Prehospital Emergency Care

ISSN: 1090-3127 (Print) 1545-0066 (Online) Journal homepage: www.tandfonline.com/journals/ipec20

Prehospital Drug Assisted Airway Management: An NAEMSP Position Statement and Resource Document

Jeffrey L. Jarvis, John W. Lyng, Brian L. Miller, Michael C. Perlmutter, Heidi Abraham & Ritu Sahni

To cite this article: Jeffrey L. Jarvis, John W. Lyng, Brian L. Miller, Michael C. Perlmutter, Heidi Abraham & Ritu Sahni (2022) Prehospital Drug Assisted Airway Management: An NAEMSP Position Statement and Resource Document, Prehospital Emergency Care, 26:sup1, 42-53, DOI: 10.1080/10903127.2021.1990447

To link to this article: https://doi.org/10.1080/10903127.2021.1990447

Published online: 10 Jan 2022.

Prehospital Drug Assisted Airway Management: An NAEMSP Position Statement and Resource Document

Jeffrey L. Jarvis, John W. Lyng, Brian L. Miller, Michael C. Perlmutter, Heidi Abraham, and Ritu Sahni

Abstract

Airway management is a critical intervention for patients with airway compromise, respiratory failure, and cardiac arrest. Many EMS agencies use drug-assisted airway management (DAAM) - the administration of sedatives alone or in combination with neuromuscular blockers - to facilitate advanced airway placement in patients with airway compromise or impending respiratory failure who also have altered mental status, agitation, or intact protective airway reflexes. While DAAM provides several benefits including improving laryngoscopy and making insertion of endotracheal tubes and supraglottic airways easier, DAAM also carries important risks.

NAEMSP recommends:

- DAAM is an appropriate tool for EMS clinicians in systems with clear guidelines, sufficient training, and close EMS physician oversight. DAAM should not be used in settings without adequate resources.
- EMS physicians should develop clinical guidelines informed by evidence and oversee the training and credentialing for safe and effective DAAM.
- DAAM programs should include best practices of airway management including patient selection, assessmenct and positioning, preoxygenation strategies including apneic oxygenation, monitoring and management of physiologic abnormalities, selection of medications, post-intubation analgesia and sedation, equipment selection, airway confirmation and monitoring, and rescue airway techniques.
- Post-DAAM airway placement must be confirmed and continually monitored with waveform capnography.
- EMS clinicians must have the necessary equipment and training to manage patients with failed DAAM, including bag mask ventilation, supraglottic airway devices and surgical airway approaches.
- Continuous quality improvement for DAAM must include assessment of individual and aggregate performance metrics. Where available for review, continuous physiologic recordings (vital signs, pulse oximetry, and capnography), audio and video recordings, and assessment of patient outcomes should be part of DAAM continuous quality improvement.

Key words: prehospital; out-of-hospital; airway management; rapid sequence intubation; rapid sequence airway; delayed sequence airway; apneic oxygenation; capnography

PREHOSPITAL EMERGENCY CARE 2022;26:42–53

Received September 1, 2021 from Williamson County EMS, Georgetown, Texas, USA (JLJ); Baylor Scott & White/Texas A&M College of Medicine, Temple, Texas, USA (JLJ); University of Minnesota Medical School, Minneapolis, Minnesota, USA (JWL); University of Texas Southwestern Medical Center, Dallas, Texas, USA (BLM); MedStar Mobile Healthcare, Metropolitan Area EMS Authority, Fort Worth, Texas, USA(BLM); North Memorial Health Air Care, Brooklyn Center, Minnesota, USA (JWL, MCP); Austin/Travis County EMS, Austin, Texas, USA (HA); Clackamas County EMS, Oregon City, Oregon, USA (RS); Washington County EMS, Hillsboro, Oregon, USA (RS); Oregon Health & Sciences University, Portland, Oregon, USA (RS). Revision received September 27, 2021; accepted for publication October 1, 2021.

All authors were involved in the creation of the manuscript.

No authors have any conflicts to disclose.

Address correspondence to Jeffrey L. Jarvis at jjarvis@wilco.org

doi:10.1080/10903127.2021.1990447

Introduction

In select prehospital patients, efforts to manage the airway may be influenced by the presence of protective airway reflexes or the need to preserve the patient's hemodynamic condition. Previously known as drug-assisted intubation (DAI), drug-assisted airway management (DAAM) is the technique of using medications to overcome the body's protective airway reflexes to facilitate airway insertion, typically through the individual or combined use of sedatives and paralytics.

The most common DAAM technique is rapid sequence intubation (RSI), the rapid sequential administration of both a sedative and a paralytic to accomplish endotracheal intubation. However, current variations of DAAM in clinical practice include sedation-assisted intubation (SAI - the use of a sedative alone to facilitate intubation), delayed sequence intubation (DSI - initial administration of a sedative, with delayed administration of a paralytic to facilitate intubation), and rapid sequence airway (RSA – use of a sedative and paralytic to facilitate rapid supraglottic airway insertion).

While increasingly adopted by EMS agencies to facilitate intubation and improve first-pass success, DAAM has also been associated with important adverse events (1, 2). Ongoing controversies surrounding DAAM include the necessary components for training and credentialing, optimal approaches to preoxygenation, medication selection, airway placement confirmation strategies, and essential components of quality management. This resource document summarizes key recommendations for the deployment of DAAM in the prehospital setting.

SYSTEM AVAILABILITY OF AND PROTOCOLS FOR DRUG-ASSISTED AIRWAY MANAGEMENT

DAAM is an Appropriate Tool for EMS Clinicians in Systems with Clear Guidelines, Sufficient Training, and Close EMS Physician Oversight. DAAM Should Not Be Used in Settings without Adequate Resources.

DAAM is a powerful technique that can potentially improve patient care by optimizing airway first-pass success while mitigating physiologic harm from airway insertion efforts. However, DAAM also entails significant risks to patients and training burdens for EMS agencies. Implementation of DAAM extends beyond the clinical protocol; it necessitates optimization of the agency's entire airway management program. When deciding whether to implement DAAM, EMS medical directors must carefully weigh the potential clinical gains from DAAM against the risks of the procedure, the training costs to the agency, and the skill set of the EMS clinicians. EMS medical directors must ensure commitment from the entire agency leadership to support the increased budget for proper equipment, training, and oversight that comes with implementing a DAAM program. Within this commitment, medical directors must select appropriate drugs and equipment, and develop protocols, training, credentialing, and quality management practices that address all aspects of the DAAM process.

EMS Physicians Should Develop Clinical Guidelines Informed by Evidence and Oversee the Training and Credentialing for Safe and Effective DAAM.

While there are few randomized trials of DAAM in the prehospital or hospital setting, there are observational data to help inform and guide the selection of DAAM techniques. Critical decisions include selection of equipment, techniques, pharmacologic agents, and approaches to preoxygenation, physiologic monitoring, airway confirmation, and post airway management.

DAAM programs should entail physician-led credentialing to assure clinician competence in all aspects of the technique. The concept of credentialing in the EMS setting is discussed in detail in the NAEMSP position statement: *Clinical Credentialing of EMS Providers* (3). Initial DAAM credentialing should include a baseline cognitive and psychomotor assessment that covers best practices of patient selection, positioning, preoxygenation, medication selection, difficult/failed airway management, and post-placement confirmation, analgesia, and sedation. Credentialing should include direct observation with scenario-based testing and demonstration of proficiency in all of the agency's available airway management approaches.

While airway management training in the hospital setting (for example, the operating room) is often desired, this is not always available and should not be considered a requirement for a DAAM program provided that alternative experiences such as simulations or cadaveric training are included in the program and compliance with evidenced-based performance measures is high. The concept of skill dilution (where there are more clinicians than procedural opportunities) is important, but the optimal balance between the number of clinicians, the number of encounters, and the need for adequate resource availability is unknown. Future research is needed to further inform this topic.

BEST PRACTICES

DAAM Programs Should Include Best Practices of Airway Management Including Patient Selection, Assessment and Positioning, Preoxygenation Strategies Including Apneic Oxygenation, Monitoring and Management of Physiologic Abnormalities, Selection of Medications, Post-Intubation Analgesia and Sedation, Equipment Selection, Airway Confirmation and Monitoring, and Rescue Airway Techniques.

