



Airway Management in Trauma Patients

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Key Points

- Airway control is the primary and principal task of the caregiver in trauma. Any flaw in airway management may lead to grave morbidity or mortality.
- Many factors may complicate airway management in trauma: patient's hemodynamic instability, C-spine injury, full stomach, emergency situation, and operator's lack of experience.
- A definitive airway is the superior method to secure the airway, which is a cuffed tube secured in the trachea. This includes orotracheal tube, nasotracheal tube, or surgical airway, meaning cricothyrotomy or tracheostomy.
- The physician may be challenged with a situation where it is difficult to intubate the patient. Being familiar with standard basic airway techniques and advanced airway devices may help in such situation. The assistance of colleagues, whose expertise includes the airways, is always recommended.
- In case of "cannot intubate, cannot ventilate" cricothyrotomy is a lifesaving procedure. It is superior to tracheostomy in emergency situations because the cricothyroid membrane is superficial and minimal dissection is required to get access to the airway. It is important that emergency department physicians are trained and practiced with this procedure.

10.1 Introduction

In compliance with the guidelines of advanced trauma life support (ATLS) for the management of patients who sustained life-threatening injuries, airway maintenance with cervical spine immobilization is a primary priority [1]. The loss of airway may be lethal and can happen faster than the

loss of the ability to breathe or the onset of circulatory problems. Thus, lifesaving intervention should begin with airway management [1–3]. The main purpose is to ventilate the patient in order to facilitate tissue oxygenation, most importantly the brain and the heart. Timely, decisive, and skillful management of the airway may often make the difference between life and death or between ability and disability in such circumstances. One should be familiar with airway anatomy, the standard basic airway techniques and devices, situations that set airway difficulties, and advanced airway management in extreme situations. The assistance of colleagues, whose expertise includes the airways, is always recommended.

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10.2 Approach to the Airway of Trauma Patient

There are several aspects in managing the trauma patient's airway. The following are needed to be considered by the physician in charge:

- (a) The primary caregiver has to determine whether the patient requires support in breathing and whether there is an indication to secure the airway and to ventilate the lungs.
- (b) Airway assessment needs to be promptly executed within the limitation of time and the patient's cooperation.
- (c) The physician has to determine whether there is likelihood for difficult mask ventilation or difficult endotracheal intubation, such as obesity or facial hair.
- (d) What is the extent, the details, and the anatomy of the injury? Does it include the head and face and cervical (C) spine? Hemodynamic stability of the patient?
- (e) What is the upcoming surgical procedure that the patient will need to have, and is prolonged mechanical ventilation predicted at this stage? [4]

10.2.1 Airway Assessment

The main purpose of airway evaluation is to determine whether difficulty in mask ventilation or endotracheal intubation is to be expected. In addition, while examining the patient's airway, the physician needs to decide which type and size of airway device is suitable for the patient and the situation. Airway assessment should be carried out as quickly as possible, and take into consideration the patient's ability to cooperate. Previous difficulty in intubation may be known to the patient or family [5, 6]. The condition of the face and neck, mouth, bony structure, and soft tissue is to be examined (Table 10.1). In addition, the inner view of the mouth is to be inspected, also known as Mallampati score (Fig. 10.1): poor vision of the hard and soft palate has a higher score and may indicate difficult intubation. Mallampati's oropharyngeal classification was first proposed as a hypothesis for prediction of difficult intubation [7, 8]; its efficacy in the prediction of difficulty at direct laryngoscopy was demon-

strated later in clinical trials [8–11], and it became a part of pre-intubation airway examination.

10.2.2 Securing the Airways

In order to decide whether there is a need for airway management and for ventilation in a trauma patient, the following questions should be answered:

- (a) Is the patient conscious?
- (b) Is the patient breathing effectively?
- (c) Is the patient hemodynamically stable?
- (d) Does the patient require surgery or transporting to another facility?
- (e) Does the trauma involve the maxillofacial region or the upper or lower airways?
- (f) Is there a head trauma with increased ICP, which may necessitate hyperventilation?

Table 10.1 Airway assessment

| |
|--|
| • Medical history |
| – History of difficult intubation, including syndromes such as Down syndrome and Pierre-Robin syndrome |
| – Pathology of the oropharynx area or neck (e.g., maxillofacial trauma, cervical spine injury) |
| – Previous treatment to the oropharynx or neck (e.g., radiation to the neck, cervical neck fixation) |
| – Obstructive sleep apnea |
| • Physical examination |
| – Mouth opening (should be more than three fingerbreadths) |
| – Thyromental distance (should be more than three fingerbreadths) |
| – Condition of the mouth cavity and teeth (e.g., denture, bleeding) |
| – Temporomandibular joint and neck mobility |
| – Size of the tongue and mandible |
| – Mallampati score |
| – Facial hair |

