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Review Article

Advancing emergency airway management practice and research

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Emergency airway management is one of the vital resuscitative procedures undertaken in the emergency department (ED). Despite its clinical and research importance in the care of critically ill and injured patients, earlier studies have documented suboptimal intubation performance and high adverse event rates with a wide variation across the EDs. The optimal emergency airway management strategies remain to be established and their dissemination to the entire nation is a challenging task. This article reviews the current published works on emergency airway management with a focus on the use of airway management algorithms as well as the importance of first-pass success and systematic use of rescue intubation strategies. Additionally, the review summarizes the current evidence for each of the important airway management processes, such as assessment of the difficult airway, preparation (e.g., positioning and oxygenation), intubation methods (e.g., rapid sequence intubation), medications (e.g., premedications, sedatives, and neuromuscular blockades), devices (e.g., direct and video laryngoscopy and supraglottic devises), and rescue intubation strategies (e.g., airway adjuncts and rescue intubators), as well as the airway management in distinct patient populations (i.e., trauma, cardiac arrest, and pediatric patients). Well-designed, rigorously conducted, multicenter studies that prospectively and comprehensively characterize emergency airway management should provide clinicians with important opportunities for improving the quality and safety of airway management practice. Such data will not only advance research into the determination of optimal airway management strategies but also facilitate the development of clinical guidelines, which will, in turn, improve the outcomes of critically ill and injured patients in the ED.

Key words: Airway management, emergency department, rapid sequence intubation, rescue intubation, video laryngoscopy

INTRODUCTION

EMERGENCY AIRWAY MANAGEMENT is a central part of emergency medicine practice. The first priority for managing an acutely unstable patient is securing the airway. Approximately 0.5–1% of emergency department (ED) patients require intubation for various conditions, such as respiratory failure, cardiac arrest, and altered mental status.[1–3] Emergency airway management in the ED is often challenging for the emergency physician because multiple ED-specific factors, for example, vomiting, facial/neck trauma, immobilized cervical spine, and chest compression for resuscitation, contribute to intubation success and failure. To achieve rapid and successful intubation for these high-risk ED patients, understanding the current evidence on emergency airway management is essential.

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Until the 1990s, emergency airway management had been carried out based on the evidence in the anesthesia field. The milestone of emergency airway management is the foundation of the National Emergency Airway Registry (NEAR) – a multicenter registry that aims to prospectively characterize the emergency airway management practices in the EDs across North America.[4–8] Since its inception, the knowledge based on other large multicenter registries, including the Korean Emergency Airway Management Registry (KEAMR) and Japanese Emergency Airway Network

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(JEAN) registry,[6,9,10] have also advanced the ED airway management, in parallel to the advent of intubation techniques and devices, such as rapid sequence intubation (RSI),[6–8] video laryngoscopies (VLs),[11–13] and supraglottic devices.[14–17] Consequently, the performance of emergency airway management with the use of these approaches is indicative of the competence of emergency physicians managing the critically ill.

The current evidence on emergency airway management emphasizes the importance of first-pass success,[9,18–20] refuting multiple intubation attempts for patients who require an intubation in the ED. Indeed, failed first intubation attempts are associated with a higher risk of adverse events, higher failure rates at the subsequent attempts, lower probability of return of spontaneous circulation (ROSC) during the early resuscitation, and prolonged time to achieve ROSC.[9,18–21] Despite its importance, studies have shown that the first-pass success rate varies across the countries and is suboptimal in Japanese EDs. For example, in large multicenter registries, the first-pass success rates were 83% in North America (from NEAR),[8] in South Korea (from KEAMR),[22] and 71% in Japan (from JEAN).[10] Furthermore, there was a high degree of variation in the first-pass success rates across the Japanese EDs, ranging from 40% to 83%.[10]

Systematic preparation and assessment for difficult airways are the keys for achieving successful intubations. The current evidenced-based algorithms are based primarily on anesthesia experiences[23] targeting elective intubations, and hence might not be applicable to ED patients with various conditions (e.g., cardiac arrest).[24] Additionally, emergency physicians might not have sufficient time to obtain medical history or to thoroughly assess the airway before an intubation attempt because of time pressure and the patient's condition.[25]

In this context, this article reviews current published works on emergency airway management with a focus on the importance of first-pass success, the use of airway management algorithms, and preparation, as well as the systematic use of rescue intubation strategies.

