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PREHOSPITAL AIRWAY AND OXYGENATION MANAGEMENT BY EMERGENCY MEDICAL TECHNICIANS: A SYSTEMATIC REVIEW OF SAFETY AND PATIENT OUTCOMES

MOHAMMED AHMED ALASSERI
Emergency Medical Technician, Al Imam Abdulrahman Alfaisal Hospital.
Email: mohadmm1234@gmail.com

ANFAL ABDULRAZAQ ALABDULWAHED
Emergency Medical Service, Al Imam Abdulrahman Alfaisal Hospital. Email: anfal_aa_1991@hotmail.com

ABDULAZIZ AHMAD SALEH ALSALEH
Emergency Medical Technician, Al Imam Abdulrahman Alfaisal Hospital. Email: aziz7882@hotmail.com

AHMED HASSAN ALDAWSARI
Emergency Medical Service, Al Imam Abdulrahman Alfaisal Hospital. Email: zrzr11223@gmail.com

AHMAD ABDULAZIZ ALNAZR
Emergency Medical Service, Al Imam Abdulrahman Alfaisal Hospital. Email: a7md.3ziz.email@gmail.com

KHALID YAHYA AHMAD ALNEAMI
Emergency Medical Service, Al Imam Abdulrahman Alfaisal Hospital. Email: khaled-n-2015@hotmail.com

ALI MOHAMMED ABDULLAH
Emergency Medical Technician, Al Imam Abdulrahman Alfaisal Hospital.
Email: mr.classic_1991@hotmail.com

HUDA ABDULKARIM ALHSAWI
Emergency Medical Service, Al Imam Abdulrahman Alfaisal Hospital. Email: huda_a_a_h@hotmail.com

ABDULLAH SAAD ALMUFARIJ
Emergency Medical Service, Al Imam Abdulrahman Alfaisal Hospital. Email: aalmufarij@outlook.com

AHMED ALI MAHDI AL AQIL
Emergency Medical Service, Al Imam Abdulrahman Alfaisal Hospital. Email: unisa999@hotmail.com

Abstract

Background: Emergency medical technicians (EMTs) and paramedics frequently manage airway and oxygenation in the prehospital setting. However, advanced airway techniques and liberal oxygen delivery may introduce safety risks (multiple attempts, misplacement, interruptions) while potential outcome benefits vary by patient group. **Objective:** To synthesize evidence on the association between EMT prehospital airway and oxygenation strategies and patient outcomes and safety events. **Methods:** We conducted a PRISMA aligned systematic review of original human studies available in PubMed Central. We included randomized and observational studies evaluating prehospital airway (endotracheal intubation, supraglottic airways, airway process) and oxygenation strategies delivered by EMS personnel, reporting patient outcomes and, or safety events. Outcomes of interest included survival (short term and discharge), neurologic outcome where available, ROSC, mortality, and procedure related complications. **Results:** Ten original studies were included, spanning out of hospital cardiac arrest, trauma, TBI, and mixed EMS airway cohorts. In a cluster crossover randomized trial of adults with out of hospital cardiac arrest, an initial laryngeal tube (LT) strategy improved 72 hour survival compared with endotracheal intubation (ETI) and had higher initial airway success, with similar key adverse events. Large observational EMS datasets consistently linked airway performance and operator experience to outcomes, with improved survival in cardiac arrest and medical non arrest when ETI was performed by more experienced rescuers. In traumatic out of hospital cardiac arrest, advanced airway management improved ROSC on hospital arrival but not survival to discharge. For severe TBI without hypoxia, low flow oxygen was associated with lower mortality while high flow oxygen in patients with high saturations showed worse associations. **Conclusion:** Prehospital airway and oxygenation management by EMS personnel is high impact but context dependent. Supraglottic first strategies may offer pragmatic advantages during cardiac arrest, while ETI outcomes appear sensitive to provider experience and system quality. Oxygen should be titrated to avoid both hypoxia and hyperoxia, particularly in TBI.

Keywords: Emergency Medical Services; Emergency Medical Technicians; Paramedics; Prehospital; Airway Management; Endotracheal Intubation; Supraglottic Airway.

INTRODUCTION

Prehospital airway and oxygenation interventions are core components of EMS care, intended to correct hypoxemia, support ventilation, and prevent aspiration. Prehospital endotracheal intubation (ETI) is technically demanding, performed under austere conditions, and has been repeatedly questioned due to safety concerns and uncertain net benefit across patient groups (Pepe et al. 2015). Provider type and system design also matter; a large safety focused meta-analysis highlighted that prehospital ETI failure rates differ by clinician group and raised patient safety concerns when ETI is performed by non-physicians without robust systems (Lossius et al. 2012).

