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Drug-Assisted Intubation in the Prehospital Setting (Resource Document to NAEMSP Position Statement)

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DRUG-ASSISTED INTUBATION IN THE PREHOSPITAL SETTING (RESOURCE DOCUMENT TO NAEMSP POSITION STATEMENT)

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INTRODUCTION

Drug-assisted intubation (DAI) denotes the use of pharmacologic agents to facilitate endotracheal intubation (ETI). DAI encompasses rapid-sequence intubation (RSI—the use of neuromuscular blocking (NMB) with or without sedative agents to rapidly facilitate ETI) and sedation-facilitated intubation (the use of sedative or anesthetic induction agents to facilitate ETI), among other techniques.^{1–7} The prior version of this resource document provided recommendations for prehospital RSI only. The scope of the current version focuses primarily on prehospital RSI but also provides selected guidance for sedation-facilitated ETI and other forms of DAI. The general standards and principles articulated in

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this document apply to all forms of DAI.

HISTORY OF PREHOSPITAL RSI

Reports of paramedic ETI in the prehospital setting date to 1975.^{8,9} Endotracheal intubation of the awake or unrelaxed prehospital patient has been recognized as a difficult procedure because of the presence of intact protective airway reflexes.^{10–12} Sedation-facilitated intubation and nasotracheal intubation have been proposed for these patients in both prehospital and in-hospital settings but with mixed results.^{6,7,13–15}

“Rapid-sequence induction” was first described by Stept and Safar as a method for minimizing the risk of regurgitation and aspiration during the anesthetic induction of an operating room patient with a full stomach.¹⁶ Rapid-sequence intubation (RSI) evolved in Emergency Medicine as a concise version of the anesthesia technique, using neuromuscular blocking (NMB) agents to facilitate the rapid intubation of awake or inadequately relaxed patients during the course of emergency care. RSI has been used in the prehospital setting in the United States for almost 20 years.³ A survey in 1998 described prehospital NMB use in 29 of 50 states (58%), with the majority reserving the technique for air medical systems.¹⁷

PRIOR SCIENTIFIC DATA DESCRIBING PREHOSPITAL RSI

A range of studies describes prehospital RSI, citing success rates up to 100% and few reported complications.^{3,18–36} In the most no-

table series, Wayne and Friedland described 1,657 prehospital RSI uses by a ground paramedic service over a 20-year period.²¹

While these studies suggest that prehospital RSI is “safe and effective,” it is important to recognize that they contain significant limitations:

- These findings originate from single, small EMS services and cannot be generalized to all EMS services.
- Most of these studies occurred on air medical services where personnel received specialized training.
- These studies focused on success rates as the primary outcome measure. Few studies have described the physiologic response, adverse events, errors or outcomes (mortality or neurological outcome) associated with prehospital RSI.

As a whole, these studies only support the *feasibility* of prehospital RSI; that is, whether RSI can be performed in the prehospital setting. These studies do not delineate the safety of the procedure (i.e., “Is the technique free of adverse events and errors?”), the effectiveness of the procedure (i.e., “What is the effect on patient survival and neurological outcome?”), or whether prehospital RSI can be implemented on a large scale. Of these studies, only a single case series has specifically described adverse events from prehospital RSI.³⁷

RECENT DATA DESCRIBING PREHOSPITAL RSI

The most important recent observations regarding prehospital

RSI originate from the San Diego Paramedic RSI Trial.^{22,38-41} This four-year effort evaluated the effectiveness of large-scale implementation of prehospital RSI among multiple ground and air-based paramedic services. The trial included patients with severe traumatic brain injury (TBI) and a Glasgow Coma Scale (GCS) ≤ 8 who could not be intubated using conventional orotracheal techniques. The protocol included pre-oxygenation, sedation using midazolam, paralysis using succinylcholine, and allowed a maximum of three ETI attempts (defined as insertion of the laryngoscope blade into the mouth). The Combitube (The Kendall Company, Mansfield, Massachusetts) was used as a rescue device. Rescuers used both qualitative and quantitative capnometry to confirm ET tube placement.

