized controlled trials (RCTs). We also included uncontrolled clinical trials, prospective and retrospective comparative observational studies, and case-control studies. For all Key Questions, we excluded case series, descriptive studies, letters to the editor, opinion papers, and case reports. Reference lists from systematic reviews were examined to identify additional studies not captured in our search.

Non-English language studies. We restricted our search to English-language articles, but reviewed English-language abstracts of non-English language articles to identify studies that would otherwise meet inclusion criteria, in order to help assess for the likelihood of language bias.

Process for selecting studies. Pre-established criteria were used to determine eligibility for inclusion and exclusion of abstracts in accordance with the *AHRQ Methods Guide for Effectiveness and Comparative Effectiveness Reviews* (hereafter "AHRQ Methods Guide"),[1] based on the Key Questions and PICOS. To ensure accuracy, all excluded abstracts were dual reviewed to confirm exclusion. All abstracts deemed potentially appropriate for inclusion by at least one of the reviewers triggered retrieval of the full-text article. Each full-text article was independently reviewed for eligibility by two team members, including any articles suggested by peer reviewers, or any that arose from the public posting process. During abstract and full-text review, all RCTs and comparative observational studies were retained and categorized according to which Key Questions they address. Authors of a paper who are on the research team did not review their own publications. Disagreements between the two team members were resolved by consensus of the investigators.

Additional selection of studies for Key Question 4. The purpose of Key Question 4 was to look for variation in outcomes from the use of one of the three airway approaches that may not be reported in the head-to-head studies included in Key Questions 1-3. We sought to increase our understanding of how patient characteristics, provider characteristics, and different airway devices and approaches might influence outcomes. After identifying all publications that might meet the criteria for Key Question 4, we eliminated studies for which there was only one paper for the topic, or the studies were too heterogeneous to compare. We further eliminated studies of

a single intervention reporting outcomes based on variations in Provider Category. The rationale was, there are a sufficient number of studies of the head-to-head comparisons in the first three Key Questions to provide information about how this modifier influences outcome. Of the remaining studies, 32 were meta-analyzed, all about variations in ETI. Twenty-eight studies about ETI and eight studies about SGA were qualitatively analyzed.

Data Extraction

After studies were selected for inclusion, data were abstracted into categories 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 above. Data were abstracted into an interactive database in order to facilitate meta-analyses. 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 was maintained (see Appendix D).

Risk of Bias Assessment of Individual Studies

Predefined criteria were used to assess the quality of included studies. The criteria used depended 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.[1] Randomized controlled trials were evaluated using selected Cochrane risk of bias criteria,[2] and observational studies were evaluated using criteria developed by the U.S. Preventive Services Task Force.[3]

Risk of Bias ratings were provided based on outcomes used in studies. Therefore, some studies were given an overall rating of "low," "moderate," or "high" risk of bias, whereas other studies were given multiple ratings based on risk of bias specific to different outcomes. Study-specific ratings can be found in Appendix G.

Studies rated "low" are considered to have the least risk of bias, be of high quality, and their results are generally considered valid. Low risk of bias intervention studies include clear descriptions of the population, setting, interventions, and comparison groups; a valid method for allocating patients to treatment; low dropout rates and clear reporting of dropouts; appropriate means for preventing bias; and appropriate measurement of outcomes.

Studies rated "moderate" are susceptible to some bias, though not enough to necessarily invalidate the results. These studies may not meet all the criteria for a rating of low, but no flaw or combination of flaws is likely to cause major bias. The study may be missing information, making it difficult to assess limitations and potential problems. The moderate category is broad, and studies with this rating vary in their strengths and weaknesses.

Studies rated "high" have significant flaws that imply biases of various types that may invalidate the results. They have a serious or "fatal" flaw (or combination of flaws) in design, analysis, or reporting; large amounts of missing information; discrepancies in reporting; or serious problems in the delivery of the intervention. The results of these studies are at least as likely to reflect flaws in the study design as to show true difference between the compared interventions. We did not exclude studies rated high risk of bias a priori, but high risk of bias studies were considered less reliable than low risk of bias studies when synthesizing the evidence, particularly if there were inconsistencies in study results.

Two team members independently assessed risk of bias. Disagreements were resolved by consensus.

Data Synthesis and Analysis

We constructed evidence tables showing study characteristics, results, and quality ratings for all included studies, along with summary tables to highlight the main findings. Results were organized by Key Question, and stratified by major subgroups.

Meta-analyses (Appendix H and Appendix I), using profile-likelihood random effects model,[4] 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).[5] 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.[6]

The Key Questions were designed to assess the comparative effectiveness and harms by airway intervention, emergency medical services (EMS) personnel, and patient characteristics. Therefore, meta-analyses were stratified by study design (e.g., randomized controlled trials [RCTs] or observational studies), emergency type (e.g. cardiac arrest, trauma), and population age (adult, pediatric, mixed age). Controlled clinical trials (CCTs) were grouped with either RCTs or observational studies in meta-analyses based on the characteristics of the study. If a study provided data for more than one definition of ROSC, we used in order of preference: sustained ROSC, any ROSC, prehospital ROSC. For neurological function, we did not pool across different measures. 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. Studies with mixed age population were grouped with the adult studies for stratification in the primary analyses. Sensitivity analyses were conducted by using other reported data (e.g., data from per-protocol, or as treated analysis for RCTs, unadjusted results), or by excluding studies with outlying results, those rated as high risk of bias, and studies in mixed age populations, as separate analyses.

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).

Qualitative Synthesis

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).

Grading the Strength of the Body of Evidence

Regardless of whether evidence was synthesized quantitatively or qualitatively, the strength of evidence for each Key Question/body of evidence was initially assessed by one researcher for each clinical outcome (see PICOS, Table A-1) by using the approach described in the AHRQ Methods Guide.[1] 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:

- Study risk of bias (low, moderate, or high level of risk of bias)
- Consistency (consistent, inconsistent, or unknown/not applicable)
- Directness (direct or indirect)
- Precision (precise or imprecise)
- Reporting bias (suspected or undetected)

Concern for publication bias was addressed by conducting searches for grey literature, responding to suggestions from public postings, and requesting additional information from authors if needed.

The strength of evidence was assigned an overall grade of high, moderate, low, or insufficient according to a four-level scale by evaluating and weighing the combined results of the above domains (Table A-2).

Table A-2. Definitions of the grades of overall strength of evidence

Grade	Definition
High	We are very confident that the estimate of effect lies close to the true effect for this outcome. The body of evidence has few or no deficiencies. We believe that the findings are stable (i.e., another study would not change the conclusions).
Moderate	We are moderately confident that the estimate of effect lies close to the true effect for this outcome. The body of evidence has some deficiencies. We believe that the findings are likely to be stable, but some doubt remains.
Low	We have limited confidence that the estimate of effect lies close to the true effect for this outcome. The body of evidence has major or numerous deficiencies (or both). We believe that additional evidence is needed before concluding either that the findings are stable or that the estimate of effect is close to the true effect.
Insufficient	We have no evidence, we are unable to estimate an effect, or we have no confidence in the estimate of effect for this outcome. No evidence is available or the body of evidence has unacceptable deficiencies, precluding reaching a conclusion.

Appendix A References

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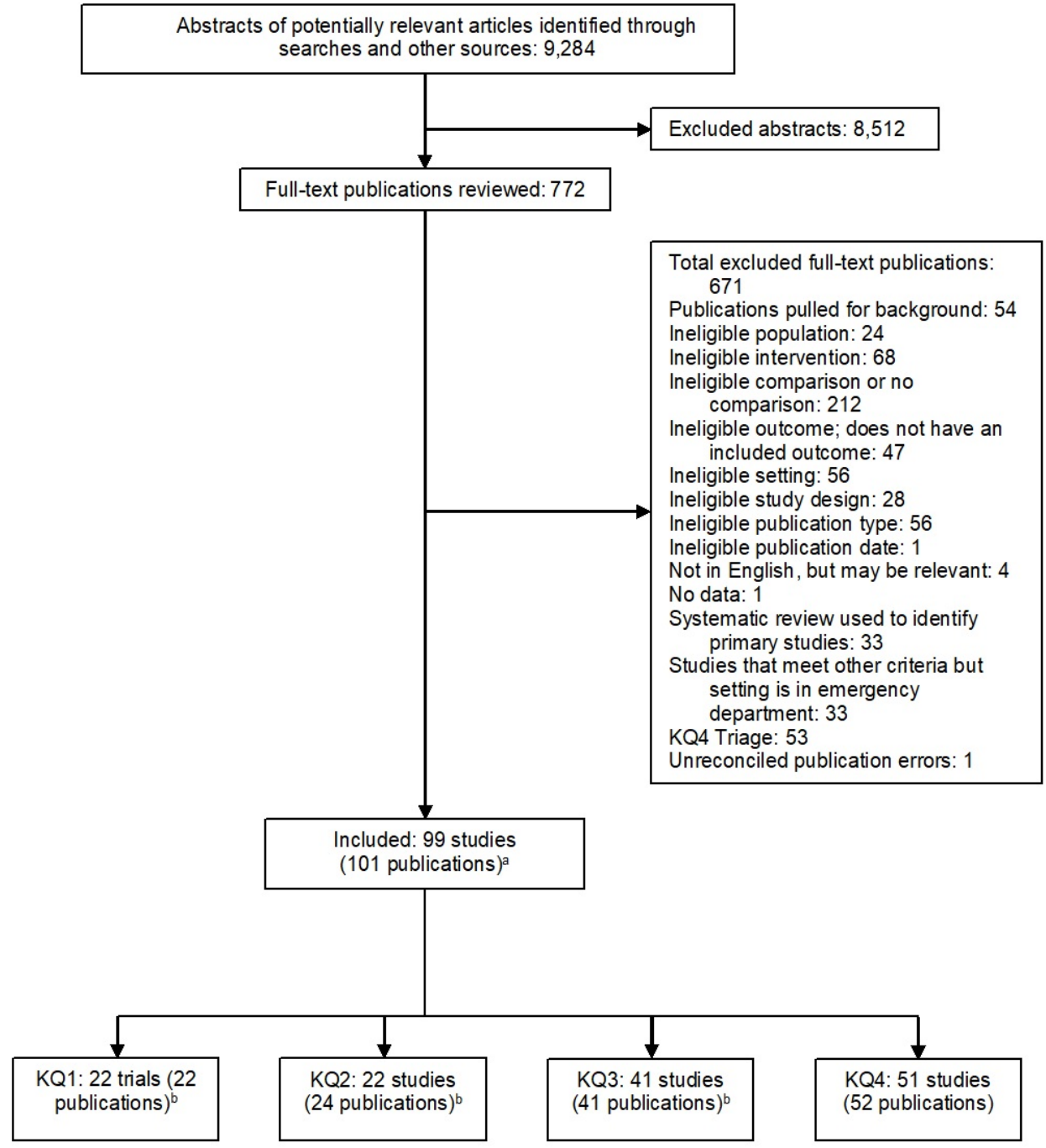
Appendix B. Literature Flow

Figure B-1. Literature flow diagram



KQ = Key Question
[a]Some included publications are counted in multiple sections
[b]Evans, 2016 was counted as two trials

Appendix C. Included Studies

1. Arima T, Nagata O, Miura T, et al. Comparative analysis of airway scope and Macintosh laryngoscope for intubation primarily for cardiac arrest in prehospital setting. Am J Emerg Med. 2014 Jan;32(1):40-3. doi: 10.1016/j.ajem.2013.09.026. PMID: 24176585.
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Appendix D. Excluded Studies

1. Bag-mask ventilation failed to improve on endotracheal intubation in cardiac arrest. RT: The Journal for Respiratory Care Practitioners. 2017;30(6):32-. Exclusion: Ineligible publication type.
2. Laryngeal vs endotracheal tubes after out of hospital cardiac arrest. RT: The Journal for Respiratory Care Practitioners. 2018;31(8):6-8. Exclusion: Ineligible study design.
3. Abdelgadir IS, Phillips RS, Singh D, et al. Videolaryngoscopy versus direct laryngoscopy for tracheal intubation in children (excluding neonates). Cochrane Database Syst Rev. 2017 May 24;5:CD011413. doi: 10.1002/14651858.CD011413.pub2. PMID: 28539007. Exclusion: Systematic review used to identify primary studies.
4. Abid ES, McNamara J, Hall P, et al. The impact of videolaryngoscopy on endotracheal intubation success by a pediatric/neonatal critical care transport team. Prehosp Emerg Care. 2020 May 15:1-8. doi: 10.1080/10903127.2020.1761492. PMID: 32347776. Exclusion: Ineligible setting.
5. Abrons RO, Zimmerman MB, El-Hattab YMS. Nasotracheal intubation over a bougie vs. non-bougie intubation: a prospective randomised, controlled trial in older children and adults using videolaryngoscopy. Anaesthesia. 2017 Dec;72(12):1491-500. doi: 10.1111/anae.14029. PMID: 28921537. Exclusion: Ineligible intervention.
6. Adams BD, Cuniowski PA, Muck A, et al. Registry of emergency airways arriving at combat hospitals. J Trauma. 2008 Jun;64(6):1548-54. doi: 10.1097/TA.0b013e3181728c41. PMID: 18545122. Exclusion: Ineligible comparison or no comparison.
7. Adams JN, Sirel J, Marsden K, et al. Heartstart Scotland: the use of paramedic skills in out of hospital resuscitation. Heart. 1997 Oct;78(4):399-402. doi: 10.1136/hrt.78.4.399. PMID: 9404259. Exclusion: Ineligible comparison or no comparison.
8. Adams K, Scott R, Perkin RM, et al. Comparison of intubation skills between interfacility transport team members. Pediatr Emerg Care. 2000 Feb;16(1):5-8. doi: 10.1097/00006565-200002000-00002. PMID: 10698134. Exclusion: Ineligible setting.
9. Adhikari DD, Mahathi K, Ghosh U, et al. Impact of pre-hospital care on the outcome of children arriving with agonal breathing to a pediatric emergency service in South India. J Family Med Prim Care. 2016 Jul-Sep;5(3):625-30. doi: 10.4103/2249-4863.197321. PMID: 28217595. Exclusion: Ineligible comparison or no comparison.
10. Adib-Hajbaghery M, Maghaminejad F. Epidemiology of patients with multiple trauma and the quality of their prehospital respiration management in kashan, iran: six months assessment. Arch Trauma Res. 2014 Jun;3(2):e17150. doi: 10.5812/atr.17150. PMID: 25147774. Exclusion: Ineligible outcome.
11. Adnet F, Cydulka RK, Lapandry C. Emergency tracheal intubation of patients lying supine on the ground: influence of operator body position. Can J Anaesth. 1998 Mar;45(3):266-9. doi: 10.1007/BF03012914. PMID: 9579267. Exclusion: KQ4 Triage.
12. Adnet F, Jouriles NJ, Le Toumelin P, et al. Survey of out-of-hospital emergency intubations in the French prehospital medical system: a multicenter study. Ann Emerg Med. 1998b Oct;32(4):454-60. doi: 10.1016/s0196-0644(98)70175-1. PMID: 9774930. Exclusion: Ineligible comparison or no comparison.
13. Agro F, Frass M, Benumof J, et al. The esophageal tracheal combitube as a non-invasive alternative to endotracheal intubation. A review. Minerva Anestesiol. 2001 Dec;67(12):863-74. PMID: 11815747. Exclusion: Ineligible publication type.
14. Agro FE, Cataldo R, Mattei A. New devices and techniques for airway management. Minerva Anestesiol. 2009 Mar;75(3):141-9. PMID: 18946431. Exclusion: Ineligible publication type.

15. Albrecht E, Yersin B, Spahn D, et al. Success rate of airway management by residents in a pre-hospital emergency setting: a retrospective study. European Journal of Trauma. 2006;32(6):516-22. Exclusion: Ineligible comparison or no comparison.

16. Al-Ghamdi AA, El Tahan MR, Khidr AM. Comparison of the Macintosh, GlideScope, Airtraq, and King VisionTM laryngoscopes in routine airway management. Minerva Anestesiol. 2016 Dec;82(12):1278-87. PMID: 27103030. Exclusion: Ineligible setting.

17. Ali QE, Das B, Amir SH, et al. Comparison of the Airtraq and McCoy laryngoscopes using a rigid neck collar in patients with simulated difficult laryngoscopy. J Clin Anesth. 2014 May;26(3):199-203. doi: 10.1016/j.jclinane.2013.10.012. PMID: 24809787. Exclusion: Ineligible comparison or no comparison.

18. Alikhanizadeh H, Sabouhi F, Haghani F, et al. A study of emergency medical technicians' cognitive and practical skills in airway management and its relationship with some related factors in emergency medical centers selected in Isfahan in the year 2015–2016. Annals of Tropical Medicine & Public Health. 2017;10(6):1691-7. Exclusion: Ineligible comparison or no comparison.

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20. Allen TL, Delbridge TR, Stevens MH, et al. Intubation success rates by air ambulance personnel during 12-versus 24-hour shifts: does fatigue make a difference? Prehosp Emerg Care. 2001 Oct-Dec;5(4):340-3. doi: 10.1080/10903120190939481. PMID: 11642582. Exclusion: Ineligible outcome.

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22. Altun D, Ali A, Camci E, et al. Haemodynamic response to four different laryngoscopes. Turk J Anaesthesiol Reanim. 2018 Dec;46(6):434-40. doi: 10.5152/TJAR.2018.59265. PMID: 30505605. Exclusion: Ineligible setting.

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24. Andrusiek DL, Szydlo D, May S, et al. A comparison of invasive airway management and rates of pneumonia in prehospital and hospital settings. Prehosp Emerg Care. 2015;19(4):475-81. doi: 10.3109/10903127.2015.1005263. PMID: 25909984. Exclusion: Ineligible comparison or no comparison.

25. Angerman S, Kirves H, Nurmi J. A before-and-after observational study of a protocol for use of the C-MAC videolaryngoscope with a Frova introducer in pre-hospital rapid sequence intubation. Anaesthesia. 2018 Mar;73(3):348-55. doi: 10.1111/anae.14182. PMID: 29315473. Exclusion: Ineligible comparison or no comparison.

26. Anonymous. Study challenges standard airway management during cardiac arrests. Bmj. 2013 Jan 16;346:f253. doi: 10.1136/bmj.f253. PMID: 23325873. Exclusion: Ineligible publication type.

27. Archambault P, Dionne CE, Lortie G, et al. Adrenal inhibition following a single dose of etomidate in intubated traumatic brain injury victims. CJEM, Can. 2012 Sep;14(5):270-82. doi: 10.2310/8000.2012.110560. PMID: 22967694. Exclusion: Ineligible outcome.

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33. Aydogmus MT, Eksioglu B, Oba S, et al. Comparison of laryngeal mask airway supreme and laryngeal mask airway proseal for laryngopharyngeal trauma and postoperative morbidity in children. Braz J Anesthesiol. 2013 Nov-Dec;63(6):445-9. doi: 10.1016/j.bjane.2012.08.004. PMID: 24565340. Exclusion: Ineligible setting.

34. Babl FE, Vinci RJ, Bauchner H, et al. Pediatric pre-hospital advanced life support care in an urban setting. Pediatr Emerg Care. 2001 Feb;17(1):5-9. doi: 10.1097/00006565-200102000-00002. PMID: 11265910. Exclusion: Ineligible comparison or no comparison.

35. Baekgaard JS, Eskesen TG, Sillesen M, et al. Ketamine as a rapid sequence induction agent in the trauma population: a systematic review. Anesth Analg. 2019 Mar;128(3):504-10. doi: 10.1213/ANE.0000000000003568. PMID: 29944524. Exclusion: Systematic review used to identify primary studies.

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38. Bankole S, Asuncion A, Ross S, et al. First responder performance in pediatric trauma: a comparison with an adult cohort. Pediatr Crit Care Med. 2011 Jul;12(4):e166-70. doi: 10.1097/PCC.0b013e3181f36f6e. PMID: 20729789. Exclusion: KQ4 Triage.

39. Bard MR, Goettler CE, Schenarts PJ, et al. Language barrier leads to the unnecessary intubation of trauma patients. Am Surg. 2004 Sep;70(9):783-6. PMID: 15481294. Exclusion: Ineligible outcome.

40. Barnard EB, Moy RJ, Kehoe AD, et al. Rapid sequence induction of anaesthesia via the intraosseous route: a prospective observational study. Emerg Med J. 2015 Jun;32(6):449-52. doi: 10.1136/emermed-2014-203740. PMID: 24963149. Exclusion: Ineligible intervention.

41. Barrett B, Guly HR. How long does it take to perform procedures on scene? Pre-hospital Immediate Care. 2000;4(1):25-9. Exclusion: Ineligible publication type.

42. Belpomme V, Ricard-Hibon A, Devoir C, et al. Correlation of arterial PCO2 and PETCO2 in prehospital controlled ventilation. Am J Emerg Med. 2005 Nov;23(7):852-9. doi: 10.1016/j.ajem.2005.04.011. PMID: 16291440. Exclusion: Ineligible comparison or no comparison.

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44. Benger JR, Voss S, Coates D, et al. Randomised comparison of the effectiveness of the laryngeal mask airway supreme, i-gel and current practice in the initial airway management of prehospital cardiac arrest (REVIVE-Airways): a feasibility study research protocol. BMJ Open. 2013;3(2)doi: 10.1136/bmjopen-2012-002467. PMID: 23408081. Exclusion: Ineligible outcome.

45. Benoit JL, Gerecht RB, Steuerwald MT, et al. Endotracheal intubation versus supraglottic airway placement in out-of-hospital cardiac arrest: a meta-analysis. Resuscitation. 2015a Aug;93:20-6. doi: 10.1016/j.resuscitation.2015.05.007. PMID: 26006743. Exclusion: Systematic review used to identify primary studies.

46. Benoit JL, McMullan JT, Wang HE, et al. Timing of advanced airway placement after witnessed out-of-hospital cardiac arrest. Prehosp Emerg Care. 2019 Nov-Dec;23(6):838-46. doi: 10.1080/10903127.2019.1595236. PMID: 30912467. Exclusion: Ineligible outcome.

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50. Berns SD, Patel RI, Chamberlain JM. Oral intubation using a lighted stylet vs direct laryngoscopy in older children with cervical immobilization. Acad Emerg Med. 1996 Jan;3(1):34-40. doi: 10.1111/j.1553-2712.1996.tb03300.x. PMID: 8749965. Exclusion: Ineligible setting.

51. Bertrand C, Hemery F, Carli P, et al. Constant flow insufflation of oxygen as the sole mode of ventilation during out-of-hospital cardiac arrest. Intensive Care Med. 2006 Jun;32(6):843-51. doi: 10.1007/s00134-006-0137-2. PMID: 16715326. Exclusion: Ineligible comparison or no comparison.

52. Bharti N, Mohanty B, Bithal PK, et al. Intra-ocular pressure changes associated with intubation with the intubating laryngeal mask airway compared with conventional laryngoscopy. Anaesth Intensive Care. 2008 May;36(3):431-5. doi: 10.1177/0310057x0803600315. PMID: 18564806. Exclusion: Ineligible outcome.

