Trauma Airway Management: Considerations and Techniques

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It's 2 am and you have just finished an emergency appendectomy when you get "that" call.

Your friend down in the emergency department (ED) has a patient arriving in a few minutes who was assaulted in a local prison. After asking for your potential assistance with his airway and mumbling something about a knife, he hangs up. You've been working nonstop since yesterday morning, so the only thing on your mind involves a pillow and the supine position. Nevertheless, you make your way down to the ED and arrive just as the medics roll in with their patient. He is awake and yelling as they roll him by you into the trauma bay. The emergency medical technician is applying pressure to the side of the patient's neck and there is a large knife sticking out of the middle of the patient's face (Figure 1). Your friend takes one look and asks you to help by managing the airway while he coordinates the rest of the trauma resuscitation. It looks like your night is about to get a lot more interesting!

Because of the need for urgent and accurate decision making in a dynamic environment, airway management in the trauma patient can be particularly

challenging. The presence of hemodynamic instability, potential for direct airway trauma, and need for cervical spine immobilization when confronted with competing surgical priorities requires a rapid evaluation for a potentially difficult airway (DA), development of an airway management plan (including rescue techniques in the event of failure), and a willingness to act quickly, often with incomplete information.

Intubation approaches commonly used in the elective setting can be difficult or impossible to apply in patients with massive oropharyngeal hemorrhage, traumatic airway injury, or combative behavior due to altered mental status. Nevertheless, sound airway management principles common to all intubations remain the key to success.

Beyond the need for emergent intubation, consideration may need to be given to semi-elective airway management in the trauma patient who is likely to require a near-term operative intervention where early intubation allows for a more controlled and planned approach to their overall care. For example, a patient who has fallen off his roof, sustaining pelvic and femoral fractures with severe pain and accompanying agitation may need to be intubated early to facilitate thorough radiologic evaluation and fracture reduction with resultant improved pain control prior to going into the operating room (OR). These decisions can be made following discussions with both the emergency medicine (EM) and operative teams to ensure that perioperative issues, such as consent, timing, and other patient considerations, are addressed appropriately.

As you move to the head of the bed, your friend directs the ED staff to establish IV access, keep pressure on the bleeding, and check vital signs as he evaluates the patient. The patient will not stay still, requiring several of the staff to keep him from climbing off the bed. He answers questions

with one or two words interspersed with profanity and threats directed at everyone in the trauma bay. His neck injury is on the right at the level of the thyroid cartilage and appears to be oozing significantly with visible hematoma formation. The knife appears to have penetrated the medial aspect of the left orbit to an unknown depth and is protruding about 5 inches from the skin surface. Your friend looks at you and says, "I'm concerned about his airway with a potentially expanding neck hematoma, and we'll have trouble keeping the hemorrhage controlled without a lot of sedation. I think we need to intubate him now."

General Considerations

Victims of trauma present with a wide range of injuries that create unique challenges for the person providing airway support and management. Although many of these patients do not require intubation outside of the OR, those requiring intubation in the ED can be some of the most challenging airway cases due to limited time for evaluation, immobilization, combativeness, direct airway trauma, presence of blood or vomit, or a combination of all these factors.

Emergency intubations outside the OR are generally associated with a higher frequency of difficult intubation and an increased complication rate,1 and in many cases, the usual paradigms of airway management used in elective perioperative care are not applicable. Care of the acute, severely injured trauma patient is best done using a team approach with a clearly designated leader who controls the decision making, sequence, and flow of the entire resuscitation effort including airway management considerations, all while consulting with other team members.

In the late 1990s, anesthesiologists performed the majority of trauma airway management in the United States, both inside and outside the OR,

with EM physicians handling the majority of nontrauma cases in the ED.2 More recently, multiple studies examining the effect of transitioning to a primarily EM-based airway management system for trauma have shown no adverse effect on complication or success rates.3-5

Currently, in the United States, trauma patients are intubated primarily by EM physicians, although patients with direct trauma to the airway may best be managed using a team approach, with EM physicians, anesthesiologists, and surgeons working in concert to achieve the best possible results. This includes determining the appropriate location to proceed with advanced airway techniques in complex cases. Internationally, there is considerable variation in the primary airway providers and capabilities available for the trauma patient.6,7

An emergency trauma intubation in the ED generally requires more assistance than an intubation performed under controlled conditions. Multiple providers are required to ventilate the patient, hold cricoid pressure (CP) if applied, administer medications, and provide manual in-line stabilization of the cervical spine as necessary.

