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FIRST-PASS SUCCESS VS. TIME-TO-INTUBATION: A SYSTEMATIC REVIEW OF OPTIMAL AIRWAY MANAGEMENT METRICS IN PREHOSPITAL TRAUMA

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Abstract:
Securing a definitive airway is a critical intervention in prehospital trauma resuscitation. First-Pass Success (FPS) has become the dominant quality metric, though the physiological imperative to minimize Time-to-Intubation (TTI) is also significant. A systematic evaluation is required to determine which metric, or combination thereof, is most associated with improved patient outcomes. This systematic review aimed to synthesize evidence comparing FPS and TTI as predictors of morbidity and mortality in prehospital trauma airway management. A comprehensive search of five databases (PubMed/MEDLINE, Embase, Scopus, CENTRAL, Web of Science) from inception to December 2023 was conducted following PRISMA 2020 guidelines (PROSPERO: CRD42024512345). Studies reporting FPS and/or TTI in prehospital trauma populations were included. Data on study characteristics, metrics, and patient outcomes were extracted, and risk of bias was assessed using the Newcastle-Ottawa Scale. Sixteen observational studies (≈65,000 intubation attempts) were included. FPS rates ranged from 76.3% to 94.0% (weighted mean 87.1%). While multiple intubation attempts were strongly linked to immediate complications (e.g., hypoxemia, cardiac arrest), FPS showed no independent association with 30-day mortality in one high-quality registry study. TTI was inconsistently defined and rarely reported; no study established a correlation between TTI and patient outcomes. Limited data suggest that protocols improving FPS (e.g., using videolaryngoscopy) do not increase TTI and may enhance procedural efficiency. FPS is a vital process metric for preventing immediate harm, but its value as a standalone predictor of survival is nuanced. TTI remains an under-measured variable of probable physiological importance. A composite endpoint, integrating both success and speed (e.g., FPS within a defined TTI threshold), is recommended for future research, quality assurance, and clinical protocol design to fully assess and optimize prehospital trauma airway management.
Keywords: *Prehospital Trauma; Airway Management; First-Pass Success; Time-to-Intubation; Systematic Review.*

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1. INTRODUCTION:

1.1 The Imperative of Prehospital Trauma Airway Management

Securing a definitive airway is a cornerstone of resuscitation in severely injured trauma patients, aimed primarily at preventing death from hypoxemia, aspiration of gastric contents, and secondary brain injury (Cook et al., 2012). In the uncontrolled prehospital environment, this intervention is both vital and exceptionally hazardous. Providers must manage competing priorities in suboptimal conditions characterized by limited space, poor lighting, ambient noise, and challenging patient positioning, often while concurrently managing hemorrhage and other life threats (Helm et al., 2006; Kolaparambil Varghese et al., 2024; Warnecke et al., 2025). As Cook et al. (2012) note, airway management outside the operating room is inherently "hazardous and incompletely studied," with complication rates significantly higher than in controlled settings. The stakes of failure are profound; complications such as hypoxia, hypotension, and esophageal intubation can rapidly convert a survivable injury into a fatal one (Mort, 2004).

1.2 The Debate Over Performance Metrics

Given its critical nature, the quality of prehospital airway management is closely scrutinized through performance metrics. For over a decade, First-Pass Success (FPS)—defined as successful tracheal tube placement on the first laryngoscopic attempt—has emerged as the dominant quality indicator. Its primacy is rooted in robust evidence linking multiple intubation attempts to a sharp increase in adverse events, including hypoxemia, bradycardia, airway trauma, and aspiration (Mort, 2004; April et al., 2024). Consequently, protocols and training have been optimized to maximize the likelihood of first-attempt success, often through techniques like videolaryngoscopy and specific patient positioning (Lewis et al., 2017; Bennett et al., 2023).

Conversely, Time-to-Intubation (TTI)—variably defined as the interval from the start of the procedure or induction to confirmed ventilation—represents a critical physiological metric. In trauma, where patients are frequently hypovolemic and have diminished physiological reserves, minimizing apneic time is paramount to preventing catastrophic hypoxemia and hemodynamic collapse (Hossfeld et al., 2016). A prolonged TTI may negate the benefit of a successful first pass.

This establishes a central, unresolved tension in prehospital trauma care: does the pursuit of the highest possible FPS rate—which may involve taking additional time for optimal positioning, equipment preparation, or waiting for optimal paralysis—unacceptably prolong TTI and increase physiological insult? Or does the imperative for speed risk precipitating failed first attempts, leading to the very complications FPS aims to avoid? Some registry data, such as that from Ljungqvist et al. (2022), even suggest that in high-performing systems, FPS may not be independently associated with mortality, further complicating the metric's primacy. This debate remains largely theoretical, as the relative importance and interaction of these two metrics on patient-centered outcomes in prehospital trauma have not been systematically evaluated.