53. Bhende MS, LaCovey DC. End-tidal carbon dioxide monitoring in the prehospital setting. Prehosp Emerg Care. 2001 Apr-Jun;5(2):208-13. doi: 10.1080/10903120190940146. PMID: 11339734. Exclusion: Ineligible publication type.

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55. Bieler D, Franke A, Lefering R, et al. Does the presence of an emergency physician influence pre-hospital time, pre-hospital interventions and the mortality of severely injured patients? A matched-pair analysis based on the trauma registry of the German Trauma Society (TraumaRegister DGU). Injury. 2017 Jan;48(1):32-40. doi: 10.1016/j.injury.2016.08.015. PMID: 27586065. Exclusion: KQ4 Triage.

56. Bilge S, Aydin A, Bilge M, et al. A study on the tactical safety of endotracheal intubation under darkness. Mil Med. 2017 Jul;182(7):e1722-e5. doi: 10.7205/MILMED-D-16-00407. PMID: 28810964. Exclusion: Ineligible outcome.

57. Billups K, Larrimore A, Li J, et al. Impact of paralytic agent on postintubation sedation. Air Med J. 2019 Jan - Feb;38(1):39-44. doi: 10.1016/j.amj.2018.09.006. PMID: 30711084. Exclusion: Ineligible population.

58. Binks MJ, Holyoak RS, Melhuish TM, et al. Apneic oxygenation during intubation in the emergency department and during retrieval: a systematic review and meta-analysis. Am J Emerg Med. 2017 Oct;35(10):1542-6. doi: 10.1016/j.ajem.2017.06.046. PMID: 28684195. Exclusion: Ineligible intervention.

59. Bjoernsen LP, Lindsay B. Video laryngoscopy in the prehospital setting. Prehospital Disaster Med. 2009 May-Jun;24(3):265-70. doi: 10.1017/s1049023x00006919. PMID: 19618365. Exclusion: Ineligible publication type.

60. Blackburn MB, April MD, Brown DJ, et al. Prehospital airway procedures performed in trauma patients by ground forces in Afghanistan. J Trauma Acute Care Surg. 2018 Jul;85(1S Suppl 2):S154-S60. doi: 10.1097/TA.0000000000001866. PMID: 29521802. Exclusion: Ineligible comparison or no comparison.

61. Bloomer R, Burns BJ, Ware S. Improving documentation in prehospital rapid sequence intubation: investigating the use of a dedicated airway registry form. Emerg Med J. 2013 Apr;30(4):324-6. doi: 10.1136/emermed-2011-200715. PMID: 22505304. Exclusion: Ineligible intervention.

62. Bobrow BJ, Clark LL, Ewy GA, et al. Minimally interrupted cardiac resuscitation by emergency medical services for out-of-hospital cardiac arrest. JAMA. 2008 Mar 12;299(10):1158-65. doi: 10.1001/jama.299.10.1158. PMID: 18334691. Exclusion: Ineligible intervention.

63. Bobrow BJ, Ewy GA, Clark L, et al. Passive oxygen insufflation is superior to bag-valve-mask ventilation for witnessed ventricular fibrillation out-of-hospital cardiac arrest. Ann Emerg Med. 2009 Nov;54(5):656-62.e1. doi: 10.1016/j.annemergmed.2009.06.011. PMID: 19660833. Exclusion: Ineligible comparison or no comparison.

64. Bochicchio GV, Ilahi O, Joshi M, et al. Endotracheal intubation in the field does not improve outcome in trauma patients who present without an acutely lethal traumatic brain injury. J Trauma. 2003 Feb;54(2):307-11. doi: 10.1097/01.TA.0000046252.97590.BE. PMID: 12579056. Exclusion: Ineligible comparison or no comparison.

65. Boehringer B, Choate M, Hurwitz S, et al. Impact of video laryngoscopy on advanced airway management by critical care transport paramedics and nurses using the CMAC pocket monitor. Biomed Res Int. 2015;2015:821302. doi: 10.1155/2015/821302. PMID: 26167501. Exclusion: Ineligible setting.

66. Bosch J, de Nooij J, de Visser M, et al. Prehospital use in emergency patients of a laryngeal mask airway by ambulance paramedics is a safe and effective alternative for endotracheal intubation. Emerg Med J. 2014 Sep;31(9):750-3. doi: 10.1136/emermed-2012-202283. PMID: 23771898. Exclusion: Ineligible comparison or no comparison.

67. Bossers SM, Schwarte LA, Loer SA, et al. Experience in prehospital endotracheal intubation significantly influences mortality of patients with severe traumatic brain injury: a systematic review and meta-analysis. PLoS ONE. 2015;10(10):e0141034. doi: 10.1371/journal.pone.0141034. PMID: 26496440. Exclusion: Systematic review used to identify primary studies.

68. Boswell WC, McElveen N, Sharp M, et al. Analysis of prehospital pediatric and adult intubation. Air Med J. 1995 Jul-Sep;14(3):125-7; discussion 7-8. doi: 10.1016/1067-991x(95)90513-8. PMID: 10151151. Exclusion: Ineligible comparison or no comparison.

69. Boyle MF, Hatton D, Sheets C. Surgical cricothyrotomy performed by air ambulance flight nurses: a 5-year experience. J Emerg Med. 1993 Jan-Feb;11(1):41-5. doi: 10.1016/0736-4679(93)90008-u. PMID: 8445185. Exclusion: Ineligible intervention.

70. Brainard C. Whose tube is it? San Diego ensures complete airway control via airway paramedics & capnography. JEMS. 2006;31(3):62-8. Exclusion: Ineligible publication type.

71. Brandling J, Rhys M, Thomas M, et al. An exploration of the views of paramedics regarding airway management. Scand J Trauma Resusc Emerg Med. 2016 Apr 27;24:56. doi: 10.1186/s13049-016-0243-2. PMID: 27121111. Exclusion: Ineligible study design.

72. Braude D, Dixon D, Torres M, et al. Brief research report: prehospital rapid sequence airway. Prehosp Emerg Care. 2020 Jul 22:1-5. doi: 10.1080/10903127.2020.1792015. PMID: 32628568. Exclusion: Ineligible study design, Ineligible comparison or no comparison.

73. Brazinova A, Majdan M, Leitgeb J, et al. Factors that may improve outcomes of early traumatic brain injury care: prospective multicenter study in Austria. Scand J Trauma Resusc Emerg Med. 2015 Jul 16;23:53. doi: 10.1186/s13049-015-0133-z. PMID: 26179747. Exclusion: Ineligible intervention.

74. Breckwoldt J, Klemstein S, Brunne B, et al. Difficult prehospital endotracheal intubation - predisposing factors in a physician based EMS. Resuscitation. 2011 Dec;82(12):1519-24. doi: 10.1016/j.resuscitation.2011.06.028. PMID: 21749908. Exclusion: Ineligible outcome.

75. Brimacombe J, Keller C. Gum elastic bougie-guided insertion of the ProSeal laryngeal mask airway. Anaesth Intensive Care. 2004a Oct;32(5):681-4. doi: 10.1177/0310057X0403200514. PMID: 15535495. Exclusion: Ineligible setting.

76. Brimacombe J, von Goedecke A, Keller C, et al. The laryngeal mask airway Unique versus the Soft Seal laryngeal mask: a randomized, crossover study in paralyzed, anesthetized patients. Anesth Analg. 2004b Nov;99(5):1560-3; table of contents. doi: 10.1213/01.ANE.0000133916.10017.6D. PMID: 15502065. Exclusion: Ineligible setting.

77. Broderick ED, Reed JJ. EMS, Pros and Cons of Drug-assisted Intubation. StatPearls Publishing. 2018 Jan;01:01. PMID: 30085511. Exclusion: Ineligible publication type.

78. Brown CA, 3rd, Cox K, Hurwitz S, et al. 4,871 emergency airway encounters by air medical providers: a report of the air transport emergency airway management (NEAR VI: "A-TEAM") project. West J Emerg Med. 2014 Mar;15(2):188-93. doi: 10.5811/westjem.2013.11.18549. PMID: 24672610. Exclusion: Ineligible setting.

79. Brown JB, Rosengart MR, Forsythe RM, et al. Not all prehospital time is equal: Influence of scene time on mortality. J Trauma Acute Care Surg. 2016 Jul;81(1):93-100. doi: 10.1097/TA.0000000000000999. PMID: 26886000. Exclusion: Ineligible outcome.

80. Brown LH, Fullagar CJ. Research review. Comparison of etomidate & midazolam for RSI. JEMS. 2004;29(10):42-4. Exclusion: Ineligible publication type.

81. Brown LH, Hubble MW, Wilfong DA, et al. Airway management in the air medical setting. Air Med J. 2011 May-Jun;30(3):140-8. doi: 10.1016/j.amj.2010.11.010. PMID: 21549286. Exclusion: Systematic review used to identify primary studies.

82. Brown LH, Prasad NH. Research review. Prehospital intubation outcomes for TBI. JEMS: Journal of Emergency Medical Services. 2005;30(2):40-1. Exclusion: Ineligible intervention.

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Appendix E. Study Characteristics Evidence Table

Shown in associated Excel® file.

Appendix F. Outcomes Evidence Table

Shown in associated Excel® file.

Appendix G. Risk of Bias

Table G-1. Risk of bias for randomized controlled trials (part 1 of 2)

Author, Year	Key Question	1. Was Randomization Adequate?	2. Was the Allocation of Treatment Adequately Concealed?	3. Were Groups Similar at Baseline?	4. Was Analysis Intent to Treat?	5. Did Analyses Include All Eligible Trial Participants Postrandomization (i.e., Were Not Excluded)?	6. Was Loss to Followup or Missing Data 20% or Less?	7. Were Comparable Groups Maintained?
Arima, 2014	4	Unclear	Yes	No	Yes	No	Yes	Yes
Benger, 2016	4	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Benger, 2018	3	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bernard, 2010	2	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chan, 2020a	4	Yes	NR	Yes	Yes	Yes	Yes	Yes
Ducharme, 2017	4	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes
Fiala, 2017	1	NR	Yes	Yes	Yes	Yes	Yes	Yes
Frascone, 2011	3	Yes	No	Yes	Yes	No	Yes	Yes
Jabre, 2011	4	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jabre, 2018	2	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Khosravan, 2015	3	Yes	Unclear	Yes	No	Yes	Yes	Yes
Kreutziger, 2019	4	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Macke, 2020	4	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Malinverni, 2019	2	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Middleton, 2014	4	Yes	No	Yes	Yes	Yes	No	Unclear
Ono, 2014	4	Unclear	No	Yes	Yes	No	Yes	Yes
Rabitsch, 2003	3	No	No	Yes	Unclear	Yes	Yes	Yes
Rumball, 1997	1, 4	Yes	Yes	Yes	Yes	Yes	Unclear	Yes for success, no for Pco2 and Po2
Trimmel, 2011	4	Yes	No	Yes	No	Yes	Yes	Yes
Trimmel, 2016	4	Yes	No	Yes	Yes	Yes	Yes	Yes
Wang, 2018 Lupton, 2020	1, 2, 3	Yes	NR	Unclear	Yes	Yes	Yes	Yes

NR = not reported

Table G-2. Risk of bias for randomized controlled trials (part 2 of 2)

Author, Year	Key Question	8. Were Outcomes Assessed Using Valid and Reliable Measures?	9. Was Outcome Measurement or Ascertainment Similar Between Groups?	10. Were Outcome Assessors Blinded, or Were Outcomes Objectively Measured?	11. Were Outcomes Prespecified and Were Primary/Prespecified Outcomes Reported?	Was the Study Registered?	Risk of Bias Quality Rating
Arima, 2014	4	Yes	Yes	Yes	Yes	NR	Moderate
Benger, 2016	4	Yes	Yes	Yes for clinical outcomes, no for process outcomes	Yes	Yes	Low for clinical outcomes, moderate for process outcomes
Benger, 2018	3	Yes	Yes	Yes	Yes	Yes	Low
Bernard, 2010	2	Yes	Yes	Yes	Yes	NR	Low
Chan, 2020a	4	Success: Unclear ROSC: Yes	Yes	Success: No ROSC: Yes	Yes	No	Success: Moderate ROSC: Low
Ducharme, 2017	4	Yes	Yes	Unclear	Yes	NR	High
Fiala, 2017	1	Unclear	Yes	No	Yes	Yes	Moderate
Frascone, 2011	3	Yes	Yes	No	Yes	NR	Moderate
Jabre, 2011	4	Yes	Yes	Yes	Yes	NR	Low
Jabre, 2018	2	Yes	Yes	Yes	Yes	Yes	Low
Khosravan, 2015	3	Yes	Yes	Yes	Yes	Yes	Moderate
Kreutziger, 2019	4	Yes	Unclear	Unclear	Yes	NR	Moderate
Macke, 2020	4	Yes	Yes	Yes	Yes	No	Low
Malinverni, 2019	2	NR	NR	NR	NR	Yes	Moderate
Middleton, 2014	4	Yes	Yes	Yes	Yes	Yes	High
Ono, 2014	4	Unclear	Yes	NR for CPC, unclear for success.	Yes	NR	Moderate for success, survival, and ROSC, high for CPC.
Rabitsch, 2003	3	Yes	Yes	Yes	Yes	NR	Low
Rumball, 1997	1, 4	No for success, yes for blood gasses	Yes	No for success, yes for blood gasses	Yes	NR	Moderate
Trimmel, 2011	4	Unclear	Yes	No blinding. Unclear if provider confirmed own placement.	Yes	NR	High
Trimmel, 2016	4	Yes	Yes	No blinding	Yes	NR	Moderate
Wang, 2018 Lupton, 2020	1, 2, 3	Yes	Yes	Yes for survival and ROSC, blinding NR for Modified Rankin Scale, no for success	Yes	Yes	Low for Survival and ROSC, moderate for Modified Rankin Scale, and success

CPC = Cerebral Performance Category Score; NR = not reported, ROSC = return of spontaneous circulation

Table G-3. Risk of bias for controlled clinical trials

Author, Year	Key Question	1. Was the Group Allocation Protocol Sufficient To Minimize Group Differences?	2. Was the Allocation of Treatment Adequately Concealed?	3. Were Groups Similar at Base-line?	4. Did Analyses Include All Eligible Trial Participants After Group Allocation (i.e., Were Not Excluded)?	5. Was Loss to Follow-up or Missing Data 20% or Less?	6. Was There Minimal Differen-tial Loss to Followup or Missing Data?	7. Were Outcomes Assessed Using Valid and Reliable Measures?	8. Was Measurement or Ascertain-ment Similar Between Groups?	9. Were Outcome Assessors Blinded, or Were Outcomes Objectively Measured?	10. Were Outcomes Pre-Specified and Were Primary/ Pre-Specified Outcomes Reported?	Was the Study Registered ?	Risk of Bias Quality Rating
Bartlett, 1992	3	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	No	High
Bozeman, 2006	4	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Moderate
Gausche, 2000	2, 4	Yes	NA	Yes	Yes	Yes	Yes	Yes for mortality, unclear for function	Yes	Yes for mortality, unclear for PCPC	Yes	No	Low for mortality, moderate for PCPC
Maignan, 2015	1	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Moderate
Rumball, 2004	3	Unclear	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Moderate
Sos-Kanto, 2009	1	NR	NR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Low

NA = not applicable, NR = not reported, PCPC = pediatric cerebral performance category

Table G-4. Risk of bias for prospective cohort studies

Author, Year	Key Question	1. Did the Study Attempt To Enroll or Include All or a Random Sample of Patients Meeting Inclusion Criteria?	2. Were the Groups Similar at Baseline, or Did the Design or Analysis Account for Important Confounding and Modifying Variables?	3. Was Loss to Followup or Missing Data 20% or Less?	4. Were Comparable Groups Maintained? (Was There Minimal Differential Loss to Followup or Missing Data?)	5. Were Outcomes Prespecified and Were Primary/ Prespecified Outcomes Reported?	6. Were Outcomes Assessed Using Valid and Reliable Measures?	7. Were Outcome Assessors Blinded, or Were Outcomes Objectively Measured?	Was the Study (Protocol) Registered ?	Risk of Bias Quality Rating
Breeman, 2020	4	Yes	Unclear	Yes	Unclear	Yes	Yes	Yes	No	Moderate
Eich, 2009	4	Yes	No	Yes	Yes	Yes	Yes	No	No	Moderate
Hankins, 1993	3	Yes	Unclear/NR	Yes	Unclear	Yes	No	No	No	High
Hansen, 2020	1, 2, 3	Yes	No	Yes	No	Yes	Yes	Yes survival, no success	No	Moderate
Hiltunen, 2016	3	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Moderate for Success Rate
Jarman, 2017	3, 4	Yes	No	No	Yes	Yes	No for first-pass success, yes for ROSC.	Yes	No	Moderate
Kajino, 2011	3	Yes	Yes	Yes	Yes	Yes	Yes	Yes for ROSC and Survival NR for CPC	No	Low for ROSC and survival, high for CPC.
McCall, 2008	3	Yes	Unclear	NA	Yes	Yes	Yes	Yes	No	Moderate
McMahan, 1992	3	Yes	Yes	NA	Yes	Yes	Yes	Yes	No	Low
Myers, 2016	4	Yes	Unclear	Yes	Yes	Yes	Unclear	No	No	High
Prekker, 2014	4	Yes	Yes	Yes	N/A	Yes	Yes	No	No	Moderate
Risse, 2020	4	Yes	Unclear	Yes	Unclear	Yes	Yes	Yes	No	Moderate
Roth, 2015	1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Low
Sulzgruber, 2018	1, 2, 3	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	NR	Low for Mortality and ROSC, moderate for CPC
Sunde, 2015	4	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Moderate
Takei, 2010	1, 2, 3	Yes	No	Unclear	Yes for short-term outcomes, unclear for 1-month survival.	Yes	Yes	Yes	NR	Moderate for short-term outcomes, high for 1-month survival

CPC = cerebral performance category, NA = not applicable, NR = not reported, ROSC = return of spontaneous circulation

Table G-5. Risk of bias for before/after study designs

Author, Year	Key Question	1. Did the Study Attempt To Enroll or Include All or a Random Sample of Patients Meeting Inclusion Criteria?	2. Were the Groups Similar at Baseline, or Did the Design or Analysis Account for Important Confounding and Modifying Variables?	3. Were Groups Comparable Across Time Periods?	4. Were Outcome Assessors Blinded, or Were Outcomes Objectively Measured?	5. Was Loss to Followup or Missing Data 20% or Less?	6. Were Comparable Groups Maintained?	7. Were Outcomes Assessed Using Valid and Reliable Measures?	8. Were Outcomes Prespecified and Were Primary/ Prespecified Outcomes Reported?	Was the Study (Protocol) Registered?	Risk of Bias Quality Rating
Chien, 2012	1	Yes	Yes	Yes	Yes	No	Unclear	Yes	Yes	No	Moderate
Dos Santos, 2011	4	Unclear	Unclear	Unclear	No	Yes	NA	Yes	Yes	No	High
Frascone, 2013	Harms	Unclear - not all eligible providers agreed to participate	No	Unclear	No	Yes	Unclear	No for Success. Yes for Harms	Yes	No	High
Gahan, 2011	3	Yes	Yes	Unclear	Yes for harms, no for success	Yes	Yes	Yes	Yes	No	Low
Jabre, 2007	4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Low
Jarvis, 2015	4	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Moderate
Louka, 2018	4	Yes	Unclear	No	Unclear	Yes	Unclear	Unclear	Yes	No	High
Wayne, 2010	4	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	No	Moderate

NA = not applicable

Table G-6. Risk of bias for retrospective studies

Author, Year	Key Question	1. Was the Selection of Patients for Inclusion Unbiased?	2. Were the Groups Similar at Baseline, or Did the Design or Analysis Account for Important Confounding and Modifying Variables?	3. Were Outcome Assessors Blinded, or Were Outcomes Objectively Measured?	4. Were Outcomes Assessed Using Valid and Reliable Measures?	5. Were Outcomes Pre-specified and Were Primary/ Prespecified Outcomes Reported?	6. Was the Study (Protocol) Registered?	Risk of Bias Quality Rating
Becker, 2018	3	Yes	No	Yes	Yes	Yes	No	High
Behrens, 2020	3	Yes	Yes	Yes: mortality, ROSC No: neurological function (CPC)	Yes	Yes	No	Low: mortality, ROSC Moderate: neurological function
Bendinelli, 2018	4	Yes	Yes	Yes: mortality, length of stay No: success	Yes: mortality, length of stay No: success	Yes	No	Low: mortality, length of stay Moderate: success
Bulger, 2005	4	Yes	Yes	Yes	Yes (not using GCS)	Yes	No	Low