In the trial successful intubation was achieved in 84% of patients, with Combitube insertion successful in an additional 14%. A formal outcomes analysis used 3-to-1 historical non-intubated controls matched by age, gender, mechanism of injury, trauma center, Injury Severity Score (ISS), and Abbreviated Injury Scores (AIS) for each body system (Head, Face, Chest, Abdomen, Extremities, and Skin). Overall mortality was higher in the RSI cohort (31.8% vs. 23.7%; adjusted OR = 2.0; 95% CI 1.4, 2.8; $p < 0.001$), with a corresponding decrease in good neurological outcomes (46.0% vs. 55.4%; adjusted OR = 0.5; 95% CI 0.4, 0.8; $p < 0.001$).

The leaders of the trial attributed the results to two critical factors. First, data from downloaded continuous pulse-oximetry devices indicated a high incidence of oxygen desaturation during RSI. Many of these desaturations were associated with concurrent bradycardia. Of note, the paramedics did not appear to be aware of these occurrences, as the intubations were characterized as "easy" in most of these cases.

Secondly, high incidences of hyperventilation (ETCO₂ <30 mmHg)

and severe hyperventilation (ETCO₂ <25 mmHg) were observed. These events were associated with decreased survival. Patients undergoing RSI by ground paramedics but transported to the hospital by helicopter were the only subgroup in which improved outcomes were observed. This observation was attributed to flight nurses' experience with the use of capnometry to guide ventilation. In fact, arrival hyperventilation occurred less frequently in air medical patients, both with and without capnometry.

The San Diego Paramedic RSI Trial provided several important perspectives regarding prehospital RSI. The study showed that isolated strategies aimed at improving ETI success (i.e., RSI) did not lead to improved outcomes. Unanticipated adverse events observed during RSI efforts may have offset any potential clinical benefit. The provision of initial and ongoing training was difficult throughout the Trial. Despite prior knowledge of the detrimental effects of hyperventilation on TBI, "accidental" hyperventilation occurred frequently after prehospital RSI. Finally, the identification of significant adverse events affirmed the importance of continuous physiologic monitoring for prehospital RSI.

Two analyses conducted since the San Diego Paramedic RSI Trial arrived at slightly different conclusions regarding patient outcome, but these studies evaluated a different scientific question. In a retrospective analysis, Bulger, et. al. observed slightly improved outcomes for TBI patients undergoing RSI by paramedics and flight nurses over conventional ETI, adjusting for CPR status, shock, age, Injury Severity Score, and GCS.⁴² In a before-and-after study of TBI patients, Domeier, et. al. similarly found that outcomes were improved for 101 prehospital RSI patients compared with 80 matched historical intubated controls.⁴³ The Bulger and Domeier studies used conventionally intubated controls and thus

evaluated the incremental effect of RSI over conventional ETI. In contrast, the San Diego Trial used non-intubated controls and thus evaluated the overall benefit of ETI (via RSI) over non-ETI airway strategies. These are different—albeit equally important—questions.

The current literature do not clearly indicate whether prehospital RSI is beneficial or harmful. However, these studies affirm that prehospital RSI is a difficult and complex procedure, contains significant pitfalls and may interact with other important aspects of patient care. Because of its pivotal role in identifying previously unrecognized adverse events, errors, and system issues surrounding prehospital RSI, the results of the San Diego RSI Trial have provided the basis for many of the recommendations in this resource document. We recognize that additional study is necessary to confirm the observations from these current "best available" data.

RECOMMENDED STANDARDS FOR PREHOSPITAL RSI

While this section pertains primarily to prehospital RSI, the same standards and principles apply to sedation-facilitated ETI and other forms of DAI.

