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DOI: 10.1177/0885066607301359

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Complications of Emergency Tracheal Intubation: Immediate Airway-related Consequences: Part II

Thomas C. Mort, MD

Airway management in the stable, elective operating room patient is typically exceptionally safe. Conversely, the acute deterioration of an intensive care unit or floor patient being rescued by a clinician unfamiliar with the patient’s past and current history combined with an incomplete physical examination places the critically ill patient in a precarious, potentially life-threatening position. Emergency airway management in remote locations outside the confines of the operating room is complex and stressful due to immense airway challenges coupled with the high risk of hemodynamic and airway complications. Despite the commonality of difficulties with mask ventilation, laryngoscopy, and tracheal intubation in this population, relatively sparse literature deals with these subjects. Consequences of airway management should be openly discussed as a first step toward improving airway safety. This is the second of 2 reviews, “Complications of Emergency Tracheal Intubation,” and focuses on the immediate airway-related consequences during emergency tracheal intubation in the remote location.

Key words: airway management; intubation; complication

Of note to the reader: This review has made every effort to evaluate available literature regarding the topics at hand; however, emergency airway management is relatively still in its infancy regarding studies defining consistent complications parameters and reporting mechanisms. Therefore, the Hartford Hospital database (3700+ patients) was used in part, to convey and provide a basis for a discussion on particular facets of emergency airway care that are currently underappreciated or underreported. Although several peer-reviewed publications have resulted from this database, it continues to grow and provide currently unpublished trends, incidences, and risks of emergency intubation that are provided to the reader for edification purposes only. This is the second of 2 articles reviewing the major complications of emergency airway management.

The sharp contrast between the elective patient in the operating room (OR) and the critically ill patient requiring tracheal intubation in the remote location is vast and certainly problematic. The elective patient is typically ambulatory, has received nothing by mouth (NPO) for more than 6 to 8 hours, and has undergone a history and physical examination with appropriate preoperative screening tests. In contrast, a “stat” call to intubate a vomiting intensive care unit (ICU) patient with hyperglycemia, febrility, tachycardia, tachypnea, hypotension, a metabolic acidosis, mental status changes, and marginal oxygenation may be challenging to the clinician. A hurried, abridged history and physical examination contributes further to compromised patient safety.

This review focuses on the immediate airway-related consequences that could be considered significant and potentially life-threatening. Although important, dental damage, awareness, lip and oral cavity lacerations, and the like will not be discussed in this review.

The consequence of most airway-related complications involves hypoxemia. Complications such as esophageal intubation (EI), regurgitation, aspiration, multiple intubation attempts, and main stem bronchus intubation (MSBI) may each, singly or in combination, lead to oxygen desaturation. In an attempt to thwart or limit desaturation during the intubation process and provide a margin of safety in the event of airway difficulties, efforts to provide adequate oxygen reserve should be aggressively pursued.

Elective preoxygenation incorporating either 4 to 8 maximal forced vital capacity breaths of 100% oxygen or 4 minutes of 100% oxygen by using a tight-fitting face mask effectively elevates the PaO₂ to more than 400 mmHg reliably in the otherwise stable patient [1-9]. The critically ill patient may be recalcitrant to standard noninvasive oxygen therapy. Despite optimal preoxygenation, the pulse oximetry
oxygen saturation (SpO₂) may barely clear the 90% saturation range commensurate to arterial oxygen tensions in the 55 to 100 mm Hg range, thus rendering the patient at risk for potentially rapid desaturation [10]. Hypoxemia may be exaggerated if multiple intubation attempts, EI, aspiration, uncorrected MSBI, or loss of the airway complicates the intervention [10,11].

Preoxygenation

The objective of emergency airway management is to primarily support oxygenation and ventilation and provide airway protection, not simply to perform endotracheal intubation. Mask ventilation and preoxygenation efforts have received tremendous emphasis in the elective OR setting, but this cannot be said for the higher risk ICU patient. The crucial need for maximizing the patient’s oxygen stores in the arterial, venous, and tissue beds—and not just the lungs (functional residual capacity)—may be difficult to achieve, but effort should be expended, nonetheless [10].

