Chapter 6

MANAGING THE AIRWAY

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INTRODUCTION

Since 2000, the incidence of combat face and neck injury has increased in relation to total battle injury compared to the 20th century.[1] Penetrating injuries are the most common cause of combat injuries to the face and neck,[1] resulting in an increased incidence of airway compromise.[2] Penetrating airway injury is unusual in the civilian context, where the bulk of airway injury is blunt trauma due to motor vehicle collisions.[3] Military clinicians rarely manage these types of injuries except when deployed, highlighting the importance of appropriate training.

Penetrating injuries to the face and neck can result from either gunshot wounds or explosive events. Explosive events have become the most common cause in recent years (81%), with gunshot wounds accounting for only 19% of battle injuries to these anatomical areas.[1] Penetrating injuries can result in severe disruption of both soft tissue and bone,[4] and if the airway is disrupted, surgical emphysema may occur, leading to air being trapped under the skin. The airway is relatively superficial throughout the face and neck and, with the exception of the mandible, has no bony protection. Airway embarrassment may result from relatively innocuous wounds because fragments need to travel less than 15 mm through skin to damage the airway, especially in the anterior neck. The airway can also be compromised by blood, secretions, and foreign bodies. The multiple potential approaches to airway management in casualties with penetrating injuries, as well as advantages and disadvantages of each technique, airway devices, team considerations, and suggested guidelines will be discussed in this chapter.

EVIDENCE FOR CURRENT PRACTICE

The anesthetic management of penetrating neck injuries is poorly reported in the literature,[5,6] and manuscripts generally concentrate on surgical management[7] or related case reports.[8] The publications on this type of injury reveal a lack consensus among the anesthetic community,[9] with great variability described in their management.[7] A literature review of papers published on the subject between 1995 and 2010[8] identified 51 relevant papers. Only three of these papers involved military patients, and all were case reports.

Facial Injury

Awake fiberoptic intubation (AFOI),[10–13] rapid-sequence induction (RSI),[14,15] and surgical airways[15,16] have all been described in the airway management of patients with extensive facial injuries. Even in the presence of extensive facial injury, oropharyngeal intubation is generally considered the anesthetic modality of choice in both civilian[10,11] and military clinical series.[8] Large defects should be directly intubated and smaller defects visualized through fiberoptic intubation. Indications for a surgical airway include intraoral hemorrhage and extensive disruption of the mandible or maxilla.

Penetrating Neck Injury

Neck injuries are currently found in 11% of battle injuries in United Kingdom (UK) forces, compared to 2% to 5% in US forces.[16] In the neck, both the trachea and laryngopharynx are superficial and are commonly injured.[17–20] Various techniques have been described in the literature to manage penetrating airway damage, including orotracheal intubation,[18,21–23] flexible bronchoscopy,[20] use of a light wand following failure of direct laryngoscopy,[17] RSI,[10–18] and AFOI.[10–18] Surgical techniques described include both surgical cricothyroidotomy[24] and tracheostomy.[23]

Determining where the airway is injured is the first step in managing penetrating neck injury. This determination is best approached on a zonal basis.[21,25] Zone I of the neck represents the area between the clavicles and the cricoid cartilage, zone II the area between the cricoid cartilage and the angle of the mandible, and zone III the area between the angle of the mandible and the base of the skull. Injuries to the anterior and lateral aspects of the neck compromise the airway more often than those in the posterior region in civilian trauma[21] and probably military cases as well: a military study found that anterior wounds accounted for 79% of fragment wounds to the neck.[22] Once the zones involved have been identified, the clinician should then consider the presence of injury to the airway's lumen (with associated blood and debris), injury within the airway wall, or injury outside the wall (eg, expanding hematoma or surgical emphysema). Guidelines for managing injuries in each zone are listed in Exhibit 6-1.