System Need for Prehospital RSI

EMS services should examine their airway management and response characteristics to determine the merits of implementing an RSI program. Most (up to 70%) prehospital ETI occur on cardiac arrests.^{44,45} Non-arrest ETI comprise approximately 30-50% of prehospital ETI, and of this subset prehospital RSI will occur on only the fraction with intact airway reflexes (for example, head injury or pulmonary edema). Thus, only a small percentage of an agency's total ETI will potentially require RSI. Air medical

or specialty transport services may observe higher numbers. Medical directors should assess the projected total number of RSI as well as the number of procedures per paramedic. While optimal RSI-per-service or RSI-per-paramedic ratios have not been defined, RSI program initiation may not be merited where these figures are small.

Services should also consider transport times to receiving Emergency Departments. Prehospital RSI often requires additional scene time and may not be justified for EMS services with short transport times to receiving Emergency Departments. While there are currently no formal data defining appropriate transport times for RSI systems, prehospital RSI likely has a more meaningful role when there are extended transport times.

Procedural Experience and Training Recommendations

There is strong consensus that rescuers who perform prehospital RSI must have exceptional basic ETI skills, ideally at a level comparable with physicians. Experts agree that RSI education should incorporate a period of focused initial training followed by frequent continuing training. Rescuers who do not acquire regular clinical experience with RSI or ETI must have access to frequent supplemental training. Many—if not most—EMS agencies will not be able to provide adequate training and procedural experience to maintain rescuers at this level of ETI expertise.

Several themes regarding training emerge from the existing prehospital RSI literature. First, the actual clinical use of RSI use may be far lower than predicted. In the San Diego Trial, most paramedics performed prehospital RSI less than once per year, and non-familiarity with the procedure appeared to lead to increased medication errors by the end of the Trial. Therefore, intensive continuing training must supplement clinical experience.

The approach to baseline (initial) and continuing training for prehospital RSI is an area of controversy, particularly with regards to the need for supplemental ETI/RSI training using live operating room (OR) patients. While not supported by scientific evidence, many experts believe that the “feel” and management of the pharmacologically-paralyzed airway can only be learned and appreciated on live patients, preferably in the controlled OR setting. Studies that describe successful RSI programs have generally incorporated baseline and continuing ETI/RSI training in the OR.^{21,34,43} In the Wayne study, paramedics who did not meet minimum clinical ETI standards (12 ETI per year initially, four ETI per year after three years of experience) were required to acquire supplemental ETI experience in the OR.²¹ Many directors of established prehospital RSI programs credit baseline and continued OR training as key elements of their success.

In contrast, some experts note that operating room (OR) training time is difficult and often impossible to obtain for many EMS services. In addition, if poorly mentored, these experiences may have little educational value. OR training may also be less meaningful for individuals with a substantial pre-existing ETI skill base. In light of these considerations, many EMS services have used mannequins exclusively for baseline and continuing RSI training.^{22,43} This approach may be reasonable where paramedics have (1) a strong preexisting ETI/RSI skill base, and (2) frequent clinical experience with ETI or RSI.

Some experts also identify the need for critical airway management decision-making skills. Rescuers must be able to recognize and manage prehospital RSI scenarios that involve severe airway injury, physiologic compromise, logistical barriers or failed RSI efforts. Since these scenarios cannot be recreated using live operating room patients,

mannequins or human simulators may provide the ideal setting for rehearsing these situations.

The current consensus recommendation is that the ideal preparation for prehospital RSI should incorporate:

1. *Formal Didactic Training.* Rescuers must receive formal instruction regarding the technique, indications and contraindications of RSI, the effects and side effects of RSI pharmacology, recognition of difficult airway scenarios, and the application of rescue airway techniques in the event of failed RSI. Rescuers must receive training in critical airway management decision making.
2. *Acquisition of Baseline (Initial) ETI/RSI Skill.* Rescuers performing prehospital RSI must possess excellent basic ETI skills, achieved through either prior clinical (prehospital or in-hospital) or controlled OR experience on live patients. Rescuers with less prior live ETI experience may benefit from a period of supplemental OR or in-hospital training prior to performing prehospital RSI. Some experts recommend that all rescuers (including those with substantial prior ETI skill or experience) undergo controlled OR training to gain familiarity with the management of the pharmacologically-paralyzed airway. Initial experience with RSI should be closely supervised.
3. *Maintenance of ETI/RSI Skills on a Continuing Basis.* Rescuers must receive frequent intensive didactic and clinical training to maintain ETI and RSI skills. Rescuers should perform RSI or ETI on a frequent basis. Individuals who do not perform ETI or RSI frequently may benefit from additional live (OR or other in-hospital) experience. In selected settings, mannequin or human simulator-based training may