Mask ventilation may be extremely difficult in the setting of obesity, limited jaw and cervical spine mobility, a lack of dentition, a bearded face, cachexia, facial bone overgrowth, facial trauma, edema (external and internal), and age older than 60 years [11]. The effectiveness of preoxygenation has been found to be limited in those with significant cardiopulmonary pathology such as congestive heart failure, pneumonitis, and respiratory failure complicated by excessive secretions, in contrast to patients having their airway secured solely for the purpose of “airway protection” [10]. Further investigation toward identifying improved preintubation oxygen-delivery methods for the critically ill population on the verge of tracheal intubation is warranted.

Hypoxemia

What level of oxygen saturation (based on pulse oximetry) represents a reasonable cutoff for clinical reference? A SpO₂ of less than 90% equates to a PaO₂ of 58 to 61 mm Hg and appears to have some support in the literature [6,8]. This level of arterial oxygen is situated on the downward slope of the oxyhemoglobin saturation curve, and further desaturation beyond this point may be rapid. Table 1 summarizes the SpO₂, the estimated PaO₂, and the expected systemic hemodynamic response. The literature is replete with studies reporting an extremely low rate of hypoxemia during emergency intubation of less than 2% to 10% [6-10,12-15], yet studies specifically designed to determine the incidence of hypoxemia, based on well-defined parameters, suggest a significantly higher incidence of 21% to 28% [10,16-18].

The Influence of Age, Comorbid, and Pathologic Conditions on Hypoxemia

Currently, there is little specific literature reporting the influence of age, comorbid conditions, and particular pathologic states on the incidence of hypoxemia during emergency airway management [11].

Reviewing the Hartford Hospital database, age, independent of all other factors, appeared to increase the incidence of hypoxemia in the young (<30 years, 14%) to the octogenarians and beyond (≥80 years, 22%), representing a 50% rise. Moreover, preexisting comorbidities such as hypertension, coronary artery disease, congestive heart failure, chronic obstructive pulmonary disease (COPD), diabetes mellitus, and renal dysfunction appeared to influence the incidence of hypoxemia by increasing the risk of hypoxemia in a step-wise fashion of approximately 7% per comorbidity.

Overall, up to one third may suffer hypoxemia to differing degrees, yet several pathologic conditions may have influenced this rate. On one extreme, a patient with a grand mal seizure had the lowest rate of hypoxemia during intubation (6%) compared with patients with primary pulmonary pathology complicated by copious secretions (65%). Conversely, pulmonary pathology with fewer secretions had a much lower incidence of desaturation to less than 90% (COPD, 21%; aspiration pneumonitis, 25%; bacterial/viral pneumonitis, 23%; and pulmonary sepsis, 17%). Depending on the site of injury, 27%

<table>
<thead>
<tr>
<th>SpO₂</th>
<th>PaO₂</th>
<th>Systemic Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>58-61/mm</td>
<td>None to mild ↑ HR, BP</td>
</tr>
<tr>
<td>80</td>
<td>50-53</td>
<td>None to moderate ↑ HR, BP</td>
</tr>
<tr>
<td>70</td>
<td>36-39</td>
<td>Moderate to significant ↑ HR, BP, occasional ↓ HR &lt; 40</td>
</tr>
<tr>
<td>60</td>
<td>28-32</td>
<td>Significant ↑ HR, BP, common HR slowing</td>
</tr>
<tr>
<td>&lt;60</td>
<td>&lt;30</td>
<td>HR slowing in many, brady cardiac-hypoxia arrest</td>
</tr>
</tbody>
</table>

SpO₂ = pulse oximetry oxygen saturation; PaO₂ = partial pressure of arterial oxygen; BP = blood pressure; HR = heart rate; brady = bradycardia.
to 30% of trauma patients experienced hypoxemia. Other specific groups included stroke/intracerebral hemorrhage (often intubated for mental deterioration and airway protection), 15% acute myocardial infarction, 13%; congestive heart failure, 16%; cardiogenic shock, 15%; and upper gastrointestinal bleeding, 28% (Hartford Hospital database).

