

Chapter 12

AIRWAY MANAGEMENT

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While the rest of the squad hurried by, he took out his knife and, grabbing the protruding piece of jaw bone, forced back the soldier's head and calmly cut open his throat, then punched a hole into his windpipe. A sputtering of blood and foam came through the incision, and as his breathing eased, the soldier quieted.¹

— Ronald J Glasser, MD

INTRODUCTION

As the “A” in “ABC,” the airway sits atop the critical lifesaving pathway of emergency resuscitation. A few minutes of cerebral anoxia results in irreversible brain cell death; therefore, rapid recognition and treatment of airway compromise is essential to the survival and successful long-term outcome of the trauma patient. Trauma airway management includes both the rapid assessment of the patient's condition and the timely and appropriate application of a lifesaving intervention.

Trauma may cause airway obstruction by one or more of three major mechanisms (Exhibit 12-1). The first, and least common, is traumatic airway injury or direct injury to the laryngotracheal complex resulting in airway disruption and obstruction. Traumatic neurological injury (high spinal cord trauma or traumatic brain injury), the second mechanism of traumatic airway obstruction, results in an inability to protect the airway and/or apnea. The third major cause of traumatic airway obstruction occurs in patients with maxillofacial trauma when soft tissues, bone, blood, and secretions, alone or in combination, obstruct the airway at the level of the pharynx. Aspiration of blood, secretions, vomitus, teeth, bone fragments, foreign bodies, or soft tissue may occur with all three mechanisms and should be considered in patients

with signs and symptoms of lower airway obstruction or failure to improve with establishment of a secure upper airway.

Blunt trauma (primarily due to motor vehicle crashes and falls) accounts for 85% of injury in civilian trauma populations, and prehospital airway intubation is attempted in approximately 12% of civilian trauma patients.² Penetrating wounds and maxillofacial trauma, primarily due to blasts and gunshot wounds, are the major causes of potential airway obstruction in combat trauma.³ Penetrating neck wounds with laryngotracheal injuries are uncommon but are more likely to be associated with fatal injuries in combat casualties.⁴ The distinction between the mechanisms of airway obstruction is important because treatment paradigms may differ depending on the cause.

The timing and choice of airway intervention depend on the patient's location (tactical environment), the patient's clinical condition, and the responder's skill level and training. The care of the combat injured takes place in three major environments: prehospital, hospital, and during transport (en-route care). While most deployed surgeons provide care only within hospitals, a thorough understanding of prehospital and en-route care paradigms is important to the overall surgical care of the trauma patient.

EPIDEMIOLOGY AND INCIDENCE OF TRAUMATIC AIRWAY OBSTRUCTION

The estimated incidence of fatal airway obstruction on the battlefield is 1% to 2%, which is largely unchanged since the Vietnam War.³⁻⁶ Eastridge et al, in a review of postmortem data from Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) casualties, estimated the incidence of fatal airway obstruction at 1.6% and noted that airway obstruction accounted for 8% of potentially survivable battlefield injuries (uncontrolled hemorrhage accounted for >90%).³ Potentially survivable injuries are classified as those injuries that might have been survivable if immediate and sufficient medical care were available. Many of the airway obstruction casualties in the study also suffered other significant head, neck, and major vascular injuries that almost certainly contributed to overall mortality. A similar autopsy review of 82 fatalities in special operations forces identified one airway cause of death in 12 potentially survivable casualties.⁵

Maxillofacial and craniomaxillofacial (CMF) injury occurs in 26% to 42% of battlefield wounded, a higher rate than either penetrating neck injury or severe traumatic brain injury.⁷⁻¹⁰ Despite accounting for this significant percentage of battlefield wounds, the majority of maxillofacial injuries are minor and non-life-threatening. Simple penetrating soft tissue wounds, abrasions, contusions, and dental injuries accounted for 55% of all CMF injuries, and more than 90% of patients with CMF injuries had an abbreviated injury score of 1 or 2 (minor to moderate injury) and a mean total Injury Severity Score (ISS) of 12.^{8,11} CMF injuries, however, may result in death if accompanied by severe neurologic injury, major vascular injury, or airway obstruction.

The incidence of airway obstruction in combat trauma casualties with CMF injuries has not been studied and, given the catastrophic nature of combat blast

EXHIBIT 12-1**MAJOR CAUSES OF AIRWAY OBSTRUCTION IN TRAUMA PATIENTS**

1. Traumatic airway injury. Laryngeal fractures or open laryngotracheal wounds can lead to obstruction from airway disruption, hemorrhage, and/or edema.
2. Neurological injury. High spinal cord trauma and/or traumatic brain injury can lead to aspiration and/or apnea.
3. Maxillofacial injury. Major bone and soft tissue damage can lead to upper airway obstruction, typically at the level of the oropharynx.

injuries and high velocity penetrating wounds of the head and neck region, it is not possible to definitively isolate an airway injury as the specific cause of death among those killed in action (KIA). However, Mabry et al's analysis of fatal airway injuries characterized 18 of 222 (8%) potentially survivable cases in which airway compromise was the likely cause of death.⁴

All 18 casualties had face or neck wounds; 67% were due to gunshot wounds, and 61% were classified as KIA. Among the seven patients classified as

died of wounds (DOW) in the study, five suffered direct injury to the laryngotracheal complex, and the other two were noted to have significant aspiration of blood from maxillofacial wounds. The average ISS in the DOW group was 34; in the KIA group it was 38.⁴ These findings suggest that combat wounded who die of airway obstruction are more severely injured (mean ISS >30 versus 12, as noted previously) than are most other casualties with maxillofacial injuries and that direct injuries to the laryngotracheal complex, although infrequent, are associated with a higher risk of airway obstruction and death.

Although most combat-related maxillofacial wounds are minor, maxillofacial injuries are common in modern combat and may lead to airway obstruction. Fatal airway injuries are more likely with direct injury to the larynx or trachea and in those patients with uncontrollable bleeding into the airway. Although combat wounded patients with ongoing truncal or extremity hemorrhage, pneumothorax, or other unrecognized or untreated injury may survive to the second or third role of care, it is exceedingly unlikely that a patient with traumatic airway obstruction will survive transport to a Role 2 or 3 facility. Therefore, any potential new developments in care aimed at improving survival and outcomes for airway trauma patients must be directed at the prehospital phase of treatment.