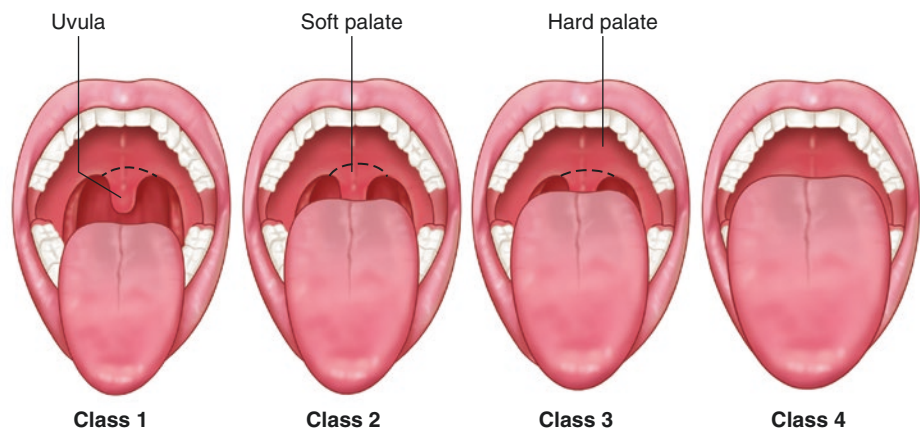


Fig. 10.1 The Mallampati score. Class 1: Complete visualization of the uvula, soft palate, and faucial pillars. Class 2: Visualization of the soft palate, major part of uvula, and faucial pillars. Class 3: Visualization of the soft palate and base of uvula. Class 4: Only hard palate visible

Table 10.2 Indications for definitive airway in trauma patient^a

| Need for airway protection | Need for ventilation or oxygenation |
|---|--|
| Severe maxillofacial trauma | Inadequate respiratory efforts <ul style="list-style-type: none"> • Tachypnea • Hypoxia • Hypercarbia • Cyanosis |
| Risk for obstruction <ul style="list-style-type: none"> • Neck hematoma • Laryngeal or tracheal injury • Stridor | Massive blood loss and need for volume resuscitation |
| Risk for aspiration <ul style="list-style-type: none"> • Bleeding • Vomiting | Severe closed head injury with need for brief hyperventilation and patients with GCS scores of 8 or less |
| Unconscious | Apnea |

^aAdvanced Trauma Life Support Student Course Manual [12]

Trauma patients presenting with apnea or a gasping breathing pattern (respiratory rate < 6/min), hypoxia (oxygen saturation < 90% despite oxygen insufflation and after exclusion of tension pneumothorax), trauma-associated hemodynamic instability [systolic blood pressure (SBP) < 90 mmHg], severe chest trauma with respiratory insufficiency (respiratory rate > 29/min), or severe traumatic brain injury [Glasgow Coma Scale (GCS) < 9] require emergency airway assistance.

Ventilation and oxygenation can be achieved through several airway devices. However, the superior approach is to secure the airway with a definitive airway, which is a cuffed tube secured in the trachea. This includes orotracheal tube, nasotracheal tube, or surgical airway, meaning cricothyrotomy or tracheostomy [12, 13]. The definitive airway is advantageous since it enables ventilating directly and only the trachea; the cuff minimizes the risk for aspiration to the lungs, and fixation is superior to other means of ventilation, thus suitable for patient's transport.

The indications for achieving a definitive airway are specified in Table 10.2.

10.3 Techniques and Devices for Airway Management

There are many techniques and devices to manage the patient's airway; however, the basic and frequently practiced approaches are mask ventilation and endotracheal intubation. One should be familiar and experienced with these techniques before advancing to other airway techniques. The necessary equipment for mask ventilation and endotracheal intubation is to be prepared and checked: face mask, oral airway, reservoir bag, direct laryngoscope, endotracheal tube, oxygen supply, and suction catheter (Fig. 10.2).

10.3.1 Mask Ventilation

Ventilating the patient with a face mask is the primary and easiest method of ventilation and oxygenation. The physician should select the proper mask size that fits the patient's face in order to have effective ventilation. In some patients, an oral or nasal airway is required to ensure adequate air passage to the patient's larynx and lungs (Fig. 10.3).

The disadvantage of mask ventilation is that it is not a definitive airway; thus (a) it is difficult to continue managing the patient for a long time with mask ventilation, for transportation or for radiologic examination, and (b) there is a chance of inflating the stomach and increasing the risk of gastric content regurgitation followed by its aspiration into the lungs.

10.3.2 Tracheal Intubation

Orotracheal intubation with direct laryngoscopy is a simple and straightforward method for securing the airway in trauma patients. It is performed with a conventional laryngoscope, e.g., Macintosh blade, with a rapid sequence induction (RSI) in order to decrease the risk of pulmonary aspiration [14, 15]. However, the incidence of a difficult intubation in the emergency department is 3–5.3% for unanticipated difficult tracheal intubation and 0.5–1.2% for failed intubation [16]. Failure to achieve successful tracheal intubation to a maximum of three attempts is defined as failed tracheal intubation and indicates the need to change strategy [17, 18]. Multiple failed attempts at tracheal intubation injure the patient's larynx and may be harmful [19]. Every additional laryngoscopy causes soft tissue edema, bleeding, and secretions, thus worsening the airway condition and decreasing the likelihood of successful intubation. Analysis of failed cases identified gaps in care that included poor identification of at-risk patients, poor or incomplete planning, inadequate provision of skilled staff and equipment to manage these events successfully, delayed recognition of events, and failed rescue because of lack or failure of interpretation of capnography [16, 20]. Therefore, emergency airway management necessitates a firm concept of techniques of securing the airway and of dealing with the potential difficult intubation, whereby establishing a definite airway is not feasible with standard techniques [21].