The body mass index (BMI, body weight in kg/height in m²) had a significant effect on the rate of desaturation. A normal BMI (<25) had an incidence of 17%, as did the overweight category (BMI, 25-30). However, as the BMI increased into the obese categories, there was a clear linear relationship: obese, 23% (BMI, 30-35); morbidly obese, 31% (BMI, 35-50); and super morbidly obese, 34% (BMI >50). The patient’s oxygenation reserves, obesity-related pulmonary limitations, and difficulty encountered when handling the obese patient’s airway may influence the incidence of hypoxemia [1,19].

Specific concerns for emergency airway management that the airway clinician should appreciate include (1) the limits of denitrogenation and adequate preoxygenation [10], (2) the rapid desaturation that may occur between face mask removal and tracheal intubation, (3) the increased incidence of multiple intubation attempts and desaturation, and (4) the increased incidence of encountering a “difficult airway” in the emergency setting [20].

An emergency department airway textbook suggests that if time is limited, one can forego the standard 3 to 5 minutes of 100% oxygen administration and simply accomplish preoxygenation with 4 to 8 vital capacity breaths of 100% oxygen [21]. A critically ill patient would likely be incapable or uncooperative enough to perform such a request in the face of tachypnea, agitation, altered mental status, intoxication, and concurrent hypoxemia.

Airway-related Complications

Airway-related complications in the emergency setting are similar in variety but easily outflank their elective counterparts in magnitude, occurrence, and consequence. Excessive secretions, edematous airway tissues, and an increased tendency for airway bleeding and swelling from instrumentation may plague these interventions. Despite numerous studies of intraoperative anesthesia care and emergency department airway management, the true incidence of complications such as laryngospasm, bronchospasm, bleeding, tissue trauma, aspiration, inadequate ventilation, difficult intubation, difficulties with extubation, and MSBI remain relatively poorly documented in the literature.

Fig 1. This schematic depicts the central role that hypoxemia plays in emergency airway management. Complications and difficulties in airway management contribute to hypoxemia, which may, in turn, lead to additional patient morbidity and potentially mortality.

The efforts of the American Society of Anesthesiologist’s closed claim analysis have brought many of these adverse respiratory events into the spotlight [22-25], but their incidences or risk factors have been addressed in only a few instances [15-18, 20]. The relative lack of reporting may be related to

1. the inability to establish a consistent definition or parameter of a complication,
2. little emphasis on airway management safety in the emergency setting for the critically ill,
3. the minimization of concern for mishaps and critical events if they do not lead to life-threatening consequences, and
4. the fear of medicolegal repercussions, embarrassment, and scrutiny by peers or the hospital administration [20, 26-30].

Hypoxemia, often the consequence of an airway-related event, is the common link to altering the patient's already fragile physiologic state [16-18] (Figure 1).

EI

Esophageal intubation and more specifically, the lack of its recognition, has been identified as a leading adverse respiratory event and is an important contributing factor in the occurrence of hypoxemia, regurgitation and aspiration, severe central neurologic damage, and death. Its incidence varies by the series but is commonly 2% to 9% in the emergency setting [12-14,16,18, 20,31]. Morbidity and mortality related to EI have been recently reviewed, and action to reduce its ill effects by vigilant monitoring and rapid detection is warranted [17,18]. Failure to recognize EI is not limited to inexperienced trainees, and despite the use of verification devices, EI-related catastrophes persist.