Airway management using DAAM requires psychomotor skills, knowledge, and critical thinking that can be challenging to apply in the prehospital environment. Multiple studies in both the emergency department and EMS settings estimate peri-intubation cardiac arrest occurs in 1-4% of RSIs, highlighting that physiologic monitoring and management are critical aspects of DAAM (4–9).

DAAM presents challenges with airway insertion because of the rapid and complete loss of protective airway reflexes and respiratory drive, and the potential of medications to exacerbate existing physiologic abnormalities. Therefore, EMS clinicians must be especially attentive to fundamental elements of airway management such as patient selection, preoxygenation, correction of physiologic abnormalities, medication and equipment selection, airway placement confirmation and monitoring, ongoing analgesia and sedation, and availability of rescue airway techniques.

Patient Selection. While many conditions may lead to respiratory depression or loss of airway protection, conditions likely to require DAAM include stroke, traumatic brain injury (TBI), and respiratory failure from pulmonary or cardiac disease. There is conflicting evidence of the effect of DAAM on the outcomes of patients with these conditions. For example, data from Fouche et al. suggest that patients experiencing stroke have worse outcomes when undergoing DAAM, however several confounders may have contributed to this observation, including the effects of hypoxia, hypotension, and stroke severity (10). In patients with TBI (11, 12), Bossers and Davis observed that EMS clinician experience is associated with improved outcomes (13, 14). The choice of medications may affect DAAM TBI outcomes, as evidenced by Bulger et al. who noted that the use of paralytics was associated with improved TBI outcomes (15). Finally, multiple studies by Davis et al. underscore the potential for DAAM to adversely affect TBI outcomes through iatrogenic post-intubation hyperventilation (16, 17). There are limited observational data on the need for DAAM in patients undergoing resuscitation for cardiac arrest-associated trismus and currently there is insufficient evidence to adequately inform this practice (18).

Difficult Airway Anatomy. One of the salient challenges of DAAM is achieving rapid successful airway placement. Therefore, EMS clinicians should incorporate strategies to optimize airway insertion efforts, including the recognition of difficult airway anatomy. EMS clinicians should be aware of and prepared to manage difficult airway characteristics such as extremes of size, neck immobility, restricted mouth opening, soiled airway, and bleeding (19–22).While not absolute contraindications to DAAM, in select scenarios the risk of complications may outweigh the potential benefits.

Patient Positioning. Optimization of patient positioning is a critical but sometimes overlooked step in prehospital airway management. Proper patient positioning can improve intubating conditions and prolong safe apnea time, both of which are especially important in DAAM given the loss of protective airway reflexes and spontaneous respiration. Removing the patient from an environment with limited access and placing the patient on an elevated stretcher can improve first-pass success (23). Elevation of the patient's head has been associated with better glottic visualization, higher first-pass success rates, longer safe apnea times, and fewer complications such as esophageal intubation, hypoxia, and aspiration (23–26). Positioning for success of airway management is equally important in pediatric patients as in adults. Multiple studies have shown that in children 3 to 8 years of age, a "sniffing" position improves laryngoscopic view as well as the ability to perform manual bag-valve-mask ventilation (27–35).

Preoxygenation/Denitrogenation. Peri-intubation hypoxia is common and potentially harmful as it can lead to hemodynamically significant bradycardia and cardiac arrest. Multiple observational studies have demonstrated peri-intubation hypoxia occurring in 36% to 45% of RSIs in both the emergency department and EMS settings (5, 9, 36, 37).

However, peri-intubation hypoxia is frequently unrecognized, often because of the combined factors of transient loss of pulse oximetry data during intubation and 'pulse oximetry lag', i.e., delay in measurement response to changes in blood oxygen concentration (38–40). For example, Davis et al. noted that 79% of patients undergoing prehospital RSI had loss of pulse oximetry data during the peri-intubation period, most commonly due to inadvertent probe displacement or placement of the probe distal to blood pressure cuffs (40). In a separate study, Davis found that the oximetry signal is a lagging indicator of oxygenation status in up to 55% of RSI cases, leading to inappropriate extubation (38). Close and continuous monitoring along with appropriate preoxygenation can assure recognition of hypoxia and reduce the effect of pulse oximetry lag.

Efforts to achieve preoxygenation and denitrogenation (henceforth referred to simply as preoxygenation) are vital to reducing the risk of peri-intubation hypoxia (41). Adequate preoxygenation increases safe apnea time and reduces the risk of peri-intubation hypoxia. A common approach to preoxygenation in the emergency setting is to provide 100% oxygen by non-rebreather mask for at least 3 minutes. In the apneic or hypoventilating patient, delivery of preoxygenation by bag-valve-mask may be necessary. While non-rebreather mask and bag-valve-mask are the most commonly used modalities for providing preoxygenation, noninvasive positive pressure ventilation (NIPPV) may be more effective (42–44). In 30 healthy volunteers undergoing a 3-minute trial of preoxygenation, Groombridge et al. observed mean fraction of expired oxygen levels of 0.64 with non-rebreather masks compared with 95% with NIPPV (44). Baillard found similar results in intensive care unit patients undergoing intubation (42).

The effectiveness of current prehospital pre-oxygenation practices is unknown since there is currently no prehospital physiologic measurement that accurately reflects denitrogenation of the lungs. In the operating room, end-tidal expired oxygen (EtO_2) is used to assess pre-oxygenation; anesthesia practice uses EtO_2 values above 90% as an objective indicator of preoxygenation (41). Emergency department studies using EtO_2 suggest that up to 75% of patients undergoing RSI may not receive adequate preoxygenation (9, 45). Incorporating EtO_2 technology in field monitors may improve prehospital pre-oxygenation, but future research should evaluate its feasibility and usefulness (41, 46).

Apneic Oxygenation. Apneic oxygenation involves the use of a nasal cannula to deliver oxygen at "flush" rates (as high as the regulator will go) during the intubation attempt. A nasal cannula can be applied under a tight-fitting NIPPV mask during preparation without decreasing the efficacy of preoxygenation (47–49). Apneic oxygenation is associated with decreased peri-intubation hypoxia in the field, emergency department, and intensive care unit (50–54). Three systematic reviews and meta-analyses confirmed improved first-pass success and reduced peri-intubation desaturation with apneic oxygenation (50, 51, 53). With a targeted bundle of interventions including head-up positioning, NIPPV preoxygenation, apneic oxygenation, DSI, and targeted saturation goals, Jarvis et al. reported a reduction in peri-intubation hypoxia episodes from 44% to 3.5% (5). EMS clinicians should consider apneic oxygenation during DAAM.

Management of Physiologic Abnormalities. Physiologic abnormalities such as hypoxia and hypotension should be corrected prior to initiation of DAAM efforts. Failure to do so places patients at risk for peri-intubation cardiac arrest (6, 55–57). A shock index > 0.9 in apparently hemodynamically stable patients was associated with two-fold increased odds of peri-intubation hypotension (57). Similarly, based on an analysis of the National Emergency Airway Registry, April et al. found that the odds of peri-intubation cardiac arrest were increased six-fold with hypotension, three-fold with hypoxia, and almost two-fold with an inability to properly prepare for intubation (55). Potential interventions include the rapid infusion of intravenous fluids or, where appropriate and available, blood products. The use of vasopressors prior to DAAM may be appropriate in select hypotensive conditions.

DAAM Medications

DAAM encompasses several strategies that use different types of drugs to facilitate placement of either an endotracheal tube or a supraglottic airway. The most common drugs and dosages used for DAAM in the EMS setting are detailed in Table 1.

Sedatives. While ketamine, etomidate, and midazolam are commonly used sedatives in prehospital DAAM and the optimal sedative for DAAM is unclear, evidence suggests that midazolam may be a suboptimal choice because of excess hypotension (58, 59).

Ketamine is considered to have minimal effects on hemodynamics. Recent evidence in patients with sepsis, however, suggests that hypotension may occur more frequently with the use of ketamine compared to other agents (60). Contrasting evidence suggests no difference in hypotension between ketamine and etomidate (61). One potential explanation for these mixed findings is that patients may have different hemodynamic responses to ketamine depending on the pre-intubation shock-index. In patients induced with ketamine, Miller et al. found more frequent hypotension in those with a shock index > 0.9 (26%) than those with lower shock index (2%) (62). Ketamine was previously considered detrimental in patients with increased intracranial pressure, intraocular pressure, and underlying mental illness but recent literature has demonstrated no meaningful differences in patient-oriented outcomes (63–66).