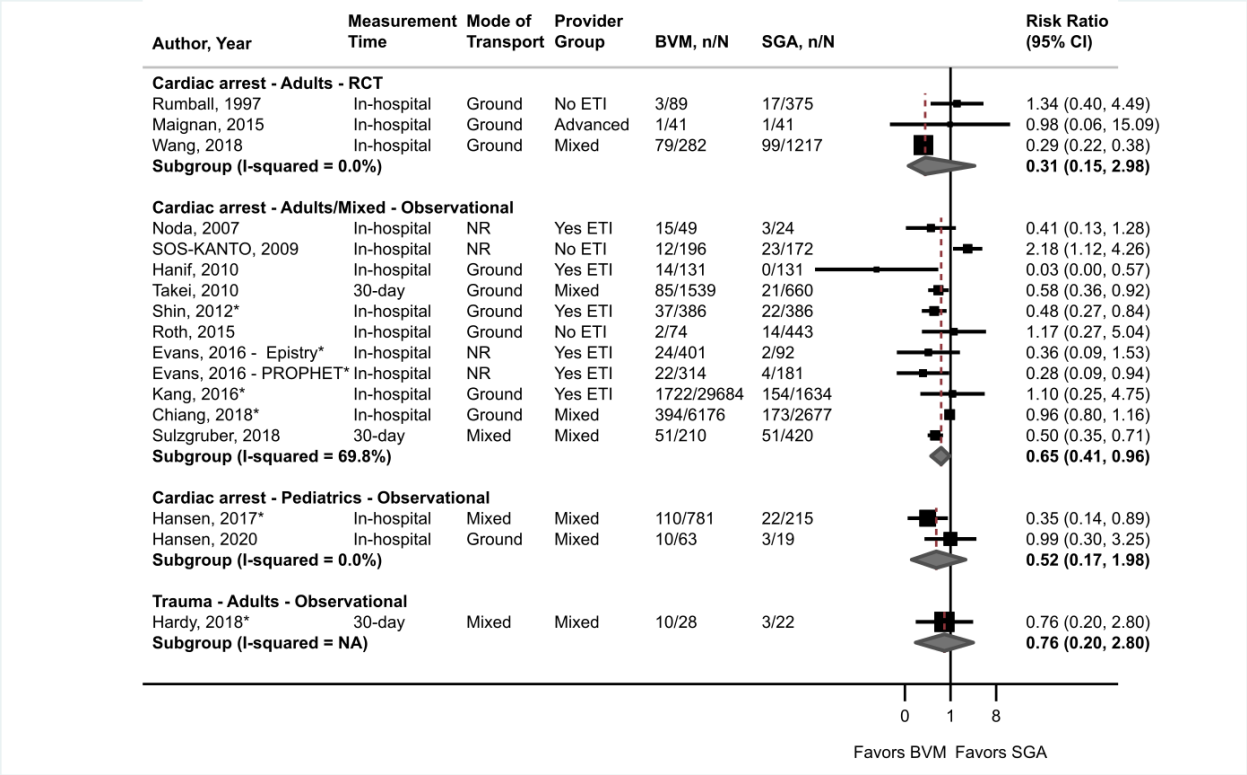
Author, Year	Key Question	1. Was the Selection of Patients for Inclusion Unbiased?	2. Were the Groups Similar at Baseline, or Did the Design or Analysis Account for Important Confounding and Modifying Variables?	3. Were Outcome Assessors Blinded, or Were Outcomes Objectively Measured?	4. Were Outcomes Assessed Using Valid and Reliable Measures?	5. Were Outcomes Pre-specified and Were Primary/ Prespecified Outcomes Reported?	6. Was the Study (Protocol) Registered?	Risk of Bias Quality Rating
Cady, 2005	3	Yes	Unclear	No	No	No	No	High
Chan, 2020b	4	Yes	Unclear	Yes	Yes	Yes	No	Moderate
Chiang, 2018	1, 2, 3	Yes	Yes	Yes	Yes	Yes	No	Low
Cooper, 2001	2	Unclear	No	No	Yes	Yes	No	High
Cudnik, 2010	4	Yes	Yes	Yes	Yes	Yes	No	Low
Davis, 2005	3	Yes	NR	Yes	No	Yes	No	Moderate
Delorenzo, 2018	4	Yes	No	Yes	Yes	Yes	No	Moderate
Duckett, 2014	3	Yes	NR	No	Unclear	Yes	No	High
Eberlein, 2019	4	Unclear	Yes	No	Unclear	Yes	No	High
Eckstein, 2000	2	Yes	Yes	Yes	Yes	Yes	No	Moderate
Edwards, 2019	3	Yes	Yes	No	Yes	Yes	No	Moderate
Evans, 2016	1, 2, 3	Yes	Yes	Yes	Yes	Yes	No	Moderate
Fouche, 2019	4	Yes	Yes	Yes	Yes	Yes	No	Low
Fukuda, 2020	3	Yes	Yes	Yes: mortality, ROSC No: neurological function (CPC)	Yes	Yes	No	Low: mortality, ROSC Moderate: neurological function
Gamberini, 2019	3	Yes	Unclear	Yes	Yes	Yes	No	Moderate
Garza, 2005	4	Yes	No	No	Yes	Yes	No	High
Gellerfors, 2014	4	Yes	NR	No	No	Yes	No	High
Hanif, 2010	1, 2, 3	Yes	Yes	Yes	Yes	Yes	No	Low
Hansen, 2017	1, 2, 3	Yes	Yes	Yes	Yes	Yes	No	Low
Hardy, 2018	1	Yes	No	Yes	Yes	Yes	No	Moderate
Hoffman, 2017	4	Yes	Unclear	Survival: Yes Neurological function (GOS): Unclear	Yes	Yes	No	Moderate
Hossfeld, 2020	4	Yes	Yes	No	Unclear	Yes	No	Moderate
Jarvis, 2019	3, 4	Yes	Yes	No	Unclear	Yes	No	High
Kang, 2016	1, 2, 3	Yes	Yes	Yes for survival, no for CPC, unclear for ROSC	Yes	Yes	No	Low for survival, moderate for CPC, moderate for ROSC
Kwok, 2013	4	Yes	Yes	Yes	Yes	Yes	No	Low
McMullan, 2014	3	No	Yes	Yes	Yes	Yes	No	Moderate
Murray, 2000	4	Yes	No	Yes	Yes	Yes	No	Moderate
Nagao, 2012	1, 2, 3	Yes	No	Yes	Yes	Yes	No	Moderate
Noda, 2007	1, 2, 3	Unclear	Unclear	Yes	Yes	Yes	No	High
Nwanne, 2020	3, 4	Yes	Unclear	No	No	Yes	No	High
Ohashi-Fukuda, 2017	1, 2, 3	Yes	Yes	Yes	Yes	Yes	No	Low

Author, Year	Key Question	1. Was the Selection of Patients for Inclusion Unbiased?	2. Were the Groups Similar at Baseline, or Did the Design or Analysis Account for Important Confounding and Modifying Variables?	3. Were Outcome Assessors Blinded, or Were Outcomes Objectively Measured?	4. Were Outcomes Assessed Using Valid and Reliable Measures?	5. Were Outcomes Pre-specified and Were Primary/ Prespecified Outcomes Reported?	6. Was the Study (Protocol) Registered?	Risk of Bias Quality Rating
Olvera, 2018	4	Yes	Unclear	Yes	Yes	Yes	No	High
Powell, 2019	4	Yes	Yes	Yes	Yes	Yes	No	Low
Prekker, 2016	4	Yes	Yes	No	Yes	Yes	No	Moderate
Rocca 2000	4	Yes	Unclear	No	Unclear	Yes	No	High
Shin, 2012	1, 2, 3	No	Yes	Yes	Yes	Yes	No	Moderate
Sobuwa, 2013	4	Yes	Unclear	Unclear	Yes	Yes	No	Moderate
Steuerwald, 2018	3	Unclear	Unclear	Yes	Yes	Yes	No	Moderate
Stockinger, 2004	2	Yes	Yes	Yes	Yes	Yes	No	Low
Studnek, 2010	4	Yes	Unclear	Yes	Yes	Yes	No	Moderate
Tanabe, 2013	3, 4	Yes	Yes	Yes	Yes	Yes	No	Low
Vilke, 1994	4	Yes	Unclear	Yes	Yes	No	No	Moderate
Wang, 2006	4	No	Unclear	No	Yes	Yes	No	High
Wang, 2012	3	Yes	Unclear	Yes	Yes	Yes	No	Low
Yanagawa, 2010	1, 2, 3	Yes	Yes	Yes for PROSC, no for CPC	Yes	Yes	No	Moderate
Yuksen, 2020	2	Yes	No	Yes	Yes	Yes	No	High

CPC = cerebral performance category; NR = not reported; PROSC = prehospital return of spontaneous circulation; ROSC = return of spontaneous circulation

Appendix H. Meta-Analysis: Primary Analyses

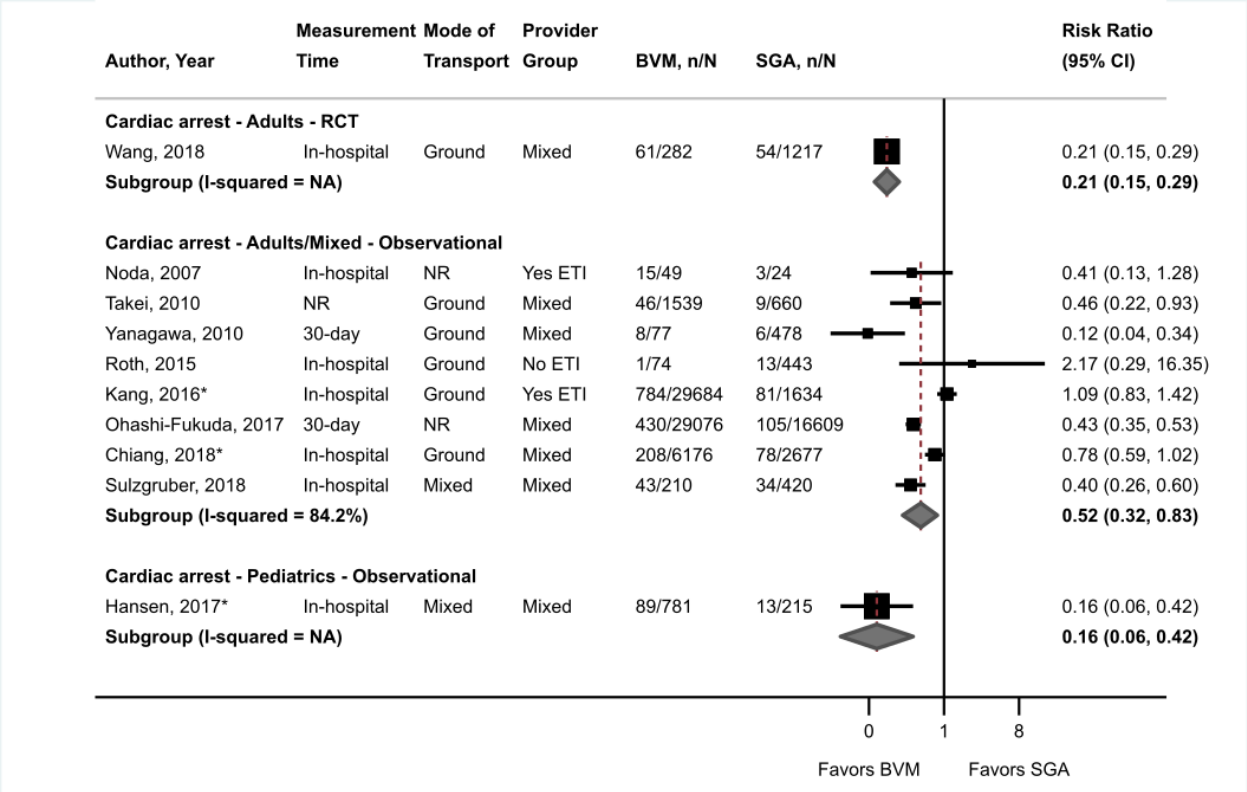
Figure H-1. BVM versus SGA (KQ1) pooled estimate of survival by emergency type, age, and study design



BVM = bag valve mask; CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported; RCT = randomized control trial; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

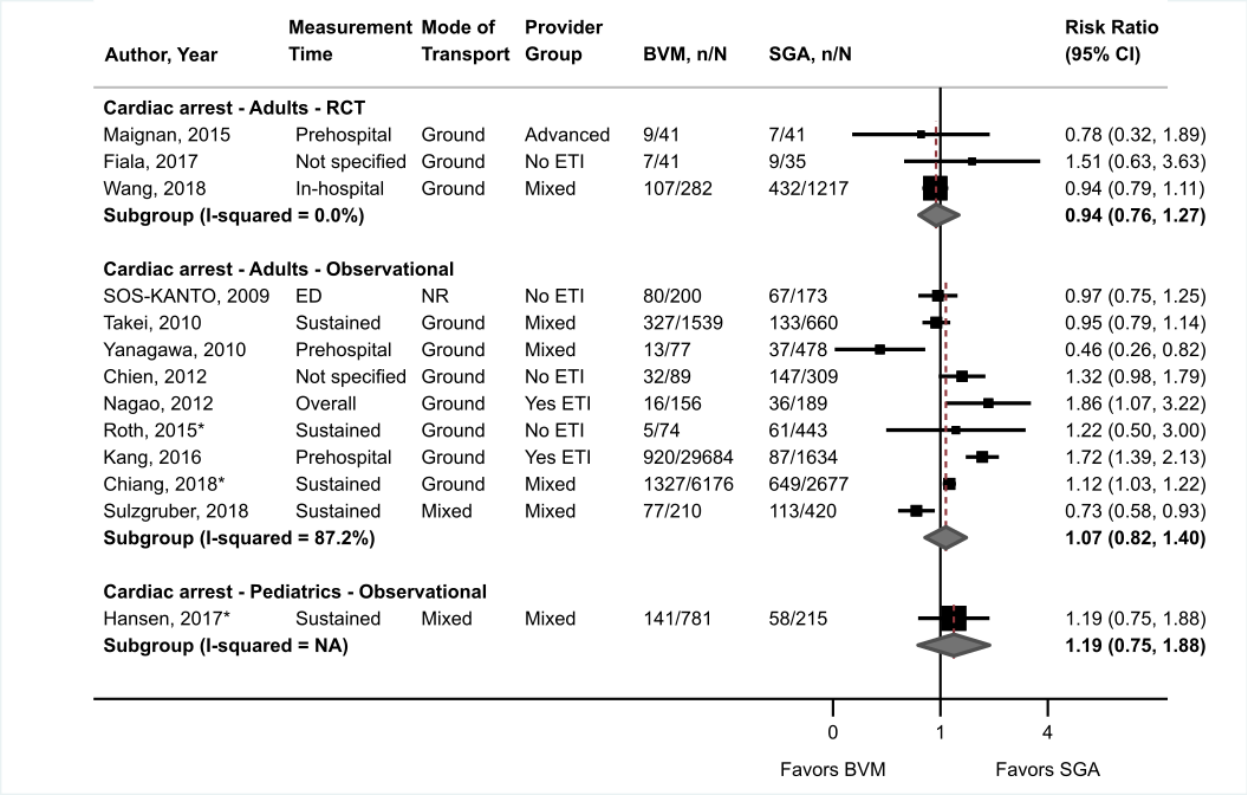
Figure H-2. BVM versus SGA (KQ1) pooled estimate of neurological function by emergency type, age, and study design



BVM = bag valve mask; CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported; RCT = randomized control trial; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

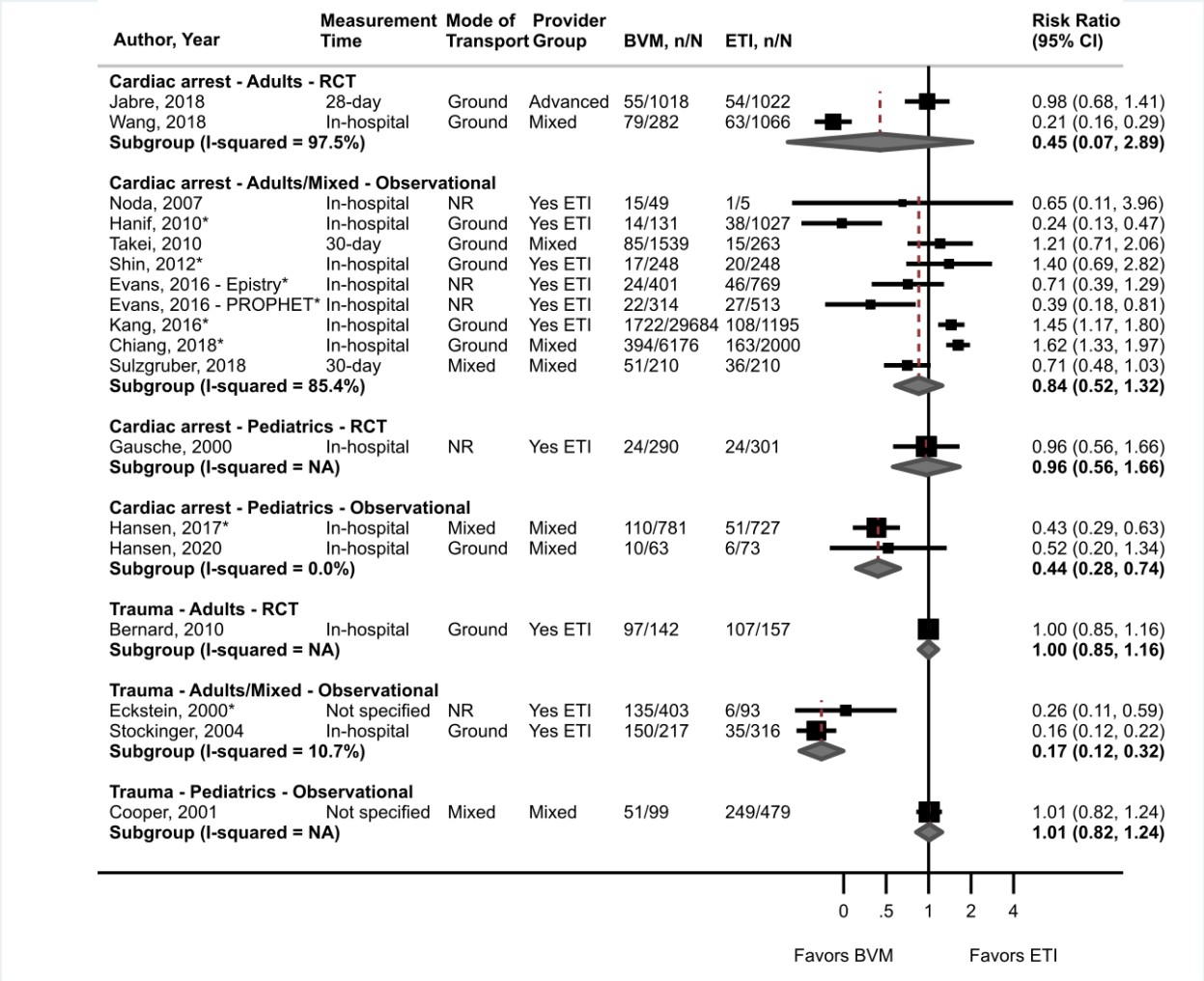
Figure H-3. BVM versus SGA (KQ1) pooled estimate of ROSC by emergency type, age, and study design



BVM = bag valve mask; CI = confidence interval; ED = emergency department; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported; RCT = randomized control trial; ROSC = return of spontaneous circulation; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

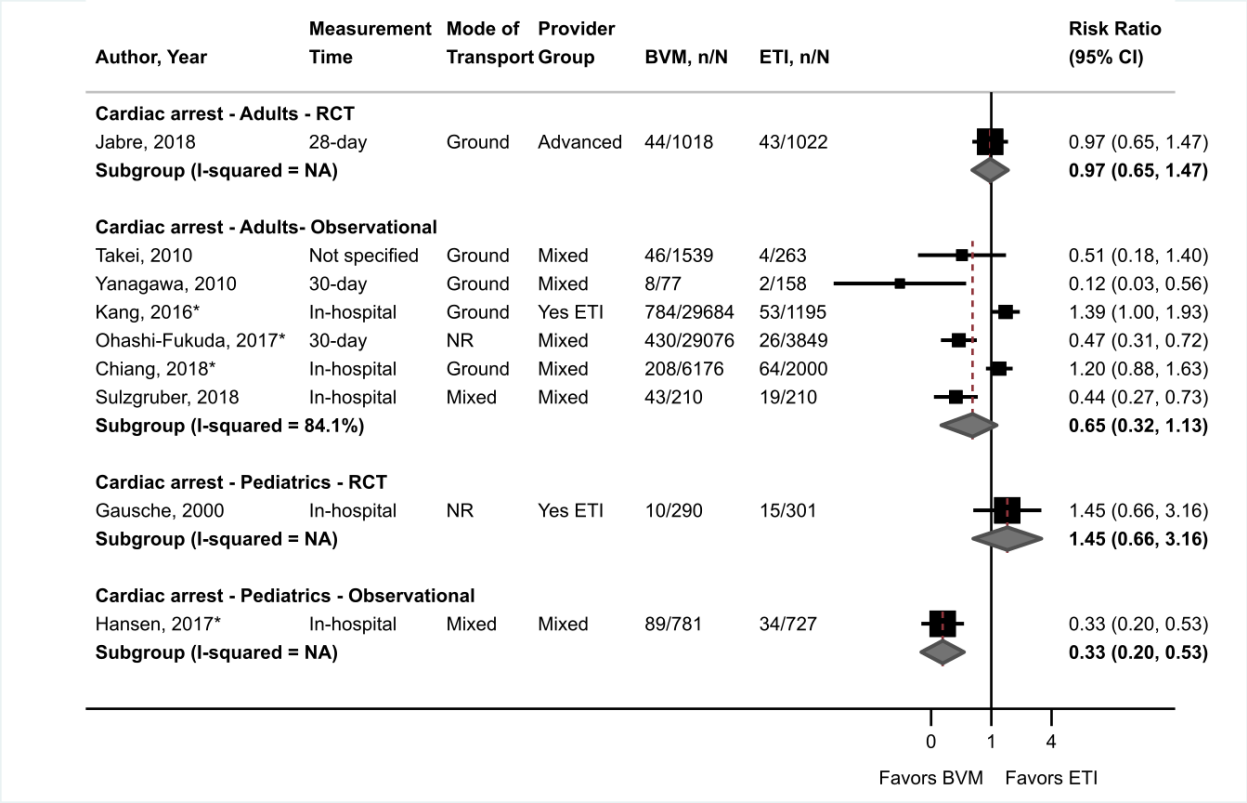
Figure H-4. BVM versus ETI (KQ2) pooled estimate of survival by emergency type, age, and study design



BVM = bag valve mask; CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported; RCT = randomized control trial

[a]Asterisk indicates where adjusted results were used in the analysis

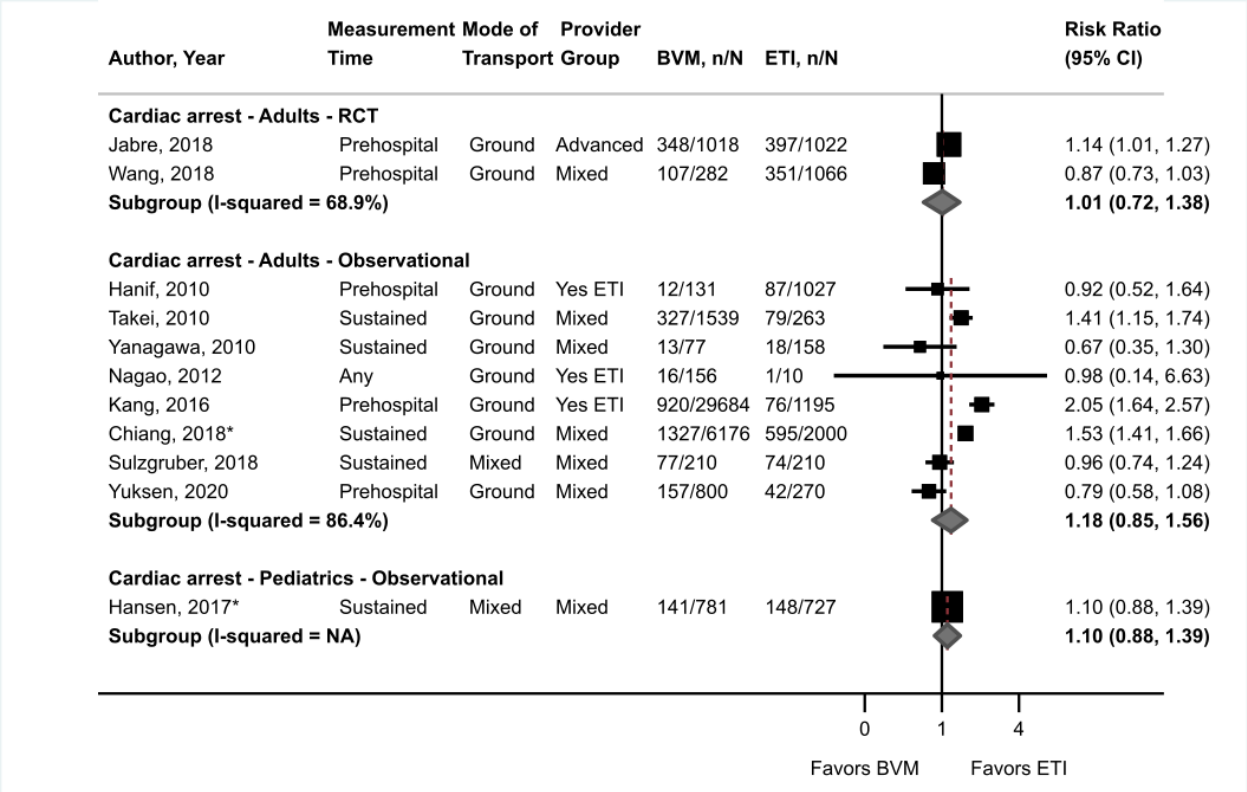
Figure H-5. BVM versus ETI (KQ2) pooled estimate of neurological function by emergency type, age, and study design