Unrecognized EI is often preventable with better monitoring because indirect clinical signs of detecting tracheal tube location are imprecise and should be
Emergency Intubation Complications

Table 2. Methods of Endotracheal Tube Verification

<table>
<thead>
<tr>
<th>Non-Fail-safe Methods</th>
<th>Less Than Fail-safe Methods</th>
<th>Fail-safe Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checking breath sounds</td>
<td>CO₂ detection</td>
<td>Direct view of ETT through glottis</td>
</tr>
<tr>
<td>Chest radiography</td>
<td>Esophageal detector device</td>
<td>Fiberoptic view of glottis/trachea</td>
</tr>
<tr>
<td>Epigastric auscultation</td>
<td>Reservoir bag movement</td>
<td></td>
</tr>
<tr>
<td>Reservoir bag compliance</td>
<td>Reservoir bag compliance</td>
<td></td>
</tr>
<tr>
<td>Cuff maneuvers and cuff palpation</td>
<td>Condensation of vapor in ETT</td>
<td></td>
</tr>
<tr>
<td>Expelled gas with sternal compression</td>
<td>Transtracheal illumination</td>
<td></td>
</tr>
<tr>
<td>Pulse oximetry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from references 31 and 34. ETT = endotracheal tube.

Regurgitation and Aspiration

The aspiration of gastric contents into the tracheobronchial tree is, fortunately, a rare occurrence in

augmented by capnography or other similar technology [22-25]. Auscultation of breath sounds, tube condensation, chest wall excursions, reservoir bag compliance and refilling, as well as many other methods of detecting tracheal tube placement are not infallible; each has shortcomings and difficulty with interpretation under normal circumstances. Their usefulness is reduced further under emergent or urgent circumstances [31-34].

The fail-safe detection method of directly viewing the endotracheal tube (ETT) between the vocal cords is impractical in 10% to 20% of emergency patients due to anatomic limitations [16]. Fiberoptic verification, ideally, is fail-safe yet is limited by the presence of blood and secretions in the airway and ETT, the need for qualified personnel to perform the bronchoscopy, and rapid access to such advanced equipment (Table 2) [31,34].

Intuitively, the use of monitors and the performance of verification maneuvers do not reduce the incidence of EI, but they may foreshorten the time from ETT placement (misplacement) and its detection. Gastroesophageal insufflation from the misplaced ETT increases the risk of regurgitation and aspiration [16-18]. The risk of aspiration, bradycardia, hypoxemia, and cardiac arrest is considerable in those who experience EI in the emergency situation (Figure 2), especially when the ETT position is confirmed without the benefit of nearly fail-safe devices (capnography) [16-18]. Therefore, confirming ETT placement with a rapid, reliable, and portable technique should be practiced in the delivery of emergency airway management services.

Regurgitation and Aspiration

The aspiration of gastric contents into the tracheobronchial tree is, fortunately, a rare occurrence in

the elective anesthesia setting. “Silent” regurgitation and aspiration may occur frequently in the sleeping adult as well as during anesthetic induction, maintenance, emergence, and postoperatively, with or without the benefit of airway protection (intubation). The frequency of perioperative pulmonary aspiration in adults and pediatric patients is approximately 1:2,600 [31,35]. The emergency setting itself, and patients with a higher anesthesia risk classification, have a higher risk of aspiration [35,36]. The incidence of regurgitation under emergency circumstances varies between 1.6% and 8.5% [12,16,18,37], whereas the aspiration risk is 0.4% to 5% [13-16, 20,37,38].

The increased risk in the emergency situation is because the airway manager has little control over NPO status, a full stomach, intestinal ileus, gastrointestinal pathology (ie, bleeding, disease-induced gastroparesis), or alteration of the airway protective reflexes (Table 3). Statistics presented by Warner [35] and Olsson et al [31] suggest the perioperative aspiration risk is nearly 50 times less than in the emergency setting (1:2,600 cases versus 1:50).

Fig 2. Incidence of complications associated with (EI) and without (Non-EI) esophageal intubation [17, 18]. All EI-related complications were clinically significant when compared with the non-EI group (P < .001).