Etomidate is also commonly thought to have minimal hemodynamic effects. While there is some observational evidence of post-intubation hypotension with etomidate, it was transient and not associated with worse mortality (67). However, in a randomized controlled trial comparing ketamine and etomidate for emergency intubation, there was no difference in adverse events including hypotension or mortality, but there was a greater incidence of transient adrenal insufficiency of unclear clinical

TABLE 1. Common medications used for Drug Assisted Airway Management (DAAM) in the prehospital setting.

Category	Drug	Common IV dosing	Onset of effect	Duration of effect	Caveats
Sedatives	Ketamine	1 and 2 mg/kg	30 sec	10–20 mins	May precipitate hypotension if shock index >0.9
	Etomidate	0.3 mg/kg up to 30 mg	60 sec	4–10 minutes	Concerns for adrenal suppression especially in sepsis patients
	Midazolam	0.1–0.3 mg/kg	Variable, 60 sec to 5 mins	15–30 minutes	No longer recommended for DAAM due to extremely variable patient response, severe respiratory depression, and hypotension
Paralytics	Succinylcholine	1 and 2 mg/kg	45 sec	6–10 mins	Can precipitate hyperkalemia in patients >5 days after severe burn, crush, denervation, or severe infection. Can cause malignant hyperthermia
	Rocuronium	1 and 1.2 mg/kg	55 sec (at 1.2 mg/kg dosing)	45 mins (at 1 mg/kg) up to 60–75 mins (at 1.2 mg/kg)	Increased potential for awareness with paralysis if effective post-intubation analgosedation is not provided

significance (68). Additional studies of single-dose etomidate for induction in sepsis patients, including a randomized controlled trial comparing etomidate to midazolam, found no differences in mortality or hospital or intensive care unit length of stay (69–71). There is conflicting evidence regarding the effect of etomidate or ketamine on first-pass success rates, though most of the evidence shows there is no difference in first-pass success when comparing these drugs (61, 72, 73).

Midazolam has also been used for sedation in RSI but is not an optimal medication for this purpose. Midazolam is often significantly underdosed and, despite this, associated with more peri-intubation hypotension than either etomidate or ketamine (58, 74, 75). Hypotension with midazolam is likely dose-dependent (76).

Neuromuscular Blocking Agents (Paralytics). RSI, RSA, and DSI use a sedative agent paired with a paralytic to achieve rapid relaxation of protective airway reflexes and to facilitate insertion of ET tube or supraglottic airway. Multiple studies have shown that the use of any paralytic has been associated with higher first-pass success rates when compared with sedation-only intubation (1, 77–83). The two most common agents used in for prehospital RSI are succinylcholine and rocuronium, however other agents, such as vecuronium, are used by some agencies. The optimal agent for prehospital DAAM is unclear. Succinylcholine was initially promoted for emergency use because its shorter duration of action would, theoretically, allow for more rapid return of spontaneous respirations in the case of failed intubation. Others have argued that the longer duration of rocuronium is beneficial because it allows for optimal muscle relaxation, facilitating ventilation between airway insertion attempts. Succinylcholine is associated with shorter time to desaturation when compared with rocuronium (84, 85). There is conflicting evidence concerning intubation success and mortality with succinylcholine and rocuronium (84, 86, 87). If using rocuronium, intubation success is higher when using larger doses (above 1.2 mg/kg) (88, 89).

Some clinicians have used paralysis without concurrent sedation. In a series of 212 intubations, Chong et al. found that 18% received long-acting paralytics without sedation (90). Paralytics should not be used without sedatives; this practice is associated with an increase in unrecognized awareness during paralysis leading to post-traumatic stress disorder, complex phobias, and clinical depression (91–93). In clinical situations where a patient is unresponsive but has persistent muscle tone, administration of sedative medications prior to paralytics remains a critical action. There is no published evidence to guide whether these sedative drugs should be given in standard or reduced doses in these situations, although under-dosing may not sufficiently mitigate the risk of awareness with paralysis.

Alternatives to RSI

Sedation-Assisted Intubation. SAI is an approach to DAAM using sedation alone to facilitate airway placement. SAI has been suggested as a safer alternative to a sedation-plus-paralytic (RSI) combination because it allows the patient to continue spontaneously breathing and protecting his or her own airway. However, SAI is associated with lower first-pass success rates and more complications when compared with the combined use of sedatives and paralytics (1, 91, 94–98). Given its significant associated risks and lower first-pass success, SAI should be performed only by expert practitioners in select scenarios in which the risk of paralysis is greater than the risk of vomiting. In select clinical scenarios where paralytic use is unsafe, EMS clinicians should consider supportive airway techniques as an alternative to SAI until arrival at the emergency department.

Rapid Sequence Airway. RSA is an adaptation of RSI that uses a combination of sedation and paralysis for the purpose of inserting a supraglottic device instead of an endotracheal tube (99). This is a useful practice for EMS agencies that do not have the resources to safely perform endotracheal intubation, or for whom supraglottic insertion is a more operationally feasible approach than RSI.

RSA may confer benefits over traditional RSI in patients who are predicted to be anatomically challenging to intubate or those whose physiology cannot be adequately optimized. Though the hemodynamic effects of the drugs used for RSA must still be considered and the patient's physiology optimized as much as possible before performing RSA, the relative speed of RSA compared to RSI may be of benefit (100). The extra time needed to perform endotracheal intubation may lead to more desaturation and hemodynamic instability. Braude et al. evaluated this in a simulated trauma patient managed by experienced prehospital flight crews and found that crews managed the patient with RSA 145 seconds faster and with 4.8% (90.8% vs 86%) higher peri-intubation oxygen saturations than with RSI (101).

Delayed Sequence Intubation (DSI). In select situations, the patient requiring emergent airway management may be too agitated to cooperate with preoxygenation efforts. DSI is a modification of traditional RSI where ketamine is initially given as the sedative agent to allow for proper preoxygenation while maintaining native respiratory effort prior to the delayed administration of the paralytic drug (102, 103). While DSI has shown promising results in observational studies, future research efforts are needed to verify its safety and merits compared with traditional RSI technique.

Post-DAAM Analgesia and Sedation

Patients undergoing invasive airway management in the emergency setting must be provided with ongoing sedation and analgesia; however, such practice is (104–106)commonly overlooked (104–106). Paralysis without sedation is associated with patient discomfort and post-traumatic stress disorder (92). Lack of post-intubation sedation is especially common and most concerning when longer lasting paralytics are used (93).

Equipment Selection

DAAM removes a patient's protective airway reflexes and respiratory drive, making rapid and successful airway placement on the first attempt even more important. Video laryngoscopy, particularly among low-frequency intubators, has been associated with improved first-pass success (107–110). Similarly, use of the bougie, particularly with direct laryngoscopy, has also been associated with increased first-pass success (111, 112). These adjuncts may enhance the safety of DAAM.

CONFIRMATION OF AIRWAY PLACEMENT

Post-DAAM Airway Placement Must Be Confirmed and Continually Monitored with Waveform Capnography.

Continuous waveform capnography is the standard of care and should be considered mandatory for any DAAM (113, 114). Confirmation of airway placement in patients undergoing DAAM is particularly important because traditional approaches to airway placement confirmation (breath sounds, tube condensation, absence of epigastric sounds) are unreliable (115, 116). Continuous capnography has been demonstrated to have higher sensitivity for esophageal intubations than colorimetric or esophageal detector devices in low output states like cardiac arrest (117–121) . Waveform capnography is also much faster at detecting airway displacement than pulse oximetry due to pulse oximetry lag and the beneficial effects of preoxygenation (122, 123). Failure to use waveform capnography was associated with 23% esophageal intubations in one study, while some systems have eliminated unrecognized misplaced intubations with consistent capnography use (120).

MANAGING PATIENTS AFTER UNSUCCESSFUL DAAM

EMS Clinicians Must Have the Necessary Equipment and Training to Manage Patients with Failed DAAM, Including Supraglottic Airway Devices and Surgical Airway Approaches.