10.3.3 The Difficult Airway

Difficulty in mask ventilation or tracheal intubation requires a quick response as to how to manage the patient's airway. Several professional societies, including the American Society of Anesthesiologists (ASA) and the Difficult Airway Society

Fig. 10.2 Necessary equipment for basic airway management: face mask, oral airway, reservoir bag, direct laryngoscope, endotracheal tube, oxygen supply, and suction catheter

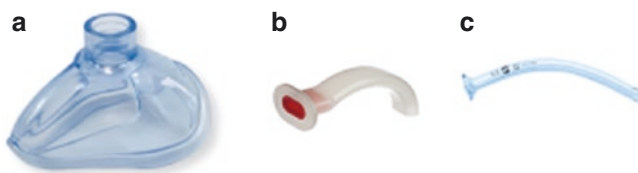
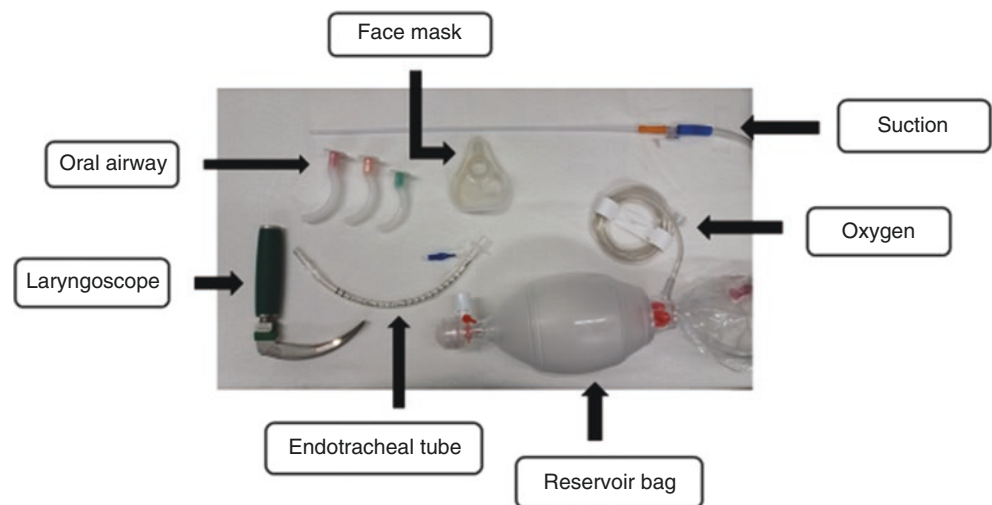


Fig. 10.3 (a) Face mask, (b) oral airway, (c) nasal airway

(DAS), have published guidelines to assist the physician in decision-making at that crucial point [18, 22]. The main issues are similar in all the guidelines, progressing from simple to more advanced airway devices, while maintaining the patient's safety.

Occasionally the difficult airway guidelines are not suitable in managing the trauma patient. Techniques of awake intubation are not always possible in a trauma patient, since these techniques are (a) time-consuming, (b) require special equipment, (c) necessitate operator's special expertise, and (d) require patient's cooperation, all of which are often absent in trauma. The hallmark of airway management of the difficult airway patient is maintaining the patient's spontaneous breathing as long as possible, which may be unfeasible in trauma patient. In addition, in a case of difficulty, the recommendations are either "cancel case" or "wake patient," neither of which is a realistic option with trauma patients. Thus, the physician in charge has to be prepared earlier than usual to proceed to the option of "invasive airway access," meaning surgical airway.

Figure 10.4 describes our suggested strategy for management of a difficult airway of trauma patient in emergency situation.

10.3.4 Alternative Airway Techniques and Devices

The main obstacle in performing successful endotracheal intubation is not having an unobstructed view of the vocal

cords. Numerous airway devices and strategies have been developed to overcome this obstacle. Some devices, such as the flexible fiber-optic bronchoscope (FOB), enable an indirect view of the vocal cords. Other devices, such as the laryngeal mask airway (LMA) or the double lumen esophageal-tracheal Combitube, can be inserted blindly and do not require a view of the vocal cords by any means. Another option for endotracheal intubation of a patient with difficult intubation is to place an LMA and then pass an endotracheal tube through the LMA. The final option is the surgical one: to establish direct access to the trachea by performing a cricothyrotomy or a tracheotomy.

10.3.4.1 Fiber-Optic Bronchoscopy

Performing awake fiber-optic intubation under local anesthesia for achieving successful endotracheal intubation in the spontaneous breathing patient is one of the recommended methods in situations where airway management is difficult [18]. However, the use of a fiber-optic bronchoscope (FOB) is sometimes unfeasible in trauma patients. Blood, vomitus, and secretions in the patient's airway may preclude vision by fiber-optic instruments. Furthermore, the patient's cooperation is essential for such an approach, and this cooperation is not easy to obtain in the pain-suffering, anxious trauma patient.