Table 3

<table>
<thead>
<tr>
<th>Condition</th>
<th>Non-EI</th>
<th>EI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regurgitation</td>
<td>0%</td>
<td>30%</td>
</tr>
<tr>
<td>Aspiration</td>
<td>10%</td>
<td>20%</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>20%</td>
<td>15%</td>
</tr>
<tr>
<td>Dysrhythmia</td>
<td>15%</td>
<td>10%</td>
</tr>
<tr>
<td>Cardiac Arrest</td>
<td>5%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Adapted from references 31 and 34.
Commensurate hypoxemia during regurgitation is the rule: Less than 10% of those who regurgitated or aspirated gastric contents maintained their SpO2 at more than 90%, respectively [16-18]. The risk of bradycardia and cardiac arrest due to profound hypoxemia was also exaggerated in the presence of regurgitation and aspiration [16-18,31,35,36]. A risk-reduction strategy that included the immediate availability of accessory airway devices for emergency intubation coupled with equipment verifying ETT placement led to a reduction of regurgitation and aspiration by 43% and 75%, respectively [17,39,40]. Upper gastrointestinal bleeding is particularly risky (regurgitation, 4 times; aspiration, 7 times) in undergoing emergency tracheal intubation compared with nonbleeding patients [41,42].

Although it has been taught that a rapid-sequence intubation is specifically indicated to reduce the risk of aspiration, recent data suggest that an awake or light sedation approach to emergency intubation may be nearly equally protective, with less overall risk to the patient, when the patient displays factors associated with a difficult airway [43].

### Airway Injury

Defining the airway as the area from the nose to the tracheobronchial tree, represents the anatomical sites within the “airway” and may sustain minor, major, and even catastrophic degrees of trauma during routine and emergency tracheal intubation. Many injuries are short-lived or nondisabling, but some may lead to life-threatening consequences. Major airway injury may occur during routine or emergency intubation unbeknownst to the practitioner and patient. Closed-claim analysis found that difficult intubation was judged to be a factor in 39% of laryngeal, pharyngeal, esophageal, and tracheal injuries, and some led to death from mediastinal soilage through perforation [44]. Severe esophageal injuries often involve a difficult intubation; yet, in one half of the esophageal perforation cases, intubation was believed to have been without consequence and atraumatic [22-25,44].

Pharyngolaryngeal mucosal injury may only present with nonspecific symptoms but more often resolves without sequelae. Major airway injury is often shrouded by generalized signs and symptoms, and this contributes to the difficulties with diagnosis. Furthermore, patients who remain intubated, heavily sedated, and unable to communicate may limit the practitioner’s consideration of the existence of an injury [44]. Any occurrence of a pneumothorax, subcutaneous emphysema, pneumomediastinum, dyspasia, chest pain, coughing, and deep cervical pain advancing to a febrile state should be investigated in light of difficulty encountered during airway management. Early signs of a perforation are not the rule, hence, a delay in diagnosis is common. It would be prudent to communicate to the primary care providers any difficulties that arise during the intubation process so that symptomatology may be promptly investigated [44].

### Bronchial Intubation

Main stem bronchus intubation (MSBI) occurs relatively frequently under elective anesthetic conditions but is quickly detected in most cases by initial chest auscultation and determination of the appropriate depth of the ETT. If it remains undetected and uncorrected, it may lead to hypoxemia, atelectasis, bronchospasm, lobar collapse, coughing, and the potential for barotrauma. Palpation of the inflated cuff above the sternal notch is a useful test in elective patients to verify the location of the ETT and may decrease the risk of MSBI or impingement of the ETT on the carina [45]. Fiberoptic evaluation is definitive and any of the above clinical signs should prompt its use. Major morbidity may occur quickly or be delayed [46,47]. Any unexplained oxygen desaturation, coughing, bronchospasm, or