In addition, more assistance may be required to control a patient who is combative as a result of intoxication, traumatic brain injury (TBI), or other causes of altered mental status associated with agitation. The immediate presence of a surgeon or other physician who can expeditiously perform a cricothyroidotomy is also desirable. Even if a surgical airway is not required, additional experienced hands may prove useful during difficult intubations. The surgeon may also wish to be present during laryngoscopy if there has been trauma to the face or neck in order to personally visualize the upper airway if video is employed during the procedure.

Airway management decisions in the trauma patient are frequently driven by considerations beyond identification of the need for an operative intervention. The decision about when and how to control a patient's airway is based on a complex series of considerations related to the patient's specific injuries and overall condition, the likelihood of clinical deterioration, and the need for transport to locations in the hospital where airway control is desirable based on these and other factors (eg, the interventional radiology suite).

Table. EAST Indications for Endotracheal Intubation

Strong Indication	Discretionary Indication
Airway obstruction	Facial or neck injury with potential for airway obstruction
Hypoventilation	Moderate cognitive impairment (GSC score >9-12)
Persistent hypoxemia (SaO2 ≤90%) despite supplemental oxygen	Persistent combativeness refractory to pharmacologic agents
Severe cognitive impairment (GCS score ≤8)	Respiratory distress (without hypoxia or hypoventilation)
Severe hemorrhagic shock	Perioperative management (eg, pain control, painful preoperative procedures)
Cardiac arrest	Spinal cord injury (complete cervical injury at C5 level or above) with any evidence of respiratory depression

Smoke inhalation with any of the following:

- airway obstruction
- severe cognitive Impairment (GSC score ≤8)
- major burn (≥40% BSA)
- major burns and/or smoke inhalation with prolonged transport time
- impending airway obstruction

Based on reference 14.

BSA, body surface area; **EAST,** Eastern Association for the Surgery of Trauma; **GCS,** Glasgow Coma Scale; **SaO2,** arterial oxygen saturation

While the need for emergent or semiurgent intubation is obvious in many patients, it is less intuitive in others. The Eastern Association for the Surgery of Trauma (EAST) has published practice management guidelines addressing emergency tracheal intubation following traumatic injury, including indications for intubation, which are summarized in the Table. The main indications for emergent intubation can be addressed by asking the following questions during the initial and subsequent evaluations:

Is there a failure to maintain or protect the airway?

Is there a failure of oxygenation or ventilation?

Is there a need for intubation based on the anticipated clinical course?8

The requirement to proceed with intubation based on failure to maintain an airway will be clinically apparent in the majority of cases. In some patients, however, the potential for rapid loss of an initially intact airway may drive the decision to intubate. Examples of this include a penetrating neck injury with an expanding neck hematoma or an inhalational injury with anticipation of progressive airway edema. The need to proceed with intubation for airway protection, however, may be less clear. Loss of the ability to protect the airway can occur because of several mechanisms, including altered mental status secondary to TBI, hemorrhagic shock, or ingestion of drugs or alcohol.

One of the most common approaches to determining the ability of a patient to maintain his or her airway is to calculate the patient's Glasgow Coma Scale (GCS) score. A GCS score of 8 or lower in the absence of a rapidly reversible cause has been used as an indicator of coma and general requirement for intubation in the setting of trauma. This cutoff has been promulgated through the Advanced Trauma Life Support (ATLS) program, although patients with a higher GCS score may still require intubation in the setting of an altered neurologic assessment.9 In a retrospective review of 1,000 consecutive patients intubated after injury, Sise et al found that twice as many patients were intubated for the discretionary indication of altered mental status (GSC score >8) as those with a lower score (GCS score ≤8), suggesting that other factors contributed to the decision to establish a definitive airway.10