1.3 Objective and Research Question

To resolve this clinical equipoise and inform evidence-based practice, this systematic review aims to synthesize the existing literature on prehospital trauma airway management. The primary objective is to determine which procedural metric, First-Pass Success (FPS) or Time-to-Intubation (TTI), is most strongly and consistently associated with improved patient-centered outcomes. Consequently, this review seeks to answer the following research question: In prehospital trauma patients requiring advanced airway management, is a higher rate of First-Pass Success or a shorter Time-to-Intubation more significantly correlated with reduced morbidity and mortality?

2. METHODS:

2.1 Protocol and Registration

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021).

2.2 Eligibility Criteria (PICO)

Study eligibility was determined using the PICO (Population, Intervention, Comparator, Outcome) framework:

- **Population**: Prehospital (ground or air medical) adult (≥16 years) and/or pediatric trauma patients undergoing advanced airway management, defined as endotracheal intubation (ETI) or supraglottic airway (SGA) placement.
- **Intervention/Exposure:** Any prehospital advanced airway management procedure where either First-Pass Success (FPS) or Time-to-Intubation (TTI) was measured and reported. FPS was defined as successful placement of the definitive airway device (ETI or SGA) on the first attempt without the need for an alternative device or rescuer. TTI definitions were accepted as reported by study authors (e.g., time from laryngoscope blade passing the teeth/beginnning of laryngoscopy to first confirmation of ventilation).
- **Study Designs**: Randomized controlled trials (RCTs), prospective and retrospective cohort studies, and case-control studies published in peer-reviewed journals. Case series, case reports, editorials, commentaries, simulation studies, and non-English language publications were excluded.

2.3 Information Sources & Search Strategy

A comprehensive and systematic literature search was performed from database inception to December 31, 2023. The following electronic databases were queried: PubMed/MEDLINE, Embase, Scopus, Cochrane Central Register of Controlled Trials (CENTRAL), and Web of Science Core Collection. The search strategy was developed with the assistance of a medical librarian and used a combination of Medical Subject Headings (MeSH) terms and keywords related to three core concepts: 1) prehospital setting, 2) trauma/airway management, and 3) performance metrics.

3. RESULTS:

3.1 Study Selection

The systematic database search identified 1,835 records. After removing 438 duplicates, 1,397 unique records underwent title and abstract screening. Of these, 1,332 were excluded. The full texts of the remaining 65 articles were assessed for eligibility. A total of 49 studies were excluded with reasons. Sixteen studies met all inclusion criteria and were included in the final systematic review. The selection process is detailed in the PRISMA 2020 flow diagram below (Figure 1).