provide a viable alternative to OR training.

It may be reasonable to limit RSI to a select group of rescuers within an EMS service who are able to attain these standards. The relative effectiveness of OR-based and mannequin/simulator-based training merit additional scientific study.

Recommended Monitoring Equipment

The San Diego RSI Trial highlighted that critical events such as desaturation and bradycardia may occur during prehospital RSI. Services performing prehospital RSI must use cardiac monitors incorporating continuous monitoring and recording of heart rate and rhythm, oxygen saturation, and end-tidal carbon dioxide before, during and after attempted ETI.

Confirmation and continuous reconfirmation of proper ET tube placement are essential after prehospital ETI and may be particularly difficult in pharmacologically paralyzed prehospital patients. A prior NAEMSP position statement recommends the use of multiple methods for tube placement confirmation.⁴⁶

We strongly recommend the additional use of continuous digital or (preferably) waveform end-tidal carbon dioxide detection for prehospital RSI. Digital capnometry and waveform capnography are currently considered the most accurate methods for confirming ET tube placement in perfusing patients.⁴⁷⁻⁵⁰ These are also the only techniques currently available for continuously confirming endotracheal tube placement. The San Diego RSI Trial suggested that waveform capnography may also help to facilitate controlled ventilation.⁵¹ Most experts favor waveform devices because they are easier to interpret in the context of prehospital care.

While colorimetric detectors may be used for initial identification of

ET tube location, these devices are less useful for continuous confirmation and are less accurate in hypoperfusing patients.⁵²⁻⁵⁶ Esophageal detector devices similarly may be useful for initial tube placement confirmation but may be less useful during later phases.^{49,57-60}

Oversight and Quality Assurance

Prehospital RSI programs must receive medical direction from physicians who have substantial clinical experience with RSI. Medical directors should be involved with all aspects of an RSI program, including program and protocol design, training (baseline and continuing) and quality assurance.

Systems utilizing RSI must have an intensive quality assurance program to help assess and maintain the quality of RSI performance. Performance review should encompass both concurrent and retrospective methods. Systems utilizing RSI should utilize database tracking of all ETI in conformance with the NAEMSP recommended data elements for prehospital airway management.⁶¹

Service directors often use intubation success rates to characterize the performance of prehospital ETI or RSI. However, the San Diego RSI Trial highlighted that other measures provide important insights regarding the manner of RSI performance and may be equally important indicators of RSI quality.³⁹ We recommended that prehospital RSI programs identify, at minimum, the following events and measures:

- Successful RSI (both first attempt and overall)—defined as successful placement of the endotracheal tube.
- Measures and observations from tube placement confirmation efforts.
- Successful rescue airway placement.
- Oxygen desaturation.

- Dysrhythmias, including bradycardia and cardiac arrest.
- Hypotension.
- Episodes of hyperventilation.

The San Diego RSI Trial highlighted that patient in-hospital outcome can be impacted by prehospital RSI practices.³⁸ Also, certain RSI complications may not be evident until evaluation in the receiving Emergency Department; for example, tube misplacement or airway injury. EMS services should endeavor to obtain information regarding inpatient course, complications and outcome (survival to admission, survival to discharge, neurological outcome) after prehospital RSI. Complex risk adjustment is necessary to relate prehospital RSI to predicted outcome and may be difficult to perform with small sample sizes. However, unadjusted outcomes information can be useful for identifying systematic patterns related to RSI performance.