PREHOSPITAL MANAGEMENT OF AIRWAY OBSTRUCTION

Prehospital combat casualty care is dictated by the principles of Tactical Combat Casualty Care (TCCC), which take into account the unique requirements of battlefield medicine and provide for additional training and treatment paradigms beyond traditional trauma life support training.¹² Most prehospital combat casualty care is provided by medics, corpsmen, and pararescuemen and almost always takes place in austere and hostile conditions. As a result, casualty management under TCCC guidelines is divided into three distinct phases, with each phase having a different care algorithm based on the tactical conditions (Table 12-1).

Direct medical care in the first phase, care under fire, is limited to stopping life-threatening hemorrhage if tactically feasible; airway management is deferred until tactical conditions warrant advancing to the next phase of care, tactical field care. Tactical field care and the third phase, tactical evacuation care (TACEVAC), take place after the hostile threat level has decreased to a point where it is safer to focus more on patient care and less on taking cover and returning fire. Airway interventions under tactical field care and TACEVAC are simple, rapid, and tiered based on the

patient's condition. Unconscious patients without airway obstruction are treated with positioning, chin lift, jaw thrust, and/or placement of a nasopharyngeal airway. Conscious or unconscious patients with impending or active airway obstruction are treated in a similar manner, with cricothyroidotomy recommended for failure to improve with the initial interventions. Supraglottic airways (eg, laryngeal mask, Combitube [Kendall Sheridan, Argyle, NY] or King LT [Kingsystems, Noblesville, IN]) or endotracheal intubation are additional treatment options utilized under the TACEVAC phase of care.

Studies from OEF and OIF show that prehospital airway interventions were performed in up to 7% of battlefield casualties, and approximately one-third or more of the all battlefield airway interventions were limited to the insertion of nasopharyngeal or oropharyngeal airways.^{13,14} Kotwal et al reported on the treatment and outcomes of 419 casualties from the 75th Ranger Regiment in OEF and OIF and found that a prehospital airway intervention was performed in 21 of 419 patients (5%).¹³ The airway interventions consisted of seven nasopharyngeal airways, four intubations, and ten cricothyroidotomies. A prospective

TABLE 12-1**TACTICAL COMBAT CASUALTY CARE AIRWAY MANAGEMENT GUIDELINES**

Phase of Care	Actions
Care Under Fire	• Return fire and take cover • Try to limit additional injury to the casualty • Airway management is best deferred to the Tactical Field Care phase
Tactical Field Care	• Unconscious casualty without airway obstruction ☐ Chin lift or jaw thrust ☐ Nasopharyngeal airway ☐ Place casualty in recovery position • Airway obstruction or pending airway obstruction ☐ Chin lift or jaw thrust ☐ Nasopharyngeal airway ☐ Allow casualty to assume position of comfort ☐ Place casualty in recovery position ☐ If above efforts fail, perform cricothyroidotomy
Tactical Evacuation Care	• Unconscious casualty without airway obstruction ☐ Chin lift or jaw thrust ☐ Nasopharyngeal airway ☐ Place casualty in recovery position • Airway obstruction or pending airway obstruction ☐ Chin lift or jaw thrust ☐ Nasopharyngeal airway ☐ Allow casualty to assume position of comfort ☐ Place casualty in recovery position ☐ If above efforts fail perform any of the following: ▶ Supraglottic airway ▶ Endotracheal intubation ▶ Cricothyroidotomy

observational study of all casualties presenting to US military medical facilities in Afghanistan between November 2009 and November 2011 found that prehospital airway interventions were performed in 70 of 1,003 casualties (7%), and 27 of these procedures (39%) consisted solely of insertion of a nasal or oral airway.¹⁴ The study also identified 4.4% of casualties as having a “missed” airway intervention, meaning that the airway should have been inserted in the prehospital setting but for some reason was not.¹⁴ Adding the number of performed airway interventions to

the number of “missed” airway interventions in this study brings the percentage of battlefield casualties who may have benefited from prehospital airway intervention to 11.4%.

Other studies focused on advanced airway interventions (intubation or cricothyroidotomy) and found similar rates for prehospital procedures. Gerhardt et al described the experience of a battalion aid station during a 1-year deployment in OIF and reported that 6% of presenting casualties underwent an airway intervention.¹⁵ The battalion aid station had trained emergency medicine personnel but no surgical care, and of the 18 advanced airway interventions performed, 11 were rapid sequence intubations (RSIs) and 7 were cricothyroidotomies. The cricothyroidotomies were performed due to time limitations, major maxillofacial injury, or blood and secretions obscuring the upper airway. A study of 6,875 OIF combat casualties presenting to combat support hospitals over a 26-month period identified 293 (4.2%) who presented with advanced prehospital airways.¹⁶ Included among the advanced airways were 253 endotracheal tube intubations (86.6%), 23 supraglottic airways (7.5%), and 17 cricothyroidotomies (5.8%). In a subgroup analysis of 1,622 patients from the same study, the authors found 76 patients (4.7%) who had one or more criteria for emergent intubation within 30 minutes of presentation to the combat support hospital.⁴ These findings, in addition to the aforementioned prospective observational study from OEF, suggest that up to 5% of combat casualties may benefit from an airway intervention but not receive one in the prehospital care environment.^{14,16}

Unfortunately, most battlefield casualties who received prehospital advanced airways also suffered ultimately fatal injuries.^{4,13,17} Morrison et al reported that more than half of all advanced airway interventions were performed in patients with an ISS over 50, and these patients had an mortality rate of over 60%.¹⁷ Others have reported survival rates of 21% to 34% for OEF and OIF casualties who underwent prehospital intubation or cricothyroidotomy.^{13,18} These low survival rates are reflective of the severe nature of combat trauma that results in the need for battlefield emergency airway management; the rates are similar to civilian trauma outcomes of patients requiring advanced prehospital airway interventions.^{19,20} Some airway-related trauma deaths may also be due to an inability to properly intervene and secure the airway in the prehospital environment. Prehospital airway management success rates for intubation have been reported as less than 50%, with decreasing rates of success with successive attempts.²¹