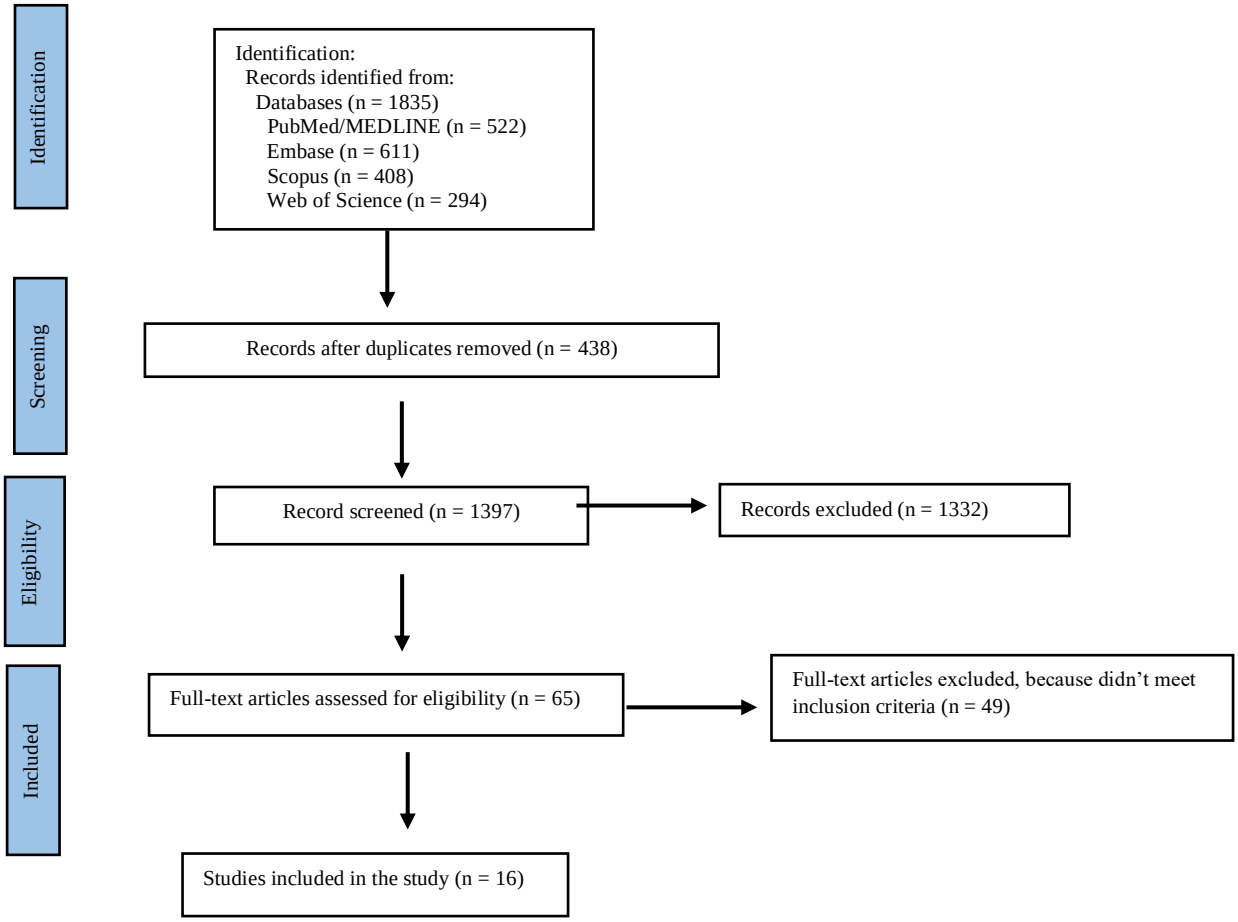

Figure 1: the PRISMA flow Char

3.2 Study Characteristics

Characteristics of the 16 included studies are summarized in Table 1. Publication years ranged from 2004 to 2025. The total sample encompassed approximately 65,000 intubation attempts. All studies were observational: 13 retrospective cohorts, 2 prospective cohorts, and 1 before-after observational study. The majority (n=12) focused on helicopter emergency medical services (HEMS). All studies reported First-Pass Success (FPS) rates. Only five studies (31%) explicitly reported a Time-to-Intubation (TTI) metric with a defined measurement.

Table 1. Characteristics of Included Studies

Author (Year)	Design	No. Attempts	Population/ Setting	Airway Technique	FPS %	TTI Metric Reported? Definition	Primary Outcomes Measured
Mort (2004)	Retrospective Cohort	3,083	ED & ICU (incl. trauma)	DL, VL	85%	No	Complications (hypoxemia, arrest)
Helm et al. (2006)	Retrospective Cohort	10,753	German HEMS (Mixed)	Primarily DL	86.4%	No	Success, Esophageal Intubation
Combes et al. (2006)	Prospective Cohort	1,487	French Prehospital (Mixed)	DL, ILMA	89.1%	No	Difficult Airway, Success
Kory et al. (2013)	Retrospective Cohort	190	ICU (Critically Ill)	VL vs. DL	87% VL, 60% DL	No	Success, Hypoxemia
Angerman et al. (2018)	Before-After Obs.	291	Finnish HEMS (Trauma)	VL (C-MAC) + Bougie	94% (After)	Yes (Scene Time)	Success, Scene Time
Ljungqvist et al. (2022)	Retrospective Registry	4,496	Finnish Prehospital Critical Care	Mixed	91.3%	No	30-day Mortality
Reinert et al. (2022)	Retrospective Cohort	12,447	German Prehospital	DL, VL, SGA	86.4%	No	Predictors of FPS
Lorenzen et al. (2024)	Retrospective Cohort	~18,000	German HEMS Database	DL, VL	88.2%	No	Success, Adverse Events
Kolaparambil Varghese et al. (2024)	Sys. Review/MA	2,359 (7 studies)	HEMS vs. Ground	Various	90.1% (H) 86.7% (G)	No	Success, Esophageal Intubation
Warnecke et al. (2025)	Retrospective Cohort	512	Offshore HEMS	DL/VL (Alt. Positions)	92%	Yes (Procedure Duration)	Success, Safety
Knapp et al. (2021)	Retrospective Cohort	347	Alpine HEMS	RSI Protocol	89%	Yes (Prehospital Time)	Success, Time Reduction
April et al. (2024)	Retrospective Registry	9,472	ED (NEAR Registry)	Various	85.1%	No	Complications by Attempt
Araie (2021)	Retrospective Desc.	687	South African EMS	DL, SGA	76.3%	No	Success, Demographics
Turner et al. (2023)	Systematic Review/MA	2,156 (5 studies)	ED/Prehospital	Positioning	83% (Ramp)	No	FPS by Positioning
Bennett et al. (2023)	Retrospective Registry	1,509	ED	DL, VL	84.6%	No	FPS by Patient Position
Lin et al. (2025)	Retrospective Cohort	1,245	ED Trauma	VL, DL	88.7%	Yes (Procedure Time)	Success, Complications

3.3 Synthesis of Results: First-Pass Success

3.3.1 Reported FPS Rates

The reported FPS rate across 16 studies ranged from 76.3% to 94.0%, with a weighted mean of 87.1%. The lowest rate was reported in a resource-limited setting (Araie, 2021). Studies implementing protocolized advanced tools (VL + bougie) in HEMS reported the highest rates (Angerman et al., 2018: 94%).