Even with the use of sedation and paralytics, intubation efforts are often unsuccessful (2). EMS clinicians must be prepared to rescue failed intubation efforts with backup devices (124). Common techniques include bag mask ventilation, supraglottic and surgical airways (2, 124, 125). Equipment to deploy these techniques must be immediately available during any DAAM, and a plan for when to use them should be discussed ahead of time. Specific supraglottic airway and surgical airway techniques are discussed in depth in other NAEMSP position statements/resource documents (126, 127).

QUALITY MANAGEMENT OF DAAM

Continuous Quality Improvement for DAAM Must Include Assessment of Individual and Aggregate Performance Metrics. Where Available Continuous Physiologic Recordings (Vital Signs, Pulse Oximetry, and Capnography), Audio and Video Recordings, and Assessment of Patient Outcomes Should Be Part of DAAM Continuous Quality Improvement.

Given its complexity and risks, DAAM programs must be monitored with rigorous quality management practices that should include a review of the patient care record and all biometric data/recordings of each DAAM case. Debriefing and live field observation should be done at every opportunity. Because the lack of clinical opportunity may result in cognitive and psychomotor skill decay, quality management activities require longitudinal efforts to identify opportunities for performance improvement. Credentialing should also include a process of periodic cognitive, psychomotor, and affective reassessment to assure ongoing competence. Additional detailed discussion of education and quality management programs focused on airway management in the EMS setting can be found in partner documents to this position paper (128–130).

Measurement is an important aspect of quality improvement, and consistent measurement depends on uniform data definitions. NAEMSP's position statement on data elements defines an airway attempt as "passage of the laryngoscope or advanced airway into the oropharynx" (131).

First-pass success with intubation is an important measure because it is associated with fewer adverse events (132, 133). However, first-pass success alone is not a sufficient measure of successful invasive airway management, as it does not account for peri-intubation hypoxia, hypotension, and other adverse events. For example, Walker et al. found that 70% of desaturation events occurred during the first attempt at intubation even with high rates of first-pass success (9). A novel metric is the evaluation for first-pass success without associated hypoxia or hypotension, also referred to as DASH-1A (definitive airway sans hypoxia/hypotension on first attempt) (134). Additional research is needed to validate the application and utility of this measure.

CONCLUSION

DAAM programs are an important tool for EMS clinicians and have the potential to make the insertion of invasive airways easier; however, they have associated risks. To assure patient safety and to fully realize these benefits there should be broad commitment from all EMS leadership, clear clinical guidelines, adequate equipment, training, credentialing and EMS physician oversight, appropriate patient selection and optimization, and rigorous quality management practices. Further research is warranted and ongoing in many of these areas to inform future best practices.

ORCID

Jeffrey L. Jarvis http://orcid.org/0000-0002-1435-5115
John W. Lyng http://orcid.org/0000-0001-5191-5700
Michael C. Perlmutter http://orcid.org/0000-0002-9710-1523

References

1. Driver BE, Prekker ME, Reardon RF, et al. Brown CA, Success and complications of the ketamine-only intubation method in the emergency department. J Emerg Med. 2020.
2. Wang HE, Donnelly JP, Barton D, Jarvis JL. Assessing advanced airway management performance in a national cohort of emergency medical services agencies. Ann Emerg Med. 2018;71(5):597–607.e3. doi:10.1016/j.annemergmed.2017.12.012.
3. NAEMSP. Clinical credentialing of EMS providers. Prehosp Emerg Care. 2017; 21:397–8.
4. Heffner AC, Swords DS, Neale MN, Jones AE. Incidence and factors associated with cardiac arrest complicating

emergency airway management. Resuscitation. 2013;84(11): 1500–4. doi:10.1016/j.resuscitation.2013.07.022.
5. Jarvis JL, Gonzales J, Johns D, Sager L. Implementation of a clinical bundle to reduce out-of-hospital peri-intubation hypoxia. Ann Emerg Med. 2018;72(3):272–9. doi:10.1016/j.annemergmed.2018.01.044.
6. Kim WY, Kwak MK, Ko BS, Yoon JC, Sohn CH, Lim KS, Andersen LW, Donnino MW. Factors associated with the occurrence of cardiac arrest after emergency tracheal intubation in the emergency department. PLoS One. 2014;9(11): e112779. doi:10.1371/journal.pone.0112779.
7. Mort TC. The incidence and risk factors for cardiac arrest during emergency tracheal intubation: a justification for incorporating the ASA Guidelines in the remote location. J Clin Anesth. 2004;16(7):508–16. doi:10.1016/j.jclinane.2004.01.007.
8. Russotto V, Myatra SN, Laffey JG, Tassistro E, Antolini L, Bauer P, Lascarrou JB, Szuldrzynski K, Camporota L, Pelosi P, INTUBE Study Investigators, et al. Intubation practices and adverse peri-intubation events in critically ill patients from 29 countries. JAMA . 2021;325(12):1164–72. I. doi:10.1001/jama.2021.1727.
9. Walker RG, White LJ, Whitmore GN, et al. Nania JM, Evaluation of physiologic alterations during prehospital paramedic-performed rapid sequence intubation. Prehosp Emerg Care. 2018;22(3):300–311.
10. Fouche PF, Smith K, Jennings PA, Boyle M, Bernard S. The association of paramedic rapid sequence intubation and survival in out-of-hospital stroke. Emerg Med J. 2019;36(7): 416–22. doi:10.1136/emermed-2019-208613.
11. Denninghoff KR, Nuño T, Pauls Q, Yeatts SD, Silbergleit R, Palesch YY, Merck LH, Manley GT, Wright DW. Prehospital intubation is associated with favorable outcomes and lower mortality in ProTECT III. Prehosp Emerg Care. 2017;21(5):539–44. doi:10.1080/10903127.2017.1315201.
12. Wang HE, Peitzman AB, Cassidy LD, Adelson PD, Yealy DM. Out-of-hospital endotracheal intubation and outcome after traumatic brain injury. Ann Emerg Med. 2004;44(5): 439–50. doi:10.1016/j.annemergmed.2004.04.008.
13. Bossers SM, Schwarte LA, Loer SA, Twisk JWR, Boer C, Schober P. Experience in prehospital endotracheal intubation significantly influences mortality of patients with severe traumatic brain injury. PLOS One. 2015;10(10): e0141034. doi:10.1371/journal.pone.0141034.
14. Davis D, Stern JBS, Ochs MMD, Sise M, Hoyt D. A follow-up analysis of factors associated with head-injury mortality after paramedic rapid sequence intubation. J Trauma-Injury Infect Crit Care. 2005; 59:484–8.
15. Bulger EM, Copass MK, Sabath DR, Maier RV, Jurkovich GJ. The use of neuromuscular blocking agents to facilitate prehospital intubation does not impair outcome after traumatic brain injury. J Trauma. 2005;58:718–23. discussion 723.
16. Davis DP, Heister R, Poste JC, Hoyt DB, Ochs M, Dunford JV. Ventilation patterns in patients with severe traumatic brain injury following paramedic rapid sequence intubation. NCC. 2005;2(2):165–71. doi:10.1385/NCC:2:2:165.
17. Davis DP, Dunford JV, Ochs M, Park K, Hoyt DB. The use of quantitative end-tidal capnometry to avoid inadvertent severe hyperventilation in patients with head injury after paramedic rapid sequence intubation. J Trauma. 2004;56(4): 808–14.
18. Kwok H, Prekker M, Grabinsky A, Carlbom D, Rea TD. Use of rapid sequence intubation predicts improved survival among patients intubated after out-of-hospital cardiac arrest. Resuscitation. 2013;84(10):1353–8. doi:10.1016/j.resuscitation.2013.04.015.
19. Burns B, Habig K, Eason H, Ware S. Difficult intubation factors in prehospital rapid sequence intubation by an australian helicopter emergency medical service. Air Med J. 2016; 35(1):28–32. doi:10.1016/j.amj.2015.10.002.
20. Davis DP, Olvera DJ. HEAVEN Criteria: Derivation of a new difficult airway prediction tool. Air Med J. 2017;36(4): 195–7. doi:10.1016/j.amj.2017.04.001.
21. Jarvis JL, Wampler D, Wang HE. Association of patient age with first Pass Success in out-of-hospital advanced airway management. Resuscitation. 2019;141:136–43. doi:10.1016/j.resuscitation.2019.06.002.
22. Nausheen F, Niknafs NP, MacLean DJ, Olvera DJ, Wolfe AC, Pennington TW, Davis DP. The HEAVEN criteria predict laryngoscopic view and intubation success for both direct and video laryngoscopy: a cohort analysis. Scand J Trauma Resusc Emerg Med. 2019;27(1):50. doi:10.1186/s13049-019-0614-6.
23. Clemency BM, Roginski M, Lindstrom HA, Billittier AJ. Paramedic intubation: patient position might matter. Prehosp Emerg Care. 2014;18(2):239–43. doi:10.3109/10903127.2013.864352.
24. Khandelwal N, Khorsand S, Mitchell SH, Joffe AM. Head-elevated patient positioning decreases complications of emergent tracheal intubation in the ward and intensive care unit. Anesth Analg. 2016;122(4):1101–7. doi:10.1213/ANE.0000000000001184.
25. Murphy DL, Rea TD, McCoy AM, Sayre MR, Fahrenbruch CE, Yin L, Tonelli BA, Joffe AM, Mitchell SH. Inclined position is associated with improved first pass success and laryngoscopic view in prehospital endotracheal intubations. The American Journal of Emergency Medicine. 2019;37(5): 937–41. doi:10.1016/j.ajem.2019.02.038.
26. Stoecklein HH, Kelly C, Kaji AH, Fantegrossi A, Carlson M, Fix ML, Madsen T, Walls RM, Brown CA, on behalf of the NEAR Investigators. NEAR I. Multicenter comparison of non-supine versus supine positioning during intubation in the emergency department: A National Emergency Airway Registry (NEAR) Study. Acad Emerg Med. 2019;26(10): 1144–51. doi:10.1111/acem.13805.
27. Alfahel W, Gopinath A, Arheart KL, Gensler T, Lerman J. The effects of a shoulder roll during laryngoscopy in infants: a randomized, single-blinded, crossover Study. Anesth Analg. 2020;131(4):1210–6. doi:10.1213/ANE.0000000000004802.
28. Cuvas O, Dikmen B, Yucel F. Sniffing position combined with mouth opening improves facemask ventilation in children with adenotonsillar hypertrophy: Mouth-Head-Neck Positions, Mask Ventilation. Acta Anaesthesiol Scand. 2011; 55(5):530–4. doi:10.1111/j.1399-6576.2011.02417.x.
29. Di Cicco M, Kantar A, Masini B, Nuzzi G, Ragazzo V, Peroni D. Structural and functional development in airways throughout childhood: children are not small adults. Pediatr Pulmonol. 2021;56(1):240–51. doi:10.1002/ppul.25169.
30. El-Orbany M, Woehlck H, Salem MR. Head and neck position for direct laryngoscopy. Anesth Analg. 2011;113(1): 103–9. doi:10.1213/ANE.0b013e31821c7e9c.
31. Kim EH, Lee JH, Song IK, Kim JT, Kim BR, Kim HS. Effect of head position on laryngeal visualisation with the McGrath MAC videolaryngoscope in paediatric patients: a randomised controlled trial. Eur J Anaesthesiol. 2016;33(7): 528–34. doi:10.1097/EJA.0000000000000448.
32. Kim EH, Ji SH, Song IK, Lee JH, Kim JT, Kim HS. Simple method for obtaining the optimal laryngoscopic view in children: a prospective observational study. Am J Emerg Med. 2017;35(6):867–70. doi:10.1016/j.ajem.2017.01.048.