10.3.4.2 The Video Laryngoscope

The video laryngoscope is a device that enables an indirect view of the epiglottis and the vocal cords, rather than a direct view as with conventional laryngoscopes. The images from the patient's larynx are displayed on a screen or a monitor in the operator's vicinity. There are many types of video laryngoscopes, such as GlideScope®, C-CAM, Truview PCD™, King Vision™, and others that are commonly used in difficult airway situations [23, 24].

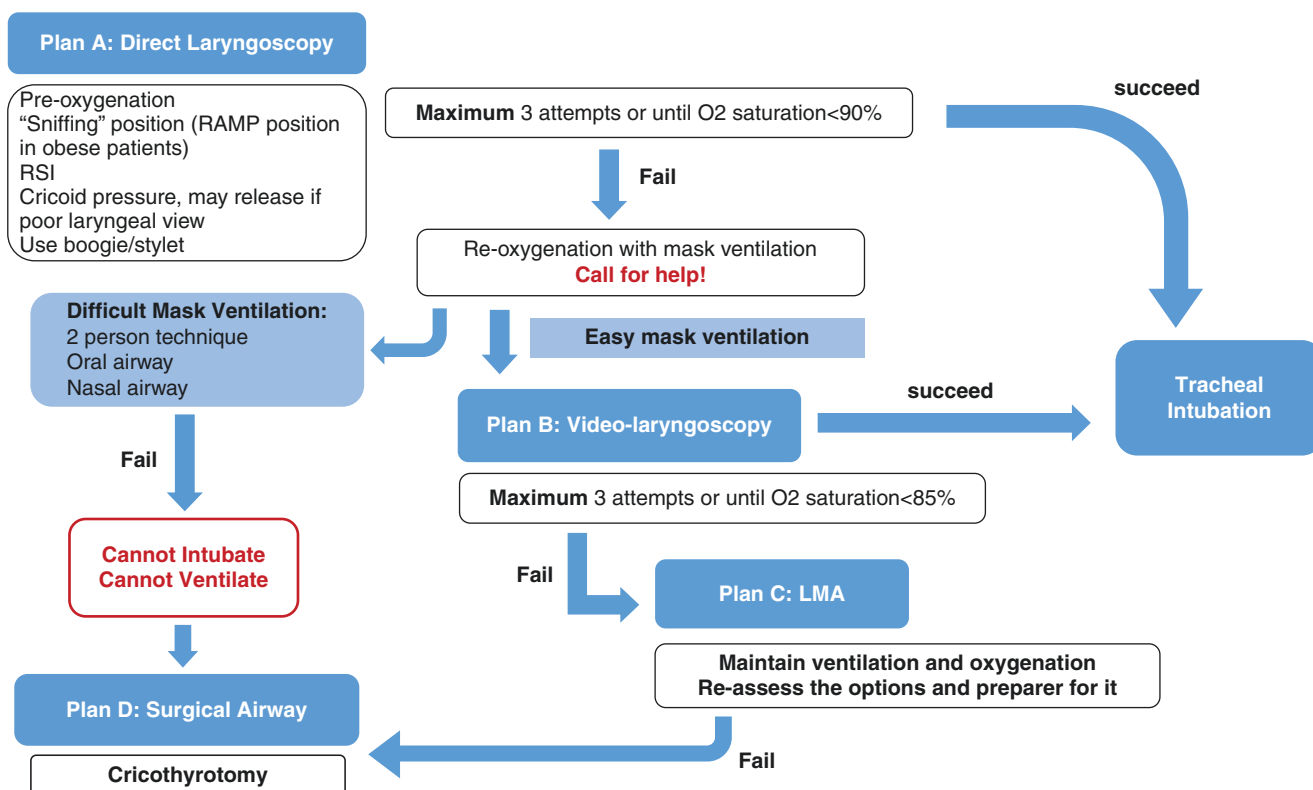


Fig. 10.4 Suggested strategy for difficult airway management of a trauma patient in an emergency situation. *RSI* rapid sequence induction



Fig. 10.5 Laryngeal mask airway (LMA)

Studies have shown that, when used for emergency intubations, video laryngoscopy was associated with better vocal cord visualization and a higher rate of first attempt successful intubations compared with a conventional direct laryngoscopy [25–27]. However, the successful use of a video laryngoscope relies on a good view of the inner airway, which may be precluded in the trauma patient by blood and secretions in the oral cavity.

10.3.4.3 Supraglottic Airway Devices

Supraglottic Airway Devices (SAD), such as the Laryngeal Mask Airway (LMA) (Fig. 10.5) and its several diverse variations, are very important devices for managing the difficult

airway [18, 21]. The SAD is placed blindly in the oropharynx, and its successful placement requires minimal experience [28–30]. However, SADs do not provide a definitive airway and can be displaced when the patient is moved and transferred. Thus, it is not a final airway tool for managing trauma patients, especially for trauma patients who require maxillofacial surgery where the oral cavity is to be empty. However, a SAD is an ideal rescue device for ventilating the patient until the definitive airway is achieved, as has been repeatedly proven in combat casualties and many other trauma victims [31–33]. When definitive surgery is to be performed, the SAD may be a bridge until it is replaced by an endotracheal tube [34] or, alternatively, by a cricothyrotomy.