The decision to intubate is a critical resuscitative decision and can greatly influence subsequent management. Airway management in trauma patients can be anxiety provoking because their airway difficulty is often exaggerated by the need for cervical spine immobility, presence of direct airway trauma, compromise of their hemodynamic status, and propensity

for clinical deterioration. Early definitive airway management must be performed in a logical and safe fashion to support evaluation and resuscitative efforts for these patients. Decision making must be based on a consistent series of principles that accounts for the patient's current condition, likelihood of deterioration, planned diagnostic and therapeutic interventions (including transport), and preinjury comorbidity, as well as an assessment of the resources and expertise that are available in the resuscitation area.

As you are getting ready to proceed with the intubation, the ED nurse calls out, "The blood pressure is 80/45 and heart rate is 132." She asks, "What do you want for induction?" You are looking down at an agitated patient being restrained by the staff, firm pressure being applied to the neck, and the handle of a knife appears to prevent an optimal fit for a face mask.

Principles of Airway Management In the Trauma Patient

Risk for Aspiration

All trauma patients are considered to be at high risk for aspiration given intoxication, trauma-induced reduction or absence of gastrointestinal motility, and unknown time of last food intake. Additionally, pharyngeal hemorrhage due to maxillofacial trauma, secretions, and foreign bodies may increase the risk. Reasonable precautions should be taken to prevent aspiration, particularly of gastric contents, during overall trauma management and airway procedures. The initial intubation method depends on the constellation of patient injuries, hemodynamic status, and the equipment and expertise available. Most patients, however, will undergo rapid sequence induction and intubation (RSII) with the intent of mitigating the risk for vomiting and aspiration during the procedure and securing the airway in a rapid, controlled fashion.

The application of CP held throughout laryngoscopy to prevent passive aspiration remains a controversial component of RSII. The use of CP was widely accepted dogma in trauma for many years based on the belief that it could prevent aspiration via passive regurgitation through compression of the upper esophagus against the anterior cervical vertebral bodies. More recently, this belief has been challenged.11-13 Controversy regarding the risk–benefit assessment for the continued use of CP in patients undergoing RSII is reflected in recent published guidelines from multiple organizations that have recommended eliminating its use or considering it an optional measure.14-16

The use of CP in the trauma patient was recently addressed in the EAST practice management guidelines for emergency tracheal intubation immediately following traumatic injury.14 Based on evidence that CP may worsen the laryngoscopic view, impair bag-valve-mask (BVM) ventilation efficiency, and not reduce the incidence of aspiration, the use of CP was removed as a level 1 recommendation. These recommendations are reflected in recent surveys of anesthesiologists, EM physicians, and surgeons, showing only 39% of physicians in Europe and 83% of physicians in the United Kingdom routinely use CP during RSII of the trauma patient.11

In contrast, a recent national survey of teaching hospitals in the United States found that 91% of participants indicated the continued use of CP as part of their modified RSII technique,17 although anecdotally this appears to be changing as more EM programs appear to be favoring the avoidance of CP. In support of CP, the most recent guidelines of the American College of Surgeons' ATLS course and the Difficult Airway Society's 2015 unanticipated difficult intubation guidelines in adults include CP as a component of RSII.18,19

If the decision is made to use CP, it should be altered or removed to facilitate ventilation, laryngoscopy, or placement of an endotracheal tube or supraglottic airway if they are noted to be difficult. Securing the airway and providing ventilation should take precedence over the potential risk for aspiration in the trauma setting, given the current level of evidence for CP during RSII.

Drug Selection

The most commonly used induction agents in the trauma patient are etomidate, ketamine, and propofol. Other less commonly used agents described in the literature include remifentanil, thiopental (no longer available in the United States), and midazolam.20 If the patient is not completely obtunded and unresponsive, it is recommended to use an induction agent to decrease the likelihood of awareness and recall. Trauma patients are frequently hypovolemic, even if their initial mean arterial blood pressure is normal. Drug selection must go hand in hand with volume resuscitation and other resuscitative measures, such as tube thoracostomy, control of external hemorrhage, and pelvic stabilization.