AIRWAY MANAGEMENT ALGORITHM AND DIFFICULT AIRWAYS

SEVERAL ALGORITHMS HAVE been proposed for emergency airway management[17,26–28] based on the universal emergency airway algorithm (Fig. 1).[29] The purpose of the algorithm is neither a tool for decision of intubation nor a "cookbook" that describes the procedures for intubation. The goals of the algorithm are to promote rapid decision-making, reduce errors, and improve the quality of airway management.[29] In emergency airway management, identification of the difficult airway is a crucial step to achieve first-pass success and avoid encountering a "cannot intubate, cannot ventilate" situation.[6,18,19,30] The presence of difficult airway is a key branch point to achieve safe, successful intubation (Fig. 1).

Definition of difficult airway

Although the impact of a difficult airway is widely recognized, there are no standardized definitions for difficult airway in the ED setting. As the definition of difficult airway varies across studies, the incidence of the difficult airway is as wide as 2% to 27%.[31–38] Difficult airway is generally divided into several dimensions:[29] (i) difficult laryngoscopy, (ii) difficult bag-mask ventilation, (iii) difficult extraglottic devices (EGD), (iv) difficult cricothyroidotomy. Of these, a particularly important dimension is difficult laryngoscopy.

Difficult laryngoscopy

The level of intubation difficulty depends on the degree of glottic view with laryngoscopy. Cormack and Lehane (C-L) grade is the most widely used system to categorize the

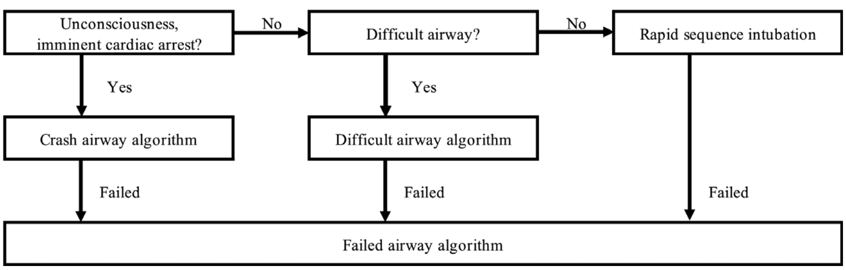

Fig. 1. Universal airway algorithm. This algorithm shows how the emergency airway algorithms work together. The upper stage is the main algorithm. If the patient is in imminent cardiac arrest or unresponsive, it shifts to the crash airway algorithm. If a difficult airway is suspected, it shifts to the difficult airway algorithm. When these algorithms cannot succeed, it shifts to the failed airway algorithm.

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degree of visualization of larynx with laryngoscopy. The C-L grades 3 and 4 are highly correlated with difficult or failed intubations.[29] However, as identification of the C-L grade needs to insert the laryngoscopy, clinicians should estimate the level of intubation difficulty before attempting the intubation.

Prediction of difficult laryngoscopy in the ED

According to the latest meta-analysis of prediction of difficult laryngoscopy in the operating room, the upper lip bite test is the best predictor.[23] If the lower incisors cannot bite the upper lip at all (class 3), the likelihood of difficult laryngoscopy will be very high (positive likelihood ratio of 14, specificity of 0.96).[23] As for the widely used Mallampati score, the positive likelihood ratio was 4 with the specificity of 0.87 in the Mallampati class 3–4.[23] However, ED patients who require airway management are frequently unable to follow commands (e.g., patients with cardiac arrest and altered mental status). Indeed, studies have shown that the Mallampati score were measured in only 30% of patients who underwent intubation in the ED.[25,39] Therefore, the difficult laryngoscopy assessment tool for the ED setting should be concise and can be undertaken without patient cooperation. The LEMON criteria devised by the National Emergency Airway Management Course are an assessment system with consideration for the use in the resuscitation room (Table 1).[29] However, the original LEMON criteria included the Mallampati score; a modified LEMON criteria excluding this score has been proposed[36] and validated externally.[37] This modified LEMON criteria is concise, and the absence of any items in the criteria indicates the absence of difficult laryngoscopy with a high sensitivity (85.7%) and negative predictive value (98.2%).[31]

