ISSN: 3152-8686

Vol2; Issue3, Nov. 2025

JOURNAL OF
TAZEEZ FOR PUBLIC HEALTH

AN OFFICIAL JOURNAL OF SAUDI HEALTH PROMOTION AND EDUCATION ASSOCIATION

Systematic review

Prehospital Airway Management in Out-of-Hospital Cardiac Arrest: Perspectives from Emergency Medical Services, Nursing, and Anesthesia Technology: A Systematic Review

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Published: 25 Nov, 2025

https://doi.org/10.65759/r0qw0w65

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Abstract

Background: Airway management during out-of-hospital cardiac arrest (OHCA) is delivered by paramedics, technicians, nurses, and anesthesia-trained personnel, and the preferred strategy for each group remains unsettled. Objective: To synthesize evidence on prehospital airway strategies in adult OHCA and interpret it from emergency medical services (EMS), nursing, and anesthesia technology perspectives. Methods: This review followed the PRISMA 2020 statement. Two authors independently searched PubMed, Scopus, and Web of Science for studies published before December 2024, screened records, extracted data, and appraised risk of bias with RoB 2 and the Newcastle-Ottawa Scale. Findings were synthesized narratively. Results: Of 3,555 records, 13 studies met the eligibility criteria: four randomized trials enrolling 15,311 patients and nine cohort studies. Trials showed no functional outcome advantage for endotracheal intubation over supraglottic airways or bag-mask ventilation, and initial laryngeal tube insertion improved 72-hour survival in one trial. Large registries linked advanced airways with lower neurologically favorable survival, an association that weakened after time-dependent or propensity matching. Earlier airway placement and certified operators were associated with better outcomes. Nordic anesthetist and nurse anesthetist teams achieved overall intubation success above 97%, and video laryngoscopy raised first-pass success among ambulance nurses. Conclusion: Supraglottic devices suit most EMS crews as a first-line strategy, while intubation performs best in the hands of highly trained operators supported by video laryngoscopy and waveform capnography.

Keywords: Out-of-hospital cardiac arrest; Airway management; Supraglottic airway; Emergency medical services; Nursing; Anesthesia

Introduction

Out-of-hospital cardiac arrest (OHCA) remains a major cause of death worldwide, and a meta-analysis of 141 studies reported pooled return of spontaneous circulation (ROSC) of 29.7% and one-month survival of 10.7% among adults who received cardiopulmonary resuscitation (CPR) (1). In Europe, the EuReCa TWO study confirmed 37,054 arrests across 28 countries, with ROSC in 33% of cases, 8% of patients discharged alive, and higher survival after bystander CPR with ventilations than after compression-only CPR (14% vs. 8%) (2). These figures place oxygenation at the center of professional resuscitation, where rescuers choose between bag-mask ventilation (BMV), supraglottic airway (SGA) insertion, and endotracheal intubation (ETI) (3).

The 2019 American Heart Association (AHA) focused update accepts either BMV or an advanced airway during CPR in any setting and supports SGA use in systems with low intubation success or minimal training opportunities (4). European Resuscitation Council (ERC) guidance recommends a stepwise approach and reserves ETI for rescuers with a success rate above 95% within two attempts (3). Both positions reflect concern about compression pauses, since paramedic intubation in one prospective series produced a first intubation-related pause with a median of 46.5 seconds, and almost one third of these pauses exceeded one minute (5).

Prehospital intubation carries risks of hypoxia, hypotension, tube misplacement, esophageal intubation, and aspiration, and an earlier meta-analysis reported success rates of 84.9% for non-physicians against 99.1% for physicians (6). The AHA update ties advanced airway practice to provider training and recommends frequent experience or frequent retraining for clinicians who perform ETI (4). A later meta-analysis of studies published between 2006 and 2016 estimated overall prehospital intubation success at 95.3% and found that the gap between physician and non-physician operators persisted (6). ERC guidance links the choice of technique to the skills of the individual rescuer rather than to professional title (3).