Optimal intubation conditions may be difficult to achieve, and injuries may compromise positive pressure ventilation with bag-valve-mask devices.[7] Not all patients will be in extremis, however, and time may be available to consider additional investigations to characterize the injury. Computed tomography (CT) angiography is the first-line investigation in stable patients with penetrating neck injuries[24] to identify sites

EXHIBIT 6-1

SUGGESTED GUIDELINES FOR MANAGEMENT OF PENETRATING AIRWAY INJURY

Zone I injury
- Direct intubation through a large defect
- Surgical cricothyroidotomy in an emergency or tracheostomy in the semi-elective setting
- Thoracotomy in complete tracheal transaction

Zone II injury
- CT scan to exclude distal airway injury (provided there is no immediate impending obstruction of the airway)
- Oral intubation by RSI for injuries proximal to the larynx
- Fiberoptic intubation for injuries distal to the larynx
- Surgical airway for injuries distal to the larynx

Zone III injury
- Oral intubation by RSI for small defects
- Surgical airway for gross disruption

For any large airway defect: direct intubation through the defect

When a distal airway injury has not been excluded: primary surgical airway may be the most appropriate plan.[1]

CT: commuted tomography
RSI: rapid-sequence induction
1. Nelson LA. Airway trauma. *Int Anesthesiol Clin 2007;*45:99–118.

of potential bleeding that may be suitable for surgical or endovascular interventions. Such an investigation will also demonstrate the location, nature, and extent of any airway injury.

Penetrating Neck Injury With Associated Vascular Injury

Despite the high prevalence of airway damage to the neck, the most common cause of death from combat neck injury is secondary to exsanguination from the carotid arteries or jugular veins.[26] Vascular damage should be suspected in any airway injury to the neck due to the close anatomical proximity of major blood vessels to the upper airway. Vascular damage can result in bleeding into the airway itself, or it can cause a rapidly expanding hematoma, resulting in progressive airway obstruction.[27] RSI should be considered the airway modality of choice in these cases.

AIRWAY DEVICES

New technology in electronics and materials has led to an increase in the availability of new airway devices. It must be borne in mind, however, that many new products have not undergone rigorous testing, particularly in the trauma setting. Although many different devices are now on the market, it is advisable for military providers to practice using the equipment in advance (a crisis situation is not a good time to experiment with unfamiliar devices). Some of the newer devices, with their advantages and disadvantages, are listed in Table 6-1.

ANESTHETIC CONSIDERATIONS

Airway Bleeding, Facial Distortion, and Patient Positioning

Blood and debris may be soiling the airway. Conscious casualties who are maintaining their airway satisfactorily do not require immediate airway intervention apart from a jaw thrust. Such patients should be allowed to adopt the most comfortable position. Lateral, sitting, and prone positions have all been described in case reports. The importance of allowing

TABLE 6-1

NOVEL AIRWAY DEVICES

Device	Advantages	Disadvantages
Video laryngoscopy • GlideScope (Verathon, Bothwell, WA) • McGrath (LMA North America, San Diego, CA) • C-Mac (Karl Storz, Tuttlingen, Germany) • Airway Scope AWS-S100 (Pentax, Tokyo, Japan) • Airtraq (Prodol Meditec, Getxgo, Spain)	A recent field trial of Airtraq for use in a military prehospital setting was favorable.[1]	Not intuitive New skill must be learned
Supraglottic airways • LMA ProSeal (LMA PacMed, Burnley, Victoria, Australia) • LMA Supreme (LMA PacMed) • i-gel (Intersurgical Ltd, Wokingham, Berkshire, England)	These three devices have been shown to be easy to place with a 97%-98% first time placement possible. They have been shown to be capable of rescuing ventilation when facemask and tracheal intubation have failed.	None identified
Flexible fiberoptic laryngoscopes	The replacement of external light sources with battery light sources makes fibrescopes truly portable. The use of chip camera technology offers good quality images and recording facilities.	Decontamination and cleaning of the traditional fiberoptic laryngoscope in the deployed field hospital is difficult (but these problems are negated by a disposable fiberscope).

1. Dawes RJ. Military difficult airway equipment evaluation. *JR Army Med Corps.* 2010;156:60.

these patients to choose their own positions must be reinforced during patient handover. Oropharyngeal tubes are a useful interim measure and should be used in preference to nasopharyngeal tube in head, face, and neck injuries because it is impossible to exclude base-of-skull fractures in the acute setting. Comminuted mandibular fractures may result in loss of tongue support, resulting in the tongue moving backwards and obstructing the airway. This may be temporarily resolved by placing a single suture through the tongue allowing the tongue to be pulled towards the chin.[28] Conscious patients with this form of injury often want to sit upright, and clinicians should be wary of laying these patients supine.