Table 1. "LEMON" mnemonic for predicting difficult laryngoscopy

L – Look externally	Look at the patient externally for characteristics that are known to cause difficult laryngoscopy, intubation, or ventilation
E – Evaluate the 3-3-2 rule	Inter-incisor distance: at least patient's three fingerbreadths Hyoid mental distance: at least patient's three fingerbreadths Thyroid to floor of mouth distance: at least patient's two fingerbreadths
M – Mallampati	The hypopharynx views are graded by the Mallampati classification: class I, soft palate, uvula, fauces, and pillars visible; class II, soft palate, uvula, and fauces visible; class III, soft palate and base of uvula visible; and class IV, only hard palate visible
O – Obstruction	Any condition that can cause an obstruction of the airway makes laryngoscopy and ventilation difficult. Such conditions are epiglottis, tumors, abscesses, and trauma
N – Neck mobility	Patients in hard-collar neck immobilization have no neck movement are therefore harder to intubate

PREPARATION

Sufficient preparation in emergency airway management includes identifying the difficult airway (see "Airway management algorithm" and "Difficult airway"), developing an airway management plan, and assembling all necessary personnel, equipment, and medications. Table 2 shows the mnemonic "STOP-MAID" to help clinicians remember the tools and steps for intubation.[40] The preparation also includes the rescue methods for failed intubations.

Preoxygenation

Desaturation and subsequent hypoxemia during intubation are associated with serious complications (e.g., myocardial ischemia and unfavorable neurological outcomes).[41–43] The main goals of preoxygenation are to extend the duration of

Table 2. "STOP-MAID" mnemonic for preparation in emergency airway management

S	Suction
T	Tools for intubation (laryngoscope blades, handle)
O	Oxygen
P	Positioning
M	Monitors, including electrocardiography, pulse oximetry, blood pressure, $EtCO_2$, and esophageal detectors
A	Assistant; Ambu-bag with face mask; airway devices (different sized endotracheal tubes 10 mL syringe, stylets); assessment of airway difficulty
I	Intravenous access
D	Drugs for pretreatment, induction, neuromuscular blockade (and any adjuncts)

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safe apnea and to prevent hypoxemia during the apneic phase of intubation.

Preoxygenation method: Unsupported ventilation

Preoxygenation is typically carried out with tidal volume breathing (i.e., normal depth and rate of ventilation) for at least 3 min, or with vital capacity breaths (i.e., eight deep breaths over 1 min). Oxygen sources without pressure support, also referred to as unsupported ventilation, include facemask with reservoir, bag valve mask (BVM), and adjunctive nasal cannula. A facemask with reservoir is the most frequently used oxygen source for preoxygenation in the ED,[42] while it delivers only 60–70% FiO_2 at flow rates of 15 L/min. A BVM with functional one−way valves connected to a reservoir is used for preoxygenation. In patients with adequate spontaneous ventilation, it is not necessary to squeeze the bag, but a tight mask seal must be achieved to deliver high FiO_2. By contrast, in patients with inadequate spontaneous ventilation, preoxygenation should be undertaken using gentle positive pressure ventilation with BVM. In the intensive care unit (ICU) setting, patients receiving ventilation with BVM during the interval between induction and laryngoscopy had higher oxygen saturations and lower rates of severe hypoxemia than those receiving no ventilation.[44]

Preoxygenation method: Apneic oxygenation

Apneic oxygenation uses nasal cannula to supply oxygen to the nasopharynx during intubation to maintain oxygenation in the absence of patient respiratory effort. The practice could reduce the incidence of hypoxemia during intubation and improve the first-pass success rate in the ED.[45]

Proper positioning

Although intubation is commonly undertaken in the supine position, recent published reports suggest that elevating the patient's head to a more upright position (20–45°) could improve preoxygenation, increase the probability of first-pass success, and decrease intubation-related adverse events (e.g., hypoxemia).[46–49]

Non-invasive ventilation

Non-invasive ventilation (NIV) should be considered in cases where sufficient oxygenation cannot be achieved with unsupported ventilation and there are no contraindications (e.g., respiratory arrest or altered mental status). Preoxygenation with NIV increases end-expiratory lung volume due to the alveolar recruitment induced by positive airway pressure and maximizes the efficacy of preoxygenation efforts. Although limited evidence exists in the ED, the rate of severe hypoxemia was lower in NIV delivered by facemask compared with standard BVM for preoxygenation in patients with acute hypoxemic respiratory failure.[50]

High-flow nasal cannula

A high-flow nasal cannula provides heated and fully humidified gas mixtures to patients through a nasal cannula interface. High-flow nasal cannula delivers continuous high gas flow resulting in higher FiO_2 than with standard oxygen, and maintains oxygenation during the apneic phase of intubation. As high-flow nasal cannula is a relatively recent development, its benefit for preoxygenation remains controversial.[51–53]