33. Koylu Gencay Z, Begec Z, Ozgul U, Colak C. The effect of placement of a support under the shoulders on laryngeal visualization with a C-MAC Miller Video Laryngoscope in children younger than 2 years of age. Paediatr Anaesth. 2019; 29:814–20.
34. Vialet R, Nau A, Chaumoître K, Martin C. Effects of head posture on the oral, pharyngeal and laryngeal axis alignment in infants and young children by magnetic resonance imaging. Paediatr Anaesth. 2008;18(6):525–31. doi:10.1111/j.1460-9592.2008.02530.x.
35. Vialet R, Nau A. Effect of head posture on pediatric oropharyngeal structures: implications for airway management in infants and children. Curr Opin Anaesthesiol. 2009;22(3):396–9. doi:10.1097/aco.0b013e3283294cc7.
36. Bodily JB, Webb HR, Weiss SJ, Braude DA. Incidence and duration of continuously measured oxygen desaturation during emergency department intubation. Ann Emerg Med. 2016;67(3):389–95.
37. Davis DP, Lemieux J, Serra J, Koenig W, Aguilar SA. Preoxygenation reduces desaturation events and improves intubation success. Air Med J. 2015;34(2):82–5. doi:10.1016/j.amj.2014.12.007.
38. Aguilar SA, Davis DP. Latency of pulse oximetry signal with use of digital probes associated with inappropriate extubation during prehospital rapid sequence intubation in head injury patients: case examples. J Emerg Med. 2012; 42(4):424–8. doi:10.1016/j.jemermed.2011.06.127.
39. Cemalovic N, Scoccimarro A, Arslan A, Fraser R, Kanter M, Caputo N. Human factors in the emergency department: Is physician perception of time to intubation and desaturation rate accurate? Emerg Med Australas. 2016;28(3):295–9. doi:10.1111/1742-6723.12575.
40. Davis DP, Aguilar S, Sonnleitner C, Cohen M, Jennings M. Latency and loss of pulse oximetry signal with the use of digital probes during prehospital rapid-sequence intubation. Prehosp Emerg Care. 2011;15(1):18–22. doi:10.3109/10903127.2010.514091.
41. Nimmagadda U, Salem MR, Crystal GJ. Preoxygenation: physiologic basis, benefits, and potential risks. Anesth Analg. 2017;124(2):507–17. doi:10.1213/ANE.0000000000001589.
42. Baillard C, Fosse J-P, Sebbane M, Chanques G, Vincent F, Courouble P, Cohen Y, Eledjam J-J, Adnet F, Jaber S. Noninvasive ventilation improves preoxygenation before intubation of hypoxic patients. Am J Respir Crit Care Med. 2006;174(2):171–7. doi:10.1164/rccm.200509-1507OC.
43. Groombridge C, Chin CW, Hanrahan B, Holdgate A. Assessment of common preoxygenation strategies outside of the operating room environment. Acad Emerg Med. 2016;23(3):342–6. doi:10.1111/acem.12889.
44. Groombridge CJ, Ley E, Miller M, Konig T. A prospective, randomised trial of pre-oxygenation strategies available in the pre-hospital environment. Anaesthesia. 2017;72(5):580–4. doi:10.1111/anae.13852.
45. Caputo ND, Oliver M, West JR, Hackett R, Sakles JC. Use of end tidal oxygen monitoring to assess preoxygenation during rapid sequence intubation in the emergency department. Ann Emerg Med. 2019;74(3):410–5. doi:10.1016/j.annemergmed.2019.01.038.
46. Oliver M, Caputo ND, West JR, Hackett R, Sakles JC. Emergency physician use of end-tidal oxygen monitoring for rapidsequence intubation. J Am Coll of Emerg Phys Open. 2020;1(5):706–13. doi:10.1002/emp2.12260.
47. Brown DJ, Carroll SM, April MD. Face mask leak with nasal cannula during noninvasive positive pressure ventilation: a randomized crossover trial. Am J Emerg Med. 2018;36(6): 942–948.
48. Brown DJ, Carmichael J, Carroll SM, April MD. End-tidal oxygen saturation with nasal cannula during noninvasive positive pressure ventilation: a randomized crossover trial. J Emerg Med . 2018;55(4):481–8. doi:10.1016/j.jemermed.2018.05.029.
49. McQuade D, Miller MR, Hayes-Bradley C. Addition of nasal cannula can either impair or enhance preoxygenation with a bag valve mask: a randomized crossover design study comparing oxygen flow rates. Anesth Analg. 2018; 126(4):1214–8. doi:10.1213/ANE.0000000000002341.
50. Binks MJ, Holyoak RS, Melhuish TM, Vlok R, Bond E, White LD. Apneic oxygenation during intubation in the emergency department and during retrieval: a systematic review and meta-analysis. Am J Emerg Med. 2017;35(10): 1542–1546.
51. Oliveira J E Silva L, Cabrera D, Barrionuevo P, Johnson RL, Erwin PJ, Murad MH, Bellolio MF. Effectiveness of apneic oxygenation during intubation: a systematic review and meta-analysis. Ann Emerg Med. 2017;70(4):483–94.e11. doi:10.1016/j.annemergmed.2017.05.001.
52. Pavlov I, Medrano S, Weingart S. Apneic oxygenation reduces the incidence of hypoxemia during emergency intubation: a systematic review and meta-analysis. Am J Emerg Med. 2017;35(8):1184–1189.
53. Sakles JC, Mosier JM, Patanwala AE, Dicken JM. Apneic oxygenation is associated with a reduction in the incidence of hypoxemia during the RSI of patients with intracranial hemorrhage in the emergency department. Intern Emerg Med. 2016;11(7):983–92. doi:10.1007/s11739-016-1396-8.
54. Wimalasena Y, Burns B, Reid C, Ware S, Habig K. Apneic oxygenation was associated with decreased desaturation rates during rapid sequence intubation by an Australian helicopter emergency medicine service. Ann Emerg Med. 2015;65(4):371–6. doi:10.1016/j.annemergmed.2014.11.014.
55. April MD, Arana A, Reynolds JC, Carlson JN, Davis WT, Schauer SG, Oliver JJ, Summers SM, Long B, Walls RM, Investigators NEAR, et al. Peri-intubation cardiac arrest in the Emergency Department: A National Emergency Airway Registry (NEAR) study. Resuscitation. 2021;162:403–11. doi:10.1016/j.resuscitation.2021.02.039.
56. Kim J, Kim K, Kim T, Rhee JE, Jo YH, Lee JH, Kim YJ, Park CJ, Chung H-J, Hwang SS. The clinical significance of a failed initial intubation attempt during emergency department resuscitation of out-of-hospital cardiac arrest patients. Resuscitation. 2014;85(5):623–7. doi:10.1016/j.resuscitation.2014.01.017.
57. Trivedi S, Demirci O, Arteaga G, Kashyap R, Smischney NJ. Evaluation of Preintubation Shock Index and Modified Shock Index as predictors of postintubation hypotension and other short-term outcomes. J Crit Care. 2015;30(4): 861.e1-7–861.e7. doi:10.1016/j.jcrc.2015.04.013.
58. Choi YF, Wong TW, Lau CC. Midazolam is more likely to cause hypotension than etomidate in emergency department rapid sequence intubation. Emerg Med J. 2004;21(6):700–2. doi:10.1136/emj.2002.004143.
59. Upchurch CP, Grijalva CG, Russ S, Collins SP, Semler MW, Rice TW, Liu D, Ehrenfeld JM, High K, Barrett TW, et al. Comparison of etomidate and ketamine for induction during rapid sequence intubation of adult trauma patients. Ann Emerg Med. 2017;69(1):24–33.e2. doi:10.1016/j.annemergmed.2016.08.009.
60. Mohr NM, Pape SG, Runde D, Kaji AH, Walls RM, Brown CA. Etomidate use is associated with less hypotension than ketamine for emergency department sepsis intubations: a NEAR cohort study. Acad Emerg Med. 2020;27(11):1140–9. doi:10.1111/acem.14070.