A systematic review prepared for the International Liaison Committee on Resuscitation (ILCOR) organized the evidence around device comparisons, rated most observational studies at serious or critical risk of bias, and judged heterogeneity too great for meta-analysis (7). Paramedics, technicians, ambulance nurses, nurse anesthetists, and anesthesia-trained teams differ in exposure,

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equipment, and supervision, and these differences shape both intubation performance and CPR quality (5,6). This review synthesized trials and cohorts of adult OHCA airway management and interpreted the findings through EMS, nursing, and anesthesia technology perspectives to inform protocols aligned with current resuscitation guidance.

Methods

Protocol and reporting

This systematic review was conducted and reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement, and the review question followed the population, intervention, comparison, outcome, and study design (PICOS) framework.

Eligibility criteria

Eligible studies enrolled adults (18 years or older) with OHCA managed by paramedics, emergency medical or life-saving technicians, ambulance or helicopter nurses, nurse anesthetists, or physician-staffed teams. Exposures comprised any prehospital airway strategy (BMV, SGA, ETI, video or direct laryngoscopy), its timing, or operator category. Outcomes included ROSC, survival, neurological status, airway success, and airway complications. Randomized controlled trials (RCTs) and cohort studies published in English before December 2024 were eligible. Studies of in-hospital arrest, pediatric-only populations, simulation, reviews, editorials, conference abstracts, and mixed populations without separate OHCA data were excluded.

Search strategy

PubMed, Scopus, and Web of Science Core Collection were searched from inception to 30 November 2024. Medical Subject Headings and free-text terms were combined with Boolean operators across three concepts: cardiac arrest ("out-of-hospital cardiac arrest", "OHCA"), airway management ("intubation, intratracheal", "supraglottic airway", "laryngeal mask", "laryngeal tube", "bag-valve-mask", "videolaryngoscopy"), and prehospital care ("emergency medical services", "paramedic*", "ambulance nurs*", "nurse anesthetist*"). Syntax was adapted to each database, and reference lists of included studies were hand-searched.

Study selection

Records were exported to a reference manager for deduplication. Two authors independently screened titles and abstracts, then full texts, and resolved disagreements by discussion. The search returned 3,555 records (PubMed n = 1,146; Scopus n = 1,382; Web of Science n = 1,027). After removal of 1,318 duplicates, 2,237 records underwent title and abstract screening, and 2,109 were excluded. Of 128 reports sought for retrieval, 4 were unavailable, leaving 124 full texts for eligibility assessment. A further 111 reports were excluded: mixed populations without separate OHCA data (n = 27), in-hospital arrest (n = 22), simulation or manikin studies (n = 19), reviews, editorials, or conference abstracts (n = 18), no airway-related outcome (n = 15), and pediatric-only populations (n = 10). Thirteen studies entered the qualitative synthesis (Figure 1).

Data extraction

Two authors independently extracted study characteristics, provider type, sample size, airway strategies, outcomes, and adjusted effect estimates into a piloted form and resolved discrepancies by consensus.

Risk of bias assessment

Two authors independently appraised RCTs with the Cochrane Risk of Bias 2 (RoB 2) tool, using its cluster-randomized variant where relevant, and cohort studies with the Newcastle-Ottawa Scale (NOS),

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where scores of 7-9, 5-6, and 0-4 denoted high, moderate, and low quality (Table 1).

Data synthesis

Heterogeneity in comparators, outcome definitions, provider types, and EMS structures precluded meta-analysis. Findings were therefore synthesized narratively following the Synthesis Without Meta-analysis (SWiM) guideline and grouped by device strategy, timing and training, and provider background.

Results

Characteristics of included studies

Four RCTs enrolled 15,311 adults with OHCA in France, Belgium, England, the United States, and Taiwan (8-11). Nine cohort studies drew on data from Japan, the United States and Canada, Taiwan, Korea, the Nordic countries, and the Netherlands (12-20). Physician-staffed mobile intensive care teams delivered the allocated strategy in the French-Belgian trial, and paramedics delivered it in the other three trials (8-11). Japanese cohorts involved emergency life-saving technicians (ELSTs), some holding ETI certification (12,13,18). Nursing and anesthesia data came from Nordic physician anesthetist and nurse anesthetist teams and from Dutch ambulance nurses, helicopter EMS (HEMS) nurses, and HEMS physicians (19,20). The three cluster trials raised some concerns of bias related to cluster allocation and crossover between strategies (Table 1) (9-11).