COMBAT THEATER HOSPITAL AIRWAY MANAGEMENT

A combat trauma patient arriving at a Role 2 or Role 3 facility will, in most cases, have been treated under TCCC guidelines, although the extent of airway management and specific airway interventions will have been dictated by the tactical environment, the patient's condition in the field, and the training and skill of the medics caring for the casualty. Combat casualties may arrive with or without an airway intervention, but all must be reassessed for evidence of airway compromise, either as a result of a deteriorating clinical condition, a missed prehospital airway intervention, or displacement, malfunction, or complication of a previously performed airway intervention. Although TACEVAC from the modern battlefield is rapid, even under the best of circumstances the transport of casualties from point of injury to definitive surgical care still takes several minutes. Casualties with complete airway obstruction would not survive if not for the rapid and successful implementation of TCCC guidelines in the prehospital care environment.

Little current information is available about the combat hospital-based management of airway obstruction. Brennan et al reported their otolaryngologist-specific Role 3 hospital experience over a 30-month period, with airway management in 195 casualties from OIF.²² Tracheostomy was the most frequently performed airway intervention (183/195), and 94% of all airway procedures were performed in the operating room. The authors described 10% of the procedures as "emergent"; however, only 4% of the interventions were performed in the emergency room, and only three cricothyroidotomies were performed. The number of emergent airway procedures performed by non-otolaryngologists and the number of missed or incorrectly performed airway interventions during the study period is not known; however, the percentage of "emergent" airway interventions performed by deployed otolaryngologists is consistent with other studies.¹⁴⁻¹⁶

Emergency airway management at Role 3 combat support hospitals generally proceeds along the pathway outlined in Advanced Trauma Life Support (ATLS) guidelines and the clinical practice guidelines (CPGs) established by the Joint Theater Trauma System (JTTS), and are described in detail in other sources.²³⁻²⁶ Otolaryngologists, general and trauma surgeons, oral-maxillofacial surgeons, anesthesiologists, and certified nurse anesthetists should all be proficient in emergency airway management at Role 3 facilities, although each specialty brings a slightly different skillset and experience. Whether performed by a surgeon, anesthesiologist, or emergency medicine physician, the airway

assessment proceeds in an orderly fashion in concert with other lifesaving maneuvers being performed by the trauma team.

Airway assessment in the non-intubated patient can begin with asking the patient a question. A clear, strong, appropriate response reassures the trauma team that, at that moment, the casualty has an intact airway, good respiratory function, and normal or near normal mental status. No response cues the examiner to then assess the patient's rate, pattern, and depth of respirations; note the presence or absence of abnormal breath sounds (stertor, stridor, or wheezing); look for signs of adequate oxygenation; and assess the upper airway for possible obstruction. Abnormal findings in any of these areas (Exhibit 12-2) call for the prompt establishment of a definitive airway, which is defined as a cuffed endotracheal tube in the trachea, secured with tape, and attached to an oxygen-rich ventilation source.²³

All airways inserted prior to arrival at the Role 3 facility must be evaluated immediately upon patient arrival and potentially revised if the airway is obstructed or unstable. In the observational study of OEF casualties, prehospital airway interventions had the highest rate of incorrect performance among all prehospital lifesaving interventions performed.¹⁴ Overall, prehospital airway interventions were performed incorrectly 8.6% of the time, in addition to the 4% of "missed" interventions as noted above. Similar data from OIF found airway-related complications in 5.8% of combat casualties presenting to a Role 3 facility.¹⁶ The complications occurred with both intubations and surgical airways and included right and left mainstem

EXHIBIT 12-2

INDICATIONS (AND EXAMPLES) FOR DEFINITIVE AIRWAY MANAGEMENT IN TRAUMA

- Airway obstruction (maxillofacial injury, penetrating neck wound)
- Loss of protective airway reflexes (loss of consciousness, neurological injury)
- Ventilatory failure (pneumothorax, thoracic wall trauma)
- Hypoxia (blast lung injury, pulmonary embolism)
- Anticipated deterioration of a "stable" airway (maxillofacial injury, head injury, facial burns)

intubations and displacement of the tube tip into the hypopharynx and subcutaneous tissues.

The incidence of incorrectly performed prehospital cricothyroidotomies is as high as 33% in OEF and OIF, and only 64% of prehospital cricothyroidotomies were judged as successful in one civilian trauma study.^{14,16,18,27} The complication rate of prehospital cricothyroidotomy is not surprising given the tactical conditions on the battlefield and the infrequent performance of the procedure by prehospital and hospital personnel. Despite these limitations, a surgical airway remains the tactical airway intervention of choice for casualties with maxillofacial or penetrating neck trauma with airway compromise when positioning fails to correct the obstruction, or in other trauma

patients following failed oral or nasal intubation attempts.^{21,28}

In summary, Role 3 providers must be aware that more than 10% of all casualties may present with an incorrectly performed or missed airway intervention, and complications occur with both intubations and surgical airways as described above. In addition, placing patients in a supine position or administering sedatives or narcotics may result in iatrogenic airway obstruction, particularly in patients with maxillofacial injuries. TCCC guidelines advocate a sit-up and lean-forward position for initial airway management, and these “stabilized” patients may quickly develop airway obstruction if placed supine or given sedation prior to definitive airway management.