10.3.4.4 The Esophageal-Tracheal Combitube

The esophageal-tracheal double-lumen tube (Combitube) is an airway device that is inserted blindly into the oropharynx. It is a double lumen tube that facilitates ventilating the patient whether its distal tip is in the trachea or in the esophagus. The Combitube was presented for difficulty in airway management in trauma and resuscitation, since it is easy to use [35–37]. However, insertion of Combitube has been associated with serious injury to the upper airway and digestive tract, such as esophageal laceration and perforation, tongue edema, vocal cord injury, tracheal injury, aspiration pneumonitis, and pneumomediastinum [38].

10.3.4.5 Surgical Airway

Performing a cricothyrotomy is a lifesaving procedure in selected patients in the “cannot intubate, cannot ventilate” situation [13, 18, 22, 39, 40]. Surgical establishment of an airway is a safe method for securing the airway when the procedure is performed by an experienced surgeon. Factors that can make the cricothyrotomy particularly challenging are lack of familiarity with the procedure, poor anatomical landmark as in morbidly obese patient, previous radiation to the neck, hematoma, injury, or previous surgery to the laryngeal region. When a patient experiences acute respiratory distress and surgical airway access is performed under local anesthesia, the patient’s movements may pose additional difficulty to the surgeon. Yet, patient’s consciousness is required to maintain patent airway and preserve spontaneous breathing until secured airway is achieved. It is prudent to consider mild sedation (midazolam); however, it is better to have a restless alive patient with an open airway than a sedated or paralyzed patient with a complete airway obstruction.

Surgical Technique

The procedure is performed with the patient in a semirecumbent position. Neck overextension should be avoided since it further narrows the airway. Disinfection of the neck is important although time is limited. The use of a 2% lidocaine injection with epinephrine to facilitate local anesthesia and hemostasis in an awake patient is preferable. After standard preparation of the skin, a 2 cm vertical incision of the skin of the neck just below the laryngeal prominence (thyroid cartilage) is performed (Fig. 10.6). The next step is to make a transverse incision in the cricothyroid membrane which lies deep to this point. Then, a tracheostomy tube or endotracheal tube is inserted into the trachea, and its cuff inflated. Securing this precious airway is of utmost importance. The tube is to be fixated to the skin with a stitch. There are several commercial supplies that are especially designed for this procedure and include all the equipment needed [41, 42]. It is recommended to have one of these in the emergency airway cart.

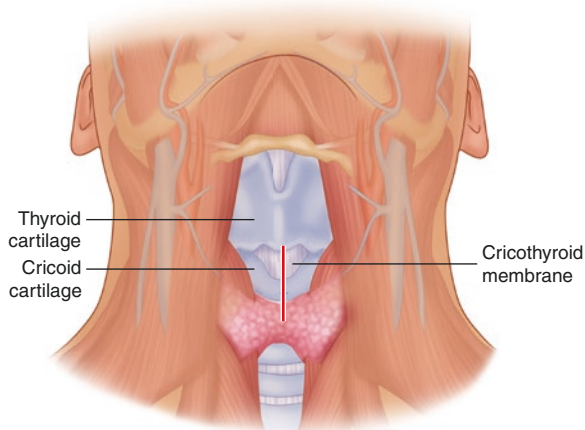


Fig. 10.6 Anatomical landmark for cricothyrotomy

Cricothyrotomy vs. Tracheostomy

The advantage of performing cricothyrotomy rather than tracheostomy is that the cricothyroid membrane is superficial and minimal dissection is required. The disadvantage of this approach is that the cricothyroid membrane’s area is small and several adjacent structures may be injured, such as the cricothyroid muscles and the central cricothyroid artery. In case of cricoid cartilage damage due to pressure necrosis or unintentional scalpel damage, perichondritis may follow, with subsequent stenosis.

Although the procedure of choice in emergent situations is cricothyrotomy, in practice there seems to be a propensity for doing a tracheotomy rather than a cricothyrotomy. In their retrospective analysis of 4312 emergent airways, Dillon et al. found that 34 patients required emergency surgical access and, in these 34 patients, a tracheotomy was done in 24 and a cricothyrotomy in 10 patients [43]. This preference may be attributed to the higher failure risk of cricothyrotomy [44]. Emergency surgical access is not frequently used, yet the surgical airway may be the route of choice when the trauma is extensive and the patient requires prolonged postoperative mechanical ventilation.

The surgical airway procedure carries a 6% rate of complications, such as hemorrhage or pneumothorax, in an elective scenario [13] and higher complication rate when the procedure is performed in an urgent or emergent situation [45–47] and can, occasionally, be fatal [48].

When cricothyrotomy is carried out as a resuscitative effort during “cannot intubate, cannot ventilate” situation, it may be extremely stressful for the operator, especially the less experienced one [49, 50], and, as a rule, the procedure is best performed by the team’s surgeon rather than the anesthesiologist. With that being said, it is important that emergency department physicians are trained and practiced with this procedure [51, 52].