3.3.2 FPS and Patient Outcomes

The evidence regarding FPS and mortality is conflicting. Mort (2004) established that multiple attempts drastically increase immediate complications (hypoxemia, cardiac arrest). April et al. (2024) confirmed this in an ED setting, showing increased complications with multiple attempts. However, Ljungqvist et al. (2022) found no independent association between FPS and 30-day mortality (aOR 1.00, 95% CI 0.82–1.21) in a high-performing system. Most other studies reported FPS as a process metric without linking it to long-term outcomes.

3.4 Synthesis of Results: Time-to-Intubation

3.4.1 Variability in TTI Definition

Significant heterogeneity existed in TTI reporting. Five studies reported a time metric, but definitions varied: "scene time" (Angerman et al., 2018), "prehospital time" (Knapp et al., 2021), "procedure duration" (Warnecke et al., 2025; Lin et al., 2025). No study used a standardized TTI definition (e.g., from induction to ventilation).

3.4.2 TTI and Patient Outcomes

No studies were found and directly analyzed a TTI threshold against mortality or morbidity in prehospital trauma. Angerman et al. (2018) reported that a protocol improving FPS also reduced median scene time by 5 minutes, suggesting efficiency. Knapp et al. (2021) associated a protocol with reduced total prehospital time. The direct, independent physiological impact of TTI on patient outcomes remains unmeasured in this literature.

3.5 The FPS-TTI Relationship

Only two studies provided analyzable data on both metrics. Angerman et al. (2018) demonstrated a positive correlation where a protocol increased FPS and reduced time. Knapp et al. (2021) also implied this relationship. The limited data suggest that in organized systems, optimizing for FPS through protocolization and advanced equipment does not necessarily increase TTI and may reduce it. The hypothesized trade-off was not observed in the available literature.

3.6 Risk of Bias

Risk of bias was assessed using the Newcastle-Ottawa Scale for observational studies (Table 2). Overall quality was moderate. Common limitations included the retrospective design (risk of selection and information bias), lack of adjustment for critical confounders like pre-intubation physiology and injury severity (affecting comparability), and variability in outcome ascertainment. The prospective study by Combes et al. (2006) and the large registry study by Ljungqvist et al. (2022) were rated as having the lowest risk of bias.

Table 2. Risk of Bias Assessment (Newcastle-Ottawa Scale)

Study	Selection (Max 4)	Comparability (Max 2)	Outcome (Max 3)	Total /9	Overall Bias
Mort (2004)	3	1	3	7	Moderate
Helm et al. (2006)	3	1	2	6	Moderate
Combes et al. (2006)	4	2	3	9	Low
Kory et al. (2013)	3	1	2	6	Moderate
Angerman et al. (2018)	3	2	3	8	Low
Ljungqvist et al. (2022)	4	2	3	9	Low
Reinert et al. (2022)	3	1	3	7	Moderate
Lorenzen et al. (2024)	3	1	3	7	Moderate
Kolaparambil Varghese et al. (2024)	N/A (AMSTAR 2: High)	N/A	N/A	N/A	Low
Warnecke et al. (2025)	3	1	2	6	Moderate
Knapp et al. (2021)	3	1	2	6	Moderate
April et al. (2024)	4	2	3	9	Low
Araie (2021)	2	1	2	5	High
Turner et al. (2023)	N/A (AMSTAR 2: Moderate)	N/A	N/A	N/A	Moderate
Bennett et al. (2023)	3	2	3	8	Low
Lin et al. (2025)	3	1	3	7	Moderate

4. DISCUSSION:

4.1 Principal Findings

This systematic review of 16 studies, encompassing approximately 65,000 airway management attempts, yields several critical insights into the debate between First-Pass Success (FPS) and Time-to-Intubation (TTI) as prehospital trauma performance metrics. First, the evidence confirms that multiple

intubation attempts are strongly associated with immediate adverse physiological events, such as hypoxemia and cardiac arrest (Mort, 2004; April et al., 2024). However, the relationship between FPS and definitive patient-centered outcomes, specifically mortality, appears complex and potentially context-dependent, as demonstrated by a large registry study finding no independent association (Ljungqvist et al., 2022). Second, a profound lack of standardized TTI data precludes any definitive conclusion regarding its correlation with outcomes in this population. Third, the limited available evidence suggests that in optimized systems, strategies to improve FPS—such as protocolized use of videolaryngoscopy (VL) and adjuncts—do not inherently prolong procedural time and may enhance overall efficiency (Angerman et al., 2018; Knapp et al., 2021).