CLINICAL CASES

Major Maxillofacial Trauma

Combat injured patients with major maxillofacial trauma may present to a Role 3 facility with or without an airway intervention having been performed in the prehospital setting (Figure 12-1). Patients who are conscious and supporting their own airway, albeit tenuously, should be approached in a calm and methodical manner, and ATLS, JTTS CPGs, and standardized, evidenced-based trauma airway management guidelines should be followed (Figure 12-2).^{22,23,29} Patients who have suffered major disruption of the mandible may be unable to maintain their airway if placed supine and are at risk for aspiration. Although RSI is the typical and preferred method employed for establishing an airway in trauma patients, a cricothyroidotomy, or, if time permits, an awake tracheostomy performed under local anesthetic may be more appropriate in patients with major maxillofacial trauma.²⁹

RSI may not be the best initial airway management strategy in patients with major maxillofacial trauma because of difficulty with direct laryngoscopy due to a lack of mandibular integrity, collapse of the tongue into the pharynx, poor visualization of the larynx due to blood and secretions, and an inability to perform mask ventilation. Adequate suction equipment is critical to intubating the trauma airway regardless of the technique employed. A surgical airway should be performed in patients with active oropharyngeal bleeding when suction is unavailable or visualization of the larynx is obscured by blood despite suctioning. A suture or towel clip placed through the anterior tongue may be used to pull the tongue base forward and improve visualization of the larynx for both direct laryngoscopy and endoscopic intubation attempts.

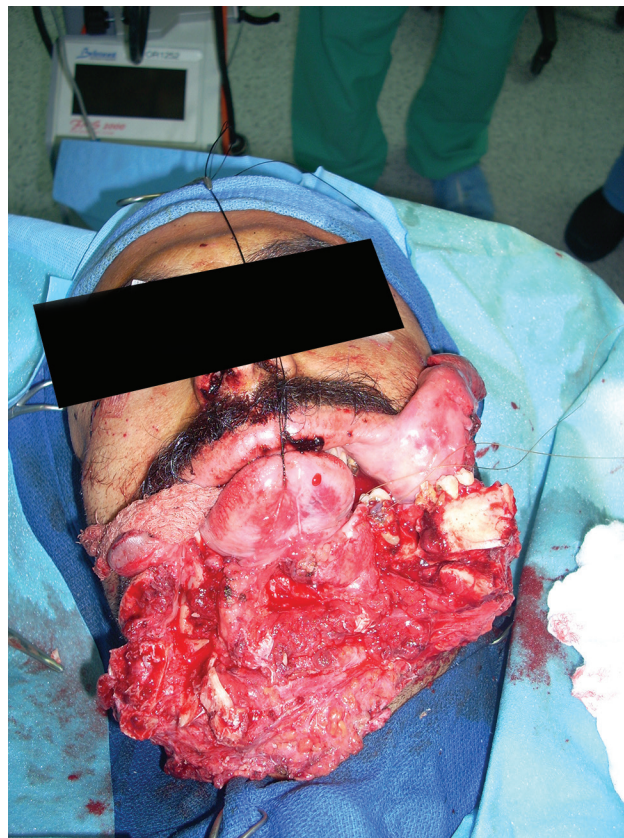
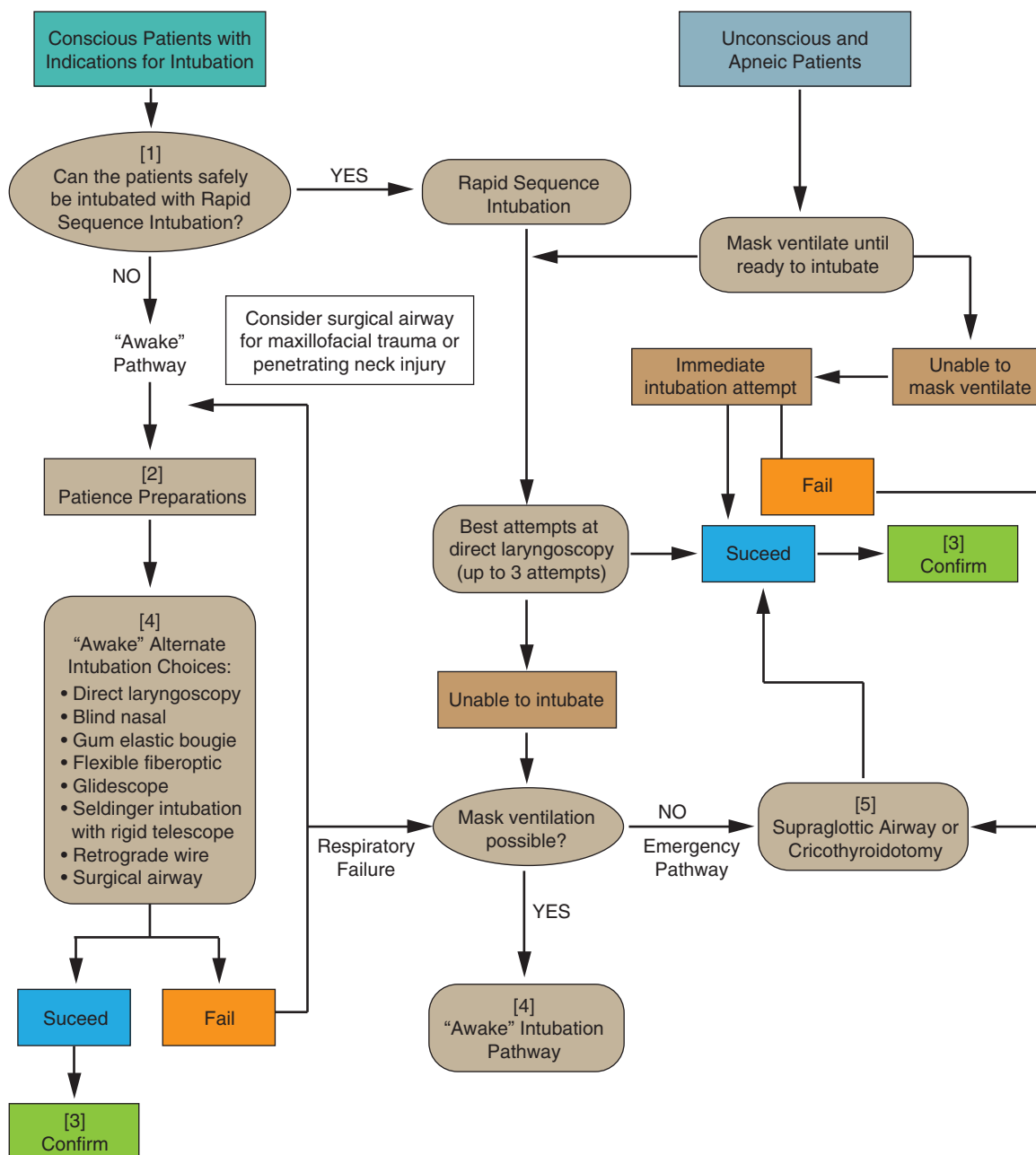


Figure 12-1. This patient suffered major maxillofacial injuries with complete loss of the anterior mandible in a blast. The patient was supporting his airway on arrival to the Role 3 hospital and was allowed to remain upright and leaning forward. A Yankauer suction was provided to allow the patient to self-clear his secretions and blood, oxygen was provided via a loose fitting face mask, and the patient was then taken to the operating room where an awake tracheotomy was successfully performed.