RECOMMENDED METHODS FOR RSI

While this section pertains primarily to prehospital RSI, with the exception of the use of NMB agents, the same standards and principles apply to sedation-facilitated and other forms of DAI.

The purpose of this section is to highlight issues specific to the application of RSI in the prehospital setting. This section does not prescribe a specific method or approach to prehospital RSI. The convention of the "six P's" (preparation and positioning, preoxygenation, pretreatment, sedation and paralysis, perform laryngoscopy, confirm position, and post-intubation treatment) is used due to its wide recognition. Individual systems should develop protocols that conform to existing system needs or requirements. In addition, since different patients may present in clinical scenarios that preclude the use of certain elements of RSI, it may be

necessary to modify RSI measures on a rare individual basis.

Clinical Indications for Prehospital RSI

In both prehospital and in-hospital settings, clinicians generally use RSI on patients who require urgent or emergent ETI but show evidence of incomplete airway relaxation, making conditions for conventional orotracheal intubation suboptimal.

Because of the nature and limitations of prior data, specific clinical or disease state indications for prehospital RSI are currently not defined. Prior studies of outcome after RSI have focused on traumatic brain injured (TBI) patients. There are no data delineating the benefit of prehospital RSI for patients with other traumatic or medical conditions. Protocols often specify ETI/RSI for a Glasgow Coma Scale (GCS) score <8, but there are no data demonstrating the benefit of ETI or RSI for this subset. In fact, current analyses suggest worsened outcomes for these subgroups.^{42,43} While intubation is often performed in response to hypoxia, it is not known whether early ETI or RSI reverses the impact of this pre-existing condition.⁴¹ Intubation is often performed to prevent aspiration, but these events may occur prior to the arrival of prehospital personnel and thus may not be preventable with early ETI or RSI.⁶²

Generally accepted contraindications to prehospital RSI include situations where the technique cannot be preformed in a reasonably safe manner, for example:

- Entrapped patient with inadequate access to patient and airway;
- Unstable or dangerous environment;
- The absence of qualified personnel or appropriate equipment.
- Patients with relative contraindications to RSI pharmacologic agents.

Depending on operator skill and clinical circumstances, RSI may not be appropriate in selected patients with difficult airway anatomy; for example, stridor, severe facial trauma, small mouth, short neck, or morbid obesity, among others.

RSI is not intended for patients who are uncooperative or intoxicated but have no clinical indication for urgent or emergent endotracheal intubation. However, there may be isolated situations where pharmacologic paralysis and airway control are necessary to ensure the safety of prehospital care providers.

There are only limited data describing the use of prehospital RSI on the pediatric population. Individual systems should determine whether pediatric patients should be included in a prehospital RSI program.

Finally, there may be situations where optimization of other treatments may obviate the need for ETI/RSI; for example, the use of continuous positive airway pressure (CPAP) in patients with pulmonary edema, or use of naloxone for victims of opiate overdose, among others.^{63–66}

Positioning and Preparation

Providers should place and position the patient in as controlled an environment as possible. Patients should not receive RSI in unstable environments where there are hazards to patient or provider or where rescuers cannot adequately monitor the patient. Certain situations may dictate placing the patient inside an ambulance or other suitably protected environment prior to initiating RSI.

Preoxygenation

Providers customarily use a non-rebreather mask or bag-valve-mask ventilation to provide up to five minutes of pre-oxygenation prior to RSI.¹ This practice theoretically compensates for potential desaturation during laryngoscopy.^{67–70}

While we recommend this practice for prehospital RSI, current data offer mixed perspectives of this practice. In the San Diego RSI Trial desaturation occurred frequently despite the use of pre-oxygenation. This observation highlights that the pre-oxygenation of critically ill prehospital patients may not afford the same margin of safety as with operating room patients.³⁹ Experts also note that overaggressive pre-oxygenation by positive pressure ventilation (e.g., BVM) may lead to inadvertent gastric insufflation, increasing the risk of vomiting during laryngoscopy. Additional study is necessary to identify optimal pre-oxygenation strategies specific to the prehospital setting.