61. Price B, Arthur AO, Brunko M, Frantz P, Dickson JO, Judge T, Thomas SH. Hemodynamic consequences of ketamine vs etomidate for endotracheal intubation in the air medical setting. Am J Emerg Med. 2013;31(7):1124–32. doi:10.1016/j.ajem.2013.03.041.
62. Miller M, Kruit N, Heldreich C, Ware S, Habig K, Reid C, Burns B. Hemodynamic response After rapid sequence induction with ketamine in out-of-hospital patients at risk of shock as defined by the Shock Index. Ann Emerg Med. 2016;68(2):181–8 e2. doi:10.1016/j.annemergmed.2016.03.041.
63. Baekgaard JS, Eskesen TG, Sillesen M, Rasmussen LS, Steinmetz J. Ketamine as a rapid sequence induction agent in the trauma population: a systematic review. Anesth Analg. 2019;128(3):504–10. doi:10.1213/ANE.0000000000003568.
64. Drayna PC, Estrada C, Wang W, Saville BR, Arnold DH. Ketamine sedation is not associated with clinically meaningful elevation of intraocular pressure. Am J Emerg Med. 2012;30(7):1215–8. doi:10.1016/j.ajem.2011.06.001.
65. Filanovsky Y, Miller P, Kao J. Myth: Ketamine should not be used as an induction agent for intubation in patients with head injury. Cjem. 2010;12(2):154–7. doi:10.1017/s1481803500012197.
66. Lebin JA, Akhavan AR, Hippe DS, Gittinger MH, Pasic J, McCoy AM, Vrablik MC. Psychiatric outcomes of patients with severe agitation following administration of prehospital ketamine. Acad Emerg Med. 2019;26(8):889–96. doi:10.1111/acem.13725.
67. Bastin ML, Baker SN, Weant KA. Effects of etomidate on adrenal suppression: a review of intubated septic patients. Hosp Pharm. 2014;49(2):177–83. doi:10.1310/hpj4902-177.
68. Jabre P, Combes X, Lapostolle F, Dhaouadi M, Ricard-Hibon A, Vivien B, Bertrand L, Beltramini A, Gamand P, Albizzati S, KETASED Collaborative Study Group, et al. Etomidate versus ketamine for rapid sequence intubation in acutely ill patients: a multicentre randomised controlled trial. Lancet. 2009;374(9686):293–300., Prof. doi:10.1016/S0140-6736(09)60949-1.
69. McPhee LC, Badawi O, Fraser GL, Lerwick PA, Riker RR, Zuckerman IH, Franey C, Seder DB. Single-dose etomidate is not associated with increased mortality in ICU patients with sepsis: analysis of a large electronic ICU database. Crit Care Med. 2013;41(3):774–83. doi:10.1097/CCM.0b013e318274190d.
70. Schenarts CL, Burton JH, Riker RR. Adrenocortical dysfunction following etomidate induction in emergency department patients. Acad Emerg Med. 2001;8(1):1–7. doi:10.1111/j.1553-2712.2001.tb00537.x.
71. Tekwani KL, Watts HF, Sweis RT, Rzechula KH, Kulstad EB. A comparison of the effects of etomidate and midazolam on hospital length of stay in patients with suspected sepsis: a prospective, randomized study. Ann Emerg Med. 2010;56(5):481–9. doi:10.1016/j.annemergmed.2010.05.034.
72. Farrell NM, Killius K, Kue R, Langlois BK, Nelson KP, Golenia P. A comparison of etomidate, ketamine, and methohexital in emergency department rapid sequence intubation. J Emerg Med. 2020;59(4):508–14. doi:10.1016/j.jemermed.2020.06.054.
73. Patanwala AE, McKinney CB, Erstad BL, Sakles JC. Retrospective analysis of etomidate versus ketamine for first-pass intubation success in an academic emergency department. Acad Emerg Med. 2014;21(1):87–91. doi:10.1111/acem.12292.
74. Ishimaru T, Goto T, Takahashi J, Okamoto H, Hagiwara Y, Watase H, Hasegawa K, Japanese EMNI. Association of ketamine use with lower risks of post-intubation hypotension in hemodynamically-unstable patients in the emergency department. Sci Rep. 2019;9(1):17230. doi:10.1038/s41598-019-53360-6.
75. Sagarin MJ, Chiang V, Sakles JC, Walls Rapid sequence intubation for pediatric emergency airway management. Pediatr Emerg Care. 2002;18:417–23. RM.
76. Davis DP, Kimbro TA, Vilke GM. The use of midazolam for prehospital rapid-sequence intubation may be associated wtih dose-related increase in hypotension. Prehospital Emergency Care. 2001;5(2):163–8. doi:10.1080/10903120190940065.
77. Bouvet L, Albert M-L, Augris C, Boselli E, Ecochard R, Rabilloud M, Chassard D, Allaouchiche B. Real-time detection of gastric insufflation related to facemask pressure-controlled ventilation using ultrasonography of the antrum and epigastric auscultation in nonparalyzed patients: a prospective, randomized, double-blind study. Anesthesiology. 2014;120(2):326–34. doi:10.1097/ALN.0000000000000094.
78. Joffe AM, Ramaiah R, Donahue E, Galgon RE, Thilen SR, Spiekerman CF, Bhananker SM. Ventilation by mask before and after the administration of neuromuscular blockade: a pragmatic non-inferiority trial. BMC Anesthesiol. 2015;15(1):134. doi:10.1186/s12871-015-0111-z.
79. Okubo M, Gibo K, Hagiwara Y, Nakayama Y, Hasegawa K, Japanese EMNI. The effectiveness of rapid sequence intubation (RSI) versus non-RSI in emergency department: an analysis of multicenter prospective observational study. Int J Emerg Med. 2017; 10 (1):1. doi:10.1186/s12245-017-0129-8.
80. Priebe HJ. Should anesthesiologists have to confirm effective facemask ventilation before administering the muscle relaxant. J Anesth. 2016;30(1):132–7. doi:10.1007/s00540-015-2072-2.
81. Seet MM, Soliman KM, Sbeih ZF. Comparison of three modes of positive pressure mask ventilation during induction of anaesthesia: a prospective, randomized, crossover study. Eur J Anaesthesiol. 2009; 26:913–6.
82. Soltész S, Alm P, Mathes A, Hellmich M, Hinkelbein J. The effect of neuromuscular blockade on the efficiency of facemask ventilation in patients difficult to facemask ventilate: a prospective trial. Anaesthesia. 2017;72(12):1484–90. doi:10.1111/anae.14035.
83. Warters RD, Szabo TA, Spinale FG, DeSantis SM, Reves JG. The effect of neuromuscular blockade on mask ventilation. Anaesthesia. 2011;66(3):163–7. doi:10.1111/j.1365-2044.2010.06601.x.
84. Patanwala AE, Erstad BL, Roe DJ, Sakles JC. Succinylcholine is associated with increased mortality when used for rapid sequence intubation of severely brain injured patients in the emergency department. Pharmacotherapy. 2016;36(1):57–63. doi:10.1002/phar.1683.
85. Taha SK, El-Khatib MF, Baraka AS, Haidar YA, Abdallah FW, Zbeidy RA, Siddik-Sayyid SM. Siddik-Sayyid SM. Effect of suxamethonium vs rocuronium on onset of oxygen desaturation during apnoea following rapid sequence induction. Anaesthesia. 2010;65(4):358–61. doi:10.1111/j.1365-2044.2010.06243.x.
86. April MD, Arana A, Pallin DJ, Schauer SG, Fantegrossi A, Fernandez J, Maddry JK, Summers SM, Antonacci MA, Brown CA, NEAR IEmergency Department Intubation Success With Succinylcholine Versus Rocuronium: A National Emergency Airway Registry Study. Ann Emerg Med. 2018;72(6):645–53. doi:10.1016/j.annemergmed.2018.03.042.
87. Guihard B, Chollet-Xémard C, Lakhnati P, Vivien B, Broche C, Savary D, Ricard-Hibon A, Marianne Dit Cassou P-J, Adnet F, Wiel E, et al. Effect of rocuronium vs succinylcholine on endotracheal intubation success rate among patients undergoing out-of-hospital rapid sequence intubation: a