- [1] The patient must be assessed for a possible difficult airway. RSI may be more difficult in patients with maxillofacial and neck trauma.
- [2] The patient must be cooperative for an awake intubation, however, sedation (Ketamine) may be used. If time permits, topically anesthetize the nose, oral cavity and oropharynx. Pre-oxygenate and monitor all patients undergoing intubation. Ensure that all necessary equipment is available and develop a plan for a failed intubation.
- [3] Confirm tube placement by carbon dioxide detection plus direct laryngoscopy, auscultation, and/or pulse oximetry monitoring.
- [4] The physician should be familiar with the use of one or more alternatives. The time to become familiar with the various devices is before you are faced with an airway emergency.
- [5] Supraglottic airways include the laryngeal mask airway (LMA), Combitube and the King LT. A tracheotomy may be performed instead of a cricothyroidotomy by personnel experienced in this technique. Cricothyroidotomies should be converted to tracheotomies within 24 hours.

Figure 12-2. Trauma airway algorithm.

Adapted from: US Army Institute of Surgical Research. Trauma Airway Management. Joint Theater Trauma System Clinical Practice Guideline. 11 June 2012. http://www.usaisr.amedd.army.mil/assets/cpgs/Trauma_Airway_Management_11_Jun_12.pdf. Accessed June 10, 2013.



Figure 12-3. The endotracheal tube is slid over the telescope to facilitate intubation under endoscopic visualization. Lubrication should be placed on the telescope and not the tube. Care must be taken to avoid bending or breaking the telescope. The physician performing the intubation must hold a laryngoscope in one hand and the telescope with tube in the other. A second person is needed to provide suction as required and to hold the endotracheal tube as the telescope is withdrawn.

Awake intubation using a standard laryngoscope or a transnasal fiberoptic bronchoscope can be performed in cooperative patients with severe lower face injuries; however, the surgical and anesthesia teams must be experienced in managing the airway using awake intubation techniques, and unavailability of equipment, lack of patient cooperation, or poor visualization may preclude the use of these techniques. Rigid bronchoscopy and intubation via a Seldinger technique using an endotracheal tube sheathed over a rigid telescope (Figure 12-3) are also useful techniques for managing the difficult airway; these methods can be used for both awake and anesthetized patients. Endoscopic equipment, however, is easily obscured by blood and secretions in the airway, potentially making endoscopic methods more challenging than direct laryngoscopy with adequate suction.

Delivery of 100% oxygen is critical for all trauma patients during airway intubation attempts, and transtracheal jet ventilation may provide additional time for advanced airway management. However, transtracheal jet ventilation should not supersede a surgical airway, except perhaps in small children (under the age of 8). Cricothyroidotomy is contraindicated in young children; a tracheostomy is the preferred method for obtaining a surgical airway in this patient population.

Most combat casualties with maxillofacial trauma do not require emergency airway management and most do not require a surgical airway; however, patients with extensive panfacial fractures from blast or blunt trauma (Figure 12-4) are probably best managed with a tracheotomy prior to definitive repair of their injuries. Maxillofacial trauma patients may be decannulated once the oropharyngeal edema has resolved and the mandibulomaxillary fixation (MMF) can be removed. Additional considerations in the patient with

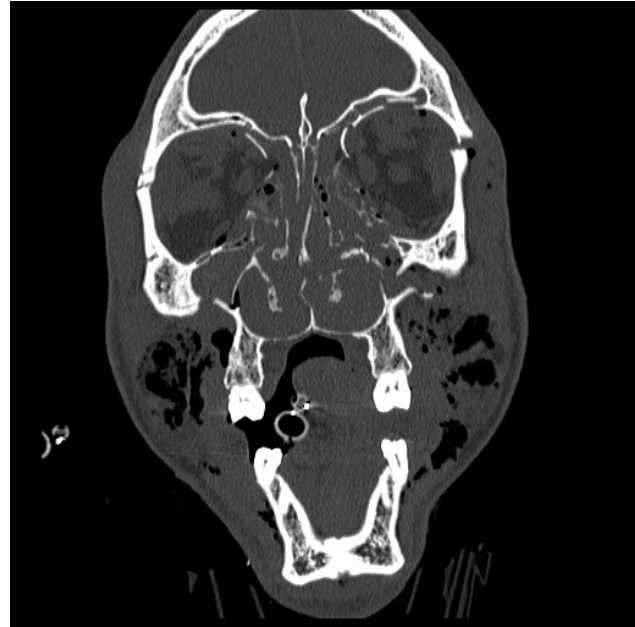


Figure 12-4. Coronal computed tomography scan of a patient with panfacial fractures resulting from a blast. Note the presence of an oral endotracheal tube. The airway was secured in the emergency department due to progressive respiratory distress and an inability to protect the airway. A tracheotomy was performed prior to open reduction and internal fixation of the extensive facial fractures. The patient recovered completely and the tracheotomy tube was removed a week after surgical repair of the facial fractures.

maxillofacial injuries are the possibility of aspirated teeth or bone fragments (Figure 12-5) and the airway requirements for transportation to the next role of care. All patients with missing or damaged teeth or

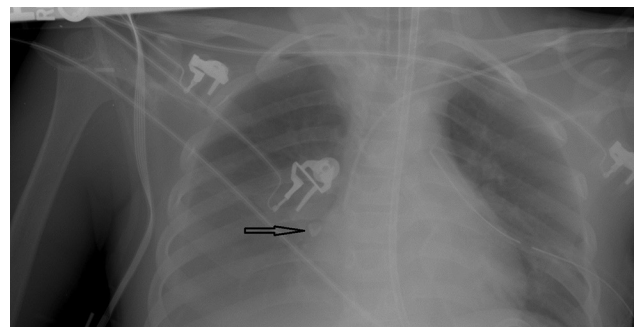


Figure 12-5. This patient, a young girl, suffered a mandible fracture and displaced teeth from a head-on collision with a military vehicle. One of the missing teeth was noted on the chest x-ray (arrow) and was retrieved with rigid bronchoscopy prior to repair of the mandible fracture.