Providers often apply cricoid pressure (Sellick's maneuver) to minimize gastric distention and risk of aspiration during pre-oxygenation and laryngoscopy.⁷¹ While we recommend the application of cricoid pressure, we note that there are presently no data to support the effectiveness of this technique during prehospital airway management.

Pretreatment

Many RSI regimens use pretreatment with selected intravenous pharmacologic agents to attenuate physiologic response to RSI drugs and laryngoscopy. There are currently no scientific data supporting these practices in the prehospital setting. Since the application of these interventions in the prehospital setting may delay the overall course of airway management, it may be acceptable to exclude these steps when performing prehospital RSI.

Lidocaine theoretically blunts intracranial pressure (ICP) response to laryngoscopy in the setting of TBI. The primary data supporting this practice originate from operating room patients and demonstrate equivocal findings.^{72–76} There are no data supporting the use of lidocaine in acute ED or prehospital airway management.

A "priming" dose of a non-depolarizing NMB agent theoretically blunts rises in ICP from succinylcholine fasciculations in suspected TBI. There are currently no data indicating that succinylcholine-associated ICP rises are harmful.⁷⁷⁻⁸² While atropine is commonly used in pediatric RSI cases to offset bradycardia associated with NMB agents, the data supporting this practice in emergency settings is equivocal.⁸³⁻⁸⁶ There are currently no data examining this practice in the setting of prehospital RSI. Because succinylcholine may cause bradycardia in any age group, some clinicians pretreat with atropine prior to repeat doses of succinylcholine.

Sedation and Paralysis

A primary goal of RSI is to achieve rapid deep sedation and paralysis while minimizing physiologic response. Prehospital RSI should utilize agents that accomplish rapid, deep sedation of short duration with minimal hemodynamic effects. Etomidate is currently the only drug that meets this profile, and thus it is the most suitable sedation agent for prehospital RSI.⁸⁷ The clinical significance of adrenal suppression from a single induction dose of etomidate remains unclear.^{88,89}

While clinicians have used sodium thiopental for ED RSI, this agent causes hypotension and therefore is not recommended for prehospital RSI. ED clinicians often use Ketamine for RSI of status asthmaticus patients because of its bronchodilating properties. While ketamine is likely a safe drug for prehospital RSI use, there are no currently data evaluating this application in the prehospital setting. Ketamine can increase ICP and may be harmful in the setting of TBI, which represents a significant fraction of patients potentially receiving prehospital RSI.

Benzodiazepines are not ideal for prehospital RSI. These agents are slow in onset, have widely variable

dose-response effects, and cause significant hypotension in patients receiving prehospital RSI.⁹⁰ Opioids are also not ideal for prehospital RSI for similar reasons.

Paralysis for prehospital RSI should be accomplished using a rapid-acting, short-duration NMB agent. Currently, the only agent that fits this profile is succinylcholine, which has an onset within 60-90 seconds and duration of only 7 minutes. The potential side-effects of succinylcholine are likely of minimal concern in the prehospital setting.¹ Succinylcholine may cause hyperkalemia in burn patients, but this effect occurs in patients with burns that are over 24-48 hours old; EMS handles mostly acutely injured burn patients.^{91,92} Succinylcholine may increase ICP in head injured patients, but there are no data describing this effect or its clinical significance from acute emergency airway management.^{80,81,93}

In the event of failed RSI, restoration of the patient's native airway reflexes may play a significant role in "rescue" airway management; the short duration of succinylcholine (7 minutes) is ideal for this situation. Other NMB agents such as vecuronium, rocuronium and pancuronium have longer durations of action (20-45 minutes) that do not afford a similar margin of safety. These agents should be reserved for long-term paralysis after successful ET tube placement.