Induction agents should be chosen to provide the best possible intubating conditions with the least likelihood for adverse hemodynamic consequences. The most commonly used induction agent in the United States in the setting of an ED or trauma resuscitation unit is etomidate.21 Etomidate administered in a range of 0.2 to 0.3 mg/kg is associated with hemodynamic stability and has an onset/duration profile similar to that of succinylcholine. Its safety for use in RSII in trauma patients has been challenged, although these studies are largely retrospective, with the potential for selection bias and other methodological deficiencies.22,23

Although single-dose etomidate is associated with transient adrenocortical suppression, this appears to be not clinically significant when a single dose is used for induction for intubation in both trauma and mixed surgical-medical patients undergoing RSII.24-26 Etomidate can cause myoclonic jerks during its onset, but use of a rapid-acting neuromuscular blocking agent, such as succinylcholine, mitigates this effect substantially.

Ketamine is also a frequently used induction agent for hypotensive trauma patients due to its centrally mediated increase in sympathetic tone and catecholamine release.27 Its use in patients with concomitant TBI has been questioned based on older reports of associated elevation of intracranial pressure.28 More recent analysis, however, suggests that the preservation of cerebral perfusion by maintenance of mean arterial blood pressure in hemodynamically unstable patients is more important than any theoretical risk to the brain caused by ketamine's potential to increase cerebral activity and intracranial pressure.28,29

Some investigators have also raised concerns that the psychotropic effects associated with ketamine may increase the risk for acute and post-traumatic stress disorders in trauma patients,30,31 although this was not found in a study examining its intraoperative use in burn patients.32

Of more concern is the potential for barriers to use based on institutional dispensing, tracking, and documentation procedures preventing timely access to ketamine. When these barriers exist, limiting its availability, ketamine may not be as readily available in the emergency setting as other induction agents. Because of its abuse potential, consideration has been given to reclassifying ketamine as a Schedule I drug, potentially placing further barriers to its availability.33 Overall, ketamine continues to be a very commonly used drug for RSII in the ED and trauma resuscitation unit.21

Other induction agents, such as propofol, sodium thiopental, and high-dose benzodiazepines, must be used with caution in the trauma patient since they have a greater tendency to cause hypotension. While propofol is the most common induction agent in the nonemergent patient presenting to the OR in the United States, it reduces systemic vascular resistance and induces myocardial depression, making it less appropriate in the hypotensive and hypovolemic trauma patient. Pharmacokinetic and pharmacodynamic studies in a swine hemorrhagic shock model suggest a significant reduction in propofol dosage of more than 80% to achieve the targeted effect site concentration.34,35

Unfortunately, there are no corresponding clinical data on the effect of reduced propofol dosing in the setting of hemorrhagic shock on recall and awareness. Patients in shock with an immediate need for intubation should be given a reduced dosage, regardless of the induction agent. This may need to be further reduced due to age and additional comorbidities.

The selection of a neuromuscular blocking agent as a component of RSII is not altered by the presence or absence of trauma. Succinylcholine and rocuronium are reasonable choices for RSII, although with several caveats.36,37 Rocuronium produces slightly inferior intubation conditions than succinylcholine for RSII.36 It also results in significant prolongation of neuromuscular relaxation. In the setting of an altered level of consciousness and suspected TBI, where the clinical exam may affect overall management decisions, succinylcholine is the preferred agent. If TBI is not suspected and the patient requires a CT scan or placement of invasive lines, the prolonged relaxation with rocuronium can facilitate these activities. With the availability of sugammadex, a rapid-onset selective binding agent for rocuronium, RSII with rocuronium followed by reversal

with sugammadex allows for more rapid return of spontaneous ventilation than with succinylcholine.38

During RSII, other pharmacologic agents such as lidocaine and opioids have been proposed to be useful in attenuating negative physiologic responses that may occur during intubation. For a number of years, lidocaine was proposed to attenuate elevations in intracranial pressure associated with intubation by blunting the sympathetic response. This practice is controversial, with limited evidence to support the preinduction administration of lidocaine in the trauma patient with suspected TBI.39 Several minutes are required after lidocaine administration for it to be effective, which may not always be possible with a trauma RSII.40

Short-acting opioids such as fentanyl are frequently used to blunt the hemodynamic response to intubation. In the trauma patient, this must be done with caution given the possibility of hypovolemia and exaggeration of the blood pressure response to RSII. In addition, rapid administration of opioids may induce respiratory depression just prior to induction, which can hinder efforts at preoxygenation.