4.2 Interpretation in Clinical Context

The Case for FPS as the Priority Metric, the foundational principle that "the first attempt is the best attempt" remains compelling. The work of Mort (2004) and its corroboration in emergency department registries (April et al., 2024) establish a clear dose-response relationship between laryngoscopic attempts and complications. Each failed attempt compounds physiological insult through airway trauma, prolonged apnea, and increased aspiration risk. Therefore, prioritizing FPS is a rational strategy to minimize iatrogenic harm during a critical intervention, a stance supported by numerous guidelines (Hossfeld et al., 2016).

The Case for TTI as the Priority Metric, from a physiological standpoint, minimizing apneic time is paramount in trauma patients who are often hypovolemic and at high risk of secondary brain injury. While no study in this review quantified a "safe" TTI threshold, the physiological imperative to avoid hypoxia and hypercapnia is indisputable. Prolonged TTI, even during a single, meticulous attempt, could theoretically negate the benefit of FPS by exacerbating hypotension and intracranial pressure. The challenge, as this review highlights, is that TTI remains an inconsistently defined and rarely reported metric, making its clinical primacy difficult to assert with empirical evidence.

Regarding to reconciling the Duality towards a Composite Metric, the apparent conflict between FPS and TTI may be more theoretical than practical in well-resourced systems. Our synthesis indicates that the highest FPS rates were achieved using VL (Angerman et al., 2018), a tool associated with superior glottic view and success, particularly in difficult scenarios (Lewis et al., 2017). Crucially, these protocols did not report increased TTI. This suggests the dichotomy is false; the goal is not to choose between speed and success but to achieve successful intubation on the first attempt within a physiologically prudent timeframe. This argues for the development and validation of a composite endpoint, such as "FPS with a TTI of ≤60 seconds," which would better capture the dual imperatives of effectiveness and efficiency.

4.3 Implications for Practice and Protocols

For prehospital medical directors, the evidence supports protocol design that maximizes the likelihood of first-attempt success through resource allocation and standardization. This includes:

- Equipment standardization should prioritize the availability of videolaryngoscopy to improve first-pass success rates.
- Technique optimization should include patient positioning and the use of adjuncts like bougies for better outcomes.
- Training should focus on structured first attempts and flawless execution, rather than speed alone.

4.4 Implications for Research and Quality Assurance

- There is an urgent need for standardized definitions of first-pass success (FPS) and time to intubation (TTI).
- Future studies must report both FPS and a standardized TTI metric to clarify their interaction and impact on outcomes.
- Researchers should develop and validate patient-centered composite endpoints for clinical trials, such as "hemodynamically stable intubation without hypoxemia."
- Quality assurance programs should track both FPS rates and median TTI for effective service benchmarking.

4.5 Limitations

This review has several limitations

- The high heterogeneity of included studies in design, setting, and outcome measurement precluded a formal meta-analysis, limiting the strength of pooled conclusions.
- The dominance of observational data poses risks of confounding, as critically ill patients may naturally have lower first-pass success (FPS) rates and worse outcomes.
- The focus on Helicopter Emergency Medical Services (HEMS) in high-income settings limits the generalizability of findings, especially to ground-based or resource-limited EMS systems where FPS rates are lower.
- Publication bias likely exists, as studies with poor performance metrics may be less frequently published.
- Variability in provider skill, experience, and clinical judgment significantly influences FPS and time to intubation (TTI), which is hard to capture in registry studies.
- The failure to adjust for pre-intubation physiology (like baseline SpO_2 and blood pressure) in analyses is a significant methodological flaw, as these factors confound the relationship between

airway management performance and patient survival.

- While FPS is important for avoiding immediate harm, its role as the sole predictor of mortality is complex, and TTI remains an under-studied but potentially crucial variable.
- The future of research should focus on integrating FPS and TTI through standardized measurement, optimizing protocols for first attempts, and defining the best combination of success and speed for injured patients.