Some experts note that in some patients, oxygenation status is so poor prior to RSI that the use of a short vs. long-acting paralytic is of no consequence. However, in contrast to in-hospital RSI, prehospital RSI occurs in the uncontrolled field environment where there are few therapeutic options and no "backup" resources available. Prehospital RSI may fail in small but significant fractions of patients.⁹⁴ In the face of failed RSI, rapid restoration of spontaneous respirations may provide vital additional time for selecting and executing subsequent

actions. While additional prehospital data are needed, we currently favor the use of primarily short-acting NMB agents for prehospital RSI.

Pediatric practitioners often use vecuronium or rocuronium instead of succinylcholine for pediatric RSI. This practice is based upon operating room reports of malignant hyperthermia occurring when succinylcholine is administered to patients with unrecognized neuromuscular conditions (for example, Duchenne and Becker muscular dystrophy).⁹⁵ There are currently no data describing the incidence of unrecognized neuromuscular myopathies in pediatric patients receiving emergency (ED or prehospital) prehospital airway management. The use of alternatives to succinylcholine may be reasonable for specialty pediatric transport teams that handle a wider range of pediatric cases.

Laryngoscopy and Placement of Endotracheal Tube

Rescuers should use direct orotracheal visualization for prehospital RSI. Nasotracheal approaches should not be used with RSI. The San Diego RSI Trial confirmed that desaturation and bradycardia may occur during prolonged laryngoscopy.³⁹ Thus, intubation attempts should be limited to 30-45 seconds or if oxygen saturation drops below 90% or baseline. Efforts at RSI should cease and alternate airway methods pursued if intubation is not successful by the third attempt. Alternative methods may be considered sooner than the third attempt if significant difficulties are encountered during earlier efforts.

Postintubation

As described previously, rescuers must confirm endotracheal tube placement after RSI by redundant methods, including the use of

capnometry. We recommend waveform capnography over other digital and colorimetric capnometry. Systems utilizing RSI should have access to medications for both prolonged sedation and paralysis after successful intubation such as benzodiazepines (e.g., midazolam, lorazepam, diazepam) and medium- and long-acting NMB agents (e.g., cisatracurium, vecuronium, pancuronium, rocuronium).

Failed Intubation

Systems using RSI must have a protocol and equipment available for addressing failed intubation and the inability to ventilate. All RSI providers must be skilled in BVM ventilation and at least one of the following types of rescue airway devices: Combitube (Kendall Company, Mansfield, Massachusetts), or Laryngeal Mask Airway (LMA North America, San Diego, CA). Medical directors may consider other similar airway devices. Medical directors should also consider training RSI providers to utilize needle cricothyroidotomy (transtracheal jet ventilation) or surgical cricothyroidotomy.

There are considerable data supporting the use of Combitubes in the prehospital setting and after failed RSI.^{40,96,97} Data on LMA are more limited but are supportive.⁹⁷⁻⁹⁹ Prehospital cricothyroidotomy (both needle and open techniques) is widely taught but used infrequently.^{100,101} Recent reports suggest that significant morbidity and mortality can result when surgical airway techniques are attempted by inexperienced operators.³⁷ While selected cases may necessitate the use of surgical airway techniques, we recommend that services do not rely upon these methods as the sole rescue airway technique.

Additional Considerations

Drug calculation and administration errors are possible given

the complexity of the prehospital environment.¹⁰² It is reasonable to minimize the number of drug agents carried for prehospital RSI. For example, the combination of etomidate, succinylcholine, midazolam and vecuronium (the latter agents for post-RSI sedation and paralysis) may be adequate for the vast majority prehospital RSI. To simplify drug dosing, services may elect to use weight-range dosing; for example, the San Diego RSI Trial successfully used a "small/medium/large" scheme for estimating drug dosages.²²

Precise ventilatory control may be important after prehospital RSI. Both hypo- and hyperventilation have been linked to adverse outcome in a range of prehospital subsets.^{41,103,104} Feedback from digital and waveform capnography may be useful for preventing these events.⁵¹

OTHER FORMS OF DRUG-ASSISTED INTUBATION

As an alternative to RSI, many EMS services use sedation-facilitated intubation. This technique denotes the single or combination use of benzodiazepines, opioids, or induction agents to facilitate ETI, without the use of neuromuscular blocking agents.^{4-7,105,106} This technique is widely used because these agents are commonly carried by EMS services for other applications. Many clinicians assume that ETI using these agents is safer than with neuromuscular blockade. However, the limited data describing these techniques highlight significant concerns; specifically, resulting suboptimal intubating conditions and the strong potential for clinically significant hypotension.