Figure 12-6. The tracheostomy tube is secured with sutures through the tracheostomy tube flanges. Sutures labeled “left” and “right” are secured laterally at the tracheal stoma to facilitate reinsertion of the tracheostomy tube in the event of accidental decannulation. Pulling out and laterally on the sutures opens the tracheostoma.

severely comminuted facial fractures should have a chest radiograph evaluated for the possibility of a tracheal or bronchial foreign body.

All possible steps must be taken to ensure that a patient's airway is secure prior to aeromedical evacuation, which presents a unique and potentially challenging patient care environment. Cricothyroidotomies should be converted to tracheotomies or endotracheal intubations, oral and nasal endotracheal tubes should be secured, and tracheotomies should be secured and performed in such a manner as to facilitate reintubation if the tube becomes dislodged (Figure 12-6). Surgeons and other Role 3 clinicians should err on the side of leaving patients intubated for aeromedical transport because of the physiological changes associated with flight and the challenges of emergency airway management on aeromedical transport platforms. In addition, patients without a tracheostomy should not be left in MMF for aeromedical transport because it may not be possible to rapidly remove the MMF wires in the event of emesis during the flight. Fortunately, inadvertent extubations and requirements for emergency airway management during Critical Care Air Transport Team (CCATT) missions from OEF and OIF are rare owing to the skill and protocols of team members and the excellent communication and patient handoffs between them and Role 3 trauma personnel (personal communication with US Air Force CCATT physicians Colonel Scott Vandehoef, Lieutenant Colonel David Steinhiser, and Lieutenant Colonel Phillip Mason, February 12, 2014).

Complex Laryngotracheal Injuries

Penetrating injuries of the airway are rare in combat casualties and occur in fewer than 5% of civilian trauma patients; however, all casualties with penetrating neck injuries must be evaluated for possible airway injuries.³⁰ Civilian data show that approximately 11% of patients with penetrating neck trauma require immediate airway intervention, and the incidence of traumatic airway injury is 0.4% in blunt trauma and 4.5% for penetrating trauma.^{30,31} Typical signs of direct injury to the airway include hoarseness, subcutaneous emphysema, or audible air escape from a neck wound, although a high index of suspicion must be maintained for possible airway injuries in all patients with both penetrating and blunt neck trauma.

Most patients with penetrating neck trauma do not require advanced airway interventions. For those who do need an advanced airway, RSI is the most common intervention used.³¹ However, patients with traumatic airway injury require advanced airways more frequently than do other trauma patients, and most airway interventions in this patient population are surgical airways. A review of civilian trauma patients with laryngotracheal injuries found that 74% of patients with laryngeal fractures (85% of which were due to blunt injury) required advanced airway management, and 75% of these interventions were surgical airways.³² The incidence of combat-related direct airway injuries is not known; however, a review of data published from deployed otolaryngologists' experiences shows that airway injuries were identified in up to 14% of combat trauma patients treated for penetrating neck injuries.^{23,33} In addition, a database study of facial and neck trauma in OEF and OIF showed that neck, larynx, and trachea wounds accounted for 17% of all soft tissue head and neck injuries in 7,177 injured service members. However, the study did not specifically address airway injuries apart from neck injuries.⁸ Although these studies suggest that the incidence of airway injuries may be three-fold higher in combat injuries compared to civilian trauma, the specific experiences of deployed otolaryngologists may not be representative of the overall incidence of airway wounding in combat.

It is not surprising that direct airway injuries in combat are rare given that the larynx and trachea are relatively protected by the mandible, clavicles, and sternum, and modern ballistic protective equipment affords additional protection (Figure 12-7). Although uncommon in both blunt and penetrating neck trauma, airway injuries are associated with a higher overall injury severity (ISS 27±13) in civilian trauma patients, causing greater morbidity and mortality as



Figure 12-7. The author in Afghanistan in 2007. Note the protection afforded to the neck by the ballistic vest and neck attachment.

a result.³⁰ Traumatic airway injury also appears to be a significant cause of death in combat casualties with airway obstruction. As discussed above, postmortem examinations identified injuries of the larynx and/or trachea in 61% of combat trauma deaths classified as potentially survivable in which airway compromise was considered a likely mechanism of death.⁴

The extent of damage to the airway in neck trauma casualties may not always be apparent on initial presentation, especially in patients with small penetrating wounds. The patient in Figure 12-8 suffered a through-and-through gunshot wound to the neck and was intubated prior to arrival at a Role 3 facility. The oral intubation was fortunate because during surgical neck exploration the patient was found to have a large tracheal defect with transection of both recurrent laryngeal nerves. A tracheostoma was matured and the patient was awakened to allow for formal vocal cord function assessment and a discussion with the family. Flexible nasopharyngoscopy revealed the anticipated bilateral vocal fold paralysis with the vocal folds in the paramedian position. Ultimately, the patient underwent a narrow-field laryngectomy because of the extensive airway injury, bilateral vocal fold paralysis, and the fact that the patient, an Afghan civilian, could not be managed with a lifelong tracheostomy. The priority in surgically managing the patient was to establish a safe airway and restore native swallowing, and the only way to do so without florid aspiration was to remove his larynx. The patient was discharged home on postoperative day 5, was maintaining all nutrition orally, and had excellent esophageal speech.