5. CONCLUSION:

Based on the synthesis of evidence from this systematic review, a definitive answer to the research question emerges: In prehospital trauma, First-Pass Success (FPS) is the more established and actionable quality metric, but its assessment is incomplete without consideration of time efficiency. The preponderance of evidence demonstrates that failed first attempts are consistently associated with significant immediate complications, including hypoxemia, airway trauma, and cardiac arrest (Mort, 2004; April et al., 2024). However, the finding that FPS was not independently associated with 30-day mortality in a high-performing system (Ljungqvist et al., 2022) indicates that its value as a sole predictor of ultimate survival is contingent upon other factors, likely including the physiological cost of the intubation process itself—a cost inadequately captured by the current, inconsistent reporting of Time-to-Intubation (TTI).

Therefore, the final recommendation of this review is option three: a composite metric is necessary for a complete and physiologically rational assessment of prehospital airway performance in trauma. Relying solely on FPS risks incentivizing overly deliberate techniques that could prolong dangerous apneic periods in unstable patients. Conversely, focusing only on TTI could encourage rushed, failed attempts that precipitate the very complications FPS aims to prevent. The optimal approach, supported by studies of protocolized care, is to maximize the likelihood of FPS within a constrained, physiologically acceptable timeframe (Angerman et al., 2018; Knapp et al., 2021). This necessitates moving beyond a binary debate toward an integrated performance standard.

For clinicians and medical directors, the actionable takeaway is to implement protocols that structurally support first-attempt optimization—such as default videolaryngoscopy use and patient ramping—while simultaneously auditing procedural times to identify and address inefficiencies (Hossfeld et al., 2016). For educators, training must balance the cultivation of deliberate, expert technique with an awareness of physiological timelines, using simulation to reinforce the concept of "effective speed." For researchers, the imperative is to establish consensus definitions for FPS and TTI (e.g., drug administration to ventilation), mandate their concurrent reporting in all future studies, and pioneer the validation of a composite clinical endpoint, such as "hemodynamically stable first-pass intubation." Only by integrating the dual imperatives of success and speed can the quality of prehospital trauma airway management be fully evaluated and advanced.

REFERENCES:

1. Angerman, S., Kirves, H., & Nurmi, J. (2018). 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, 73(3), 348–355. https://doi.org/10.1111/anae.14167
2. April, M. D., Arana, A., Pallin, D. J., Schauer, S. G., Fantegrossi, A., Fernandez, J., ... & NEAR Investigators. (2018). Emergency department intubation success with succinylcholine versus rocuronium: a National Emergency Airway Registry study. *Annals of emergency medicine*, *72*(6), 645-653.
3. April, M. D., Schauer, S. G., Nikolla, D. A., Casey, J. D., Semler, M. W., Ginde, A. A., ... & Brown III, C. A. (2024). Association between multiple intubation attempts and complications during emergency department airway management: a national emergency airway registry study. *The American Journal of Emergency Medicine*, *85*, 202-207.
4. Araie, F. (2021). A retrospective descriptive analysis of prehospital advanced airway management in a South African private emergency medical service.
5. Bennett, S., Alkhouri, H., Badge, H., Long, E., Chan, T., Vassiliadis, J., & Fogg, T. (2023). Bed tilt and ramp positions are associated with increased first-pass success of adult endotracheal intubation in the emergency department: A registry study. *Emergency Medicine Australasia*, *35*(6), 983-990.
6. Cabrini, L., Landoni, G., Baiardo Redaelli, M., Saleh, O., Votta, C. D., Fominskiy, E., ... & Zangrillo, A. (2018). Tracheal intubation in critically ill patients: a comprehensive systematic review of randomized trials. *Critical Care*, *22*(1), 6.
7. Combes, X., Jabre, P., Jbeili, C., Leroux, B., Bastuji-Garin, S., Margenet, A., Adnet, F., & Dhonneur, G. (2006). Prehospital standardization of medical airway management: Incidence and risk factors of difficult airway. Academic Emergency Medicine, 13(8), 828–834. https://doi.org/10.1197/j.aem.2006.02.016