10.4 General Consideration of a Trauma Patient’s Airway Management

Apart from the possibility of facing difficult intubation, several other factors may worsen the scenario of managing the trauma patient’s airway: hemodynamic instability, C-spine injury, full stomach, emergency situation, and operator’s lack of experience.

10.4.1 Hemodynamic Instability

Airway management in the hemodynamic unstable patient is different than in the stable patient for several reasons. First and foremost, hemodynamic instability sets a very short time limit for airway control, since the physician has

to aim the efforts in managing the cause for instability [53, 54]. Usually the patient is to be operated very soon and, in such circumstances, every minute counts. In cases where instability results from massive bleeding, the patient's peripheral perfusion is poor, and the extremities are cold, along with low arterial blood pressure and patient's movements. The pulse oximeter often fails to give accurate reading, and the patient's oxygenation is unknown to the caretaker [55, 56]. Perfusion is progressively decreasing to the lungs as well, and alveolar dead space is increased ("West zone 1"), causing tachypnea and worsening the tachycardia. For all these reasons, it is better to achieve a definitive airway as soon as possible.

10.4.2 C-Spine Injury

A patient with a supraclavicular injury or with blunt trauma is considered to have a C-spine injury, until proven otherwise by imaging [57]. Since a complete C-spine clearance may take several hours and sometimes days to achieve, the patient has to be fitted with a neck collar for cervical spine immobilization. At the time of intubation, the intubator's assistant performs "in-line stabilization" in order to support the head and neck in place and prevent neck movement throughout the procedure [58, 59]. However, several studies have indicated that direct laryngoscopy and intubation are unlikely to cause clinically significant neck movements. On the other hand, "in-line stabilization" may not always immobilize the injured segments effectively. In addition, "in-line stabilization" worsens the laryngoscopic view which may, in turn, worsen the outcome in traumatic brain injury by delaying endotracheal intubation and causing hypoxia [58, 59]. Using a video laryngoscope instead of a conventional laryngoscope with a Macintosh blade may be beneficial for intubating patients whose neck needs to be in a neutral position and whose cervical spine requires immobilization [60–62]. Neck movements during laryngoscopy using a conventional Macintosh laryngoscope have been compared to that using the Glidescope® video laryngoscope [61] and the Truview PCD™ laryngoscope [62]. Both these studies found that neck movements are reduced when using the video laryngoscopes for endotracheal intubation.

10.4.3 Full Stomach

All trauma patients must be assumed to have a "full stomach." Accordingly, the risk of regurgitation and aspiration is high. In order to diminish such risks, evacuating the contents of the stomach through the nasogastric tube before

proceeding with airway management is recommended. However, insertion of a nasogastric tube in a confused, uncooperative, sometimes intoxicated patient who sustained a facial injury may, by itself, trigger vomiting. Another mean of reducing the risk of pulmonary aspiration of regurgitated gastric contents is to use Sellick's maneuver [63], a technique in which the esophagus is occluded by applying pressure on the cricoid cartilage, in order to compress the esophagus against the underlying vertebral body. Over the years Sellick's maneuver, which is also called cricoid pressure, has been incorporated into "rapid sequence induction" (RSI), a method intended to minimize the risk of gastric content aspiration during endotracheal intubation [14, 15]. Although Sellick's maneuver and RSI are widely used, the maneuver may significantly hamper endotracheal intubation because the laryngeal view is worsened [64–66]. Moreover, doing Sellick's maneuver forcefully may injure the esophagus or the laryngeal cartilages [67, 68].

10.4.4 Emergency Situations

Managing the airway in an emergent situation poses additional difficulties, resulting from the fact that the time to accomplish the task is short and the patient's condition may deteriorate quickly. Both decision-making and performance are impaired at such times. The performance of urgent or emergent intubation is associated with remarkably high complication rates, which may exceed 20% [19, 69]. This is the result of several factors, including repeated intubation attempts, performing direct laryngoscopy without muscle relaxation, and lack of operator experience.

10.4.5 Personnel Experience

In emergency situations, the care of acute trauma patients is provided by individuals who are often not experienced—the "inverse care law" [70]. The responsibility for acute airway management often falls into the hands of non-anesthesiologists [71, 72]. In their multicenter analysis of 8937 intubations in the emergency department, Walls et al. reported that anesthesiologists performed only 3% of the intubations, and the remaining 97% of the intubations were performed by emergency physicians (87%) and physicians from other specialties (10%) [72]. In order to improve the clinical outcome of trauma patients, skillful personnel should be tasked with their airway management. That indicates conducting a training program for teaching airway management to emergency department physicians and supplying the equipment and conditions that are suitable for performing endotracheal intubation.

10.5 Maxillofacial Trauma and Airway Injuries

The patient with maxillofacial trauma presents a special challenge in managing the airway. This is a situation that combines all the potential difficulties of airway management:

- (a) We anticipate difficult mask ventilation and difficult intubation.
- (b) The patient often swallows blood from the trauma site in the upper airways and is at a high risk for gastric content regurgitation.
- (c) In many cases, the C-spine is injured, and securing the airway is to be done without moving the neck.
- (d) Head injury is another component in many of these trauma patients.
- (e) The patient who is starved for air and may already be hypoxicemic could also be uncontrollable and combative.