Blind oral or nasal intubation is contraindicated in patients with suspected airway injuries. Endoscopic intubation with flexible or rigid scopes or surgical

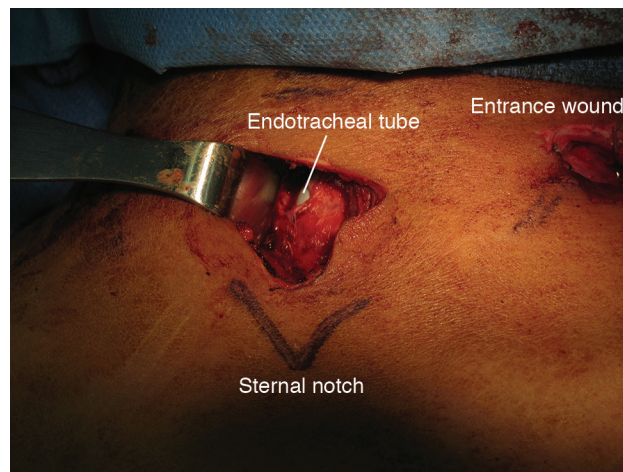


Figure 12-8. Left-sided entrance wound with an anterior-lateral tracheal wall defect. The cuff of the endotracheal tube can be seen in the wound. An extended neck exploration revealed a through-and-through high tracheal defect with transection of both recurrent laryngeal nerves.

airways are better alternatives and allow for intubation of the trachea under direct visualization. Intubation from above may result in the tip of the tube being positioned in the neck or mediastinum or may cause additional injury to the larynx or trachea. Patients presenting with large laryngotracheal defects are best managed with a tracheostomy or intubation of the distal tracheal opening.

Burn Injuries

Facial and neck burns account for fewer than 10% of head and neck wounds in OEF and OIF, but all patients with facial burns must be assessed for airway burns as well.⁹ Initial airway management is directed by the patient's clinical condition; RSI is the primary option in burn patients. Laryngoscopy and bronchoscopy in the operating room is indicated for patients with face and neck burns. When airway burn injuries are suspected, early intubation is preferred. Securing the endotracheal tube or tracheostomy tube can be challenging in patients with significant facial and neck burns (Figure 12-9). A nasal endotracheal tube is an option or, alternatively, an oral tube may be secured to the lower teeth. A tracheostomy in a patient with neck burns is challenging to maintain and may place the patient at risk for aspiration of infected material, leading to pneumonia and sepsis. Intubation, either oral or nasal, may be preferred in the setting of extensive burns to the neck and face. Stenting of the burned airway segment and periodic bronchoscopic reevaluation is indicated for the long-term management of these challenging patients.

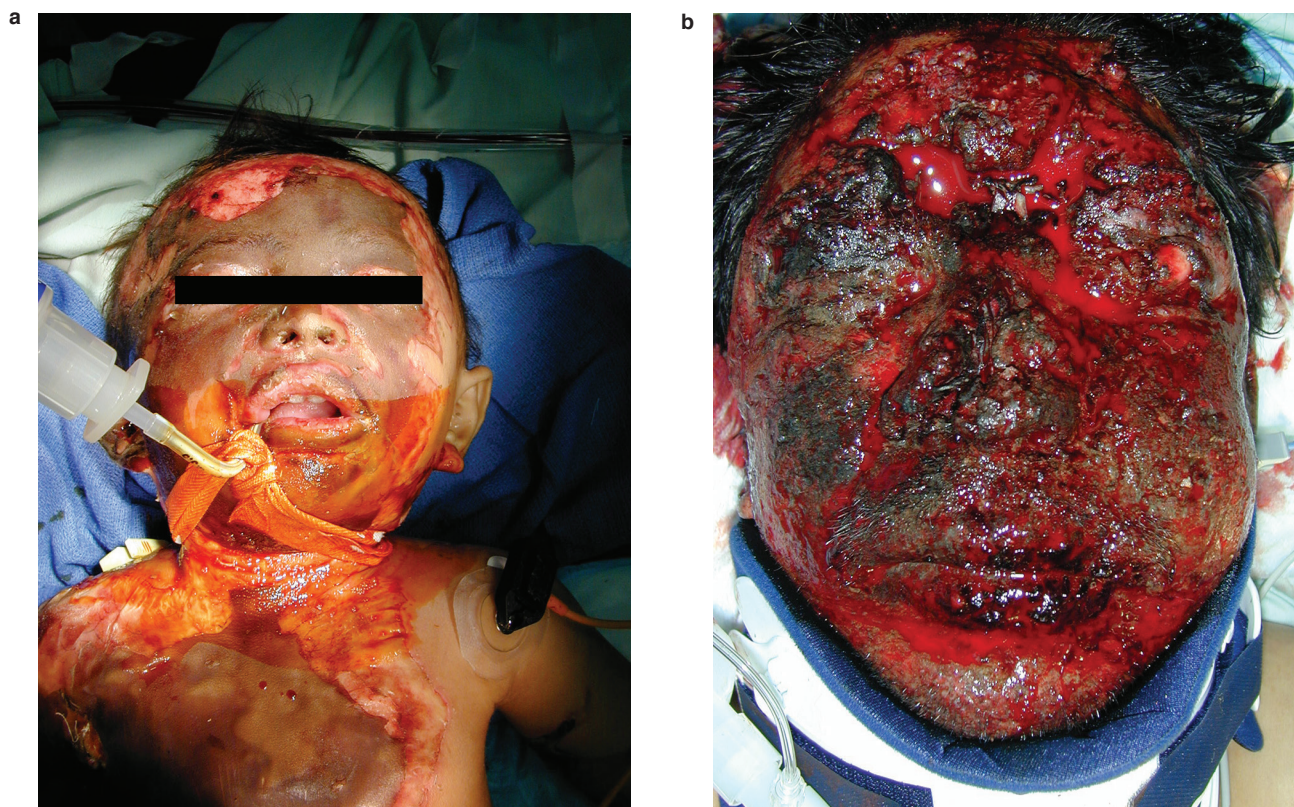


Figure 12-9. (a) Face and neck burns in a young child following a house fire. Bronchoscopy revealed mild airway edema and soot consistent with an inhalational injury. The eschar from neck burns may also compromise the airway. (b) Facial burns and extensive soft tissue trauma following a mine blast. The patient did not suffer inhalational injuries.