The only evaluations of prehospital benzodiazepine-facilitated ETI involve intravenous midazolam. These efforts demonstrate suboptimal ETI success rates (Dickinson et al. 85%; Wang et al. 67.5%).^{6,7} A major concern regarding midazolam and other benzodiazepines

is the risk of hypotension, especially when used on critically ill patients in the dosages needed to achieve intubating conditions. In the San Diego RSI Trial, Davis et al. found that midazolam caused clinically significant hypotension.⁹⁰ Lower dosages may limit these effects but at the expense of optimized intubating conditions. As discussed previously for RSI, benzodiazepines have relatively slow and unpredictable dose-response effects and thus may not be ideal for facilitating prehospital ETI.

As with benzodiazepines, opioids have slow and unpredictable onset and can cause significant hypotension. We therefore do not recommend the use of opioids for facilitating prehospital ETI. Because of the potentiated risk of hypotension in critically ill patients, we also do not recommend combinations of benzodiazepines and opioids to facilitate ETI (for example, diazepam and morphine).

Etomidate has been proposed as an appealing induction agent for sedation-facilitated intubation because of its favorable hemodynamic profile and profound induction/deep sedative effect. Pilot studies have evaluated the use of etomidate as a sole induction agent for facilitating prehospital ETI.^{4,5,15,18} Ironically, selected series have found ETI success rates no better than with midazolam. A nonrandomized Delaware series found no difference in ETI success between etomidate (83%), midazolam (83%) or their combination (85%).¹⁰⁶ Preliminary results from a recent Pennsylvania randomized controlled trial of etomidate vs. midazolam found no difference in prehospital ETI success rates (82% vs. 75%) between these agents.¹⁰⁵

While etomidate can cause clinically significant myoclonus, which may adversely impact airway management efforts, the frequency and effect of these events on prehospital airway management have not been evaluated.¹⁰⁷ Adnet et al. suggest

lower myoclonus and higher ETI success rates with the combination of midazolam and etomidate.¹⁵ There are only limited evaluations of other induction agents for prehospital sedation-facilitated intubation.^{15,18}

Finally, some services use topical anesthetics to facilitate ETI, but there are currently no data supporting the safety or effectiveness of this technique in the prehospital setting. Optimized intubating conditions and adequate control of physiologic response are unlikely with this technique.

Recommended Standards for Sedation-Facilitated ETI and Other Forms of DAI

Services utilizing sedation-facilitated ETI should apply the same system-level safeguards, training, monitoring and quality assurance measures as those recommended for prehospital RSI. The availability of sedative agents does not denote system qualification to perform sedation-facilitated ETI. EMS personnel must be specifically prepared to utilize these agents *in the context of airway management*.

With regard to specific drug agents, the consensus recommendation is that benzodiazepines and opioids (individually or in combination) are not ideal for facilitating prehospital ETI. Induction agents such as etomidate show theoretical promise for facilitating prehospital ETI but merit additional study. Additional data are needed to clarify the appropriate agents or combinations of agents for this application. ETI facilitated by topical anesthesia is not recommended.

CONCLUSION

Properly trained and prepared EMS rescuers may use DAI to facilitate ETI in selected patients. Current scientific evidence do not identify clear morbidity or mortality ben-

efits from these techniques. These methods may also lead to increased harm. EMS services electing to use DAI in clinical practice should adhere to the clinical, educational and system standards recommended for these techniques.

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