Device strategy and patient outcomes

In the French-Belgian trial, favorable neurological survival at 28 days was 4.3% with BMV and 4.2% with ETI, an inconclusive noninferiority result, with more regurgitation under BMV (8). AIRWAYS-2 reported good functional outcome in 6.4% of the SGA group and 6.8% of the ETI group (9). The Pragmatic Airway Resuscitation Trial (PART) found higher 72-hour survival with initial laryngeal tube (LT) insertion than with ETI (18.3% vs. 15.4%) (10). The Taipei SAVE trial showed sustained ROSC in 26.9% after ETI and 25.8% after SGA (11). Regurgitation, aspiration, airway injury, and pneumonia were similar between strategies in the two largest trials (9,10).

Among 649,359 Japanese patients, advanced airways were associated with lower odds of favorable neurological outcome than BMV (adjusted odds ratio [aOR] 0.38, 95% confidence interval [CI] 0.37-0.40) (12). A later nationwide cohort using time-dependent propensity matching found higher one-month survival with advanced airways in non-shockable rhythms (adjusted risk ratio 1.27, 95% CI 1.20-1.35) and no difference in shockable rhythms (13). In the Cardiac Arrest Registry to Enhance Survival (CARES), ETI outperformed SGA for neurologically intact survival (odds ratio 1.44, 95% CI 1.10-1.88) (14). The Resuscitation Outcomes Consortium (ROC) PRIMED analysis also favored ETI over SGA for ROSC (aOR 1.78) (15). Successful intubation by Taipei paramedics was associated with greater survival to discharge than BMV (aOR 1.98) (16). In the Korean KoCARC registry, the crude disadvantage of advanced airways disappeared after propensity matching (9.6% vs. 10.0%; hazard ratio 0.98) (17).

Timing and operator training

In Osaka, ETI and SGA produced identical favorable neurological outcome (3.6% each), and each minute of delay to airway placement lowered the odds of a good outcome (aOR 0.91, 95% CI 0.88-0.95) (18). Initial airway success in PART reached 90.3% for LT and 51.6% for ETI (10). An ETI-certified ELST on scene was linked with better neurological outcome in Osaka (aOR 1.86, 95% CI 1.04-3.34) (18). First-attempt success in SAVE was 77% for ETI and 83% for SGA (11).

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Provider background and video laryngoscopy

Among 2,028 intubations by Nordic anesthesia teams, 53% involved cardiac arrest, with first-pass success of 78.4% in arrest patients against 84.5% overall (19). In the Netherlands, video laryngoscopy (VL) raised first-pass success from 45.5% to 64.8% among ambulance nurses and from 57.6% to 77.2% among HEMS nurses, with no change among HEMS physicians (20). Overall success reached 99.0% for Nordic physician anesthetists and 97.6% for nurse anesthetists (19). Unrecognized esophageal intubation in Dutch medical cardiac arrests occurred in about 20% of direct laryngoscopy (DL) attempts and in none with VL (20).