---

**Table 3. Risk Factors for Regurgitation and Aspiration**

<table>
<thead>
<tr>
<th>Recent oral intake, enteral feeding</th>
<th>GI pathology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding, nausea, vomiting, obstruction</td>
<td>Ulcers, incompetent sphincter, instrumentation of GI tract (ie, NGT)</td>
</tr>
<tr>
<td>Opioids, CNS depressants, other medications</td>
<td>Neurologic neuromuscular disease</td>
</tr>
<tr>
<td>Extremes of age, debility</td>
<td>Air swallowing</td>
</tr>
<tr>
<td>Cardiovascular instability</td>
<td>Airway management difficulties</td>
</tr>
<tr>
<td>Esophageal intubation</td>
<td>Anesthetic induction agents</td>
</tr>
<tr>
<td>Neuror muscular blocking agents?</td>
<td>Difficult mask ventilation with aerodigestive tract insufflation</td>
</tr>
<tr>
<td>Multiple laryngoscopic attempts</td>
<td>Chest compressions/CPR</td>
</tr>
<tr>
<td>Coma/unconsciousness of any etiology</td>
<td></td>
</tr>
</tbody>
</table>

GI = gastrointestinal; CNS = central nervous system; NGT = nasogastric tube; CPR = cardiopulmonary resuscitation.
changes in peak inspiratory pressures (volume controlled ventilation), or an abrupt or gradual reduction in tidal volume (pressure control ventilation), should prompt evaluation [45-47].

Undetected MSBI discovered by a postintubation chest radiograph in the emergency intubation scenario is relatively common (3.5%). The incidence nearly triples after difficult intubation (EI, regurgitation, and ≥3 intubation attempts) [16]. Schwartz et al [47] noted 15.5% of ETT placed in an emergency were inappropriately positioned (within 2 cm of the carina on chest radiograph), especially in women. The fiberoptic bronchoscope is one of the most underutilized yet clinically applicable diagnostic tools to investigate a suspected MSBI and potentially reverse its consequences.

Multiple Intubation Attempts

What is the threshold number of intubation attempts that should prompt the practitioner to categorize the number of attempts as an “airway complication”? National guidelines define difficult intubation as the inability to intubate within 3 attempts [48,49]. These guidelines have further suggested, on the basis of expert opinion, that the practitioner should limit the number of laryngoscopic attempts to 3, at which point alternative airway techniques should be used to secure the airway.

Limiting laryngoscopy attempts is suggested because of concern that repeated interventions may potentiate tissue trauma, bleeding, and mucosal edema and may transform a ventilatable airway to one that is not (cannot ventilate, cannot intubate) [48,49]. This opinion has recently been substantiated by a study that demonstrated that the rate of complications was directly related to the number of laryngoscopic attempts during emergency airway management. The risk of airway and hemodynamic complications increased with the second laryngoscopic attempt and accelerated rapidly with 3 or more attempts [16,43].

A high level of suspicion should be placed on all critically ill patients who require emergency airway management, and each should be regarded as potentially difficult (“unanticipated difficult airway”). A limit of 1 or 2 attempts under optimal conditions before rapidly moving to a secondary plan or an alternative strategy seems prudent in light of the complications associated with repetitive laryngoscopy [16,17,39,40,50].

Simplifying the approach to emergency airway management has been stressed in the emergency department literature to recommend that a rapid-sequence intubation technique is the preferred approach compared with sedation alone [12-14,21,51]. Unfortunately, airways are as individual as their owners, and the skill level amongst practitioners is extremely variable. Thus, each patient may benefit from an individualized approach rather than a standard regimen or protocol. Incorporating an airway management strategy that provides practitioners with suggested management maneuvers that depend on their own personal skill and experience, the airway itself, and any previously failed technique, has recently gained momentum and may lead to a lower incidence of complications and loss of the airway [39,40,43,52-55].