BVM = bag valve mask; CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported; RCT = randomized control trial

[a]Asterisk indicates where adjusted results were used in the analysis

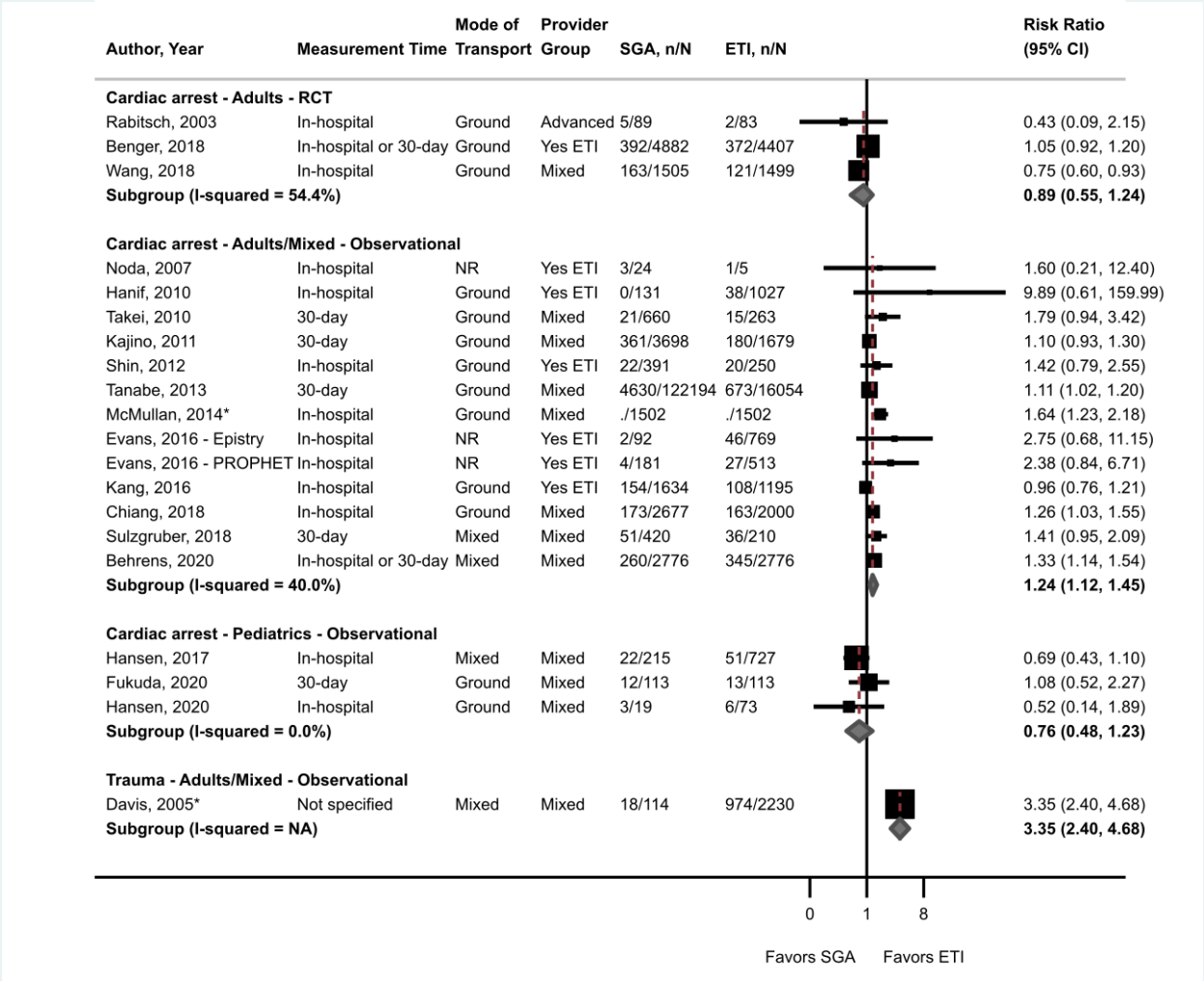
Figure H-6. BVM versus ETI (KQ2) pooled estimate of ROSC by emergency type, age, and study design



BVM = bag valve mask; CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; RCT = randomized control trial; ROSC = return of spontaneous circulation

[a]Asterisk indicates where adjusted results were used in the analysis

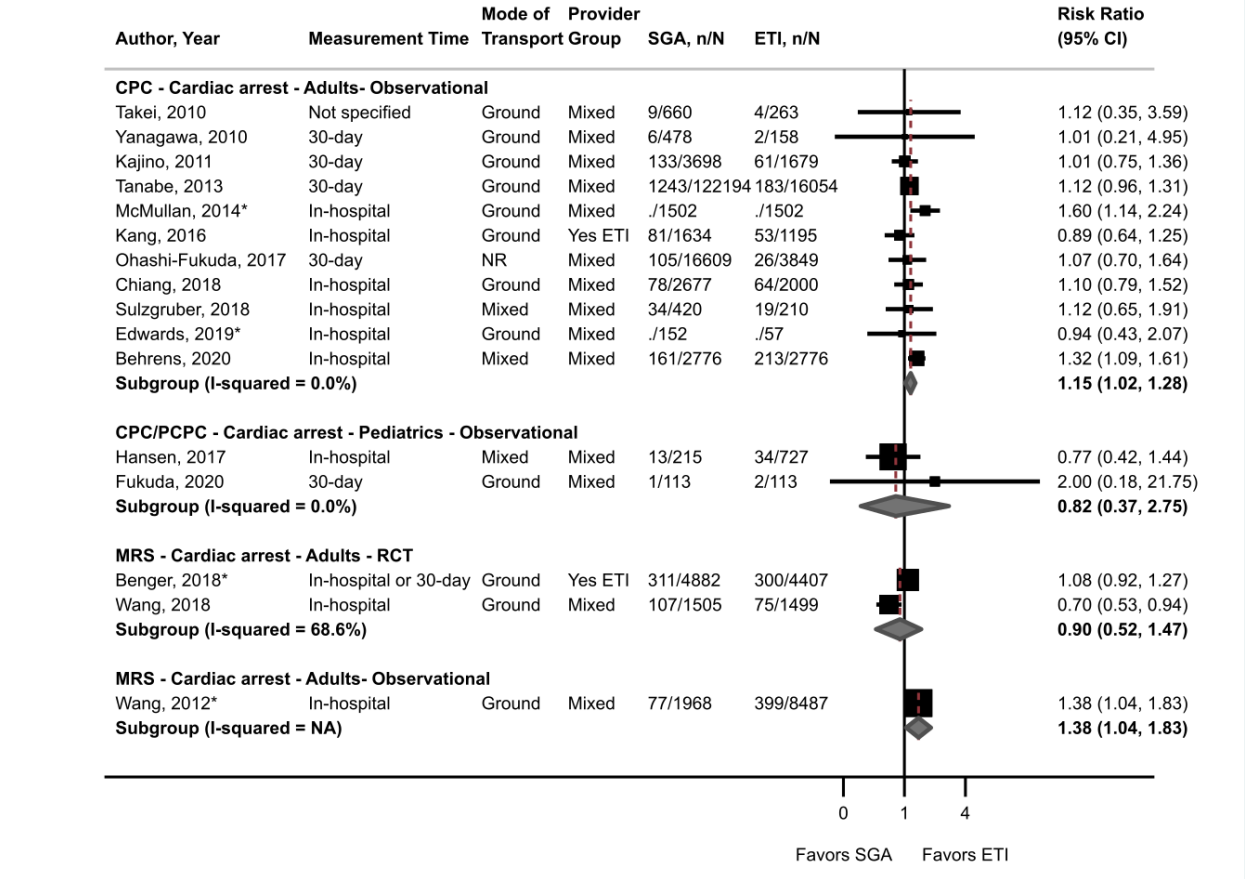
Figure H-7. SGA versus ETI (KQ3) pooled estimate of survival by emergency type, age, and study design



CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported; RCT = randomized control trial; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

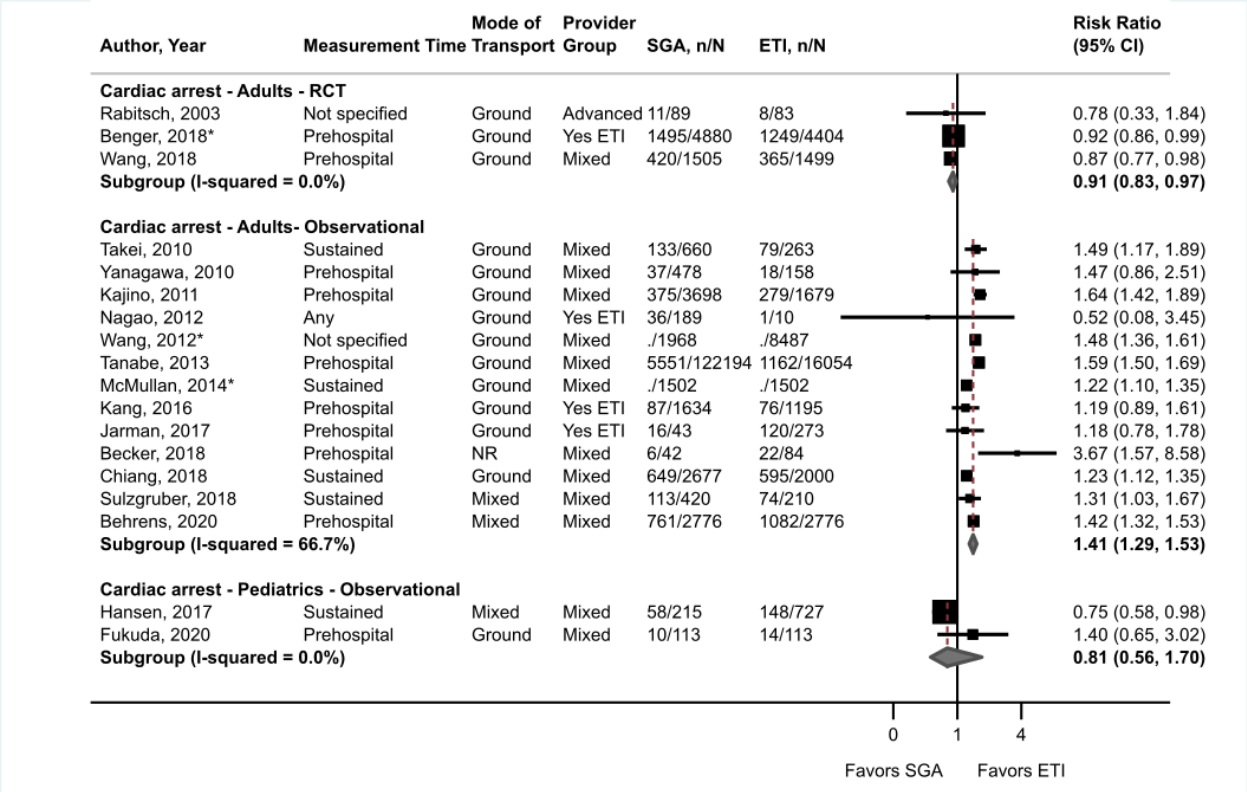
Figure H-8. SGA versus ETI (KQ3) pooled estimate of neurological function by emergency type,



CI = confidence interval; CPC = Cerebral Performance Category; ETI = endotracheal intubation; KQ = Key Question; MRS = Modified Rankin Scale; NA = not applicable; NR = not reported; PCPC = Pediatric Cerebral Performance Category; RCT = randomized control trial; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

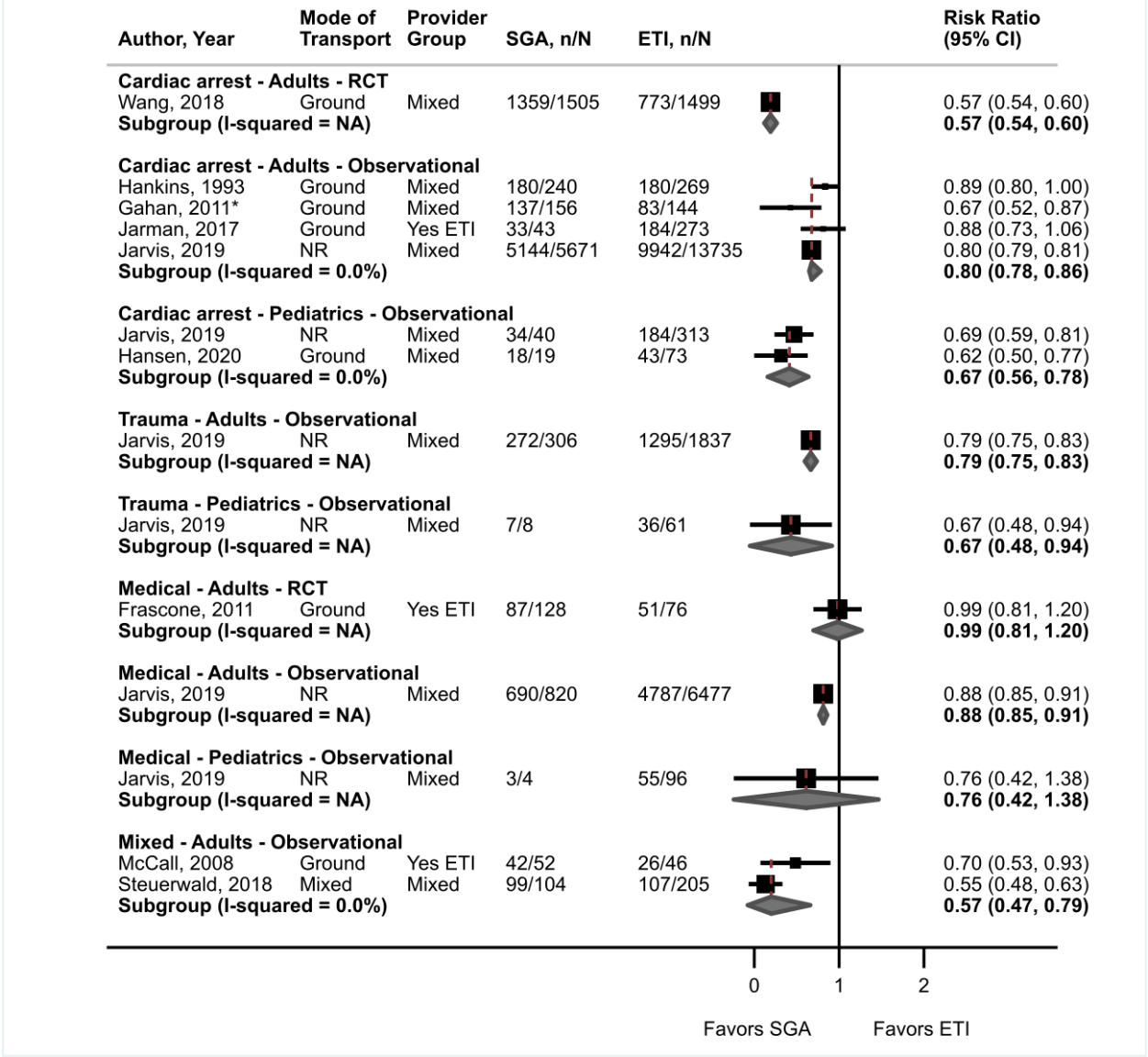
Figure H-9. SGA versus ETI (KQ3) pooled estimate of ROSC by emergency type, age, and study design



CI = confidence interval; CPC = Cerebral Performance Category; ETI = endotracheal intubation; KQ = Key Question; NR = not reported; RCT = randomized control trial; ROSC = return of spontaneous circulation; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

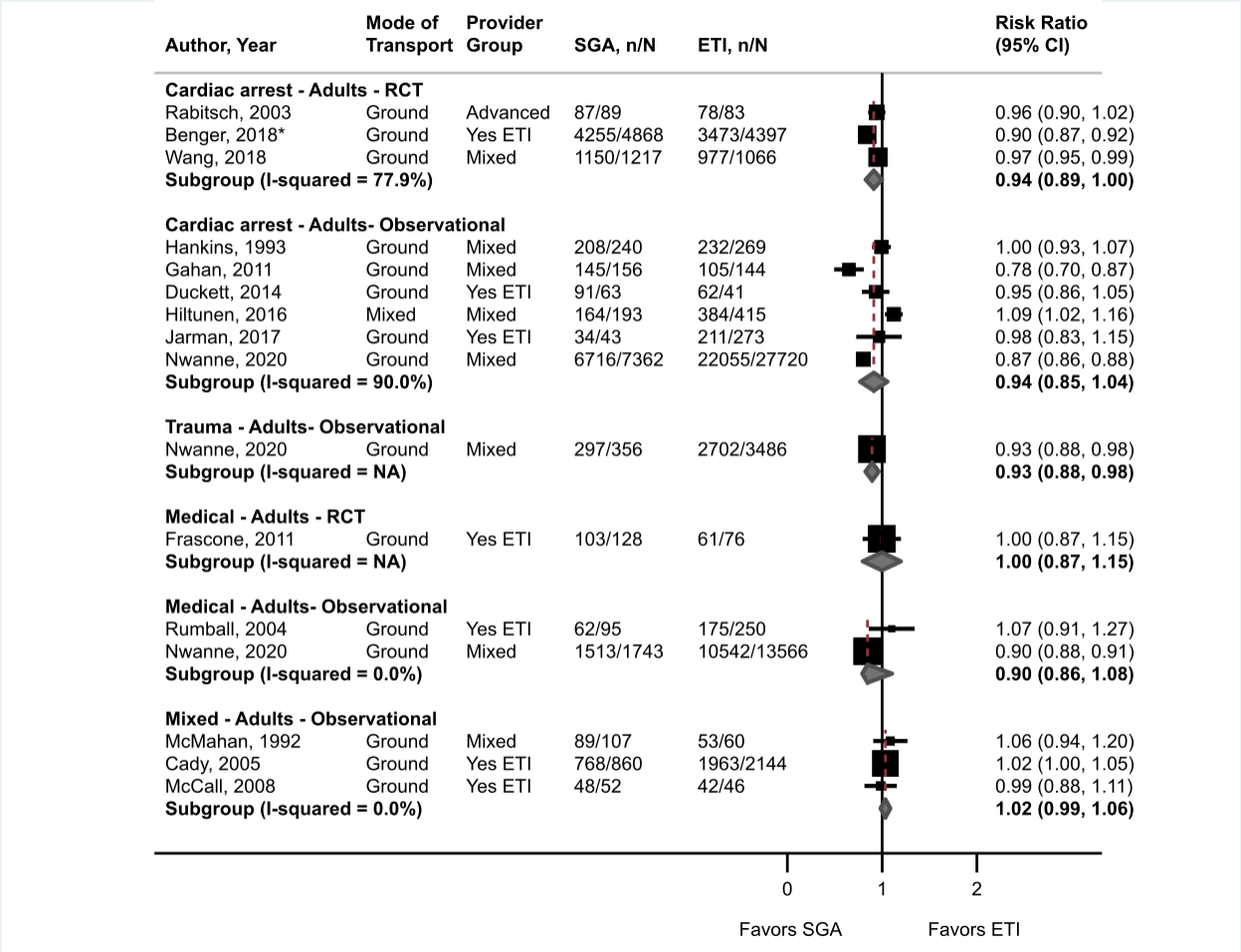
Figure H-10. SGA versus ETI (KQ3) pooled estimate of first-pass success by emergency type, age,



CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported; RCT = randomized control trial; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

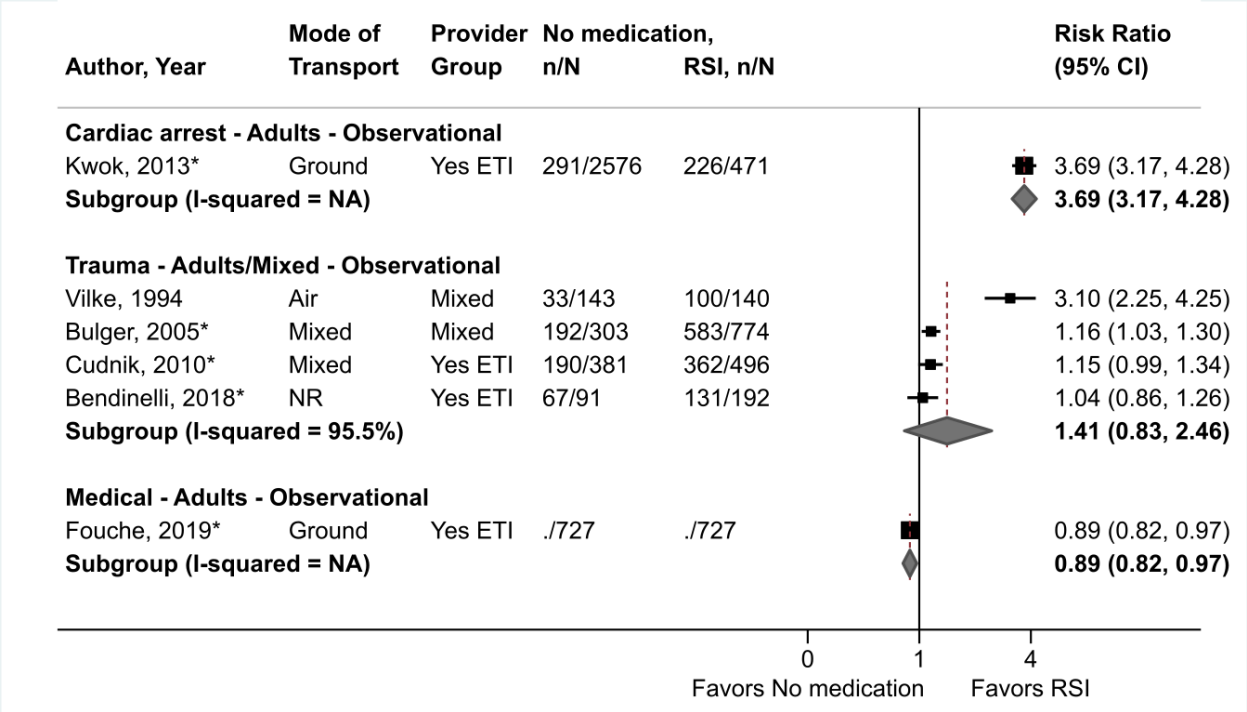
Figure H-11. SGA versus ETI (KQ3) pooled estimate of overall success by emergency type, age, and study design



CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; RCT = randomized control trial; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