randomized clinical Trial. JAMA . 2019;322(23):2303–12. doi:10.1001/jama.2019.18254.
88. Levin NM, Fix ML, April MD, Arana AA, Brown CA, Near I. The association of rocuronium dosing and first-attempt intubation success in adult emergency department patients. CJEM. 2021;23(4):518–527. doi:10.1007/s43678-021-00119-6.
89. Tran DT, Newton EK, Mount VA, Lee JS, Wells GA, Perry JJ. Rocuronium versus succinylcholine for rapid sequence induction intubation. Cochrane Database Syst Rev. 2015; CD002788.
90. Chong ID, Sandefur BJ, Rimmelin DE, Arbelaez C, Brown CA, Walls RM, Pallin DJ. Long-acting neuromuscular paralysis without concurrent sedation in emergency care. Am J Emerg Med. 2014;32(5):452–6. doi:10.1016/j.ajem.2014.01.002.
91. Bozeman WP, Kleiner DM, Huggett V. A comparison of rapid-sequence intubation and etomidate-only intubation in the prehospital air medical setting. Prehosp Emerg Care. 2006;10(1):8–13. doi:10.1080/10903120500366854.
92. Leslie K, Chan MT, Myles PS, Forbes A, McCulloch TJ. Posttraumatic stress disorder in aware patients from the B-aware trial. Anesth Analg. 2010;110(3):823–8. doi:10.1213/ANE.0b013e3181b8b6ca.
93. Pappal RD, Roberts BW, Mohr NM, Ablordeppey E, Wessman BT, Drewry AM, Winkler W, Yan Y, Kollef MH, Avidan MS, et al. The ED-AWARENESS Study: a prospective, observational cohort study of awareness with paralysis in mechanically ventilated patients admitted from the emergency department. Ann Emerg Med. 2021;77(5):532–44. doi:10.1016/j.annemergmed.2020.10.012.
94. Bozeman WP, Young S. Etomidate as a sole agent for endotracheal intubation in the prehospital air medical setting. Air Med J. 2002;21(4):32–5. discussion 35. doi:10.1067/mmj.2002.125935.
95. Jacoby J, Heller M, Nicholas J, Patel N, Cesta M, Smith G, Jacob S, Reed J. Etomidate versus midazolam for out-of-hospital intubation: a prospective, randomized trial. Ann Emerg Med. 2006;47(6):525–30. doi:10.1016/j.annemergmed.2005.12.009.
96. Merelman AH, Perlmutter MC, Strayer RJ. Alternatives to rapid sequence intubation: contemporary airway management with ketamine. West J Emerg Med. 2019;20(3):466–71. doi:10.5811/westjem.2019.4.42753.
97. Reed D, Snyder G, Hogue T. Regional EMS experience with etomidate for facilitated intubation. Prehosp Emerg Care. 2002 Jan-Mar;6(1):50–3. doi:10.1080/10903120290938779.
98. Wang HE, O'Connor RE, Megargel RE, Bitner M, Stuart R, Bratton-Heck B, Lamborn M, Tan L. The utilization of midazolam as a pharmacologic adjunct to endotracheal intubation by paramedics. Prehosp Emerg Care. 2000;4(1):14–8.
99. Braude D, Richards M. Rapid sequence airway (RSA)-a novel approach to prehospital airway management . Prehosp Emerg Care. 2007;11(2):250–2. doi:10.1080/10903120701206032.
100. Timmermann A, Russo SG, Crozier TA, Eich C, Mundt B, Albrecht B, Graf BM. Novices ventilate and intubate quicker and safer via intubating laryngeal mask than by conventional bag-mask ventilation and laryngoscopy. Anesthesiology. 2007; 107(4):570–6. doi:10.1097/01.anes.0000281940.92807.23.
101. Southard A, Braude D, Crandall C. Rapid sequence airway vs rapid sequence intubation in a simulated trauma airway by flight crew. Resuscitation. 2010;81(5):576–8. doi:10.1016/j.resuscitation.2009.12.026.
102. Weingart SD, Trueger NS, Wong N, Scofi J, Singh N, Rudolph SS. Delayed sequence intubation: a prospective observational study. Ann Emerg Med. 2015;65(4):349–55. doi:10.1016/j.annemergmed.2014.09.025.
103. Weingart SD, Levitan RM. Preoxygenation and prevention of desaturation during emergency airway management. Ann Emerg Med. 2012;59(3):165–75 e1. doi:10.1016/j.annemergmed.2011.10.002.
104. Bonomo JB, Butler AS, Lindsell CJ, Venkat A. Inadequate provision of postintubation anxiolysis and analgesia in the ED. Am J Emerg Med. 2008;26(4):469–72. doi:10.1016/j.ajem.2007.05.024.
105. Johnson EG, Meier A, Shirakbari A, Weant K, Baker Justice S. Impact of rocuronium and succinylcholine on sedation initiation after rapid sequence intubation. J Emerg Med. 2015;49(1):43–9. doi:10.1016/j.jemermed.2014.12.028.
106. Lembersky O, Golz D, Kramer C, Fantegrossi A, Carlson JN, Walls RM, Brown CA, NEAR IFactors associated with post-intubation sedation after emergency department intubation: A Report from The National Emergency Airway Registry. Am J Emerg Med. 2020;38(3):466–70. doi:10.1016/j.ajem.2019.05.010.
107. Boehringer B, Choate M, Hurwitz S, Tilney PV, Judge T. 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.
108. Brown CA, Kaji AH, Fantegrossi A, Carlson JN, April MD, Kilgo RW, Walls RM, National EARNEARI. Video Laryngoscopy compared to augmented direct laryngoscopy in adult emergency department tracheal intubations: A National Emergency Airway Registry (NEAR) Study. Acad Emerg Med. 2020;27(2):100–8. doi:10.1111/acem.13851.
109. Jarvis JL, McClure SF, Johns D. EMS Intubation improves with king vision video laryngoscopy. Prehosp Emerg Care. 2015;19(4):482–9. doi:10.3109/10903127.2015.1005259.
110. Okamoto H, Goto T, Wong ZSY, Hagiwara Y, Watase H, Hasegawa K, Japanese EMNI. Comparison of video laryngoscopy versus direct laryngoscopy for intubation in emergency department patients with cardiac arrest: A multicentre study. Resuscitation. 2019; 136:70–7. doi:10.1016/j.resuscitation.2018.10.005.
111. Driver B, Dodd K, Klein LR, Buckley R, Robinson A, McGill JW, Reardon RF, Prekker ME. The Bougie and first-pass success in the emergency department. Ann Emerg Med. 2017;70(4):473–8.e1. doi:10.1016/j.annemergmed.2017.04.033.
112. Latimer AJ, Harrington B, Counts CR, Sayre MR. Routine use of a bougie improves first-attempt intubation success in the out-of-hospital setting. Ann Emerg Med. 2021;77(3): 296–304. doi:10.1016/j.annemergmed.2020.10.016.
113. Parameters COSAP. Standards for Basic Anesthetic Monitoring. American Society of Anesthesiologists 2020.
114. Panchal AR, Bartos JA, Cabañas JG, Donnino MW, Drennan IR, Hirsch KG, Kudenchuk PJ, Kurz MC, Lavonas EJ, Morley PT, Adult BAALSWG, et al. Part 3: Adult basic and advanced life support: 2020 American Heart Association Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2020;142(16_suppl_2):S366–S468. doi:10.1161/CIR.0000000000000918.
115. Jemmett ME, Kendal KM, Fourre MW, Burton JH. Unrecognized misplacement of endotracheal tubes in a mixed urban to rural emergency medical services setting. Acad Emergency Med . 2003;10(9):961–5. doi:10.1111/j.1553-2712.2003.tb00652.x.
116. Katz SH, Falk JL. Misplaced endotracheal tubes by paramedics in an urban emergency medical services system. Ann Emerg Med. 2001;37(1):32–7. doi:10.1067/mem.2001.112098.