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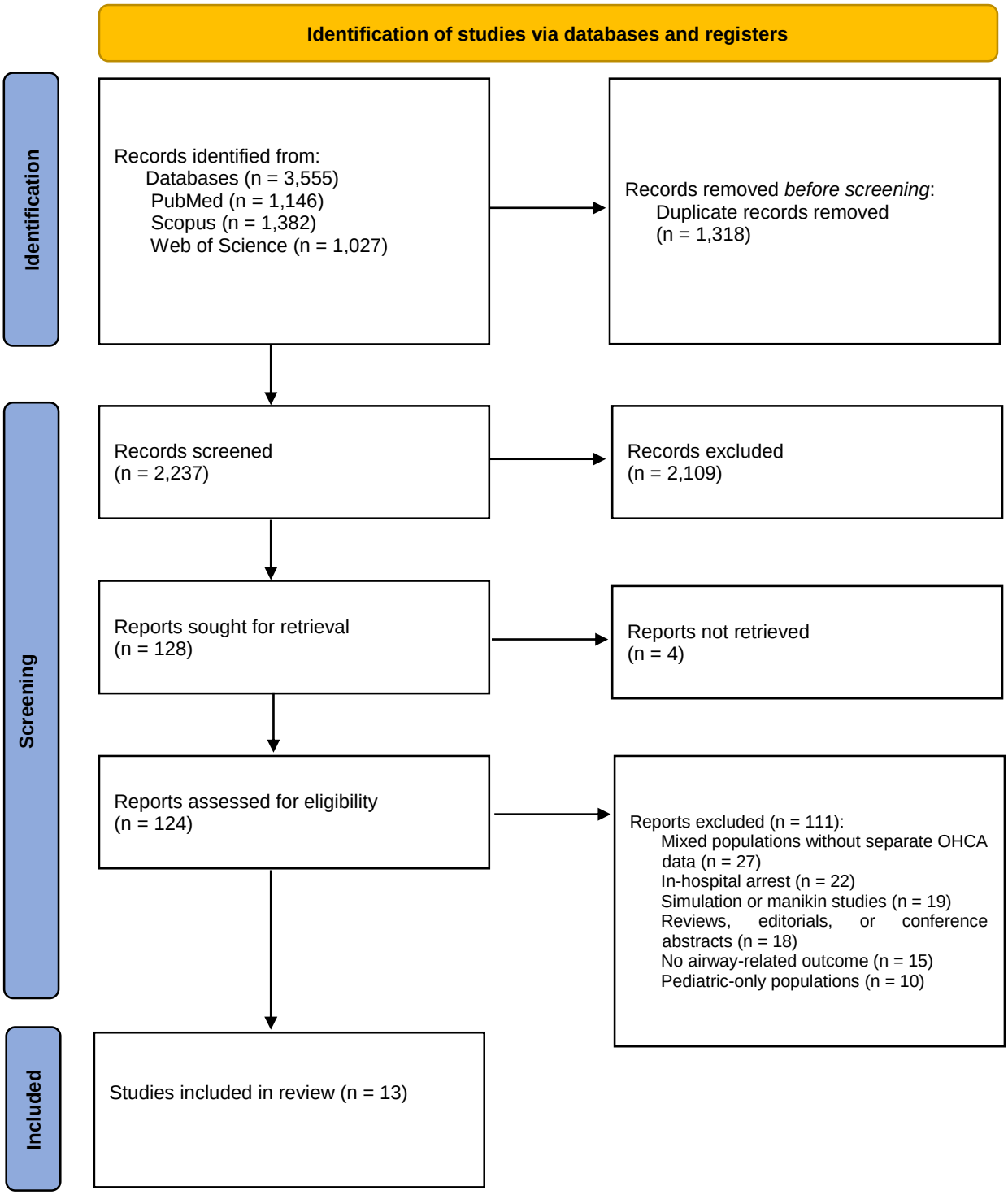

Figure 1. PRISMA 2020 flow diagram of study selection.

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Table 1. Risk of bias assessment of included studies

(A) Randomized controlled trials (RoB 2)

Study	Randomization	Deviations from intervention	Missing data	Outcome measurement	Reported result	Overall
Jabre et al., 2018	Low	Some concerns	Low	Low	Low	Some concerns
Benger et al., 2018	Low	Some concerns	Low	Low	Low	Some concerns
Wang et al., 2018	Some concerns	Some concerns	Low	Low	Low	Some concerns
Lee et al., 2022	Some concerns	Some concerns	Low	Low	Low	Some concerns

(B) Cohort studies (Newcastle-Ottawa Scale)

Study	Selection (0-4)	Comparability (0-2)	Outcome (0-3)	Total (0-9)	Quality
Hasegawa et al., 2013	4	2	3	9	High
Izawa et al., 2019	4	2	3	9	High
McMullan et al., 2014	3	2	3	8	High
Wang et al., 2012	3	2	3	8	High
Chiang et al., 2018	3	2	3	8	High
Chang et al., 2022	3	2	3	8	High
Kajino et al., 2011	4	2	3	9	High
Gellerfors et al., 2018	4	0	2	6	Moderate
Maissan et al., 2022	4	0	2	6	Moderate

Table 2. Characteristics of included studies (n = 13)