Finally, some clinicians advocate the use of alpha-adrenergic agents, such as phenylephrine or epinephrine, as a pretreatment prior to RSII in the hemodynamically unstable patient. There are no trials examining the clinical effect of this practice, so this will be a clinical decision for the practitioner based on assessment of the patient's vital signs, volume status and cardiac function at the bedside. This presumes that appropriate resuscitation is ongoing at the time of RSII.

The ED staff have established IV access and started administering emergency uncrossmatched blood. The patient continues to be uncooperative with attempts at preoxygenation and continues to bleed from

the neck with his excessive movements. It's time to control the situation. With your guidance, the team proceeds with RSII after administration of etomidate and succinylcholine. You decide to forgo CP due to the need to maintain pressure on any active bleeding from the neck injury. The trauma surgeon is now available and is prepared to proceed with a surgical airway in the event it is needed. After a stable induction, you are able to fit a mask over the lower portion of the face and achieve an adequate seal allowing for positive pressure ventilation.

Technique

For the trauma patient, the choice of intubation technique must take into account the injury pattern, underlying physiologic state of the patient, potential difficulties, urgency, and timely availability of various devices and surgical backup. RSII remains the preferred method for most trauma intubations for a number of reasons, including those discussed above. In addition, unrelaxed patients present the potential for significantly more cervical spine motion as a result of coughing, bucking, gagging, or other movement during an awake intubation attempt. In a published report of 17,583 ED intubations from the National Emergency Airway Registry, including 5,451 trauma intubations, 85% were done with RSII.21

Because patients in an emergency setting are more likely to present as a difficult intubation, early recognition of the DA is essential.42 A thorough DA assessment is ideal before RSII in the multitrauma patient, but may not be possible in the trauma bay. Acquired characteristics, such as airway trauma, cervical spine immobility, hemodynamic compromise, and other potentially life-threatening injuries, can exacerbate inherent DA markers, necessitating rapid decision making without a complete evaluation. Thus, the use of rapidly identified and easily obtained factors associated with

difficult intubation in the ED setting would be optimal in identifying the subset of highest-risk patients.

The modified LEMON criteria have been shown to have a high sensitivity and a reasonable negative predictive value in several studies (Figure 3).42,43 The original criteria included the Mallampati score, but this was dropped due to difficulty in obtaining valid assessments in the emergent airway management setting and poor correlation with a difficult intubation grade.44 Although the tool is overly sensitive at the cost of specificity, its application in the trauma setting should alert the provider to the more high-risk patient.

L	Look externally: · facial trauma · Large incisors · Beard or mustache · Large tongue
E	Evaluate the 3-3-2 rule: · mouth opening=3 finger breadths · hyoid-mental distance=3 finger breadths · thyroid-to-mouth distance=2 finger breadths
M	Mallampati score: · no longer counted in total score
O	Obstruction: · presence of obstructing airway
N	Neck mobility: · decreased

Each of the listed elements is worth 1 point.
Total maximum airway assessment score = 9

Figure 3. Modified LEMON mnemonic.

Based on reference 42.

In the setting of a difficult trauma airway, several issues should be considered. First, there may be limited time for evaluation, as stated above, making it necessary to proceed without a full airway assessment. Even in the setting of a likely DA, the presence of hemodynamic instability (eg, shock) or lack of cooperation (eg, intoxication, TBI, combativeness) will override or limit some airway management options. Second, waking up the

patient or canceling the procedure is rarely an option, as the need for emergent airway control likely will remain. Finally, several conditions associated with trauma (discussed below in more detail) may further alter the airway management plan.

Modifications to the American Society of Anesthesiology (ASA) Difficult Airway Algorithm for trauma have been proposed by the ASA Committee on Trauma and Emergency Preparedness.45 It consists of a general algorithm for DA in the trauma patient (Figure 4) with additional recommendations for specific trauma conditions, including closed head injury, airway disruption, cervical spine injury, oral/maxillofacial trauma, and potential airway obstruction.