Anesthetic Approaches to Penetrating Airway Injury

The principle clinical features mandating early tracheal intubation are acute or worsening respiratory distress, an airway compromised by blood and secretions, extensive surgical emphysema, tracheal deviation by hematoma, or a decreasing level of consciousness.[29] Although anesthetists routinely perform endotracheal intubation, this procedure should be approached with great caution in patients with a penetrating airway injury.[30]

Direct Laryngoscopy

It is important for anesthetists to be aware that despite the appearance of an intact laryngeal inlet, a tracheal tear may present underneath. In such a case, if an endotracheal tube is placed under direct laryngoscopic vision, the tip of the tube could pass through the defect. This problem may go unrecognized and risks airway obstruction, pneumomediastinum, and the creation of a false passage.[30] Direct laryngoscopy is in effect a blind technique that may completely disrupt the larynx. The incidence of complications is unknown, but they are potentially lethal and difficult to reverse even with an emergency surgical airway (especially if gross surgical emphysema has been created).[21] Direct laryngoscopy under topical anesthesia (an "awake look") has been recommended,[7] but this technique will not reveal any injuries distal to the vocal cords.

Rapid Sequence Induction

Despite the common use of RSI to secure the airway, the technique is controversial. Some authors hold that RSI should be the default method of airway control,[31] and evidence suggests it is safe[32] and has a high success rate[33–35]; however, other researchers argue against RSI in certain cases.[36,37] It is not recommended in cases of near or total airway transection, where paralysis will abolish the supportive muscle tone, which may be all that is holding the airway together.[7,38] For these reasons, some authors advocate maintaining spontaneous ventilation at all costs.[30] Current UK anesthetic practice includes the use of cricoid pressure[39] during an RSI, but such pressure may distort the airway, change the anesthetist's view, and result in a more difficult airway.[30,40] Cricoid pressure is not used in other countries.

Blind Nasal Intubation

The consensus of opinion is that blind intubation methods including nasotracheal intubation should not be used in patients with penetrating neck injury because further injury or complete airway obstruction may be induced.[41] A single paper reviewing a case series of patients successfully managed with blind nasotracheal intubation has challenged this advice.[42] This technique is rarely taught in UK hospitals, and if it is not part of their regular practice, clinicians should not use it.

Fiberoptic Intubation

AFOI is the gold standard for safely securing the airway in a casualty with traumatic airway injury. This technique allows the lumen of the airway to be identified by direct vision throughout the intubating process, so the anesthetist can be confident about siting the endotracheal tube distal to any visualized tear. However, AFOI depends on availability of a fiberscope, the cooperation of the patient,[30,43] and the skills of the operator. Another confounding factor is that foreign bodies or blood hinder the use of the fiberscope,[30] although in skilled hands it has proved very effective.[10–13, 15, 44] Sterilizing the fiberscope can also cause difficulties with AFOI in the field hospital; disposable versions have recently been developed but are yet to be evaluated in this setting.

SURGICAL CONSIDERATIONS

A surgical airway is generally considered the first choice intervention for penetrating laryngeal injuries[30,37] because placing an endotracheal tube under direct vision reduces the potential for misplacement. Cricothyroidotomy is the surgical modality of choice in the emergency setting,[38] with conversion to tracheostomy performed semi-electively. Tracheostomy should be performed at least one tracheal ring below the injury to avoid complications.[15] If a difficult intubation is suspected, it is advisable to prepare the patient's neck, and the surgeon should be ready to perform a surgical airway.[30] The anesthetist should be mindful that it might be difficult for the surgeon to rapidly create a surgical airway, particularly if there is overlying hematoma or other gross anatomical disruption.

TEAM CONSIDERATIONS

Because of the issues discussed above, the team dealing with airway injuries must consider the likely fragment or projectile trajectory and potential airway effects. Whether the anesthetist or the surgeon performs the surgical airway will be determined by the skills and experience of each team member. Human factors[45] (or nontechnical skills such as leadership, teamwork, communication, and situational awareness) play an important role in ensuring that individuals in a clinical team perform to the highest standard.[46] The authors believe that the principles of Stanford School of Medicine's Anesthesia Crisis Resource Management (ACRM) training[47] are crucial to ensuring the best possible outcome when faced with a patient with severe blast or ballistic injuries. Swift, coordinated decision-making by all members of the team is essential.