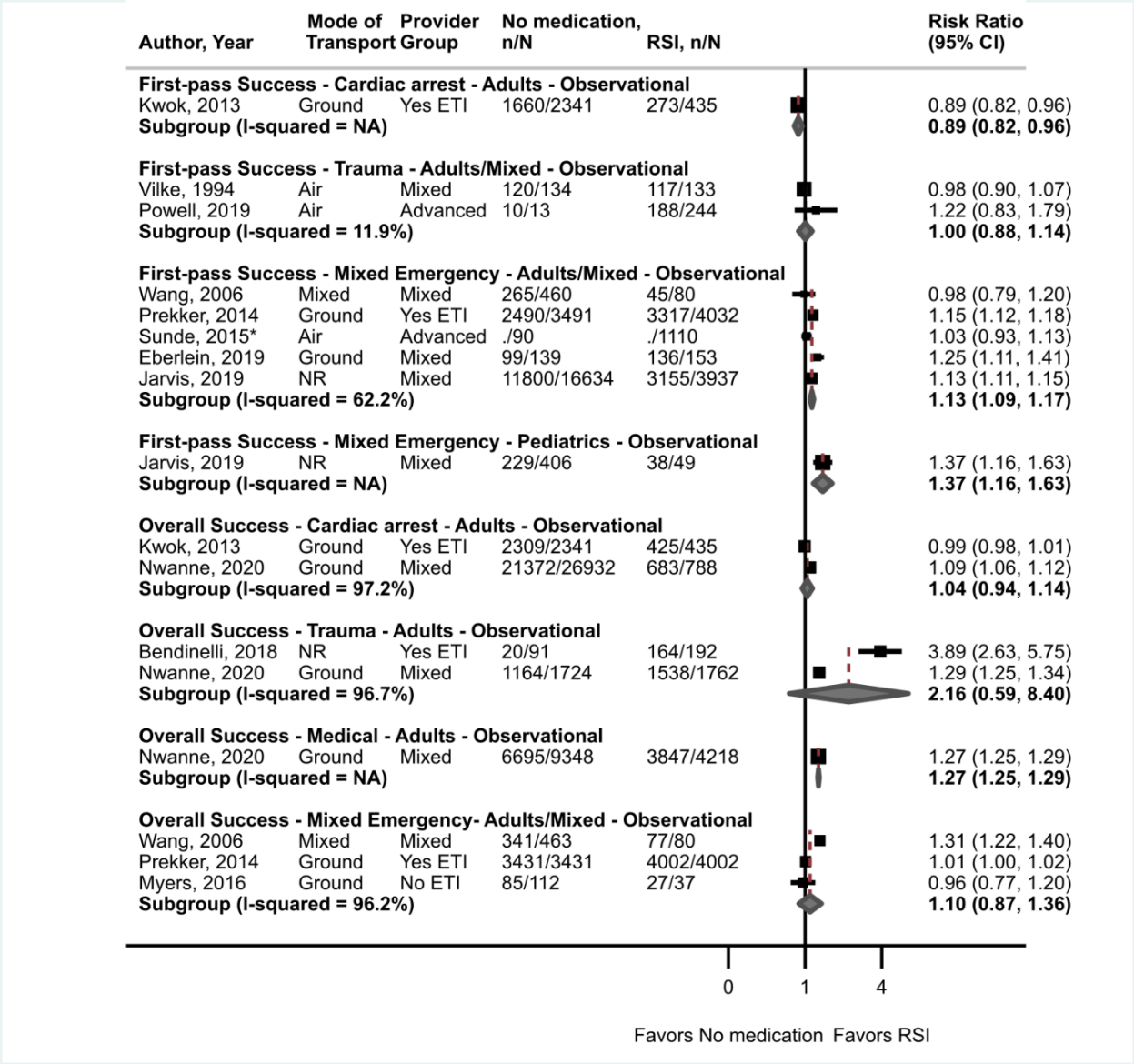
Figure H-12. RSI versus no medication (KQ4) pooled estimate of survival by emergency type, age, and study design



CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported; RCT = randomized control trial; RSI = rapid sequence intubation

[a]Asterisk indicates where adjusted results were used in the analysis

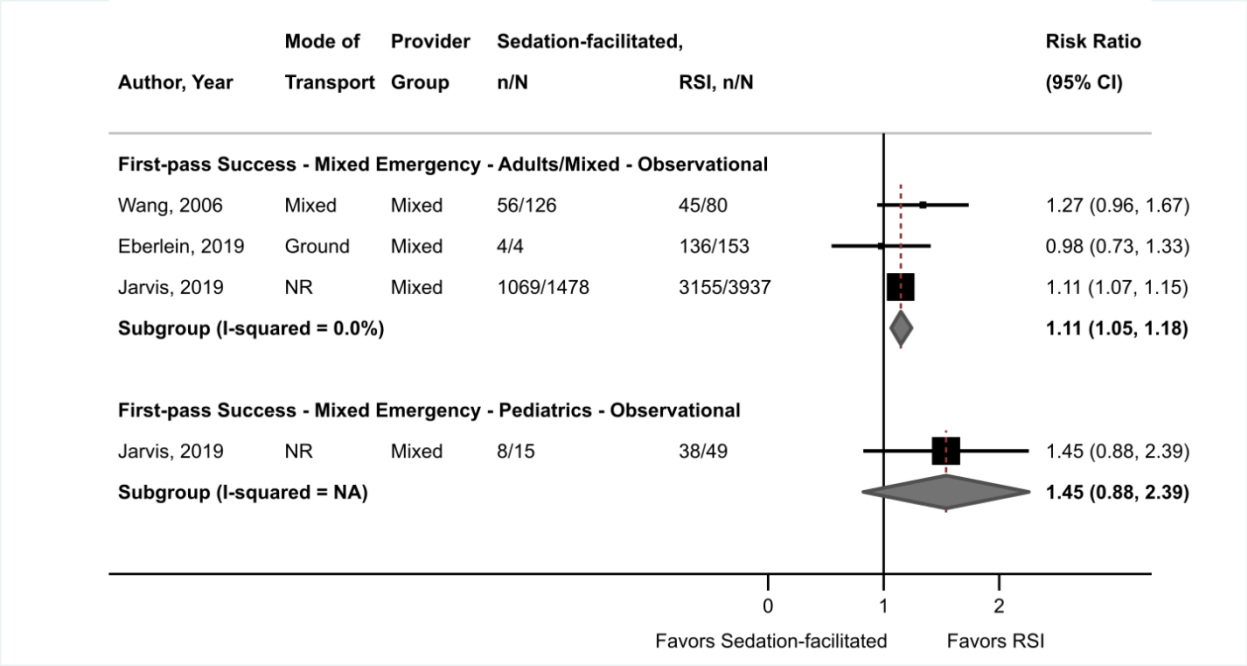
Figure H-13. RSI versus no medication (KQ4) pooled estimate of success by emergency type, age, and study design



CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported; RSI = rapid sequence intubation

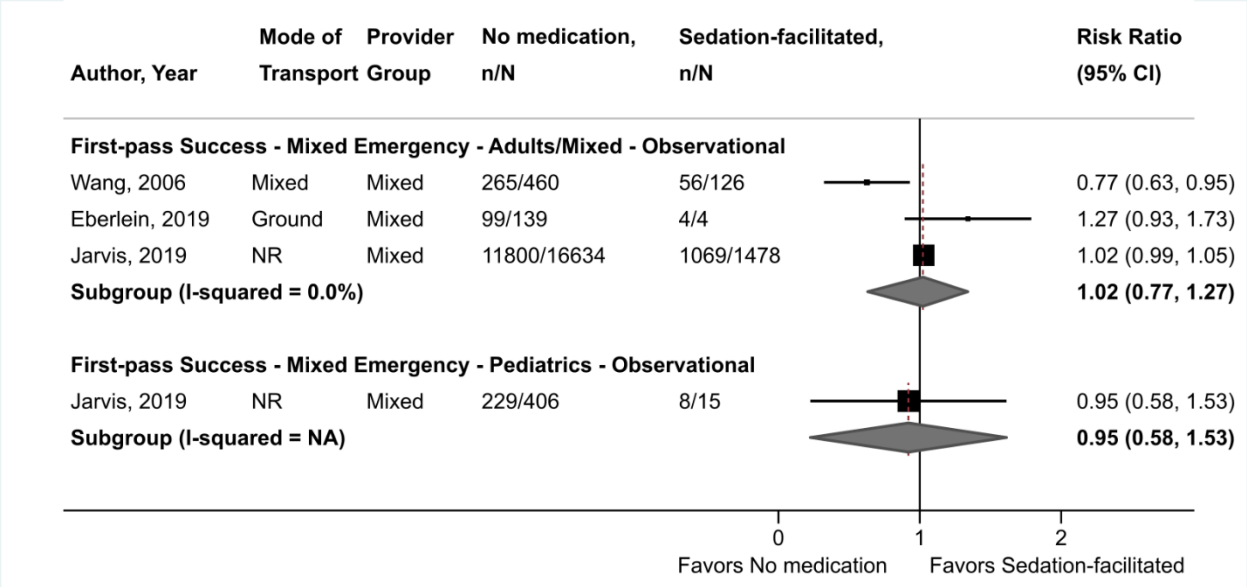
[a]Asterisk indicates where adjusted results were used in the analysis

Figure H-14. RSI versus sedation-facilitated (KQ4) pooled estimate of first-pass success by emergency type, age, and study design



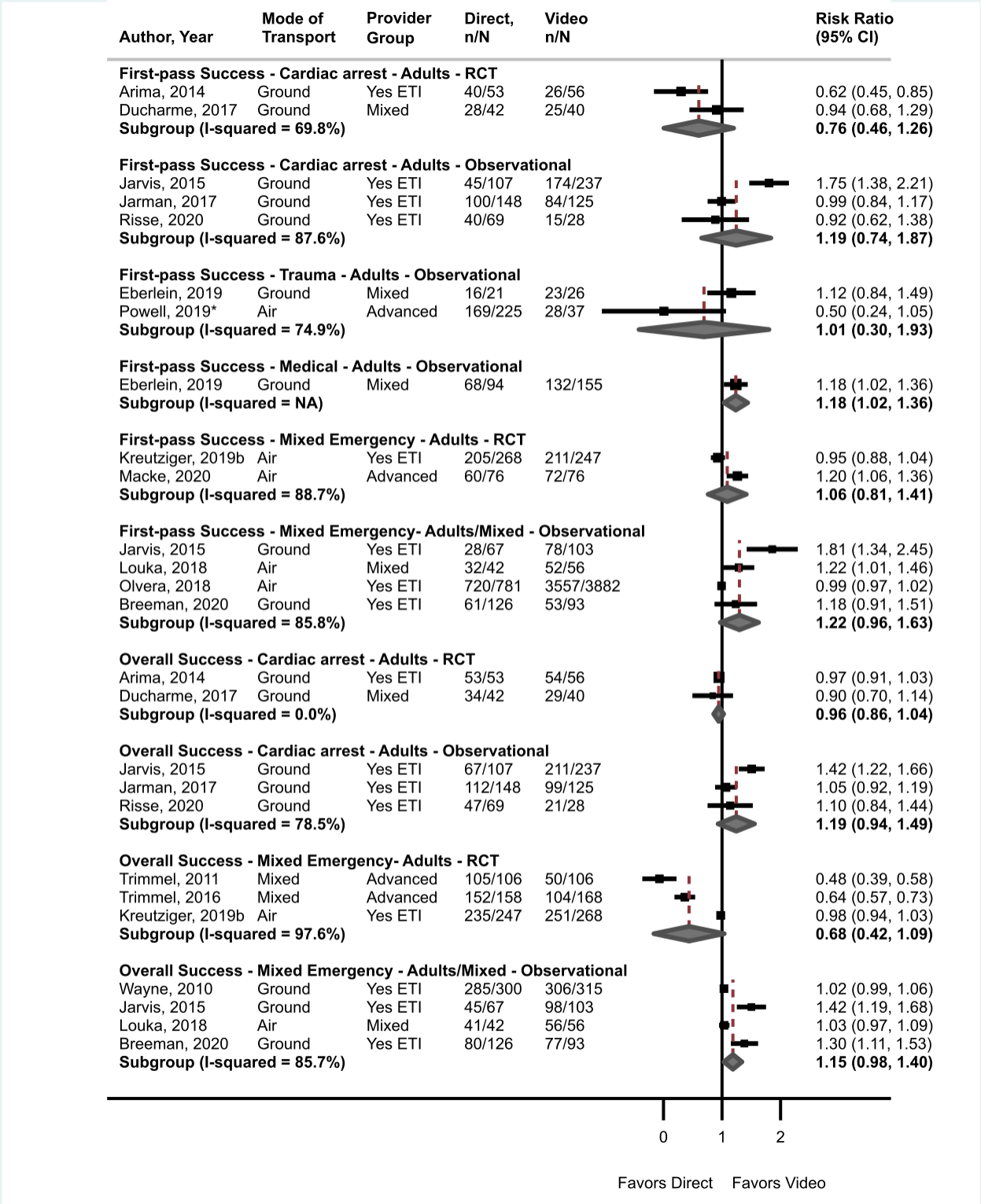
CI = confidence interval; KQ = Key Question; NA = not applicable; NR = not reported; RSI = rapid sequence intubation

Figure H-15. Sedation-facilitated versus no medication (KQ4) pooled estimate of first-pass success by emergency type, age, and study design



CI = confidence interval; KQ = Key Question; NA = not applicable; NR = not reported

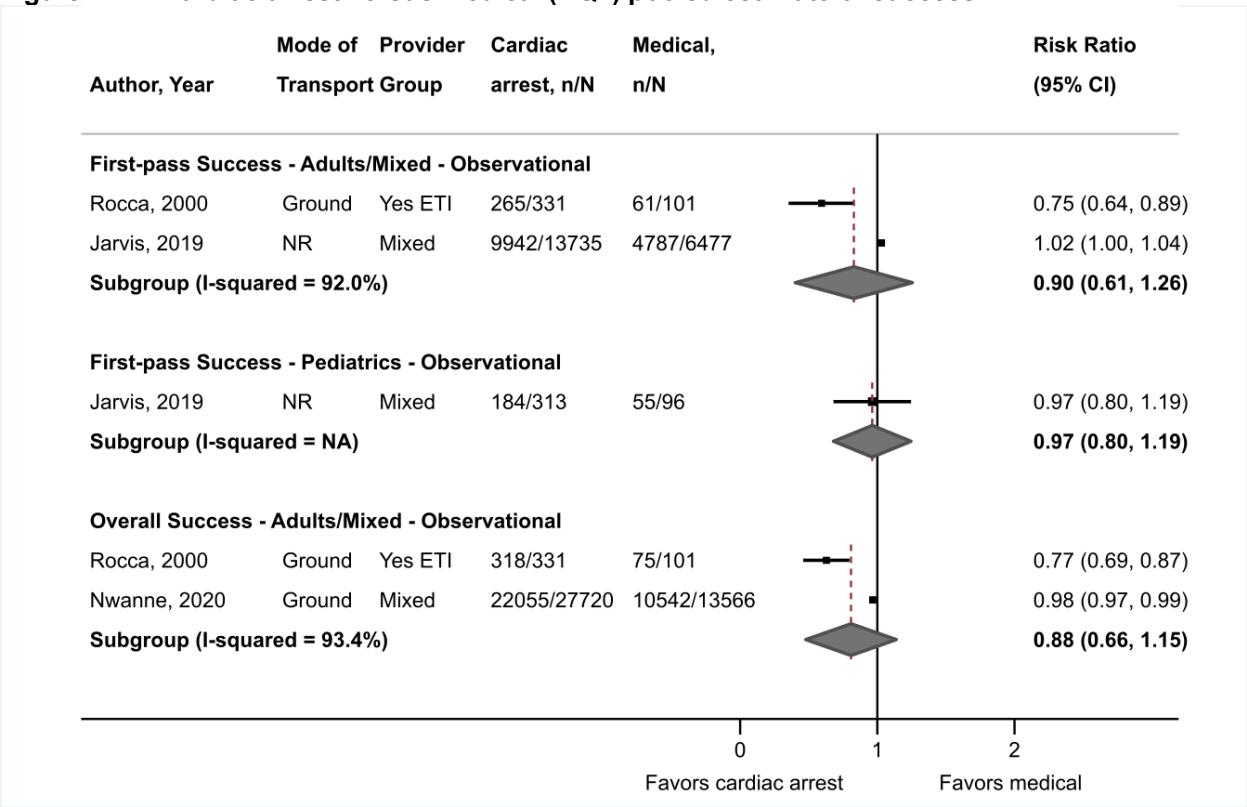
Figure H-16. Direct versus video (KQ4) pooled estimate of success by emergency type, age, and study design



CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; RCT = randomized control trial

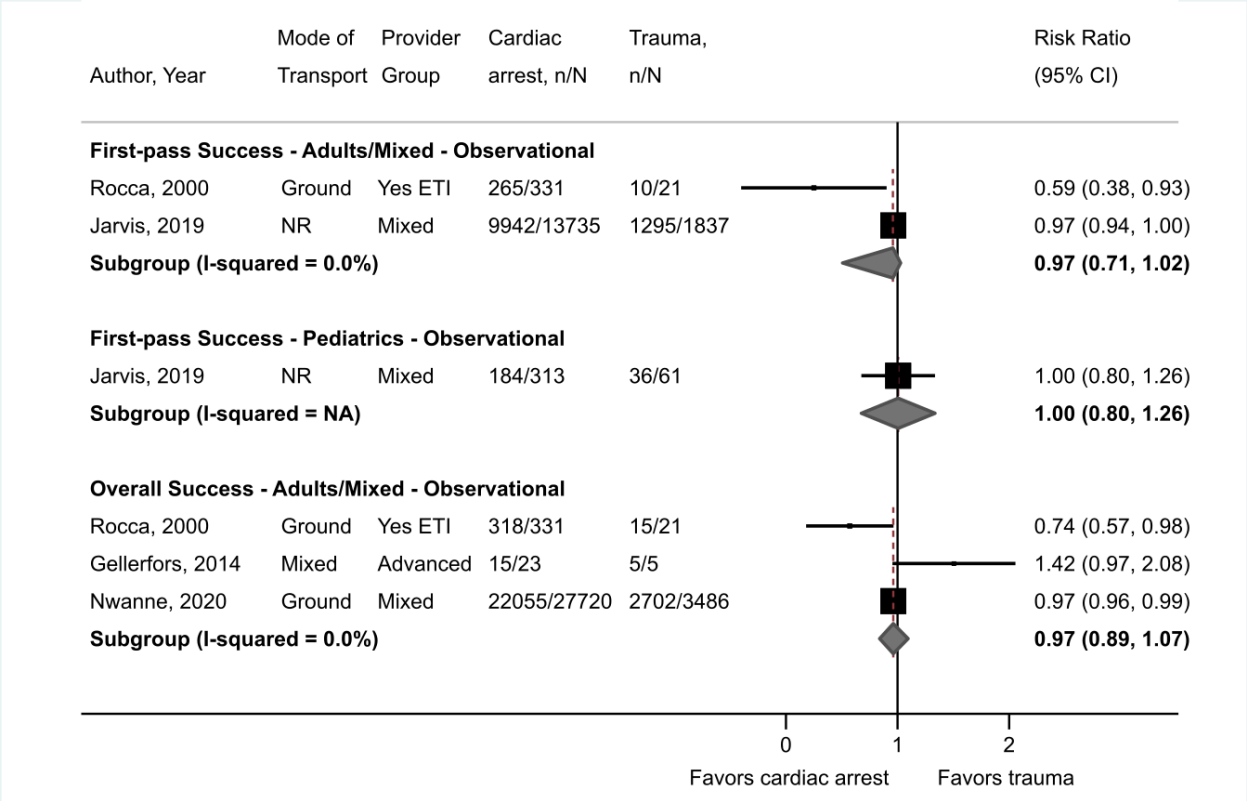
[a]Asterisk indicates where adjusted results were used in the analysis

Figure H-17. Cardiac arrest versus medical (KQ4) pooled estimate of success



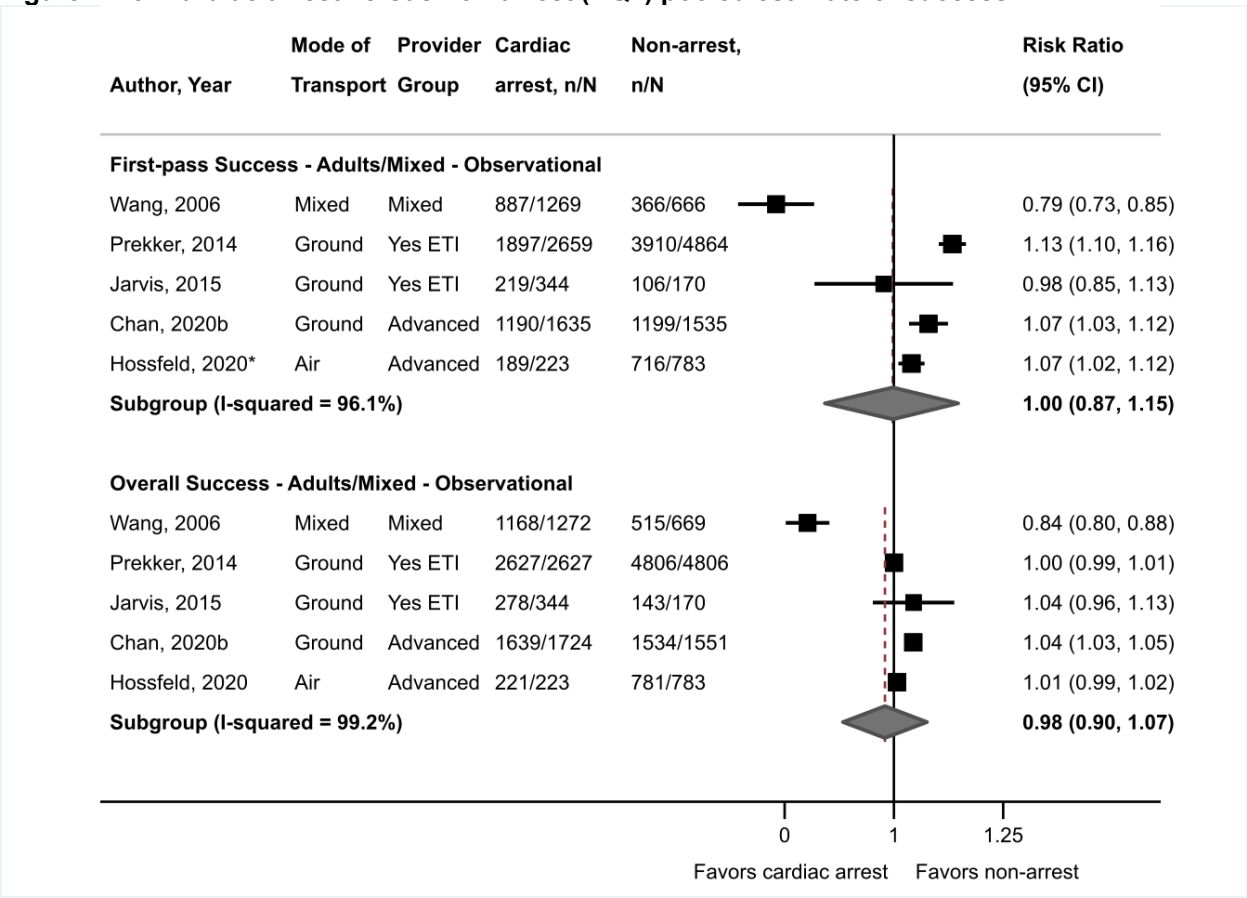
CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported

Figure H-18. Cardiac arrest versus trauma (KQ4) pooled estimate of success by age and study design



CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported

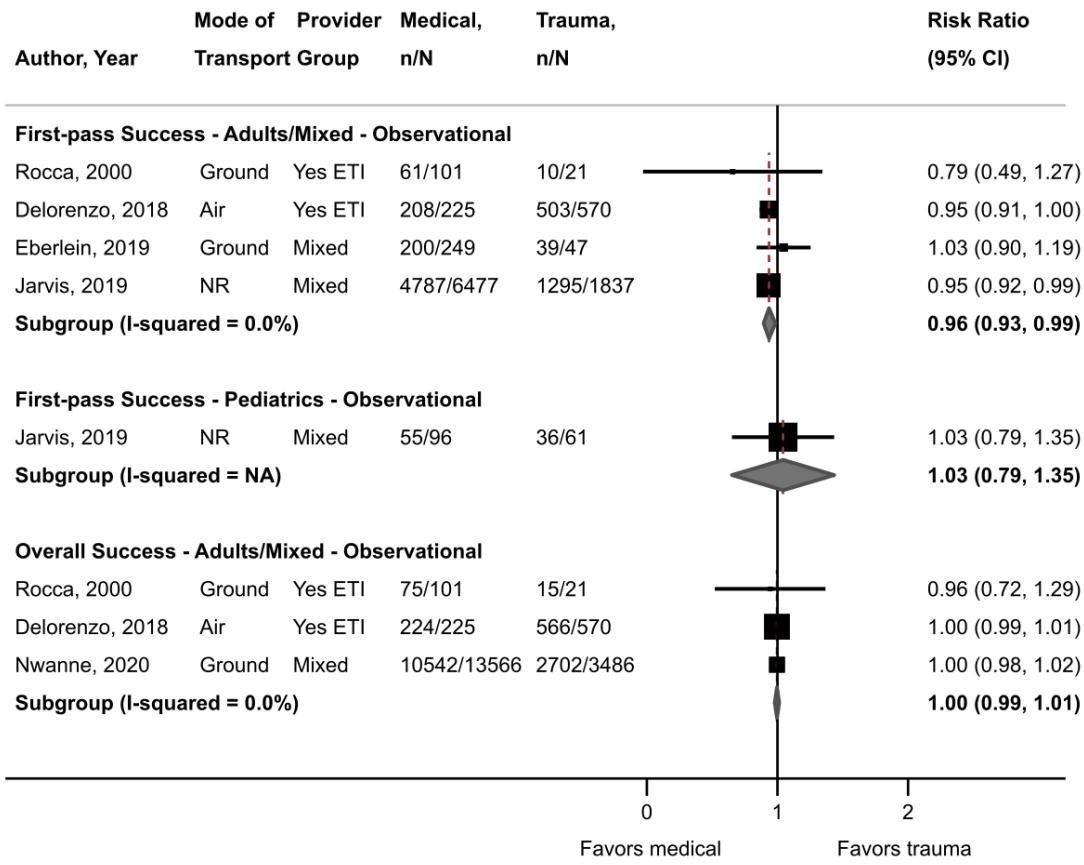
Figure H-19. Cardiac arrest versus non-arrest (KQ4) pooled estimate of success



CI = confidence interval; KQ = Key Question; ETI = endotracheal intubation

[a]Asterisk indicates where adjusted results were used in the analysis

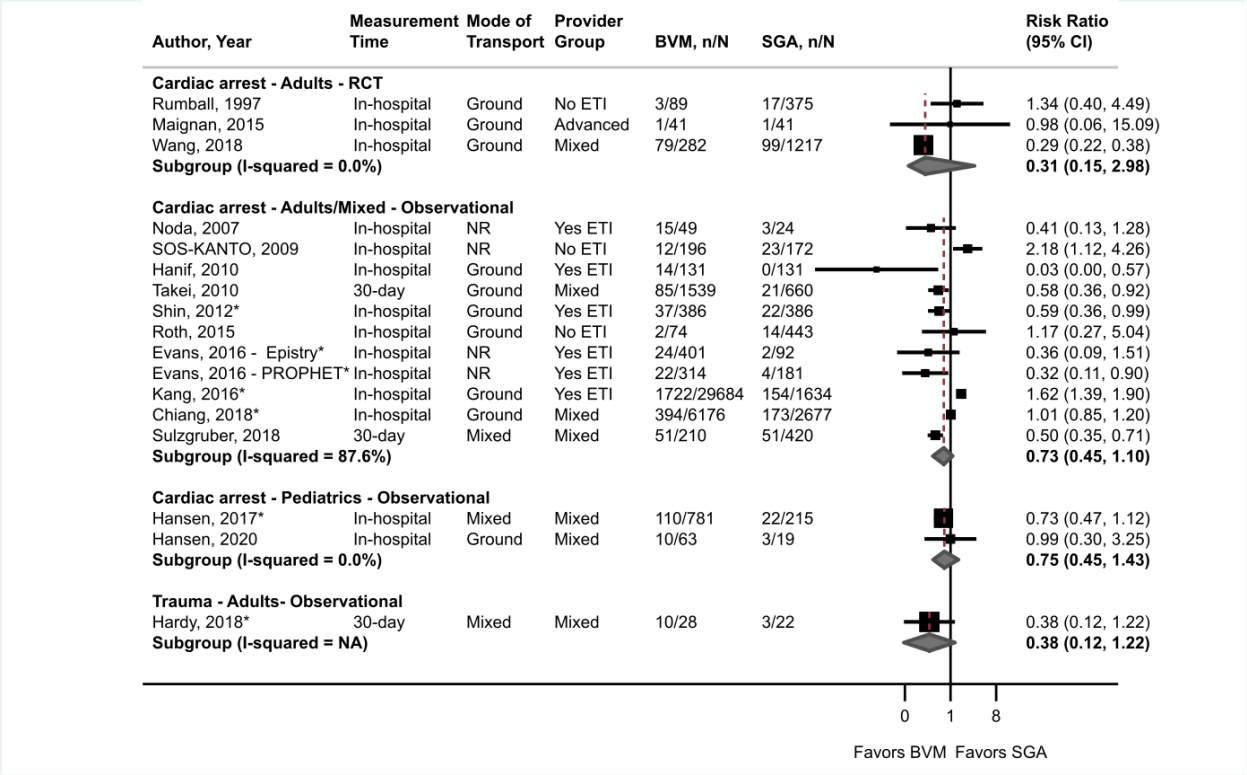
Figure H-20. Medical versus trauma (KQ4) pooled estimate of success by age and study design



CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported

Appendix I. Meta-Analysis: Sensitivity Analyses

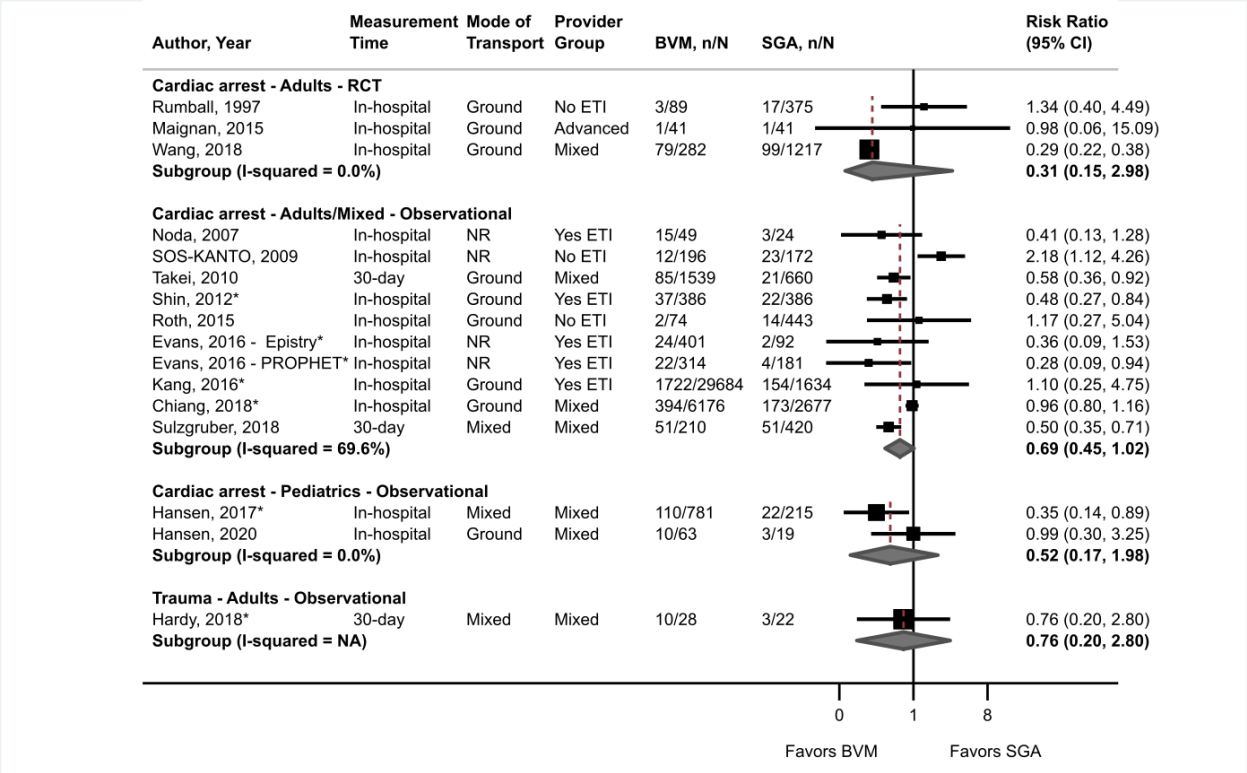
Figure I-1. BVM versus SGA (KQ1) pooled estimate of survival by emergency type, age, and study design; unadjusted



BVM = bag valve mask; CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported; RCT = randomized control trial; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

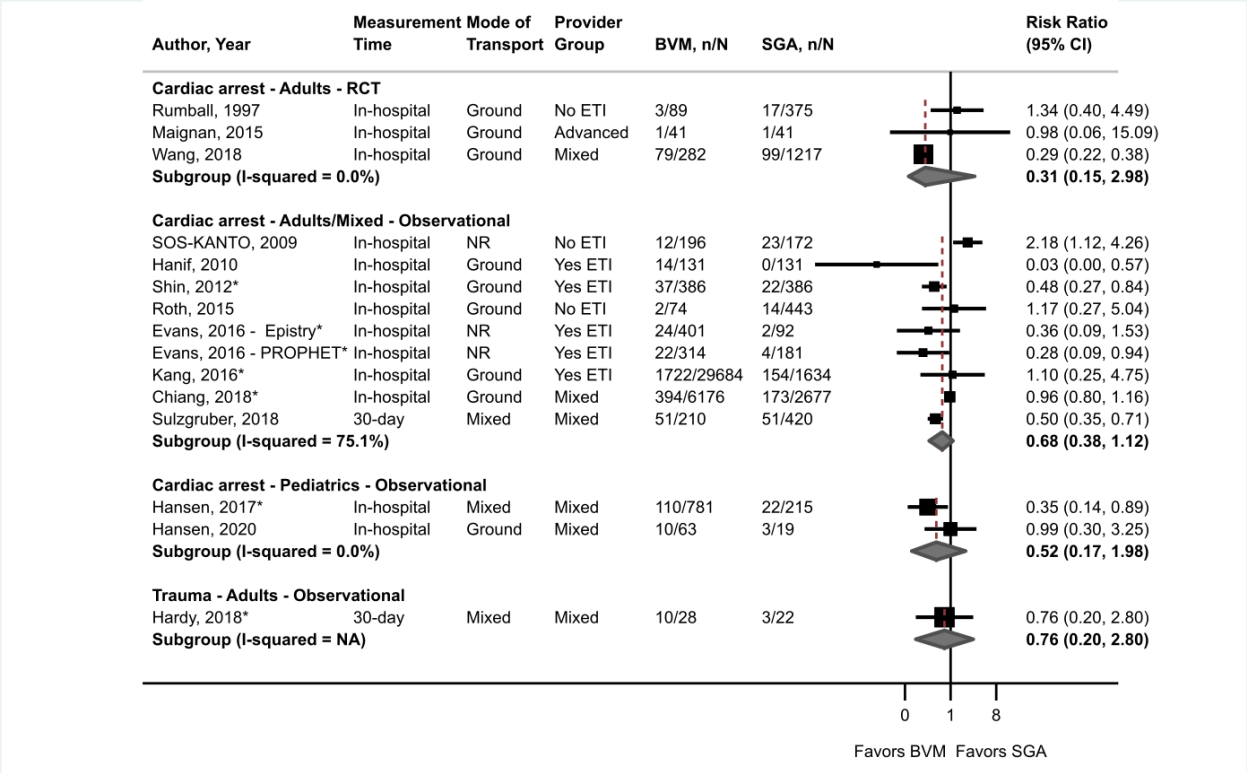
Figure I-2. BVM versus SGA (KQ1) pooled estimate of survival by emergency type, age, and study design; excluding Hanif, 2010



BVM = bag valve mask; CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported; RCT = randomized control trial; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

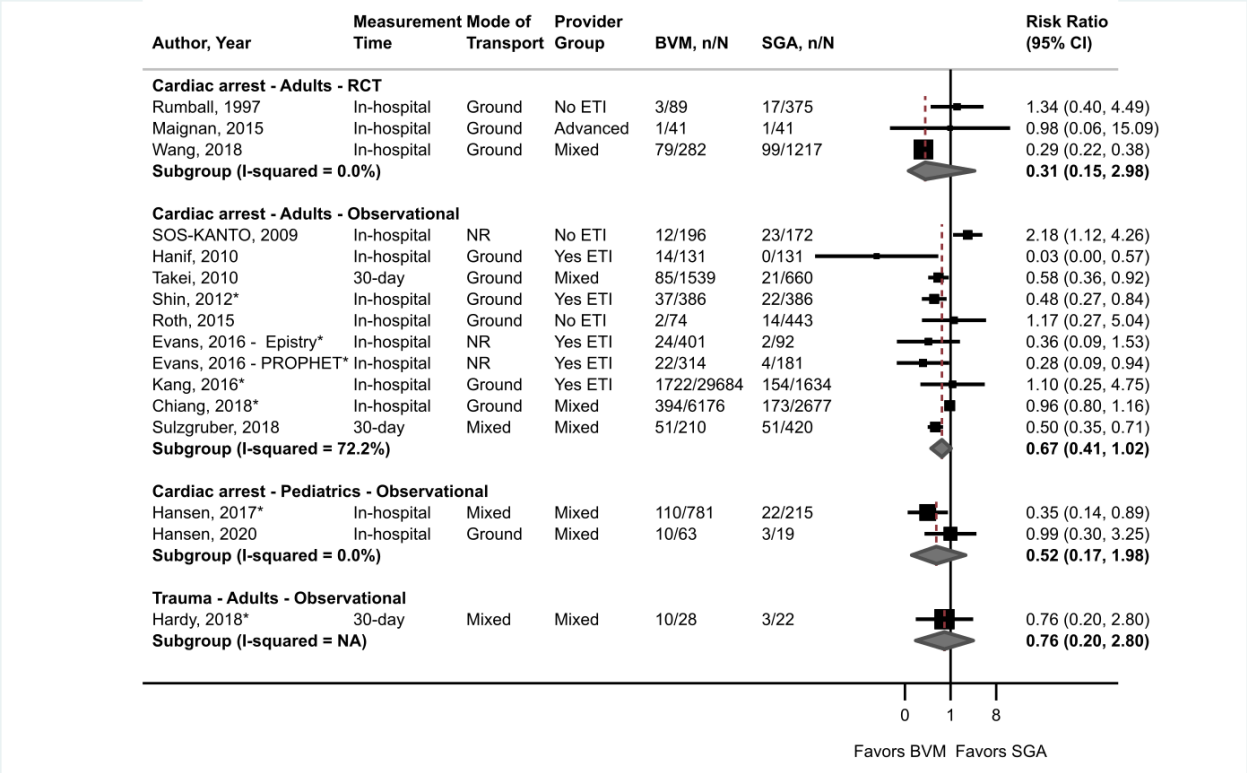
Figure I-3. BVM versus SGA (KQ1) pooled estimate of survival by emergency type, age, and study design; excluding high risk of bias studies



BVM = bag valve mask; CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported; RCT = randomized control trial; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

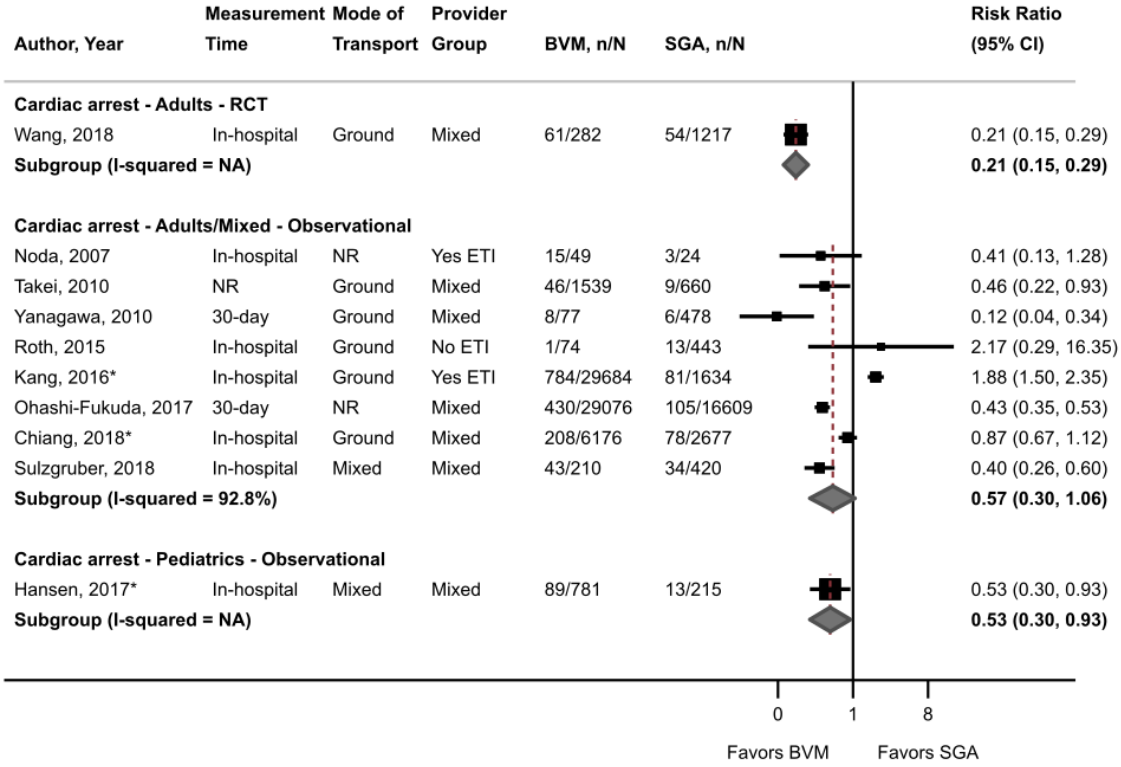
Figure I-4. BVM versus SGA (KQ1) pooled estimate of survival by emergency types, age, and study design; excluding the mixed age studies



BVM = bag valve mask; CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = applicable; NR = not reported; RCT = randomized control trial; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

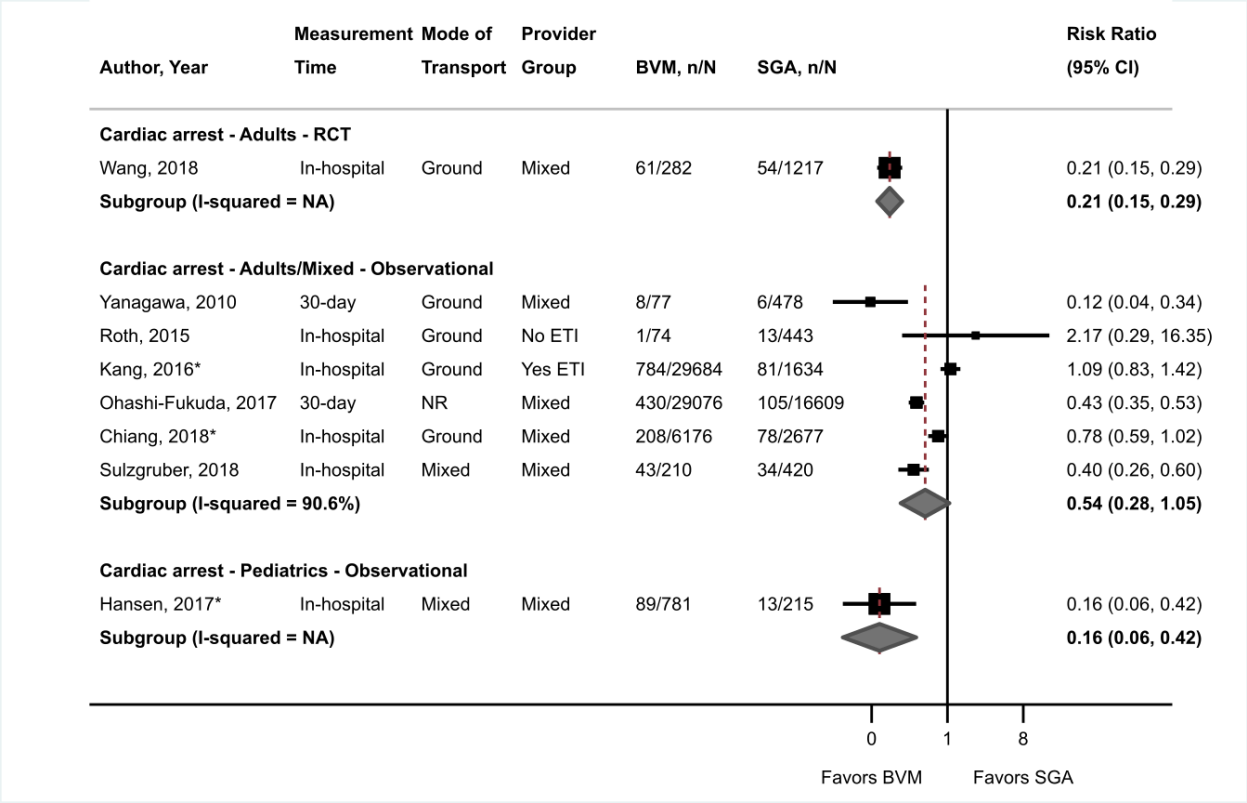
Figure I-5. BVM versus SGA (KQ1) pooled estimate of neurological function by emergency types, age, and study design; unadjusted



BVM = bag valve mask; CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = applicable; NR = not reported; RCT = randomized control trial; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