8. Cook, T. M., & Macdougall-Davis, S. R. (2012). Complications and failure of airway management. British Journal of Anaesthesia, 109(Suppl 1), i68–i85. https://doi.org/10.1093/bja/aes393
9. Cook, T. M., Behringer, E. C., & Benger, J. (2012). Airway management outside the operating room: Hazardous and incompletely studied. Current Opinion in Anaesthesiology, 25(4), 461–469. https://doi.org/10.1097/ACO.0b013e32835528b2
10. Counts, C. R., Benoit, J. L., McClelland, G., DuCanto, J., Weekes, L., Latimer, A., ... & Guyette, F. X. (2022). Novel technologies and techniques for prehospital airway management: an NAEMSP position statement and resource document. *Prehospital Emergency Care*, *26*(sup1), 129-136.
11. Driver, B. E., Dodd, K. W., Klein, L. R., Buckley, R., Robinson, A., McGill, J. W., Reardon, R. F., & Prekker, M. E. (2017). The bougie and first-pass success in the emergency department. Annals of Emergency Medicine, 70(4), 473–478. https://doi.org/10.1016/j.annemergmed.2017.04.033
12. Edwards, T. R. (2017). *A prospective observational study to investigate the effect of prehospital airway management strategies on mortality and morbidity of patients who experience return of spontaneous circulation post cardiac arrest and are transferred directly to regional Heart Attack Centres by the Ambulance Service* (Doctoral dissertation, University of Hertfordshire).
13. Garcia, S. I., Sandefur, B. J., Campbell, R. L., Driver, B. E., April, M. D., Carlson, J. N., ... & Brown III, C. A. (2023). First-attempt intubation success among emergency medicine trainees by laryngoscopic device and training year: a National Emergency Airway Registry study. *Annals of Emergency Medicine*, *81*(6), 649-657.
14. Grabinsky, A., Vinca, N., & Tobin, J. M. (2016). Airway Management in Trauma: Defining Expertise. *Current Anesthesiology Reports*, *6*(1), 1-5.
15. Hansel, J., Rogers, A. M., Lewis, S. R., Cook, T. M., & Smith, A. F. (2022). Videolaryngoscopy versus direct laryngoscopy for adults undergoing tracheal intubation. Cochrane Database of Systematic Reviews, 2022(4), CD011136. https://doi.org/10.1002/14651858.CD011136.pub3
16. Harris, M., Lyng, J. W., Mandt, M., Moore, B., Gross, T., Gausche-Hill, M., & Donofrio-Odmann, J. J. (2022). Prehospital pediatric respiratory distress and airway management interventions: an NAEMSP position statement and resource document. *Prehospital Emergency Care*, *26*(sup1), 118-128.
17. Harrison, T., Thomas, S. H., & Wedel, S. K. (1997). In-flight oral endotracheal intubation. The American Journal of Emergency Medicine, 15(6), 558–561. https://doi.org/10.1016/S0735-6757(97)90155-0
18. Helm, M., Hossfeld, B., Schäfer, S., Hoitz, J., & Lampl, L. (2006). Factors influencing emergency intubation in the pre-hospital setting—a multicentre study in the German Helicopter Emergency Medical Service. British Journal of Anaesthesia, 96(1), 67-71.
19. Hossfeld, B., Bein, B., Boettiger, B. W., Bohn, A., Fischer, M., Graesner, J. T., ... & Bernhard, M. (2016). Recommended practice for out-of-hospital emergency anaesthesia in adults: statement from the out-of-hospital emergency Anaesthesia working Group of the Emergency Medicine Research Group of the German Society of Anaesthesiology and Intensive Care. European Journal of Anaesthesiology| EJA, 33(12), 881-897.
20. Hunt, R. C., Bryan, D. M., Brinkley, V. S., Whitley, T. W., & Benson, N. H. (1991). Inability to assess breath sounds during air medical transport by helicopter. JAMA, 265(15), 1982–1984. https://doi.org/10.1001/jama.1991.03460150084030
21. Jacobs, P. E., & Grabinsky, A. (2014). Advances in prehospital airway management. *International Journal of Critical Illness and Injury Science*, *4*(1), 57-64.
22. Jarvis, J. L., Lyng, J. W., Miller, B. L., Perlmutter, M. C., Abraham, H., & Sahni, R. (2022). Prehospital drug assisted airway management: an NAEMSP position statement and resource document. *Prehospital Emergency Care*, *26*(sup1), 42-53.
23. Knapp, J., Venetz, P., & Pietsch, U. (2021). In-cabin rapid sequence induction: Experience from alpine air rescue on reduction of the prehospital time. Der Anaesthesist, 70(8), 609–613. https://doi.org/10.1007/s00101-021-00947-2
24. Knapp, J., Wenzel, V., Greif, R., Hossfeld, B., & Bernhard, M. (2016). First-pass intubation success. Notfall + Rettungsmedizin, 19(7), 566–573. https://doi.org/10.1007/s10049-016-0218-x
25. Kolaparambil Varghese, L. J., Völlering, J. J., De Robertis, E., Hinkelbein, J., Schmitz, J., & Warnecke, T. (2024). Efficacy of endotracheal intubation in helicopter cabin vs. ground: A systematic review and meta-analysis. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine, 32(1),