Study	Country	Design	Airway operators	Patients (n)	Comparison
Jabre, 2018 (8)	France, Belgium	RCT	Physician-staffed mobile ICU teams	2,043	BMV vs. ETI
Benger, 2018 (9)	England	Cluster RCT	Paramedics	9,296	SGA (i-gel) vs. ETI

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Study	Country	Design	Airway operators	Patients (n)	Comparison
Wang, 2018 (10)	United States	Cluster-crossover RCT	Paramedics	3,004	LT vs. ETI
Lee, 2022 (11)	Taiwan	Cluster RCT	Paramedics	968	ETI vs. SGA
Hasegawa, 2013 (12)	Japan	Registry cohort	ELSTs	649,359	AAM vs. BMV
Izawa, 2019 (13)	Japan	Registry cohort	EMS personnel	310,620	AAM vs. no AAM
McMullan, 2014 (14)	United States	Registry cohort	EMS personnel	10,691	ETI vs. SGA vs. no AAM
Wang, 2012 (15)	United States, Canada	Secondary cohort	Paramedics	10,455	ETI vs. SGA
Chiang, 2018 (16)	Taiwan	Registry cohort	Paramedics	10,853	ETI vs. LMA vs. BMV
Chang, 2022 (17)	Korea	Registry cohort	EMS personnel	9,616	AAM vs. BMV
Kajino, 2011 (18)	Japan	Population cohort	ELSTs	5,377	ETI vs. SGA
Gellerfors, 2018 (19)	Nordic countries	Prospective cohort	Physician and nurse anesthetists	1,075 arrests	Operator type
Maissan, 2022 (20)	Netherlands	Retrospective cohort	Ambulance and HEMS nurses, HEMS physicians	3,632	VL vs. DL

Table 3. Main airway process and patient outcome findings

Study	Main findings
Jabre, 2018 (8)	Favorable neurological survival 4.3% (BMV) vs. 4.2% (ETI); regurgitation 15.2% vs. 7.5%
Benger, 2018 (9)	mRS 0-3: 6.4% (SGA) vs. 6.8% (ETI)
Wang, 2018 (10)	Initial success 90.3% (LT) vs. 51.6% (ETI); 72-hour survival 18.3% vs. 15.4%
Lee, 2022 (11)	First-attempt success 83% (SGA) vs. 77% (ETI); sustained ROSC 25.8% vs. 26.9%
Hasegawa, 2013 (12)	Favorable neurological outcome 1.1% (AAM) vs. 2.9% (BMV); aOR 0.38
Izawa, 2019 (13)	Survival aRR 1.27 (non-shockable) and 1.00 (shockable)
McMullan, 2014 (14)	Intact survival 18.6% (no AAM), 5.4% (ETI), 5.2% (SGA)
Wang, 2012 (15)	ETI vs. SGA: ROSC aOR 1.78; functional survival aOR 1.40
Chiang, 2018 (16)	Successful ETI vs. BMV: survival to discharge aOR 1.98

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Study	Main findings
Chang, 2022 (17)	Matched favorable survival 9.6% (AAM) vs. 10.0% (BMV)
Kajino, 2011 (18)	Collapse-to-airway 17.2 (ETI) vs. 15.8 minutes (SGA); per-minute delay aOR 0.91
Gellerfors, 2018 (19)	First-pass success 78.4% in arrest; overall success 99.0% (physicians) vs. 97.6% (nurse anesthetists)
Maissan, 2022 (20)	Ambulance nurse first-pass success 64.8% (VL) vs. 45.5% (DL); unrecognized esophageal intubation about 20% (DL) vs. 0% (VL)

Discussion

Three of the four randomized trials found no outcome difference between airway strategies, and the only benefit came from initial LT insertion in one pragmatic trial (8-11). An earlier meta-analysis that excluded physician and nurse intubators favored ETI over SGA for ROSC, hospital admission, and neurologically intact survival (21). A network meta-analysis of controlled trials later found no differences among ETI, SGA, and BMV for survival or neurological outcome at discharge, with results sensitive to system intubation success rates (22). The reversal of the Japanese registry signal after time-dependent matching shows how confounding by indication and resuscitation-time bias shape observational estimates (12,13).