In addition, the type of maxillofacial operation that is planned and the postoperative airway status of the patient are to be considered, since for some operations, the oral cavity needs to be empty for performing the procedure and closed with maxilla-mandibular fixation (MMF) at the end of surgery, and prolonged mechanical ventilation is sometimes expected.

10.5.1 Maxillofacial Trauma Anatomy

Safe and optimal airway management of the patient with maxillofacial trauma requires appreciation of the nature of the trauma. There are several maxillofacial injuries that require immediate treatment, especially in acute upper airway compromise and/or when profuse hemorrhage occurs. According to Hutchinson [73], there are six specific situations associated with maxillofacial trauma, which can adversely affect the airway:

1. Posteroinferior displacement of a fractured maxilla parallel to the inclined plane of the base of the skull may block the nasopharyngeal airway.
2. A bilateral fracture of the anterior mandible may cause the fractured symphysis and the tongue to slide posteriorly and block the oropharynx in the supine patient.
3. Fractured or exfoliated teeth, bone fragments, vomitus, blood, and secretions, as well as foreign bodies, such as dentures, debris, and shrapnel, may block the airway anywhere along the oropharynx and larynx.
4. Hemorrhage from distinct vessels in open wounds or severe nasal bleeding from the complex blood supply of the nose may also contribute to airway obstruction.

5. Soft tissue swelling and edema which result from trauma to the head and neck may cause delayed airway compromise.
6. Trauma to the larynx and trachea may cause swelling and displacement of structures, such as the epiglottis, arytenoid cartilages and vocal cords, thereby increasing the risk of cervical airway obstruction.

A high index of suspicion, a meticulous physical examination, and close observation of the patient may assist in the early detection of such situations. Once early airway management has been completed and hemorrhage is controlled at all sites, the patient should have a computerized tomography (CT) scan of the head and neck to provide more detailed information on the type and extent of the trauma for definitive management of bone and soft tissue injuries. The imaging and the definitive maxillofacial operation may be deferred until all life- and/or organ-threatening injuries have been properly managed.

10.5.2 Early Airway Management of Maxillofacial Trauma Patient

Endotracheal intubation is expected to be difficult in a maxillofacial trauma patient. The challenge in performing the intubation arises mainly from a difficulty in viewing the vocal cords using conventional direct laryngoscope. The oral cavity, pharynx, and larynx may be filled with blood, secretions, soft tissue, and bone fragments, all of which preclude a good view of the vocal cords. In patients where endotracheal intubation is expected to be feasible, it should be performed with RSI and a manual in-line stabilization maneuver, in order to decrease the risk of pulmonary aspiration and take into account a potential C-spine injury.

Regarding mask ventilation: mask ventilation is problematic in the patient with maxillofacial trauma because the anatomy of the oral cavity and/or oropharynx could be disarranged by the trauma and obscured by bleeding. Thus, the ventilation mask cannot be properly fitted to the face for effective mask ventilation. Furthermore, an injured airway may prevent efficient air transfer from the mask to the lungs.

10.5.3 Preparing the Patient for Maxillofacial Surgery

Maxillofacial surgery is done after stabilization of the patient and the radiographic tests have been performed and all the injuries identified. In some patients, maxillofacial surgery is performed at the same time as the surgery on other injured organs. Operating on patients with maxillofacial trauma, and

especially those with severe complex comminuted panfacial fractures, is challenging for the surgeon. The surgeon has to perform fracture reduction, repair soft tissue injuries, and restore the occlusion. In order to facilitate optimal operating conditions and to achieve proper pre-traumatic figuration and function, the occlusion has to be maintained and checked at all times during the surgery. At the end of the surgery, the mouth is to be set closed with MMF. These surgical requirements preclude the use of an oral endotracheal tube. In cases when MMF is not required, an oral tube may be suitable. The choice of the airway device that will be used during the operation is to be agreed upon by the surgeon who is familiar with the planned procedure, including possible intraoperative change of plan and potential postoperative complications.

Some trauma patients reach the operating room conscious and spontaneously breathing and their maxillofacial trauma is not extensive. In selected patients, naso-endotracheal intubation can be used for airway control during surgery [74] (Fig. 10.7). However, naso-endotracheal intubation is relatively contraindicated in patients with midface fractures or fractures at the base of the skull [75].

Severely injured major trauma patients usually arrive at the operating room with one of the following airway control devices, namely, endotracheal tube, a SAD, a cricothyrotomy, or a tracheotomy, performed earlier in the field or emergency department. For these trauma patients where a tracheostomy or a cricothyrotomy was performed as the first line of securing the airway, it is useful subsequently for the



Fig. 10.7 Nasal endotracheal tube in a patient with maxillofacial trauma (From Barak M et al. [76] with permission)

surgery and postoperative recovery period. It is recommended, however, that cricothyrotomy be converted to tracheotomy at that time [76, 77]. If the patient arrives at the operating room with an oral endotracheal tube and prolonged ventilation is expected, the oral tube is to be changed to open tracheostomy. In a patient with no mandibular fracture, with a contraindication to nasal intubation, and there is no need for prolonged intubation, submental orotracheal intubation is to be used as the method for securing the airway during surgery [76, 78–80].