Delayed sequence intubation

Delayed sequence intubation has been proposed as an alternative to RSI for the use in patients with altered mental status preventing adequate preoxygenation.[54] The technique of delayed sequence intubation temporally separates the administration of induction agents from that of neuromuscular blockades (NMBs) to allow adequate pre-intubation oxygenation and preparation. Ketamine is the currently preferred induction agent because of its dissociative properties and established safety margins. A prospective observational study found that delayed sequence intubation allowed the provision of preoxygenation and denitrogenation to patients who were intolerant of traditional means of preoxygenation.[55]

INTUBATION METHODS

Rapid sequence intubation

SELECTING AN APPROPRIATE intubation method, such as RSI or non-RSI (e.g., intubation with sedatives or intubation without medications), is critical and the intubator needs to consider not only the patient condition but also the environmental factors, including the available equipment (e.g., rescue devices) and pharmacologic agents, and staffing (e.g., experienced intubators). Rapid sequence intubation is the standard method in emergency airway management for patients without an anticipated difficult airway.[40] The technique involves the simultaneous administration of a sedative and NMB. In the prehospital setting, the more inclusive term of "drug-assisted intubation" is widely used for any use of

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medications to facilitate tracheal intubation, with or without the use of NMB (i.e., intubation with the use of NMB is RSI). Studies indicate that RSI is more successful than intubation with sedatives alone both in the prehospital and ED settings. For example, compared to the non-RSI methods, RSI has consistently shown a higher success rate and lower or equal adverse event rate in patients without difficult airway characteristics in the ED.[7,56–58] Nevertheless, the rate of RSI use in ED patients varies across countries: 85% in North America,[59] in South Korea,[22] and 53% in Japan:[60] Moreover, in Japan, the rate of RSI use also varied across the EDs, ranging from 0% to 79% in 2010–2011.[10] Rapid sequence intubation is the standard method for emergency airway management, but non-RSI is an appropriate choice in some cases (including patients with a difficult airway) by allowing the patient to maintain respiratory drive (Airway Management Algorithm and Difficult Airway for the prediction of difficult airway). The medications frequently used for RSI are summarized in Table 3.

Surgical intubation

When a successful intubation cannot be achieved by laryngoscopy and available adjuncts, a surgical intubation, such as cricothyroidotomy[61] and transtracheal needle ventilation must be carried out.[62,63]

Supportive techniques

Recent reports have supported the use of ultrasonography to confirm the correct and timely placement of an endotracheal tube.[64,65] Ultrasound enables us to identify sonoanatomy of the upper airway and facilitates the assessment of airway anatomy for difficult intubation, tube placement and depth, and assessment of airway size.[64]

Although cricoid pressure had been used to reduce the risk of aspiration during intubation, it may be unnecessary to undertake RSI safely.[66,67] Likewise, there is no concrete evidence on the use of the backward, upward, rightward pressure (BURP) method to improve the glottis view during intubation.[68–70]

MEDICATIONS

EXCEPT FOR SEVERAL specific conditions (e.g., cardiac arrest), the use of premedications, sedatives, and NMBs are used to optimize intubation conditions (e.g., glottic visualization and immobilization), mitigate physiologic responses, protect patients from intubation-related adverse events (e.g., tachycardia) and reflexive actions (e.g., gagging, coughing) during intubation, and provide sedation and amnesia. The characteristics of each medication are summarized in Table 3.

Premedications

Premedication is generally given at least 3 min prior to intubation. In critical cases, the premedication can be given <3 min before the intubation, or omitted entirely. Lidocaine is used for reducing the risk of bronchospasm when β_2 agonist therapy has not been given.[40] Fentanyl can mitigate the cardiovascular effects of sympathetic nervous system stimulation but has a potential risk of hypotension.[71] Of note, atropine is not used for premedication in adults but it should be available as a rescue medication if bradycardia occurs.