For EMS crews, SGA insertion offered faster or more reliable airway control, with shorter collapse-to-airway intervals in Osaka and higher first-attempt success in Taipei (11,18). Chest compression fraction differed only marginally between ETI and SGA in ROC data, indicating that device choice alone does not determine CPR quality (23). First-pass airway success in PART was associated with ROSC and not with later outcomes (24). A timing analysis of the same trial found no association between insertion timing and survival to discharge, whereas Osaka data favored earlier placement (18,25). Successive meta-analyses have shown lower intubation success among non-physician providers, so EMS systems that retain ETI need structured exposure and audit of first-pass success (6,26).

Nurses deliver prehospital airway care in Dutch and Nordic services, and their performance depended on equipment and exposure (19,20). A prospective Rotterdam study found that VL raised overall success within two attempts for ambulance nurses from 63% to 83% (27). Cochrane evidence supports this pattern, showing with moderate certainty that Macintosh-style and hyperangulated videolaryngoscopes reduce failed intubation across clinical settings (28). The absence of a VL effect among HEMS physicians suggests that the device narrows the experience gap between nurses and physicians without removing it (20). Nordic nurse anesthetists approached the overall success of physician anesthetists, supporting structured anesthesia training for nurses in prehospital critical care units (19).

Provider-level meta-analyses have classified operators mainly as physicians or non-physicians, and no included study reported anesthesia technologists as a distinct group (6,26). Continuous end-tidal carbon dioxide monitoring eliminated unrecognized misplaced intubation in a regional EMS system, compared with a 23% rate when monitoring was absent (29). The Dutch esophageal placement data and the Cochrane findings identify device readiness, capnography availability, and routine equipment checks as core anesthesia technology contributions to OHCA care (20,28). ERC

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guidance requires waveform capnography to confirm tracheal tube position during CPR (3).

This review combined randomized and registry evidence from 13 studies across Europe, North America, and Asia, with duplicate screening and formal bias appraisal (8-20). Heterogeneity in comparators, outcome definitions, and EMS structures precluded pooling, a limitation also reported in the ILCOR review (7). Nursing and anesthesia data came from European systems with physician backup, which limits transfer to paramedic-only services (19,20). Pragmatic cluster trials have proven feasible in paramedic systems and now need replication in nurse-led and anesthesia-supported services (9-11).

Conclusion

Across randomized trials and large registries, no prehospital airway strategy showed a consistent functional survival advantage in adult OHCA. Supraglottic devices give EMS crews a fast and reliable first-line option, and intubation delivers its best results with operators who maintain high success rates, such as anesthesia-trained physicians and nurse anesthetists. Video laryngoscopy improves intubation success for ambulance nurses, and waveform capnography prevents unrecognized tube misplacement. EMS agencies, nursing leaders, and anesthesia technology departments need shared training, equipment maintenance, and audit of first-pass success. Future trials stratified by provider background, including anesthesia technologists, are required to guide workforce-specific airway protocols.

List of Abbreviations

AAM: advanced airway management; AHA: American Heart Association; aOR: adjusted odds ratio; aRR: adjusted risk ratio; BMV: bag-mask ventilation; CARES: Cardiac Arrest Registry to Enhance Survival; CI: confidence interval; CPR: cardiopulmonary resuscitation; DL: direct laryngoscopy; ELST: emergency life-saving technician; EMS: emergency medical services; ERC: European Resuscitation Council; ETI: endotracheal intubation; EuReCa: European Registry of Cardiac Arrest; HEMS: helicopter emergency medical services; ICU: intensive care unit; ILCOR: International Liaison Committee on Resuscitation; KoCARC: Korean Cardiac Arrest Research Consortium; LMA: laryngeal mask airway; LT: laryngeal tube; mRS: modified Rankin Scale; NOS: Newcastle-Ottawa Scale; OHCA: out-of-hospital cardiac arrest; PART: Pragmatic Airway Resuscitation Trial; PICOS: population, intervention, comparison, outcome, and study design; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RCT: randomized controlled trial; RoB 2: Risk of Bias 2 tool; ROC: Resuscitation Outcomes Consortium; ROSC: return of spontaneous circulation; SAVE: Supraglottic Airway Device vs Endotracheal Intubation trial; SGA: supraglottic airway; SWiM: Synthesis Without Meta-analysis; VL: video laryngoscopy.

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