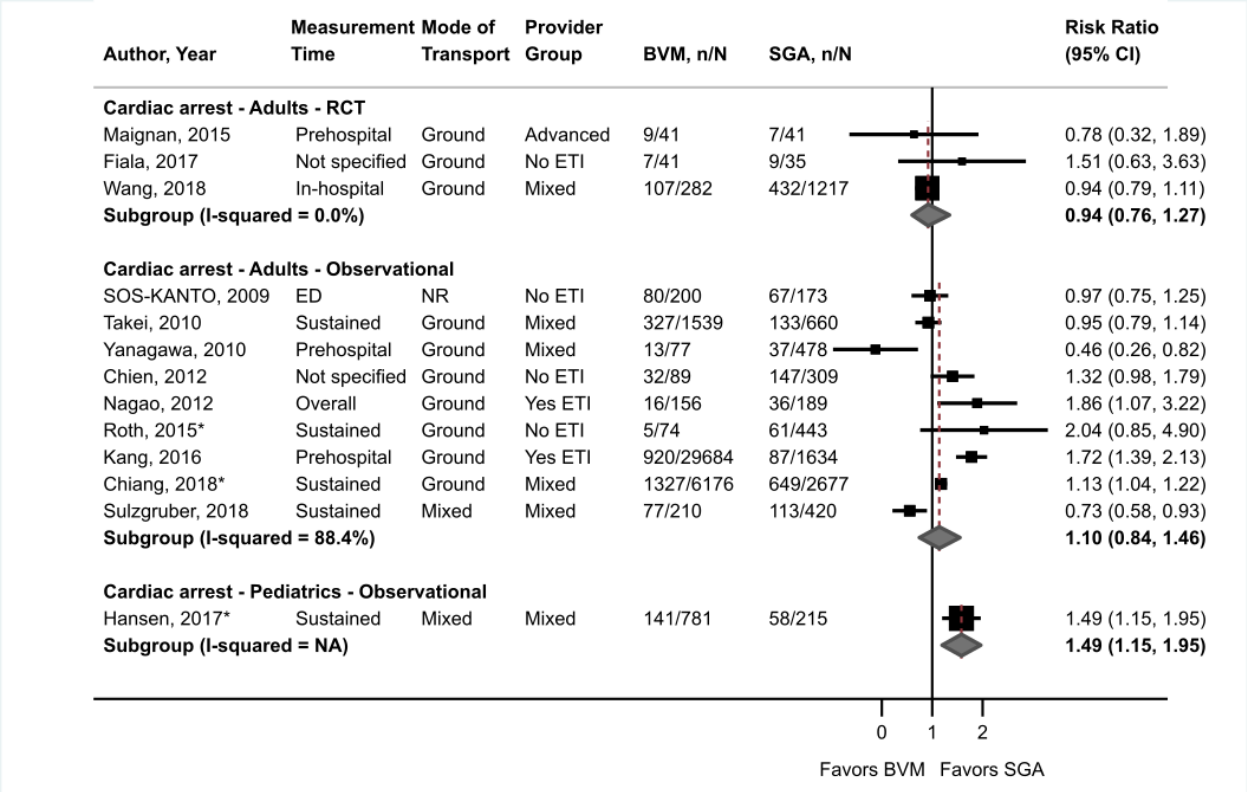
Figure I-6. BVM versus SGA (KQ1) pooled estimate of neurological function by emergency types, age, and study design; excluding high risk of bias studies



BVM = bag valve mask; CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = applicable; NR = not reported; RCT = randomized control trial; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

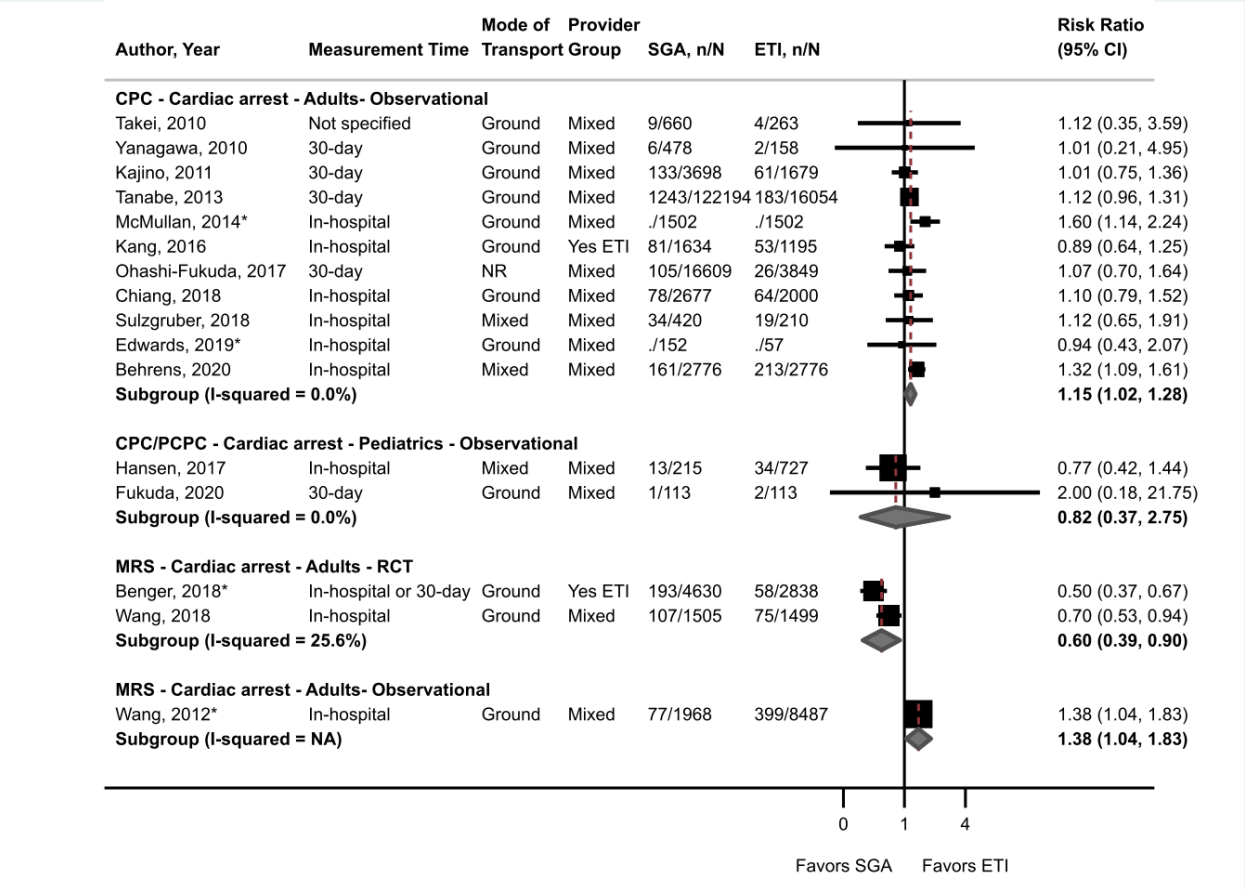
Figure I-7. BVM versus SGA (KQ1) pooled estimate of ROSC by emergency types, age, and study design; unadjusted



BVM = bag valve mask; CI = confidence interval; ED = emergency department; ETI = endotracheal intubation; KQ = Key Question; NA = applicable; NR = not reported; RCT = randomized control trial; ROSC = return of spontaneous circulation; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

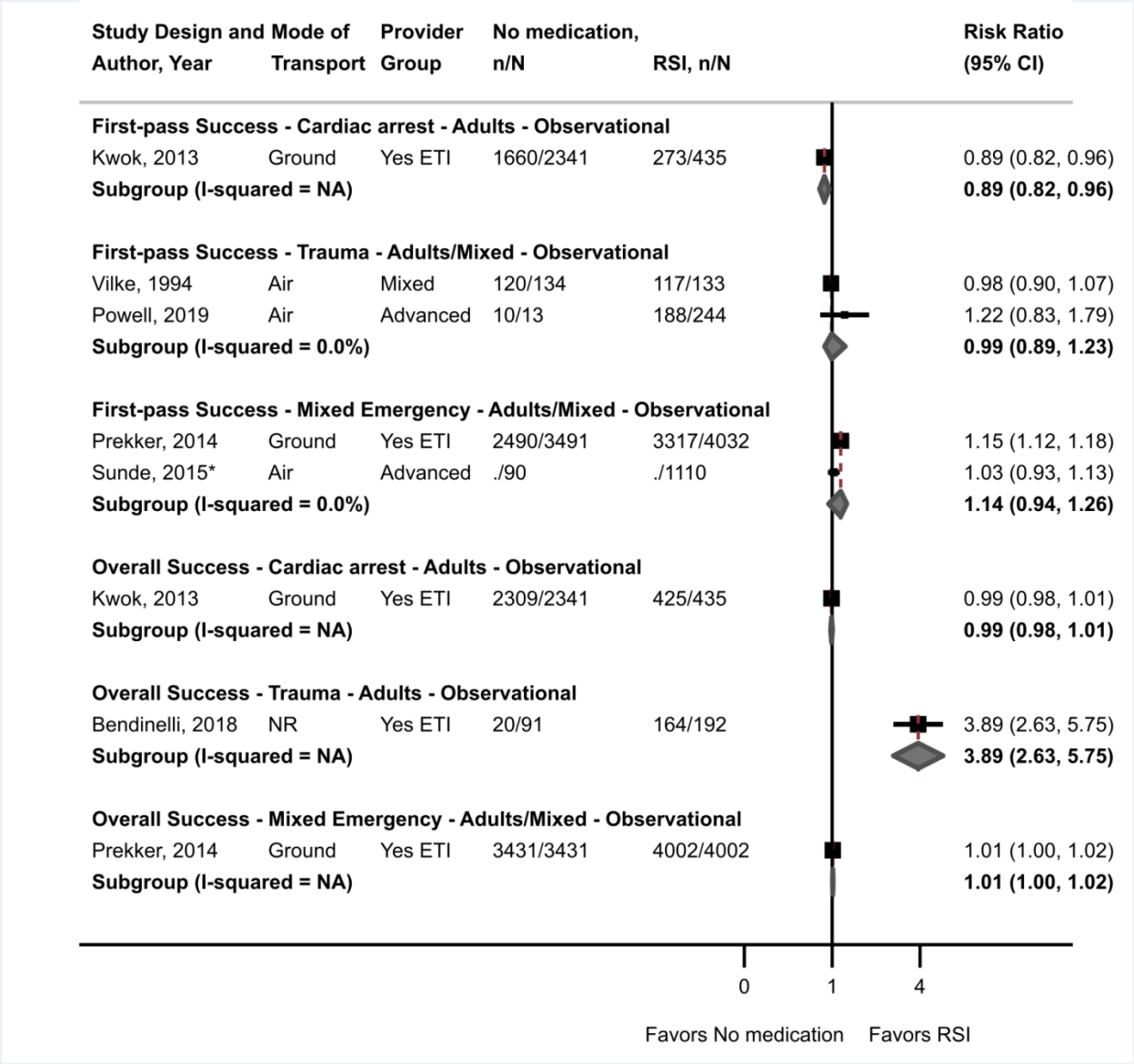
Figure I-8. SGA versus ETI (KQ3) pooled estimate of neurological function by emergency type, age, and study design; as treated



CI = confidence interval; CPC = Cerebral Performance Category; ETI = endotracheal intubation; KQ = Key Question; MRS = Modified Rankin Scale; NA = not applicable; NR = not reported; PCPC = Pediatric Cerebral Performance Category; RCT = randomized control trial; SGA = supraglottic airway

[a]Asterisk indicates where adjusted results were used in the analysis

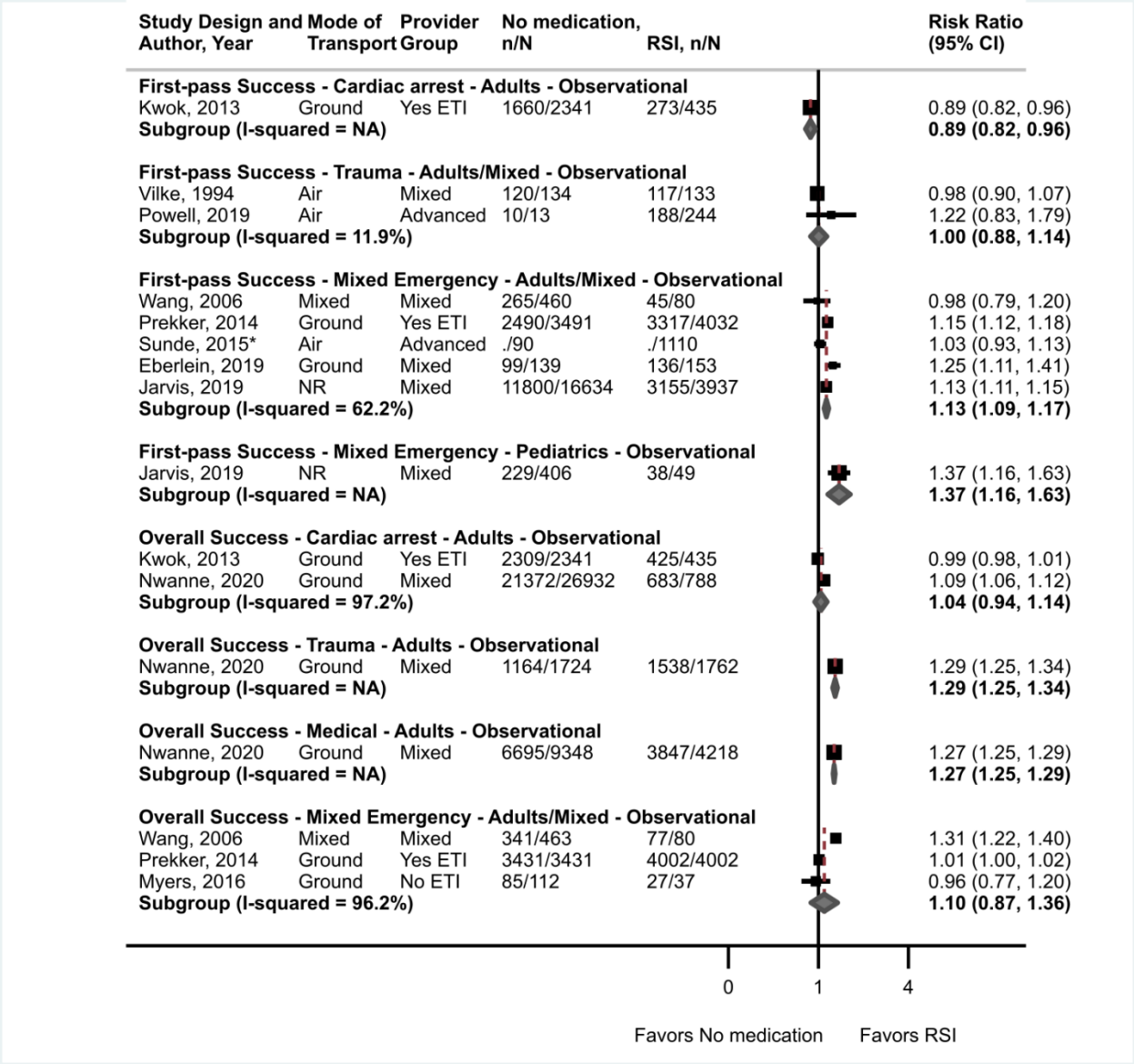
Figure I-9. RSI versus no medication (KQ4) pooled estimate success by age and study design; excluding high risk of bias studies



CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported; RSI = rapid sequence intubation

[a]Asterisk indicates where adjusted results were used in the analysis

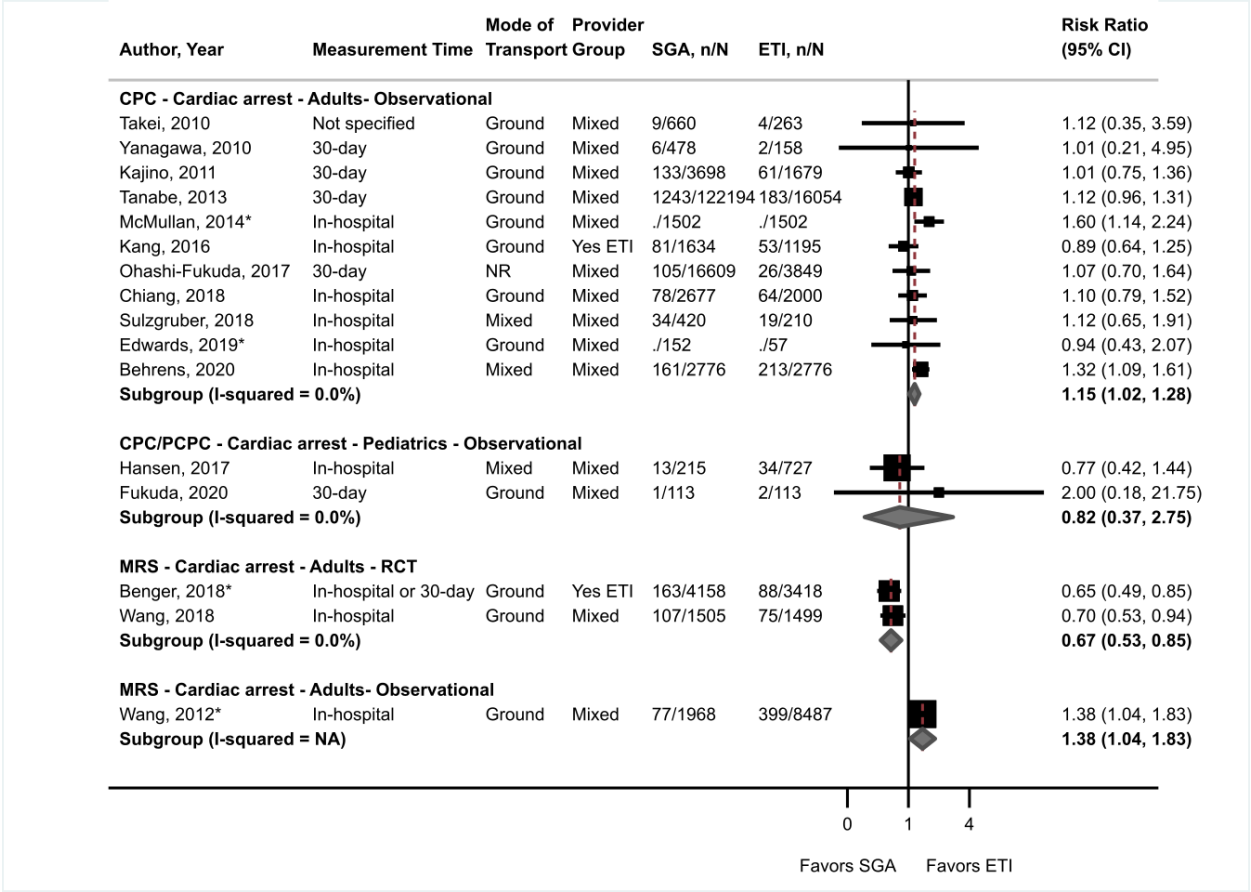
Figure I-10. RSI versus no medication (KQ4) pooled estimate success by age and study design; excluding outlier studies



CI = confidence interval; ETI = endotracheal intubation; KQ = Key Question; NA = not applicable; NR = not reported; RSI = rapid sequence intubation

[a]Asterisk indicates where adjusted results were used in the analysis

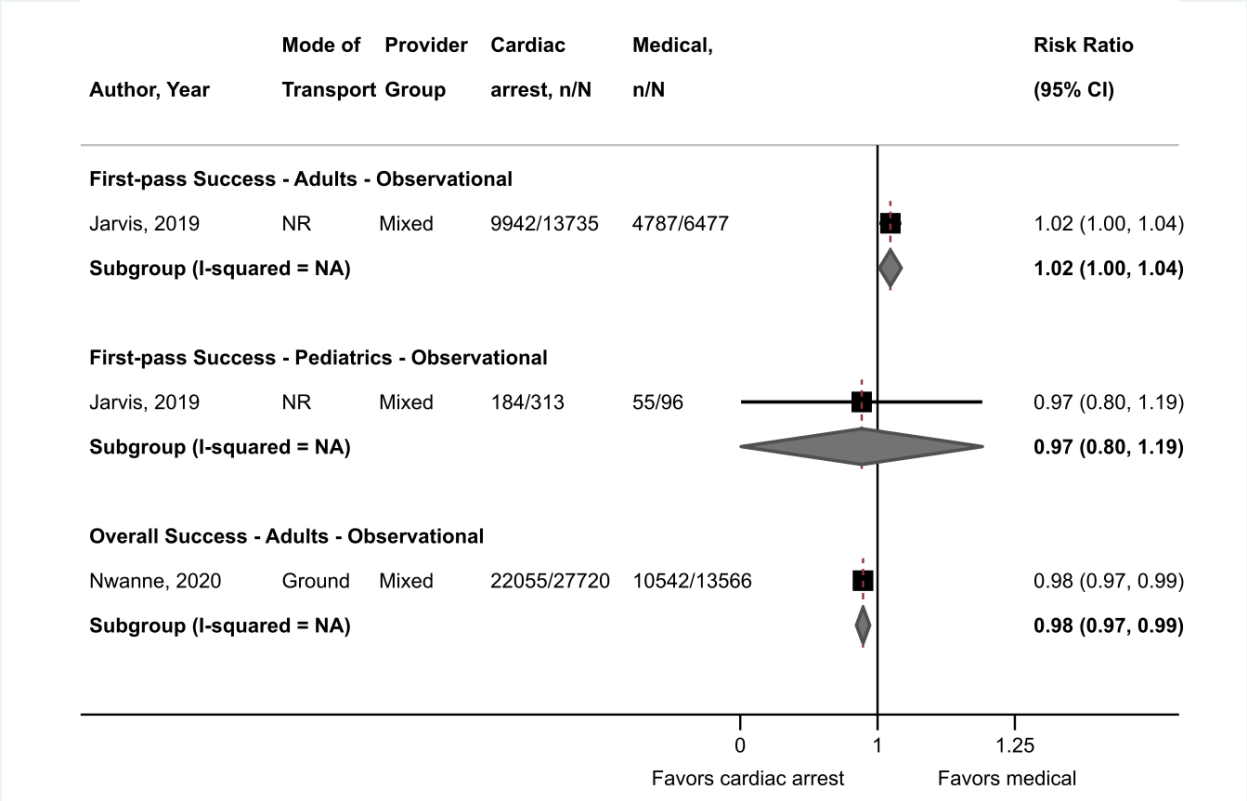
Figure I-11. SGA versus ETI (KQ3) pooled estimate of neurological function by scale, emergency type, age, and study design; per protocol



CI = confidence interval; CPC = Cerebral Performance Category; ETI = endotracheal intubation; KQ = Key Question; MRS = Modified Rankin Scale; NA = not applicable; NR = not reported; PCPC = Pediatric Cerebral Performance Category; RCT = randomized control trial; SGA = supraglottic airway