Sedatives

A short-acting i.v. drug with sedative or combined sedative, analgesic, and amnestic properties is necessary for intubation. Although etomidate is frequently used for intubation in North America, it is not approved in some countries (e.g., Japan).[26] In this case, ketamine is considered a good alternative to etomidate.[72,73] Benzodiazepines (e.g., midazolam) are widely used in Japan,[21] and can be used as an infusion for long-term sedation. Propofol is also a commonly used sedative but it can cause cardiovascular depression leading to hypotension.[74]

Neuromuscular blockades

Succinylcholine has a rapid onset property but is contraindicated in several conditions, such as patients with burn, musculoskeletal crush injury, spinal cord injury, or renal failure (Table 3). Rocuronium has been increasingly used given its advantages, including rapid onset action, minimal adverse effects, broader eligibility than succinylcholine, and capability of rapid reversal using sugammadex.[8,60] A recent large observational study reported no differences in the first-pass success rate and intubation-related adverse events between succinylcholine and rocuronium use for RSI in the ED.[75]

DEVICES

Direct laryngoscopy and VL

DIRECT LARYNGOSCOPY (DL) has been used as the standard device for intubation over decades, but the evolution of VL has advanced airway management.[7,8,22,60,76–83] Table 4 summarizes the advantages and disadvantages of VL in comparison with DL. Studies have reported the superiority of VL over DL in the ED. More

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Table 3. Medications for airway management in the emergency department

Medications	Dose	Onset	Duration of action	Beneficial characteristics	Potential adverse effects	Major indications
Premedication should be given 2–3 min before intubation						
Lidocaine	1.5 mg/kg	NA	NA	Reduce intracranial and bronchospastic response† by intubation	Potential cardiac arrest in patients with a high-grade atrioventricular block	Head injuryUnknown mechanism injury with an elevated ICP
Fentanyl	1–3 µg/kg given over 30–60 s	NA	NA	Reduce sympathetic response	Respiratory depression Hypotension	Elevated ICPCardiovascular disease
Sedatives						
Etomidate‡	0.3 mg/kg	15–45 s	3–12 min	Rapid onset and short acting Limited effects on hemodynamics	Potential adrenocortical suppression MyoclonusNeuroexcitation	Most commonly used for emergency RSI Not used for the maintenance of sedation after intubation
Ketamine	1–2 mg/kg	45–60 s	10–20 min	Reduction in airway resistance Catecholamine release	Increased blood pressure and heart rate	Hemodynamically stable patient with severe bronchospasm Septic shockUsed for non-RSI for patients with an expected difficult airway
Midazolam	0.1–0.3 mg/kg	30–60 s	15–30 min	Amnesic properties Anticonvulsant effects	HypotensionRespiratory depression	May be used for post-intubation sedation
Propofol	1.5–3 mg/kg	15–45 s	5–10 min	Rapid onset and short acting Reduction in airway resistance	Myocardial depression and peripheral vasodilation Dose-related hypotension	Obstructive airway diseasesStatus epilepticusPost-intubation sedation
Thiopental	3 mg/kg	<30 s	5–10 min	Cerebroprotective and anticonvulsive	Vasodilation and myocardial depressionRelatively contraindicated in reactive airway disease	Rarely used

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Table 3. (Continued)

Medications	Dose	Onset	Duration of action	Beneficial characteristics	Potential adverse effects	Major indications
Neuromuscular blockades						
Succinylcholine	1.5 mg/kg	45 s	5–9 min	Rapid onset and offset, and short acting	Absolutely contraindicated in patients with malignant hyperthermia history, neuromuscular disease, and hyperkalemia Stroke, onset of >72 h RhabdomyolysisBurn, onset of >72 h Denervation syndrome	Essentially all patients except contraindication
Rocuronium	1 mg/kg	45–60 s	45 min	Rapid onset and long acting Reversal by sugammadex	Caution with difficult airway	If succinylcholine contraindicated

†Little evidence to support the use of lidocaine with a goal of reducing bronchospasm.
‡Not approved in Japan.
RSI, rapid sequence induction; ICP, intracranial pressure; NA, not applicable.

specifically, compared to DL use, VL use is associated with a better laryngeal visualization, higher first-pass success rate, shorter time to successful intubation, and lower rate of intubation-related adverse events (e.g., esophageal intubation) in general ED patients,[8,60,76,77,81,82] and patients with trauma,[22] difficult airway,[78,79] and cardiac arrest.[83] Furthermore, the use of VL is also associated with a lower force to oral structures[84–87] regardless of the experience of the intubator.[60,80,82] In Japan, the rate of VL use on the first intubation attempt has increased from 2% in 2010 to 40% in 2016.[60]

Adjunct devices

Extraglottic devices

Extraglottic devices (e.g., laryngeal masks and laryngeal tubes) provide effective oxygenation and ventilation without entering the trachea. Extraglottic devices can be used as a “transitional” device, until a definitive airway is established, when intubation cannot be successfully achieved or the patient has a difficult airway.