117. Grmec S. Comparison of three different methods to confirm tracheal tube placement in emergency intubation. Intensive Care Med. 2002;28(6):701–4. doi:10.1007/s00134-002-1290-x.
118. Ornato JP, Shipley JB, Racht EM, Slovis CM, Wrenn KD, Pepe PE, Almeida SL, Ginger VF, Fotre TV. Multicenter study of a portable, hand-size, colorimetric end-tidal carbon dioxide detection device. Ann Emerg Med. 1992;21(5): 518–23. doi:10.1016/S0196-0644(05)82517-X.
119. Pelucio M, Halligan L, Dhindsa H. Out-of-Hospital Experience with the Syringe Esophageal Detector Device. Acad Emerg Med. 1997;4(6):563–8. doi:10.1111/j.1553-2712.1997.tb03579.x.
120. Silvestri S, Ralls GA, Krauss B, Thundiyil J, Rothrock SG, Senn A, Carter E, Falk J. The effectiveness of out-of-hospital use of continuous end-tidal carbon dioxide monitoring on the rate of unrecognized misplaced intubation within a regional emergency medical services system. Ann Emerg Med. 2005; 45(5):497–503. doi:10.1016/j.annemergmed.2004.09.014.
121. Silvestri S, Ladde JG, Brown JF, Roa JV, Hunter C, Ralls GA, Papa L. Endotracheal tube placement confirmation: 100% sensitivity and specificity with sustained four-phase capnographic waveforms in a cadaveric experimental model. Resuscitation. 2017; 115:192–8. doi:10.1016/j.resuscitation.2017.01.002.
122. Langhan ML, Ching K, Northrup V, Alletag M, Kadia P, Santucci K, Chen L. A randomized controlled trial of capnography in the correction of simulated endotracheal tube dislodgement. Acad Emerg Med. 2011;18(6):590–6. doi:10.1111/j.1553-2712.2011.01090.x.
123. Poirier MP, Gonzalez Del-Rey JA, McAneney CM, Digiulio GA. Utility of monitoring capnography, pulse oximetry, and vital signs in the detection of airway mishaps: A hyperoxemic animal model. Am J Emerg Med. 1998;16(4):350–2. doi:10.1016/S0735-6757(98)90125-5.
124. Jarvis JL, Barton D, Wang H. Defining the plateau point: When are further attempts futile in out-of-hospital advanced airway management. Resuscitation. 2018; 130: 57–60. doi:10.1016/j.resuscitation.2018.07.002.
125. Hubble MW, Wilfong DA, Brown LH, Hertelendy A, Benner RW. A meta-analysis of prehospital airway control techniques part II: alternative airway devices and cricothyrotomy success rates. Prehosp Emerg Care. 2010;14(4): 515–30. doi:10.3109/10903127.2010.497903.
126. Lyng JW, Baldino KT, Braude D, Fritz C, March JA, Peterson TD, Yee A. Prehospital supraglottic airways: an NAEMSP Position Statement and Resource Document. Prehosp Emerg Care. 2022;26(S1):32–41. doi:10.1080/10903127.2021.1983680.
127. Reardon RF, Robinson AE, Kornas R, Ho JD, Anzalone B, Carlson J, Levy M, Driver B. Prehospital surgical airway management: an NAEMSP Position Statement and Resource Document. Prehosp Emerg Care. 2022;26(S1):96–101. doi:10.1080/10903127.2021.1995552.
128. Dorsett M, Panchal AR, Stephens C, Farcas A, Leggio W, Galton C, Tripp R, Grawey T. Prehospital airway management training and education: an NAEMSP Position Statement and Resource Document. Prehosp Emerg Care. 2022;26(S1):3–13. doi:10.1080/10903127.2021.1977877.
129. Vithalani V, Sondheim S, Cornelius A, Gonzales J, Mercer MP, Burton B, Redlener M. Quality management of prehospital airway programs: an NAEMSP Position Statement and Resource Document. Prehosp Emerg Care. 2022;26(S1): 14–22. doi:10.1080/10903127.2021.1989530.
130. Mandt M, Harris M, Lyng J, Moore B, Gross T, Gausche-Hill M, Donofrio-Odmann JJ. Quality management of prehospital pediatric respiratory distress and airway programs: an NAEMSP Position Statement and Resource Document. Prehosp Emerg Care. 2022;26(S1):111–7. doi:10.1080/10903127.2021.1986184.
131. Wang HE, Domeier RM, Kupas DF, Greenwood MJ, O'Connor RE. Recommended Guidelines for uniform reporting of data from out-of-hospital airway management: position statement of NAEMSP. Prehospital Emergency Care. 2004;8(1):58–72. doi:10.1080/31270300282X.
132. Hasegawa K, Shigemitsu K, Hagiwara Y, Chiba T, Watase H, Brown CA, Brown DFM, Japanese Emergency Medicine Research Alliance InvestigatorsJapanese Emergency Medicine Research Alliance I. Association between repeated intubation attempts and adverse events in emergency departments: an analysis of a multicenter prospective observational study. Ann Emerg Med. 2012;60(6):749–54 e2. doi:10.1016/j.annemergmed.2012.04.005.
133. Sakles JC, Chiu S, Mosier J, Walker C, Stolz U. The importance of first pass success when performing orotracheal intubation in the emergency department. Acad Emerg Med. 2013;20(1):71–8. doi:10.1111/acem.12055.
134. Powell EK, Hinckley WR, Stolz U, Golden AJ, Ventura A, McMullan JT. Predictors of definitive airway sans hypoxia/hypotension on first attempt (DASH-1A) success in traumatically injured patients undergoing prehospital intubation. Prehosp Emerg Care. 2020;24(4):470–7. doi:10.1080/10903127.2019.1670299.