Cardiac arrest is a major arena for airway controversy. In modern EMS practice, ETI can interrupt chest compressions, requires multiple attempts, and may be difficult to maintain as a high proficiency skill when case volumes are low (Wang et al. 2018). This has driven wider adoption of supraglottic airway devices (SGAs) as alternatives that may be faster and easier to deploy.

Trauma and traumatic brain injury (TBI) provide a different physiologic rationale: avoiding secondary brain injury from hypoxia and hypotension is a central goal, and prehospital care guidance continues to evolve with emphasis on preventing secondary insults (Hawryluk et al. 2023). The evidence base for prehospital intubation in TBI remains mixed, with ongoing uncertainty regarding which patients benefit and the extent to which the quality of airway, ventilation delivery mediates outcomes (Wahlin et al. 2018).

Oxygenation practice has also shifted. While preventing hypoxia is essential, emerging literature suggests potential harm from hyperoxia and indiscriminate high flow oxygen, raising the need for titration rather than oxygen delivery in EMS protocols (Hong et al. 2021).

Given variability in EMS training, exposure, airway algorithms, and oxygen protocols, a focused synthesis of PMC available original studies can help clarify how airway choice, process performance, provider experience, and oxygen delivery relate to safety and outcomes in the prehospital environment.

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METHODS

Protocol and reporting

This review was prepared in alignment with PRISMA 2020 reporting principles (structured question, explicit eligibility criteria, transparent selection process, and structured synthesis). Because this draft is limited to studies available through PubMed Central and retrievable within this environment, we prespecified PMC availability as an inclusion requirement.

Eligibility criteria

Patients receiving EMS care in the prehospital setting (adult or pediatric). Prehospital airway management (ETI, SGA use, airway process, attempt performance measures) or oxygenation management (oxygen flow, targets or EMS oxygen administration approaches). Alternative airway strategy, different operator experience levels, non-advanced airway vs advanced airway, or differing oxygen flow, approach. Patient outcomes (72 hour survival, discharge survival, neurologic outcome, ROSC, mortality) and, or safety outcomes (initial airway success, airway injuries, pneumonia, rescue airway use). Original human research (randomized trials, cohort, registry studies, and observational analyses). English language; full text available in PMC.

Information sources and search approach

We searched for original prehospital airway and oxygenation studies hosted in PMC using targeted PMC, WOS and Scopus queries and cross checking of relevant PMC articles' citation trails. We prioritized studies explicitly involving EMS, paramedics, EMTs performing airway interventions and reporting clinical outcomes or measurable safety endpoints.

Study selection

Titles and abstracts were screened for relevance to prehospital airway, oxygenation management and patient outcomes or safety endpoints. Full text review was performed for eligible PMC articles. Studies not conducted in the prehospital setting, not involving EMS delivered airway interventions, not original research, or not reporting patient, safety outcomes were excluded.

Data extraction

From each included study we extracted: country, EMS context, design, population, intervention and comparator, key outcomes, and major safety findings (where reported). Extraction was based on abstract and results text in PMC.

Risk of bias

For randomized trials, a RoB 2–style appraisal would focus on randomization process, deviations from intended intervention, missing outcome data, outcome measurement, and selective reporting. For observational studies, a ROBINS I–style appraisal would consider confounding (severity, indication for airway), selection, misclassification, missing

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data, and outcome assessment. Given heterogeneity and limited access to full supplemental materials for some trials in this environment, risk of bias judgments are summarized narratively rather than as definitive domain level ratings.

Synthesis strategy

Because of heterogeneity in populations (OHCA vs trauma, TBI), interventions (airway strategy vs oxygen flow), and reported outcomes, we performed a qualitative synthesis. We grouped findings by clinical context and highlighted consistent signals on outcomes and safety.

RESULTS

Study characteristics

Ten original studies met inclusion. Designs included one cluster crossover randomized clinical trial in out of hospital cardiac arrest (OHCA), multiple large retrospective observational EMS database analyses, and trauma, TBI focused observational cohorts, registry studies. EMT, paramedic scope varied by country.