Bougie

The tracheal tube introducer, also known as the bougie, is used to facilitate intubation in patients with poor laryngoscopic views. When the bougie is used, it is generally in combination with RSI, and can be used in conjunction with DLs, VLs, or fiberoptic intubation devices. In particular, the bougie is beneficial when the epiglottis is visible but the vocal chords cannot be visualized.[88] A recent randomized controlled trial found that the use of a bougie, compared with a tracheal tube and stylet, resulted in a significantly higher first-pass success rate among patients undergoing emergency airway management.[89,90]

RESCUE INTUBATION

AS DISCUSSED ABOVE, although first-pass success is the primary goal of emergency airway management, the rate of failed first intubation attempts remains high, at 17–32% in the ED.[6–8,10,18,60,91] Therefore, early and systematic rescue intubation approaches should be prepared in advance of the first intubation attempt (e.g., use of alternative methods, devices, and change in intubators). Figure 1 shows the airway algorithm.

Rescue methods

Rapid sequence intubation is not only the primary method but also the principal backup method when the initially utilized intubation method fails in the ED.[4,9,18] Studies using

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large multicenter registries have reported that RSI was used in 20% of first rescue intubation attempts[18] and was a factor associated with a higher second-attempt success rate.[91] When a failed airway occurs and oxygenation cannot be maintained, immediate rescue cricothyrotomy is indicated. Rescue surgical methods, including cricothyrotomy, are required in 0.2–0.5% of all emergency intubations in the ED.[6,7,10,60]

Devices

Video laryngoscopy has become the first choice of intubation in the ED,[8,60] instead of DL. Video laryngoscopy generally improves the view of the glottis, without the need to align the airway axes to achieve a direct view from outside the patient's mouth, and can be considered as a rescue device. Nevertheless, the superiority of VL over DL for rescue intubation remains controversial.[9,76,92,93]

Adjuncts (EGDs and bougie):

Extraglottic devices

As summarized in "Devices", EGDs (e.g., laryngeal masks and laryngeal tubes) should be prepared in advance of initiating an intubation. Extraglottic devices are used as rescue devices after a failed intubation attempt to provide oxygenation and ventilation until a definitive airway is established. Although the use of EGDs as rescue devices is infrequent practice in the ED, emergency physicians should be familiar with the EGDs.[4,18]

Bougie

As summarized in "Devices", a bougie is an alternative device for rescue intubation. Bougies are used to facilitate intubation in patients with poor laryngoscopic views or after a failed intubation attempt.

Intubators

In the ED, emergency physicians play major roles on emergency airway management, including those requiring rescue techniques. The international anesthesia consensus recommends the use of alternative approaches, such as use of experienced intubators for subsequent intubation attempts after a failed first attempt.[33] It is clinically plausible that an experienced intubator is likely to intubate more successfully than a novice intubator. This approach is also supported by the data from a large multicenter registry. For example, second intubation attempts by a single intubator, compared with those by alternate intubators, were associated with a decreased success rate.[94] Likewise, rescue intubation by emergency physicians or senior physicians is also associated with a higher probability of success at the second attempt.[91]

SPECIAL CIRCUMSTANCE: PATIENTS WITH TRAUMA

ONE OF THE priorities in critically injured patients in the ED is intubation with the aim to protect the airway, deliver sufficient oxygen, and maintain adequate ventilation. Approximately 10–30% of intubations in the ED were undertaken for patients with trauma,[3,8,60] with a first-pass success rate ranging from 64% to 86%.[22,95–100]

Specific issues in patients with trauma

Intubation for patients with trauma is challenging due to its urgency, anatomical distortion, oral secretion and blood, the risk of vomiting, and hemodynamic instability.[101,102]

Table 4. Advantages and disadvantages of video laryngoscopy over direct laryngoscopy

Advantages	Disadvantages
Improved laryngeal view in patients with a limited mouth opening, neck mobility, or difficult airway	Variable learning curve and multiple devices available requiring different skills
Faster time to achieve a successful intubation	Obscured view by fogging, secretions, or blood in the airway
Useful tool for teaching and training in airway education	Loss of depth perception
Lower risk at inducing local tissue injury	Expensive cost
Permitting others to share of the view and help facilitate intubations	
Higher overall and first success rate, especially in difficult airway, cardiac arrest, and intubations by less experienced providers	
Lower risk of esophageal intubation	

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Additionally, all critically injured patients should be treated as having a cervical spine injury until proven otherwise, which also makes the intubation more difficult by inhibiting the optimal positioning for intubation. To overcome these challenges, several approaches have been proposed.