10.5.4 Submental Orotracheal Intubation

Submental orotracheal intubation was presented to avoid the need for tracheotomy and to permit unfettered access to the oral region. This type of intubation is done (a) in patients with comminuted fracture of the midface or the nose, where nasal intubation is contraindicated, (b) in patients who require restoration of the occlusion, and (c) in patients whose condition permits extubation at the end of surgery.

However, this type of intubation is contraindicated in patients with comminuted mandibular fractures.

10.5.4.1 Surgical Technique

Submental orotracheal intubation requires the use of a spiral reinforced armored endotracheal tube (Fig. 10.8) to prevent the tube from kinking during usage. Following an orotracheal intubation, a 2 cm incision is made halfway between the chin and the angle of the mandible, and blunt dissection is performed to the oral floor. A surgical access is made through the superficial fascia, platysma, and deep fascia. The opening is positioned in the floor of the mouth. After accomplishing the dissection, forceps are used to create a tunnel for passing the tube without interference. When creation of the surgical access is complete, the tube is pulled through the tunnel, using gentle rotational movements. Following this maneuver, sutures are used to fix the tube's position (Fig. 10.9). When indicated, extubation is done through the



Fig. 10.8 Spiral reinforced armored tube, for the use in submental endotracheal intubation



Fig. 10.9 Submental orotracheal tube in a patient with maxillofacial trauma (From Barak M et al. [76] with permission)

external skin incision. There is no need to suture the intraoral incision, and the skin incision is closed using the sutures that were placed at the time of intubation.

Complications from submental endotracheal intubation do occur and include bleeding, damage to the lingual nerve and the marginal mandibular branch of the facial nerve, damage to the duct of the submandibular gland, damage to the sublingual gland, salivary fistulae, and skin infections [81, 82].

10.6 Postoperative Airway Management of the Difficult Airway Patient

The patient with a difficult airway is also at high risk for post-extubation complications [83, 84]. Following surgery, the mucous membranes are edematous, the soft tissues are swollen, and the airway may be compressed. Neck expandability is relatively low, and even a small hemorrhage in the region could result in airway compromise. The risk of airway-related complications during the perioperative period was analyzed from the American Society of Anesthesiologists Closed Claims database in order to identify the patterns of liability associated with the management of the difficult airway. It was found that 12% of complications arose at extubation and 5% during recovery [85].

In intubated patients with maxillofacial trauma, extubation should be deferred until the edema subsides. During extubation, the patient should be monitored closely, and the care providers should be prepared for the possibility of re-intubation. It is important to prevent nausea and vomiting because of the risk of gastric content aspiration [86], especially in those patients with MMF because pulmonary aspiration is plausible. For those patients with a tracheotomy tube, the patient may be awakened and allowed to breathe spontaneously through the tracheostomy tube for a few days in order to ensure a safe recovery.

Case Scenario

A 30-year-old female patient sustained a superficial gunshot wound to the head, on her right temporal region. Emergency personnel found her conscious, breathing, and talking. Her blood pressure was 130/70, and her heart rate was 120/min.

1. At that point:
 - A. The patient is to be intubated immediately.
 - B. Emergency surgical airway (cricothyrotomy) is to be performed urgently.
 - C. The patient is to be transferred to the hospital, breathing spontaneously with oxygen supplement.
 - D. The patient is to be ventilated with LMA.
2. On arrival to the emergency department, the patient deteriorated rapidly, lost consciousness, and became hemodynamically unstable.
 - A. The patient is to be intubated immediately.
 - B. Emergency surgical airway (cricothyrotomy) is to be performed urgently.
 - C. The patient can continue breathing spontaneously with oxygen supplement.
 - D. It is better to use the Combitube to ventilate the patient.
3. The emergency department physician failed three times to intubate the patient. What is the best thing to do now?
 - A. Try again, until success is achieved.
 - B. Call for help.
 - C. Mask ventilation with face mask and reservoir bag.
 - D. B and C.
4. The patient further deteriorates during failed mask ventilation. Her O₂ saturation drops to 70%, followed by bradycardia of 40/min. Now is the time to:
 - A. Try again to intubate the patient.
 - B. Urgently perform an emergency surgical airway (cricothyrotomy).
 - C. Get ready for resuscitation with drugs and chest compressions.
 - D. B and C.
5. The emergency department surgeon performed cricothyrotomy on the patient. She was ventilated effectively, her O₂ saturation rose to 96%, and she was taken to the operating room for an urgent explorative laparotomy. At the end of the operation, it is planned to transfer the patient to the intensive care unit for prolonged mechanical ventilation. The best way to continue to ventilate her is:
 - A. Continue to use the cricothyrotomy for ventilation.
 - B. Change to a tracheostomy tube.
 - C. Change to an endotracheal tube.
 - D. Extubate the patient.

Please see Chap. 58 for the correct answer.

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