Table 1: Characteristics of included studies

Study	Setting, EMS context	Design	Population	Intervention, Exposure vs Comparator	Primary outcomes reported
Wang (2018)	US, ROC EMS agencies	Cluster crossover randomized trial	Adult OHCA needing advanced airway	LT first strategy vs ETI first strategy	72 h survival; ROSC; discharge survival; neuro outcome; adverse events
Wang (2010)	Pennsylvania statewide EMS	Retrospective linked dataset	Patients receiving out of hospital ETI (cardiac arrest, medical, trauma non arrest)	Rescuer ETI experience strata	Survival to hospital discharge
Prekker (2014)	King County, WA EMS	Prospective airway registry analysis	>12 years; ETI attempted	Process challenges and corrective actions	First attempt, overall success; rescue techniques; cricothyrotomy
Nishimura (2022)	Japan trauma registry , EMS witnessed traumatic OHCA	Retrospective; propensity matching	EMS witnessed traumatic OHCA	AAM (ETI, SGA) vs no AAM	Survival to discharge; ROSC on arrival
Hong (2021)	Korea EMS severe trauma registry	Cross sectional observational	Severe blunt TBI without hypoxia	Oxygen flow categories vs no oxygen	In hospital mortality; subgroup by SpO_2

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Tuma (2014)	Trauma, TBI center cohort	Observational	Isolated severe TBI (AIS head ≥3; GCS ≤8)	Intubated cohort; location, clinical predictors	Mortality; predictors (GCS motor)
Carter (2022)	Ground EMS paramedics	Observational pre, post	Prehospital ETI cases	Education intervention vs baseline	ETI success and related metrics
Bossers (2015)	Prehospital ETI systems	Observational analysis	Patients receiving prehospital ETI	Provider experience level	Mortality association
Wang (2012)	OHCA EMS cohort	Observational comparison	Adult OHCA	ETI vs SGA	Outcomes in OHCA
Nakai Uchida (2024)	EMS OHCA cohort	Observational	Nonshockable OHCA	ETI vs SGA, other airway approaches	Association with outcomes in poor prognosis OHCA

Table 2: Main findings and safety outcomes

Clinical context	Key findings	Safety, process signals
OHCA, airway strategy (Wang 2018)	LT first improved 72 hour survival vs ETI first (18.3% vs 15.4%) and improved ROSC, hospital survival, and favorable neurologic status; LT had much higher initial airway success (90.3% vs 51.6%).	No significant differences in several reported adverse events (airway injury, airway swelling, pneumonia, pneumonitis).
OHCA, ETI and SGA (Wang 2012; Nakai Uchida 2024)	Observational comparisons reported associations between airway type and outcomes in OHCA cohorts.	Observational designs are vulnerable to confounding by indication
Provider experience and outcomes (Wang 2010; Bossers 2015)	Higher rescuer ETI experience was associated with improved discharge survival in cardiac arrest and medical non arrest groups; no clear association in trauma non arrest in the Pennsylvania analysis. Limited experience in prehospital ETI was associated with higher mortality in one analysis.	Supports airway quality, systems emphasis (training, frequency, performance monitoring).
Airway process and rescue actions (Prekker 2014; Carter 2022)	Large paramedic registry: first pass success 77%, ultimate success 99%; RSI used in 54% of first attempts.	Common barriers after first attempt failure included fluids obstructing view (50%) and obesity (28%); corrective actions included suctioning (43%), repositioning (38%), bougie (19%); cricothyrotomy rare (0.4%). Education interventions targeted performance metrics.
Trauma, OHCA (Nishimura 2022)	In EMS witnessed traumatic OHCA, AAM was not associated with survival to discharge but improved ROSC on arrival (21.0% vs 11.4%).	Suggests physiologic benefit without downstream survival gains, likely dominated by injury severity and hemorrhage.
Oxygenation in severe TBI without hypoxia (Hong 2021)	Compared with no oxygen, low flow oxygen had lower mortality association overall; high flow oxygen showed higher mortality association when SpO_2 was ≥99%.	Supports titration to avoid hyperoxia; highlights need for EMS oxygen targets rather than routine high flow oxygen.

The strongest causal evidence came from the pragmatic cluster crossover randomized PART trial. A strategy of initial LT insertion (vs initial ETI) improved 72 hour survival and several secondary outcomes, and dramatically improved initial airway success (Wang et

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al. 2018). Large scale observational analyses indicate that performs ETI and how often they do it can influence outcomes. In Pennsylvania, discharge survival after out of hospital ETI was higher when rescuers had very high cumulative ETI experience for cardiac arrest and medical non arrest cases, but not clearly for trauma non arrest (Wang et al. 2010). Complementing this, another analysis reported higher mortality odds when prehospital intubation was performed by providers with limited experience (Bossers et al. 2015). In a large paramedic ETI registry, first pass success was 77% and ultimate success 99%, but failures often involved contaminated airways and challenging anatomy. Corrective actions frequently required suctioning, repositioning, and bougie use; surgical cricothyrotomy was rare (Prekker et al. 2014). In EMS witnessed traumatic OHCA, advanced airway management was associated with improved ROSC on arrival but not survival to discharge (Nishimura et al. 2022). This pattern suggests that oxygenation, ventilation optimization alone may not overcome lethal injury mechanisms. In severe blunt TBI without hypoxia, oxygen flow rate mattered: low flow oxygen was associated with lower mortality, whereas high flow oxygen in patients with very high saturations (≥99%) was associated with higher mortality (Hong et al. 2021).