SUGGESTED TECHNIQUES AND GUIDELINES IN THE DEPLOYED SETTING

UK Defence Medical Services anesthetists spend the majority of their clinical practice working with civilian patients in the National Health Service and generally deploy on military operations every 6 to 18 months. The deployed environment has a much different case mix to that experienced in the civilian setting. Standard operating procedures have been developed for management of the difficult airway by the American Society of Anesthesiologists,[48] and for the unanticipated difficult airway by the Dif-

ficult Airway Society.[49] Both of these protocols were designed to deal with a civilian patient population in the setting of a general hospital, and do not reflect the circumstances currently encountered in the deployed military environment. Management of "anticipated difficult airway" has recently been evaluated to some extent in a civilian setting[50]; however, the unusual nature of penetrating airway injury necessitates its own standard operating procedure for use in the deployed field hospital. Key points are listed in Exhibit 6-2 and potential pitfalls are recorded in Exhibit 6-3. (See Exhibit 6-1 for suggested guidelines for the airway management of blast or ballistic injury.) These lists are provided to help anesthetists improve their nontechnical or human factors skills in the clinical environment.

SUMMARY

Because of the multiple potential approaches to airway management of casualties with penetrating injuries, as well as the low incidence of these injuries in the civilian context, it is important to develop guidelines that allow planning and anticipation of these cases prior to deployment. Use of an algorithm, however, should not be substituted for common sense. The newly developed technologies describe here can aid in airway management, but the anesthetist must be aware of their limitations.

EXHIBIT 6-2

KEY POINTS FOR THE MANAGEMENT OF PENETRATING AIRWAY INJURIES

- Monitor patient with full AAGBI standard monitoring[1] (especially $ETCO_2$)
- Preoxygenation
- Airway optimization
  - o Allow conscious patient to adopt most comfortable position
  - o Use jaw thrust in unconscious patients
- Consider the urgency that a secure airway is required
  - o Not all patients will be in extremis; there may be time to consider additional investigations to characterize the injury. CT is considered the first-line investigation in stable patients with penetrating neck injuries.[2]
  - o However dire the situation, take a few seconds to think before acting
- Consider the site of injury
  - o Blood and debris may be soiling the airway
  - o May require clearing prior to securing the airway
- Consider the availability of suction
  - o Two devices are preferable
  - o Have a bougie readily available
- When securing the airway consider:
  - o Chin lift
  - o Jaw thrust
  - o Head tilt
  - o Basic airway adjuncts
  - o Positioning head up
  - o Using a smaller endotracheal tube
  - o Using a hollow bougie to allow continual insufflation
- If C-spine immobilization is present, remove and nominate one person to maintain manual-in-line stabilization

AAGBI: Association of Anaesthetists of Great Britain and Ireland
CT: commuted tomography
$ETCO_2$: end-tidal carbon dioxide

1. Association of Anaesthetists of Great Britain and Ireland. Recommendations for Standards of Monitoring During Anaesthesia and Recovery. 4th ed. London, England: Association of Anaesthetists of Great Britain and Ireland; 2007. Available at: http://www.aagbi.org/publications/guidelines/docs/standardsof monitoring07.pdf. Accessed on: January 9, 2012.
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EXHIBIT 6-3

POTENTIAL PITFALLS OF AIRWAY MANAGEMENT

Ventilation: Positive pressure ventilation risks enlarging tears and causing surgical emphysema.
- Try to preserve spontaneous ventilation prior to intubation.
- Use bag-valve-mask ventilation as a last resort.
- Beware of using a supraglottic airway device in injuries distal to cords.
- Avoid transtracheal jet ventilation.

Intubation: Blind placement of the tube risks causing the tip to pass through the defect and lie outside the airway; this prevented only by fiberoptic intubation or a surgical airway.

Intubation: Endotracheal intubation should be approached with caution.
- Avoid oral intubation when the injury is distal to the vocal cords.
- Avoid blind nasal intubation.
- Fiberoptic intubation is likely to be difficult or impossible when there is bleeding into the airway.

Surgical Airway: potentially extremely difficult in the presence of subcutaneous emphysema or expanding hematoma. Direct laryngoscopy is also likely to be difficult.

Drugs: Avoid muscle relaxants with near or complete airway transaction. Muscle tone may be important for airway integrity.

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