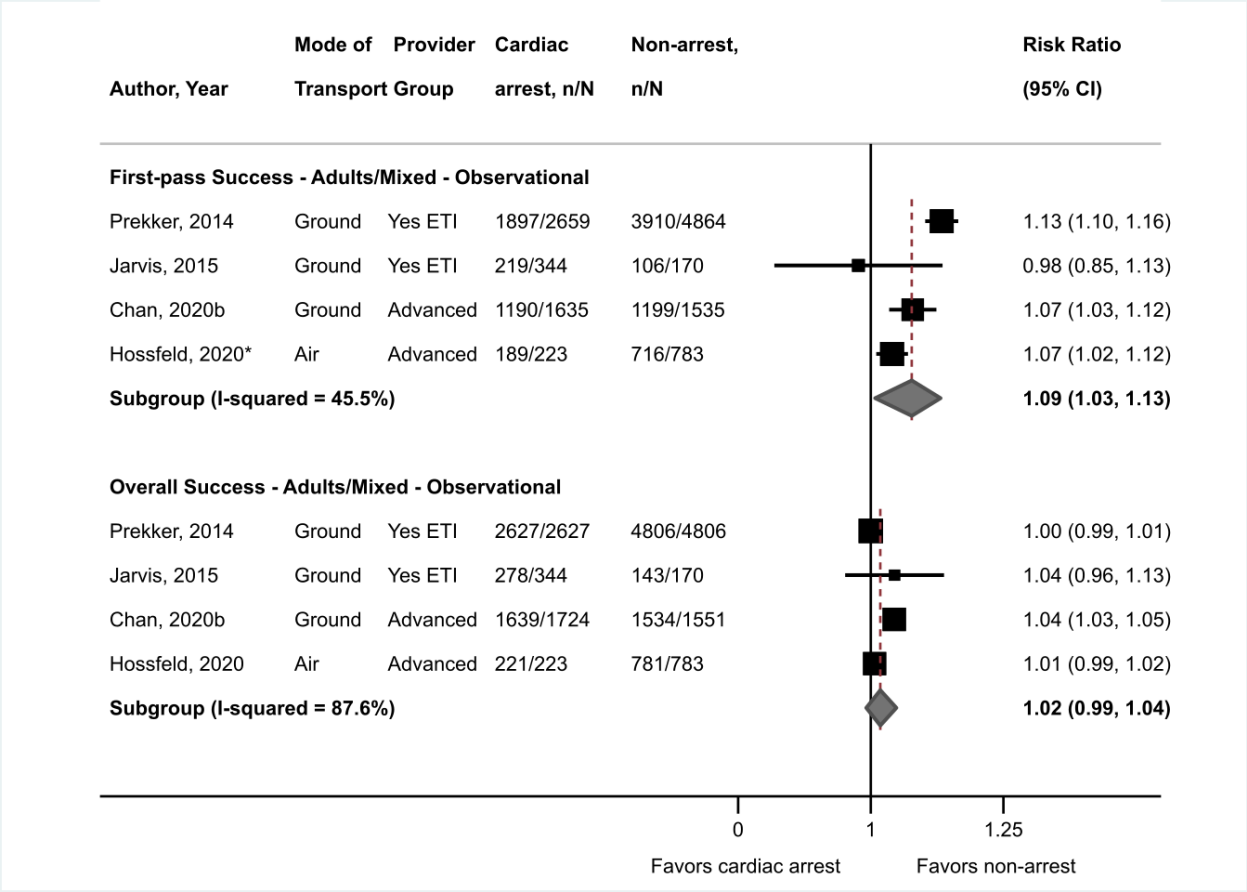
[a]Asterisk indicates where adjusted results were used in the analysis

Figure I-12. Cardiac arrest versus medical (KQ4) pooled estimate of success by age and study design; excluding mixed age groups



CI = confidence interval; KQ = Key Question; NA = not applicable; NR = not reported

Figure I-13. Cardiac arrest versus non-arrest (KQ4) pooled estimate of success by age and study design; excluding high risk of bias/mixed age groups



CI = confidence interval; KQ = Key Question; ETI = endotracheal intubation

[a]Asterisk indicates where adjusted results were used in the analysis

Appendix J. Strength of Evidence

Table J-1. Strength of evidence: Key Question 1

KQ: Comparison Outcome	Subgroup	Number of Studies (Combined N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency (Consistent, Inconsistent, Unknown)	Precision (Precise, Imprecise)	Reporting Bias (Not Detected, Possible, Suspected)	Conclusion	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
KQ1: BVM vs. SGA Survival	Cardiac arrest: Adults/Mixed Ages	3 RCT[1-3] 11 OBS[4-13] (49,103)	Medium	Direct	Consistent	Imprecise	Not detected	No difference in survival	Low
	Cardiac arrest: Pediatrics	2 OBS[14,15] (1,078)	Medium	Direct	Consistent	Imprecise	Not detected	No difference in survival	Low
	Trauma: Adults	1 OBS[16] (50)	Medium	Direct	Unknown	Insufficient	Not detected	No conclusion	Insufficient
KQ1: BVM vs. SGA Neurological function	Cardiac arrest: Adults/Mixed Ages	1 RCT[3] 8 OBS[4,7-9,12,13,17,18] (91,329)	Medium	Indirect	Inconsistent	Imprecise	Not detected	Favors BVM in good neurological function	Low
	Cardiac arrest: Pediatrics	1 OBS[15] (996)	Medium	Indirect	Unknown	Insufficient	Not detected	No conclusion	Insufficient
KQ1: BVM vs. SGA ROSC	Cardiac arrest: Adults	3 RCT[1,3,19] 9 OBS[4,7,9,11-13,18,20,21] (46,845)	Medium	Direct	Inconsistent	Imprecise	Not detected	No difference in ROSC	Low
	Cardiac arrest: Pediatrics	1 OBS[15] (996)	Medium	Direct	Unknown	Insufficient	Not detected	No conclusion	Insufficient

KQ: Comparison Outcome	Subgroup	Number of Studies (Combined N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency (Consistent, Inconsistent, Unknown)	Precision (Precise, Imprecise)	Reporting Bias (Not Detected, Possible, Suspected)	Conclusion	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
KQ1: BVM vs. SGA Qualitative Analysis	Length of stay	1 OBS[16] (50)	Medium	Direct	Unknown	Insufficient	Not detected	No conclusion	Insufficient
	Successful airway	1 RCT[19] 1 OBS[9] (593)	Medium	Indirect	Inconsistent	Insufficient	Not detected	No conclusion	Insufficient
	Oxygenation/ Ventilation	2 RCT[2,19] 3 OBS[11,12,20] (2,525)	Medium	Direct	Consistent	Insufficient	Not detected	No difference in oxygenation and ventilation	Moderate
	Harms	2 RCT[1,19] 2 OBS[9,14] (696)	Medium	Direct	Consistent	Insufficient	Not detected	No difference in harms	Moderate

Table J-2. Strength of evidence: Key Question 2

KQ: Comparison Outcome	Subgroup	Number of Studies (Combined N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency (Consistent, Inconsistent, Unknown)	Precision (Precise, Imprecise)	Reporting Bias (Not Detected, Possible, Suspected)	Conclusion	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
KQ2 BVM vs. ETI Survival	Cardiac Arrest: Adults/Mixed Ages	2 RCT[3,22-24] 9 OBS[4-8,10,12,13] (48,629)	Medium	Direct	Inconsistent	Imprecise	Not detected	No difference	Moderate
	Cardiac Arrest: Pediatrics	1 RCT[25,26] 2 OBS[14,15] (2,235)	Low	Direct	Inconsistent	Imprecise	Not detected	No difference	Low
	Trauma: Adults/Mixed Ages	1 RCT[27] 2 OBS[28,29] (1,328)	Low	Direct	Inconsistent	Imprecise	Not detected	No difference	Low
	Trauma: Pediatrics	No RCT 1 OBS[30] (578)	High	Direct	Unknown	Imprecise	Not detected	No conclusion	Insufficient
KQ2: BVM vs. ETI Neurological Function	Cardiac Arrest: Adults	1 RCT[22,23] 6 OBS[4,7,12,13,17,18] (76,477)	Low	Direct	Inconsistent	Precise	Not detected	No difference	Moderate
	Cardiac Arrest: Pediatrics	1 RCT[25,26] 1 OBS[15] (2,099)	Medium	Direct	Inconsistent	Imprecise	Not detected	No difference	Low
KQ2: BVM vs. ETI ROSC	Cardiac Arrest: Adults	2 RCT[3,22-24] 8 OBS[4,6,7,12,13,18,21,31] (47,244)	Low	Direct	Inconsistent	Imprecise	Not detected	No difference	Low
	Cardiac Arrest: Pediatrics	1 OBS[15] (1,508)	Low	Direct	Unknown	Precise	Not detected	No difference	Low

KQ: Comparison Outcome	Subgroup	Number of Studies (Combined N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency (Consistent, Inconsistent, Unknown)	Precision (Precise, Imprecise)	Reporting Bias (Not Detected, Possible, Suspected)	Conclusion	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
KQ2: BVM vs. ETI Qualitative Analysis	Length of stay	1 RCT[27] 1 CCT[25,26] (1,142)	Low	Indirect	Consistent	Imprecise	Not detected	No difference in ICU or Hospital LOS	Low
	Successful airway	1 RCT[22] 1 CCT[25,26] (2,873)	Low	Indirect	Inconsistent	Imprecise	Not detected	No conclusion	Insufficient
	Oxygenation/ Ventilation	1 RCT[27] 1 OBS[12] (2,535)	Low	Indirect	Consistent	Imprecise	Not detected	No difference	Low
	Harms	2 RCT[22,27] 1 CCT[25,26] 2 OBS[14,30] (3836)	Medium	Direct	Inconsistent	Precise	Not detected	No difference	Moderate
	Survival to hospital admission	1 RCT[22] 3 OBS[6,10,15] (10,339)	Medium	Direct	Inconsistent	Imprecise	Not detected	No difference	Low
	Neurological Function (not in Meta-analyses)	1 RCT[3,24] 2 OBS[8,30]	High	Direct	Inconsistent	Imprecise	Not detected	No conclusion	Insufficient

Table J-3. Strength of evidence: Key Question 3

KQ: Comparison Outcome	Subgroup	Number of Studies (Combined N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency (Consistent, Inconsistent, Unknown)	Precision (Precise, Imprecise)	Reporting Bias (Not Detected, Possible, Suspected)	Conclusion	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
KQ3: SGA vs. ETI Survival	Cardiac Arrest: Adults	3 RCT[3,32,33] 13 OBS[4-8,10,12,13,34-37] (177,088)	Low	Direct	Inconsistent	Precise	Not detected	No difference	Low
	Cardiac Arrest: Pediatrics	3 OBS[14,15,38] (1,260)	Medium	Direct	Inconsistent	Precise	Not detected	No difference	Low
	Trauma: Adults	1 OBS[39] (2,344)	Medium	Direct	NA	Precise	Not detected	No Conclusion	Insufficient
KQ3: SGA vs. ETI Neurological function – mRS	Cardiac Arrest: Adults	2 RCT[3,32] 1 OBS[40] (22,748)	Medium	Direct	Inconsistent	Precise	Not detected	No difference	Low
KQ3: SGA vs. ETI Neurological function – CPC/PCPC	Cardiac Arrest: Adults (CPC)	11 OBS[4,7,12,13,17,18,34-37,41] (179,330)	Medium	Direct	Inconsistent	Precise	Not detected	Difference favoring ETI	Low
	Cardiac Arrest: Pediatrics (PCPC)	2 OBS[15,38] (1,168)	Medium	Direct	Consistent	Imprecise	Not detected	No difference	Low
KQ3: SGA vs. ETI ROSC	Cardiac Arrest: Adults	3 RCT[3,32,33] 13 OBS[4,7,12,13,18,21,35-37,40,42,43] (185,474)	Medium	Direct	Inconsistent	Precise	Not detected	Difference favoring SGA	Low
	Cardiac Arrest: Pediatrics	2 OBS[15,38] (1,168)	Low	Direct	Inconsistent	Imprecise	Not detected	No difference	Low
KQ3: SGA vs. ETI First-pass Success	Cardiac Arrest: Adults	1 RCT[3] 4 OBS[43-46] (23,535)	Moderate	Indirect	Inconsistent	Precise	Not detected	Difference favoring SGA	Low
	Cardiac Arrest: Pediatrics	2 OBS[14,46] (445)	High	Indirect	Consistent	Precise	Not detected	Difference favoring SGA	Low

KQ: Comparison **Outcome**	**Subgroup**	**Number of Studies (Combined N)**	**Study Limitations** (Low, Medium, High)	**Directness** (Direct, Indirect)	**Consistency** (Consistent, Inconsistent, Unknown)	**Precision** (Precise, Imprecise)	**Reporting Bias** (Not Detected, Possible, Suspected)	**Conclusion**	**Strength of Evidence Grade** (Insufficient, Low, Moderate, High)
	Trauma: Adults	1 OBS[46] (2,143)	High	Indirect	NA	Precise	Not detected	No conclusion	Insufficient
	Trauma: Pediatrics	1 OBS[46] (69)	High	Indirect	NA	Precise	Not detected	No Conclusion	Insufficient
	Medical: Adults	1 RCT[47] 1 OBS[46] (7,501)	Moderate	Indirect	Inconsistent	Precise	Not detected	No difference	Low
	Medical: Pediatrics	1 OBS[46] (100)	High	Indirect	NA	Precise	Not detected	No conclusion	Insufficient
	Mixed Emergency Types: Adults	2 OBS[48,49] (407)	Moderate	Indirect	Consistent	Precise	Not detected	Difference favoring SGA	Low
KQ3: SGA vs. ETI Overall Success	Cardiac Arrest: Adults	3 RCT[32,33,40] 6 OBS[43-45,50-52] (48,703)	Moderate	Indirect	Inconsistent	Precise	Not detected	No difference	Moderate
	Trauma: Adults	1 OBS[52] (3,824)	High	Indirect	NA	Precise	Not detected	No conclusion	Insufficient
	Medical: Adults	1 RCT[47] 2 OBS[52,53] (15,848)	Moderate	Indirect	Inconsistent	Precise	Not detected	No difference	Moderate
	Mixed emergency types: Adults	3 OBS[48,54,55] (3,267)	Moderate	Indirect	Consistent	Precise	Not detected	No difference	Moderate
KQ3: SGA vs. ETI	24-hour survival	3 OBS[34,40,42] (29,777)	High	Direct	Inconsistent	Precise	Not detected	No conclusion	Insufficient

KQ: Comparison **Outcome**	**Subgroup**	**Number of Studies (Combined N)**	**Study Limitations** (Low, Medium, High)	**Directness** (Direct, Indirect)	**Consistency** (Consistent, Inconsistent, Unknown)	**Precision** (Precise, Imprecise)	**Reporting Bias** (Not Detected, Possible, Suspected)	**Conclusion**	**Strength of Evidence Grade** (Insufficient, Low, Moderate, High)
Survival, other timepoints	72-hour survival	2 RCT[3,24,32] (12,300)	Low	Direct	Consistent	Mixed	Not detected	No difference	Moderate
	Survival to ED, hospital, or ICU admission	2 RCT[3,24,33] 5 OBS[6,10,15,36,45] (20,682)	Medium	Direct	Inconsistent	Unknown	Not detected	No difference	Low
KQ3: SGA vs. ETI Additional Outcomes	Oxygenation/ventilation	4 OBS[12,41,42,56] (2,665)	High	Indirect	Imprecise	Unknown	Not detected	No difference	Low
	Neurological Function: Glasgow Outcome Scale	1 OBS[8] (78)	High	Direct	N/A	Unknown	Not detected	No conclusion	Insufficient
	Harms Aspiration	1 RCT[32] 1 OBS[49] (9,552)	Medium	Direct	Consistent	Precise	Not detected	No difference	Moderate
	Harms Oral/Airway Trauma	1 RCT[3] 1 OBS[14] (3,159)	Medium	Direct	Consistent	Mixed	Not detected	No difference	Moderate
	Harms Multiple Insertions	1 RCT[3] (3,004)	Low	Direct	N/A	Precise	Not detected	Favors SGA	Moderate
	Harms Inadequate Ventilation	1 RCT[3] (3,004)	Low	Direct	N/A	Precise	Not detected	Favors ETI	Moderate
	Harms Regurgitation	1 RCT[32] (9,296)	Low	Direct	N/A	Precise	Not detected	No difference	Moderate
	Harms Dislodged/Misplaced Intubation Any Complication Fatal Complication Need for Additional Airway Blood in Airway	2 RCT[3,32] 3 OBS[15,44,45] (13,264)	Low	Direct	Inconsistent	Mixed	Not detected	No conclusion	Insufficient

Table J-4. Strength of evidence: Key Question 4

KQ: Comparison Outcome	Subgroup	Number of Studies (Combined N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency (Consistent, Inconsistent, Unknown)	Precision (Precise, Imprecise)	Reporting Bias (Not Detected, Possible, Suspected)	Conclusion	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
KQ4: RSI vs. no medication Survival	Cardiac Arrest: Adults	1 OBS[57] (3,047)	Medium	Direct	Unknown	Imprecise	Not detected	No conclusion	Insufficient
	Trauma: Adults/Mixed ages	4 OBS[58-61] (2,520)	Medium	Direct	Inconsistent	Imprecise	Not detected	No difference	Low
	Medical: Adults	1 OBS[62] (1,454)	Medium	Direct	Unknown	Precise	Not detected	No conclusion	Insufficient
KQ4: RSI vs. no medication First-pass success	Cardiac Arrest: Adults	1 OBS[57] (2,776)	Medium	Indirect	Unknown	Precise	Not detected	No conclusion	Insufficient
	Trauma: Adults/Mixed ages	2 OBS[61,63] (530)	Medium	Indirect	Consistent	Precise	Not detected	No difference	Low
	Mixed emergency: Adults/Mixed ages	5 OBS[46,64-67] (30,126)	High	Indirect	Consistent	Precise	Not detected	Favors RSI	Low
	Mixed emergency: Pediatrics	1 OBS[46] (455)	High	Indirect	Unknown	Precise	Not detected	No conclusion	Insufficient
KQ4: RSI vs. no medication Overall success	Cardiac Arrest: Adults	2 OBS[52,57] (30,496)	Medium	Indirect	Inconsistent	Precise	Not detected	No difference	Low
	Trauma: Adults	2 OBS[52,59] (3,769)	Medium	Indirect	Inconsistent	Precise	Not detected	Favors RSI	Low
	Medical: Adults	1 OBS[52] (13,566)	High	Indirect	Unknown	Precise	Not detected	No conclusion	Insufficient
	Mixed emergency: Adults/Mixed ages	3 OBS[64,65,68] (8,215)	High	Indirect	Consistent	Precise	Not detected	No difference	Low
KQ4: RSI vs. sedation-facilitated First-pass success	Mixed emergency: Adults/Mixed ages	3 OBS[46,64,67] (5,778)	High	Indirect	Consistent	Imprecise	Not detected	Favors RSI	Low
	Mixed emergency: Pediatrics	1 OBS[46] (64)	High	Indirect	Unknown	Imprecise	Not detected	No conclusion	Insufficient

KQ: Comparison Outcome	Subgroup	Number of Studies (Combined N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency (Consistent, Inconsistent, Unknown)	Precision (Precise, Imprecise)	Reporting Bias (Not Detected, Possible, Suspected)	Conclusion	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
KQ4: Sedation-facilitated vs. no medication First-pass success	Mixed emergency: Adults/Mixed ages	3 OBS[46,64,67] (18,841)	High	Indirect	Inconsistent	Precise	Not detected	No difference	Low
	Mixed emergency: Pediatrics	1 OBS[46] (421)	High	Indirect	Unknown	Imprecise	Not detected	No conclusion	Insufficient
KQ4: Direct vs. video laryngoscopy First pass success	Cardiac Arrest: Adults	2 RCT[69,70] 3 OBS[43,71,72] (905)	Medium	Indirect	Inconsistent	Precise	Not detected	No difference	Low
	Trauma: Adults	2 OBS[63,67] (310)	Medium	Indirect	Inconsistent	Imprecise	Not detected	No difference	Insufficient
	Medical: Adults	1 OBS [67] (249)	High	Indirect	Unknown	Precise	Not detected	No conclusion	Insufficient
	Mixed emergency: Adults/Mixed ages	2 RCT[73,74] 4 OBS[71,75-77] (5,816)	Medium	Indirect	Consistent	Precise	Not detected	No difference	Moderate
KQ4: Direct vs. video laryngoscopy Overall Success	Cardiac Arrest: Adults	2 RCT[69,70] 3 OBS[43,71,72] (905)	Medium	Indirect	Consistent	Precise	Not detected	No difference	Moderate
	Mixed emergency: Adults	3 RCT[73,78,79] 4 OBS[71,75,77,80] (2,155)	Medium	Indirect	Inconsistent	Precise	Not detected	No difference	Low
KQ4: Medical vs. cardiac arrest First pass sucess	Adults/Mixed Ages	2 OBS[46,81] (20,644)	High	Indirect	Inconsistent	Precise	Not detected	No conclusion	Insufficient
	Pediatrics	1 OBS[46] (409)	High	Indirect	Unknown	Precise	Not detected	No conclusion	Insufficient

KQ: Comparison Outcome	Subgroup	Number of Studies (Combined N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency (Consistent, Inconsistent, Unknown)	Precision (Precise, Imprecise)	Reporting Bias (Not Detected, Possible, Suspected)	Conclusion	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
KQ4: Medical vs. cardiac arrest Overall success	Adults/Mixed Ages	2 OBS[52,81] (41,718)	High	Indirect	Consistent	Precise	Not detected	No difference	Low
KQ4: Non-arrest vs. cardiac arrest First pass success	Adults/Mixed Ages	5 OBS[64,65,71,82,83] (14,148)	High	Indirect	Consistent	Precise	Not detected	No difference	Low
KQ4: Non-arrest vs. cardiac arrest Overall success	Adults/Mixed Ages	5 OBS[64,65,71,82,83] (14,259)	High	Indirect	Consistent	Precise	Not detected	No difference	Low
KQ4: Trauma vs. cardiac arrest First pass success	Adults/Mixed Ages	2 OBS[46,81] (15,924)	High	Indirect	Inconsistent	Precise	Not detected	No conclusion	Insufficient
	Pediatrics	1 OBS[46] (374)	High	Indirect	Unknown	Precise	Not detected	No conclusion	Insufficient
KQ4: Trauma vs. cardiac arrest Overall Success	Adults/ Mixed Ages	3 OBS[52,81,84] (31,586)	High	Indirect	Inconsistent	Precise	Not detected	No difference	Low
KQ4: Medical vs. Trauma First pass success	Adults/Mixed Ages	4 OBS[46,67,81,85] (9,527)	High	Indirect	Consistent	Precise	Not detected	Favors medical	Low
	Pediatrics	1 OBS[46] (157)	High	Indirect	Unknown	Precise	Not detected	No conclusion	Insufficient

KQ: Comparison **Outcome**	**Subgroup**	**Number of Studies (Combined N)**	**Study Limitations** (Low, Medium, High)	**Directness** (Direct, Indirect)	**Consistency** (Consistent, Inconsistent, Unknown)	**Precision** (Precise, Imprecise)	**Reporting Bias** (Not Detected, Possible, Suspected)	**Conclusion**	**Strength of Evidence Grade** (Insufficient, Low, Moderate, High)
KQ4: Medical vs. Trauma Overall Success	Adult/Mixed Ages	3 OBS[52,81,85] (17,969)	High	Indirect	Consistent	Precise	Not detected	No difference	Low

Appendix J References

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