DISCUSSION

This review found that prehospital airway and oxygenation management outcomes depend heavily on clinical context, the selected airway strategy, and EMS system performance. The most robust evidence in our dataset comes from a pragmatic randomized trial in OHCA demonstrating better short term and discharge outcomes with a supraglottic first strategy compared with ETI first, alongside markedly higher initial airway success (Wang et al. 2018). For EMT, paramedic practice, this is clinically meaningful because initial airway success and speed are central to minimizing interruptions and enabling controlled ventilation during CPR. ETI remains widely used, and observational datasets suggest outcomes are tied to operator experience and system level competence. In the Pennsylvania linked analysis, higher cumulative rescuer ETI experience was associated with improved discharge survival in cardiac arrest and medical non arrest patients (Wang et al. 2010). A related theme in the prehospital safety literature is that ETI is not uniformly safe across provider groups; a meta-analysis focusing on patient safety in prehospital ETI raised concerns about failure rates and recommended considering alternatives where prehospital physician models are absent (Lossius et al. 2012). Process level evidence from a large paramedic registry helps explain why experience and systems matter. After failed first attempts, common barriers included airway contamination and obesity; successful rescue often required suction, repositioning, bougie use, and sometimes operator change (Prekker et al. 2014). In traumatic arrest, improved ROSC without improved discharge survival (Nishimura et al. 2022) suggests that advanced airway management may improve short term physiology but not overcome irreversible injury. This finding aligns with the broader trauma guidance emphasis that airway is one component of a larger resuscitation package and that preventing secondary insults must be paired with definitive injury control (Hawryluk et al. 2023). Oxygenation strategy is increasingly recognized as a safety domain rather than a

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trivial adjunct. In severe TBI without hypoxia, low flow oxygen was associated with better mortality patterns than no oxygen, while high flow oxygen in patients with very high saturations was associated with worse mortality (Hong et al. 2021). This supports a shift toward titrated oxygen targets (avoid hypoxia and avoid unnecessary hyperoxia), particularly when pulse oximetry is available and transport times are not extreme.

Consider SGA first pathways (LT) when ETI success is limited or causes delays, interruptions, with clear escalation criteria (Wang et al. 2018). ETI quality: If ETI is maintained, prioritize competency tracking and case volume strategies; evidence links experience to outcomes (Wang et al. 2010); Rescue readiness: Standardize suction, bougie availability, and attempt limiting rules based on common failure mechanisms (Prekker et al. 2014); Oxygen titration: Implement SpO_2 guided oxygen titration and avoid routine high flow oxygen in normoxic TBI patients (Hong et al. 2021). Restriction to PMC hosted studies may omit important EMS airway trials published outside PMC. Heterogeneity and confounding limit causal inference. Some included studies were summarized from accessible abstract, results text rather than full supplementary datasets.

CONCLUSION

Across PMC available original studies, prehospital airway and oxygenation management by EMS personnel shows context specific benefits and risks. In OHCA, a supraglottic first approach improved survival and achieved far higher initial airway success than ETI first, supporting pragmatic SGA pathways where ETI performance is limited. Provider experience and system quality strongly influence ETI associated outcomes. In trauma, advanced airway may improve ROSC without improving discharge survival. Oxygen should be titrated to avoid both hypoxia and hyperoxia, particularly in TBI.

Abbreviations

AAM: Advanced Airway Management
BVM: Bag Valve Mask Ventilation
CI: Confidence Interval
EMS: Emergency Medical Services
EMT: Emergency Medical Technician
ETI: Endotracheal Intubation
GCS: Glasgow Coma Scale
LT: Laryngeal tube
OHCA: Out of hospital cardiac arrest
OR: Odds Ratio
ROSC: Return of Spontaneous Circulation
RSI: Rapid Sequence Intubation
SGA: Supraglottic Airway
SpO_2: Peripheral Oxygen Saturation
TBI: Traumatic Brain Injury

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