Current Literature

Although a large number of emergency intubation studies are available, relatively few report a wide breadth of complications. The rate of complications, adverse events, and serious consequences are categorized differently by the various authors, with no clear defining parameters to assist the reader in comparing the studies. Many of these studies have not focused on 2 important questions: What was the specific immediate airway-related complications of the emergency intubation? And what may be done to limit patient morbidity? (Table 4).

Conclusion

Airway-related complications appear to be relatively common in the emergency management of the airway outside the OR. These critically ill patients appear to be at higher risk for numerous critical incidents and adverse events than their elective counterparts. Although there is no panacea to halt these mishaps from taking place, improving the delivery of emergency airway service by optimizing medical staff preparation and education; assuring equipment availability in a variety of patient locations; and formulating an “airway management game plan” to handle the potential failure of an airway securing technique should provide an improved level of patient care and reduce the risk of airway-related complications in this population.
Table 4. Airway-Related Events

<table>
<thead>
<tr>
<th>First Author</th>
<th>Hypox (%)</th>
<th>EI (%)</th>
<th>Regurg (%)</th>
<th>Aspir (%)</th>
<th>MSBI (%)</th>
<th>M. Att (%)</th>
<th>“Cric” (%)</th>
<th>Comment by Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mateer [9]</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>We...monitor pulse oximetry for intubations in ED</td>
</tr>
<tr>
<td>Sakles [12]</td>
<td>3.3</td>
<td>5.4</td>
<td>1.6</td>
<td>3.0</td>
<td>5.3</td>
<td>1.1</td>
<td></td>
<td>8% complication rate, “low rate of serious complications”</td>
</tr>
<tr>
<td>Tayal [13]</td>
<td>0.5</td>
<td>1.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Complication rate is high, consider formal training</td>
</tr>
<tr>
<td>Schwartz [15]</td>
<td>8</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td>“Associated with a significant frequency of complications”</td>
</tr>
<tr>
<td>Gnauck [37]</td>
<td>2.3</td>
<td>8.5</td>
<td>3.3</td>
<td>8.5</td>
<td>22</td>
<td></td>
<td></td>
<td>Intubation protocols using paralyzing agents are needed</td>
</tr>
<tr>
<td>Norwood [38]</td>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Intubation is a safe method of airway control</td>
</tr>
<tr>
<td>Sagarin [51]</td>
<td></td>
<td>1</td>
<td>0.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>High success rate, ED residents are successful</td>
</tr>
<tr>
<td>Sagarin [56]</td>
<td>1.5</td>
<td>2</td>
<td>0</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td>High success rate, low rate of serious adverse events</td>
</tr>
<tr>
<td>Levitan [57]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>High success rate, low rate of complications</td>
</tr>
<tr>
<td>Taryle [58]</td>
<td>0.2</td>
<td>1.7</td>
<td>4.85</td>
<td>5.2</td>
<td>3</td>
<td>0.7</td>
<td></td>
<td>1.4% had major adverse events, RSI...few major events</td>
</tr>
<tr>
<td>Rotondo [59]</td>
<td>1.5</td>
<td></td>
<td>3.5</td>
<td></td>
<td>7</td>
<td>1</td>
<td></td>
<td>“Low morbidity, no mortality and can be used safely”</td>
</tr>
<tr>
<td>Vijayakumar [60]</td>
<td>2.5</td>
<td>6?</td>
<td></td>
<td></td>
<td>6?</td>
<td>3.1</td>
<td></td>
<td>15% had difficult intubations</td>
</tr>
<tr>
<td>Mort [16, 20]</td>
<td>20</td>
<td>9</td>
<td>5.3</td>
<td>1.6</td>
<td>4</td>
<td>9</td>
<td>0.4</td>
<td>Airway and hemodynamic mishaps are very common</td>
</tr>
</tbody>
</table>

Hypox = hypoxemia; EI = esophageal intubation; Regurg = regurgitation; Aspir = aspiration; MSBI = mainstem bronchus intubation; M. Att = multiple attempts (3+); Cric = cricothyrotomy; ED = emergency department; RSI = rapid-sequence intubation.

References

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