In addition to RSII with direct laryngoscopy (DL), the use of video laryngoscopy (VL) for airway management in the trauma patient provides additional functionality. Although it is susceptible to lens contamination from secretions and blood, glottic visualization nearly always improves. There has been a significant interest in the use of VL in the ED for both the trauma and nontrauma population.46,47 As a result, it is now commonly employed in many centers with results comparable to DL.48 There has been some evidence that while glottic view improves with VL, it may prolong intubation time slightly.49

Difficult airway management algorithm in trauma.

1. a) Other options in ASA algorithm:
   Ventilation with a face mask or SGA might be difficult or impossible in a patient with maxillofacial trauma.
   Local anesthesia infiltration or regional nerve blockade are of limited value in extensive trauma surgery.

1. b) Invasive airway access includes surgical or percutaneous cricothyrotomy or tracheostomy, transtracheal jet ventilation and retrograde intubation.
2. c) Alternative difficult intubational approaches include (but are not limited to): VAL, SGA (e.g., laryngeal mask airway [LMA] as an intubation conduit with or without flexible scope guidance), flexible scope intubation (FSI), intubating stylet or tube changer, and light wand. Blind intubation (oral or nasal) is discouraged in patients with maxillofacial trauma and laryngeal or tracheal injury.
3. d) Aborting the case and awakening the patient to optimize and re-attempt intubation via different airway technique (e.g., awake intubation) is impractical in most trauma cases due to the emergent condition of the patient.
4. e) Emergency non-invasive airway ventilation consists of SGA.
5. f) Surgical airway kit should be immediately available.

× Confirm ventilation, tracheal intubation or SGA placement with standard confirmatory techniques (exhaled CO2, misting of tube, auscultation of breath sounds, improving SpO2). If perfusion (and exhaled CO2) absent, use additional confirmation methods (e.g., repeat laryngoscopy, bronchoscopy, esophageal detector device, chest X-ray).

BVM, big-valve-mask; CP, cricoid pressure; DA, difficult airway; DL, direct laryngoscopy; FIS, flexible intubation scope; GA, general anesthesia; MILS, manual in-line stabilization; O2, oxygen; RSI, rapid sequence intubation; SGA, supraglottic airway device; VAL, video-assisted laryngoscopy

Based on reference 45. Reprinted with permission from the American Society of Anesthesiologists.

While VL appears to be playing an increased role in trauma airway management, the importance of other adjuncts should not be forgotten. It cannot be overemphasized that the “bougie” intubating stylet is arguably the most important DA adjunct during DL. The combination of DL and bougie may be the optimal approach to successful first-pass success in the

trauma airway with anything less than a grade 1 Cormack-Lehane laryngeal view. The bougie stylet is low-profile and allows less cervical movement, as well as permitting a “blind” insertion under the epiglottis during poor view attempts.50

In summary, when dealing with the difficult trauma airway, a team approach is the best solution in any scenario. The most experienced airway operator should be present to increase the first-attempt success rate, as the first attempt is always the best. In managing the severely traumatized patient, it is important to have a clear definition of airway failure and a prepared action plan, such as the one shown in Figure 4.

Using the video laryngoscope available in the trauma bay, you proceed with an uneventful intubation. There’s a moderate amount of blood in the airway but the anatomy is not distorted. The airway is secured and you head back to the operating room; your night is not over yet.

Conclusion

The trauma airway is a subset of the difficult airway. The need to integrate airway management into a dynamic environment with ongoing evaluation and resuscitation potentially complicated by hemodynamic instability, cervical spine immobilization, and/or direct airway trauma can be very challenging. At the same time, fundamental principles of difficult airway management must be applied to the trauma patient, with the realization that rarely will you have the opportunity to wake the patient and start over.

The foundation for success is an orderly approach, including prioritization of resuscitation steps, evaluation of the specific characteristics of the difficult airway, careful selection of pharmacologic agents, early use of

video or optically enhanced airway tools, and coordination with other members of the resuscitation team.

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