Intubation methods

Rapid sequence intubation (see also Intubation methods above) has been recommended for patients with trauma by both international and Japanese clinical practice guidelines unless difficult laryngoscopy is anticipated.[103,104] Rapid sequence intubation is used for patients with trauma in up to 85% in North America,[1,103] whereas that is used in 36% in Japan.[95]

Medications

Similar to airway management in the general ED population, etomidate, ketamine, propofol, and midazolam are commonly used sedatives for patients with trauma (see Medications).[105] Ketamine has a preferable cardiorespiratory safety profile.[106,107] Ketamine has been considered contraindicated in patients with head trauma due to the concern of increasing intracranial pressure,[108] but the current evidence to refute ketamine use is not strong.[109–112] Reports have suggested that ketamine does not reduce regional glucose metabolism or augment oxygen consumption but could benefit patients with an intracranial injury by a catecholamine-mediated increase in cerebral perfusion. Propofol and benzodiazepines have been used for hemodynamically stable patients with trauma with a caution for their negative inotropic effects. Neuromuscular blockade is used as a part of RSI, for example, succinylcholine has been the first choice for patients with trauma due to its rapid onset action and short half-life.[103]

Devices

Although the use of VL has been increasing in the ED,[8,60] there is a concern for the vulnerability of VL in patients with trauma where the airway could be contaminated by blood and vomitus.[113] Although VL can provide better a glottic visualization compared to DL,[92] VL should be used cautiously in this patient population according to the clinical practice guidelines for trauma management.[103,104]

SPECIAL CIRCUMSTANCE: CARDIAC ARREST

IN THE ED, up to 40% of intubations were carried out in patients with cardiac arrest.[3,8,22,60] Although the best intubation strategy during cardiopulmonary resuscitation (CPR) has not been established,[114,115] intubation is considered the definitive method to secure the airway.[116–118] However, the conditions unique to this population, for example, continuous chest compression during CPR[116,117,119,120] and regurgitation, successful emergency airway management is a challenge. Indeed, studies have reported that the first-pass success rate ranges from 36% to 94% and the adverse events rate ranges from 9% to 27% in this population,[9,83,121–124] and that patients with failed first intubation attempts have a lower probability of achieving ROSC, prolonged time to achieve ROSC, and decreased probability of ROSC during the first 15 min compared to those who had a first-pass success.[9]

Devices

The use of VL in patients with cardiac arrest could improve the first-pass success rate and minimize the chest compression interruption when compared to DL.[83,124] For example, in the recent multicenter study from Japan, the use of VL was associated with an increased first-pass success rate compared to DL among novice intubators, but not among experienced intubators. Similar findings have been reported in single-center studies from South Korea.[123,124]

Intubators

The experience of the intubator affects first-pass success.[122] Experienced intubators have a higher first-pass success rate compared to inexperienced intubators (82% versus 36%) in patients with cardiac arrest.[122] Therefore, the clinical practice guidelines recommend intubation for patients with cardiac arrest should be carried out by a highly skilled intubator.[116,117] Although the definition of experience intubator is not standardized, >240 intubation experiences were expected to achieve a 90% success rate without a prolonged chest compression interruption (<10 s) and complication.[122]

SPECIAL CIRCUMSTANCE: CHILDREN

AS INTUBATION FOR children is a rare event (e.g., 2–33/10,000 ED visits),[125–128] emergency physicians are likely unfamiliar with airway management in children. Additionally, the highly stressed clinical situation within limited resources might further contribute to low success rates and errors, such as miscalculation for medication doses.[129] Indeed, the first-pass success rate in children aged <18 years was 60% (and 50% in children aged <2 years) in Japanese EDs,[130] whereas the rate was 74% in overall ED patients.[60] In other studies, the first-pass success rates in

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children varied from 39% to 78%.[56,125,128,131–133] Furthermore, published works have shown that the intubator's experience plays a major role in first-pass success in children. Pediatric emergency medicine attending physicians had a higher success rate (89%), compared with pediatric emergency medicine fellows (43%) and pediatric residents (35%).[132]

Specific issues in children

The principles of airway management for children in the ED are the same as for adults. The major challenges for airway management in children are largely attributable to age-related issues, including the airway anatomy, choice of intubation devices and tubes, and the calculation for appropriate dose of medications. To promptly secure the airway, length-based resuscitation tape (e.g., Broselow pediatric emergency tape) should be used to determine the appropriate equipment sizes and medication doses.[134–137]