Gunshot Wounds to the Face and Neck

Gunshot wounds present unique and often severe injuries that require a low threshold for early airway control with endotracheal intubation or a surgical airway. The damage caused by high velocity penetrating projectiles can be significant, although its extent is not always apparent on initial exam (Figure 12-10). Patients with gunshot wounds to the head or neck may be alert and appear reasonably stable on initial exam but may rapidly decompensate due to vascular or neurological injuries. Civilian data on gunshot wounds to the face reveal that over one third of pa-

tients underwent airway control in the emergency department, with the vast majority being managed with endotracheal intubation.^{34,35} The primary indications for airway control in civilian gunshot wounds to the face are hemodynamic instability, high spinal cord injury, head injury (traumatic brain injury), moderate-sized hematomas of the face or neck, and significant intraoral bleeding. The same criteria can be applied to the care of those wounded by gunshots in combat. RSI, awake intubation, or a surgical airway are all options for gunshot wound-associated airway obstruction depending on the severity of injury and the patient's clinical condition.

SUMMARY

The precise incidence of traumatic airway obstruction in combat is not known; however, data from postmortem studies and a review of the literature describing patient care beyond the point of injury suggest an overall 1% to 2% incidence of fatal traumatic airway obstruction among the combat injured. At least one in ten battlefield casualties require an airway

intervention within the first hour after injury, and up to 10% of combat casualties may require revision of a prehospital airway intervention or an emergent airway intervention within minutes of arrival at a Role 2 or 3 facility. Combat hospital-based physicians must be alert to the fact that up to one-third of prehospital airway interventions fail to properly secure the airway

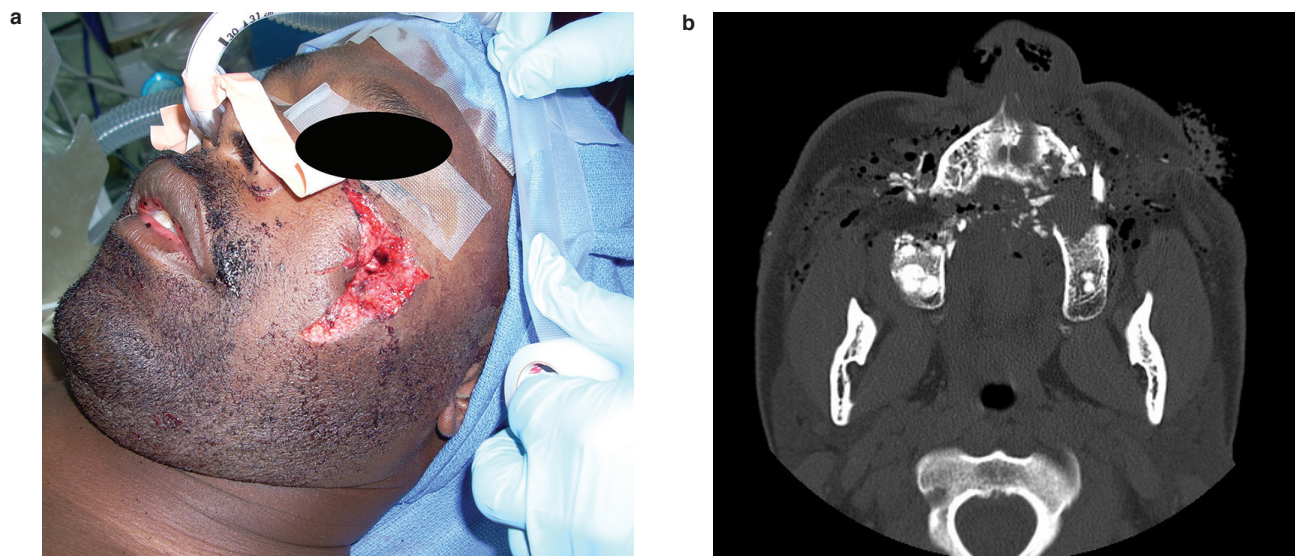


Figure 12-10. Gunshot wound to the face with soft tissue damage at the exit wound (a) and extensive bilateral damage to the maxilla (b). Nasopharyngeal and oropharyngeal bleeding can be significant in these patients and make airway management more difficult.

or are associated with complications. The assessment and management of all combat trauma patients should proceed according to the guidelines established by ATLS and the JTTS in conjunction with the use of sound clinical judgment.

Deployed otolaryngologists participate in the care of the combat wounded as members of a larger trauma team and provide valuable insight, experience, and surgical skills for managing difficult airways. Military otolaryngologists and other surgeons should be familiar with the assessment of potential or impending airway obstruction and have experience managing the difficult airway, including performing oral and nasal intubation, surgical airways, and other methods of securing the airway. Otolaryngologists and other physicians skilled in trauma airway management must continue to lead efforts to improve the prehospital management of airway obstruction.

Current data from OEF and OIF point to a need for continued research and development into the prevention and treatment of traumatic airway obstruction. The high mortality rate among casualties

with traumatic airway injuries can be addressed by improvements in personal protective equipment to shield the larynx and trachea from the devastating effects of penetrating injuries. The significant number of incorrectly performed or missed prehospital airway interventions certainly reflect the difficult tactical situations under which the care is provided; however, the training and experience of prehospital medical personnel must be continually assessed and improved. Typical in-garrison healthcare provides few opportunities for combat medics to maintain their airway management skills. A greater emphasis must be placed on airway training, simulation, and hands-on involvement by prehospital medical personnel in the in-garrison healthcare environment. Trauma surgeons, otolaryngologists, anesthesiologists, and other emergency airway experts should play a more active role in the training of combat medics. In addition, the development of a simple, safe, rapid, and reliable method of securing the airway, either surgical or supraglottic, could reduce the number of complications and missed airways.

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