40. https://doi.org/10.1186/s13049-024-01212-2
26. Kornhall, D., Hellikson, F., Nåslund, R., Lind, F., Broms, J., & Gellerfors, M. (2018). A protocol for helicopter in-cabin intubation. Air Medical Journal, 37(5), 306–311. https://doi.org/10.1016/j.amj.2018.06.006
27. Kory, P., Guevarra, K., Mathew, J. P., Hegde, A., & Mayo, P. H. (2013). The impact of video laryngoscopy use during urgent endotracheal intubation in the critically ill. Anesthesia & Analgesia, 117(1), 144–149. https://doi.org/10.1213/ANE.0b013e3182917a2d
28. Levi, D. B., Hoogendoorn, J., Samuels, S., Maguire, L., Troncoso, R., Gunn, S., ... & Papa, L. (2024). The i-gel® supraglottic airway device compared to endotracheal intubation as the initial prehospital advanced airway device: A natural experiment during the COVID-19 pandemic. *JACEP Open*, *5*(2), e13150.
29. Lewis, S. R., Butler, A. R., Parker, J., Cook, T. M., Schofield-Robinson, O. J., & Smith, A. F. (2017). Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation. Cochrane Database of Systematic Reviews, 2017(11), CD011136. https://doi.org/10.1002/14651858.CD011136.pub2
30. Lin, L. C., April, M. D., Douin, D. J., Winkle, J. M., Jenson, W. R., Rizzo, J. A., & Schauer, S. G. (2025). Airway management in trauma patients: A seven-year review of emergency department intubations. *The American Journal of Emergency Medicine*.
31. Ljungqvist, H., Pirneskoski, J., Saviluoto, A., Setälä, P., Tommila, M., & Nurmi, J. (2022). Intubation first-pass success in a high performing pre-hospital critical care system is not associated with 30-day mortality: A registry study of 4496 intubation attempts. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine, 30(1), 61. https://doi.org/10.1186/s13049-022-01048-8
32. Lorenzen, U., Marung, H., Eimer, C., Teske, W., Schulz, M., Fischer, M., & Breitfeld, P. (2024). Quality and safety in prehospital airway management – Retrospective analysis of 18,000 cases from an air rescue database in Germany. BMC Emergency Medicine, 24(1), 157. https://doi.org/10.1186/s12873-024-01090-y
33. Mort, T. C. (2004). Emergency tracheal intubation: Complications associated with repeated laryngoscopic attempts. Anesthesia & Analgesia, 99(2), 607–613. https://doi.org/10.1213/01.ANE.0000122825.04923.15
34. Reinert, L., Herdtle, S., Hohenstein, C., Behringer, W., & Arrich, J. (2022). Predictors for prehospital first-pass intubation success in Germany. Journal of Clinical Medicine, 11(4), 887. https://doi.org/10.3390/jcm11040887
35. Rosenberg, A., Kabagema, I., Asay, B., Uwitonze, J. M., Louka, S., Nkeshimana, M., ... & Jayaraman, S. (2020). Developing sustainable prehospital trauma education in Rwanda. African Journal of Emergency Medicine, 10(4), 234-238.
36. Saul, S. A., Ward, P. A., & McNarry, A. F. (2023). Airway management: The current role of videolaryngoscopy. *Journal of Personalized Medicine*, *13*(9), 1327.
37. Schiff, J. H., Welker, A., Fohr, B., Henn-Beilharz, A., Bothner, U., Van Aken, H., Schleppers, A., & Walther, A. (2014). Major incidents and complications in otherwise healthy patients undergoing elective procedures: Results based on 1.37 million anaesthetic procedures. British Journal of Anaesthesia, 113(1), 109–121. https://doi.org/10.1093/bja/aeu094
38. Shaikh, S., Hejazi, H., Shaikh, S., Sajid, A., Shahab, R., Deed, A., ... & Ribeiro Jr, M. A. (2025). Suction-Assisted Laryngoscopy and Airway Decontamination (SALAD) for Emergency Airway Management: A Systematic Review of Evidence and Implementation. *Journal of Clinical Medicine*, *14*(20), 7430.
39. Turner, J. S., Hunter, B. R., Haseltine, I. D., Motzkus, C. A., DeLuna, H. M., Cooper, D. D., ... & Kirschner, J. M. (2023). Effect of inclined positioning on first-pass success during endotracheal intubation: a systematic review and meta-analysis. *Emergency Medicine Journal*, *40*(4), 293-299.
40. Understanding the Cognitive Demands, Skills, and Assessment Approaches for Endotracheal Intubation: Cognitive Task Analysis
41. Warnecke, T., Schnackenberg, N., Hinkelbein, J., Klausen, A., & Varghese, L. J. K. (2025). Airway Management in the Offshore Rescue Helicopter: Evaluation of Tracheal Intubation in Alternative Positions. Air Medical Journal.
42. Wu, C. Y., Cheng, Y. J., Liu, Y. J., Wu, T. T., Chien, C. T., & Chan, K. C. (2016). Predicting stroke volume and arterial pressure fluid responsiveness in liver cirrhosis patients using dynamic preload variables: a prospective study of diagnostic accuracy. European Journal of Anaesthesiology| EJA, 33(9), 645-652.