To successfully achieve intubation, emergency physicians must consider unique pediatric features. In children, the lower functional residual volume and higher oxygen metabolism cause hypoxia more quickly than adults.[29,138] Although it has been reported that RSI improves the success rate in children similar to adults,[56,130] intubation without RSI (e.g., awake intubation with preserved spontaneous respiration) is undertaken more frequently compared to adults.[56,128,130,139] Additionally, apneic oxygenation was associated with a lower risk of hypoxemia during intubation of children in the ED.[140]

Difficult airway in children

Although there is limited evidence on airway management for children in the ED, approximately 9% of children had difficult airway (required three or more attempts by attending or fellow providers) in the pediatric ICU setting.[38] Infants and young children have relatively large oropharyngeal structures (i.e., tongue, tonsils, and adenoids) and occiput, which lead to an upper airway obstruction. Additionally, the larger and floppier epiglottis and superior laryngeal position make visualization of the vocal chords difficult.[29,138] History of difficult airway and signs of upper airway obstruction have been reported as a risk factor of difficult airway.[38]

SUMMARY AND FUTURE DIRECTIONS

IN 1998, WALLS and colleagues founded the NEAR.[4–8] Their data not only provided high-quality evidence on emergency airway management in the earlier decades, but also revealed the competence of emergency physicians in the care of critically ill and injured patients in the ED. Their findings have defined the role of emergency physicians and proved their worth, thereby playing a pivotal role in the history of emergency medicine in the USA.[141]

Over the past decade, the NEAR group has also made a substantial impact on the international emergency medicine research community, including the KEAMR[22,91,142,143] and JEAN groups.[10,13,18,19,21,31,58,60,71,73,94,95,130,144–147] For example, the JEAN study is a multicenter prospective effort that is run by the Japanese Emergency Medicine Network (JEMNet) (http://jemnet.asia/wp/). JEAN has enrolled >10,000 children and adults across geographically diverse EDs in Japan, and comprehensively characterized emergency airway management with a >95% capture rate. During this decade, the JEAN study has significantly contributed to airway management research by determining, for example, the association of multiple intubation attempts with a higher risk of intubation-related adverse events,[19] the association of repeated intubation attempts by a single intubator with a decreased success rate,[94] and overall improvement in the airway management performance in Japanese EDs in the 2010s.[60] These findings underscore the importance of first-pass success and support strategies to maximize the probability of first-pass success as well as the systematic use of rescue intubation strategies.

Yet, despite the ubiquitous presence of current emergency medicine practice, many fundamental questions on emergency airway management remain to be elucidated. For example, what are the optimal intubation techniques to achieve the best outcome in different patient populations who require emergency airway management? What are the minimal competency thresholds for resident physicians and board-certified emergency physicians? These important knowledge gaps provide many opportunities for further investigations. Ideal randomized controlled trials (i.e., randomized experiments with a well-defined treatment, full adherence to the assigned treatment, double-blind assignment, and no loss to follow-up) has been considered as "the gold standard" to establish the causal relations between a treatment (e.g., airway management strategy) and patient outcome. Yet, such trials are methodologically and logistically challenging in the ED setting. Additionally, published works have also shown that subjects who are enrolled into the controlled trial framework could be systematically different from general populations.[148] Alternatively, high-quality observational data reflect the natural setting of a real population and clinical practice, and hence enhance the generalizability of inferences. Furthermore, the recent advent of causal models with the use of counterfactual concepts (e.g., g-methods including marginal structural models) have

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enabled us to robustly infer causal relations between a specific airway management technique and patient outcomes using observational data (i.e., without data from a randomized controlled trial).[149]

We believe that, in collaborative efforts between research teams that are adept at generating high-quality science,[82,84,86,150–154] such investigations will provide emergency physicians with important opportunities for improving the quality and safety of airway management practice. For researchers and professional organizations, the gained knowledge will not only advance research into the determination of optimal airway management strategies but also facilitate the development of high-quality clinical guidelines as well as their dissemination to the EDs nationally, which will, in turn, improve the outcomes of critically ill and injured patients in the ED.

DISCLOSURE

Approval of the research protocol: N/A.
Informed consent: N/A.
Registry and the registration no. of the study/trial: N/A.
Animal studies: N/A.
Conflict of interest: None.

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