Review Article

Airway management in maxillofacial trauma

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Abstract

Airway management of patients with maxillofacial trauma remains a challenging task for an anesthesiologist in the emergency and perioperative settings due to anatomical distortion. Detailed knowledge of maxillofacial and airway anatomy is desired for the correct diagnosis of extent and severity of the injury. Basic principles of advanced trauma life support protocols should be followed while managing such patients. Establishing unobstructed airway remains the top priority while maintaining C-spine immobilization and preventing aspiration. Although multiple options exist for securing the airway, a universal technique of airway management may not be applicable to all the patients. Hence, a high index of suspicion along with timely and skillful management is warranted. In this brief review, issues affecting the airway management in cases of maxillofacial trauma are addressed with the possible uses of a wide range of airway management devices available in emergency and elective scenarios.

Keywords: Difficult airway, fiber-optic intubation, maxillofacial trauma, submental intubation, supraglottic devices, tracheostomy, video laryngoscope

Introduction

Maxillofacial trauma is of utmost concern to anesthesiologists due to their close proximity to the airway. Majority of patients present with multiple trauma that requires coordinated management between various specialities. Anesthesiologists play an important role in securing the airway, initial resuscitation, and stabilization of these patients. Appropriate planning is mandatory for establishing the airway during elective surgical procedures and in the postoperative period. Anesthesiologists need to be skilled and familiar with the available equipments and techniques to expedite airway management. In the current review, relevant anatomy, pathophysiology, initial management in an emergency, and late operative management for semielective surgeries has been discussed.

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Etiology and Incidence

According to WHO, injuries contribute to 9% of the global mortality.[1] Etiology of maxillofacial trauma varies with the geographical location and socioeconomic culture.[2] Assaults and road traffic accidents are the most frequent causes of facial trauma in developed and developing countries, respectively.[2,3] By 2020, trauma has become the third-largest cause for mortality in the developing world. The growing number of vehicles on roads, inadequate infrastructure, low compliance of traffic rules, and increasing interpersonal violence have significantly increased maxillofacial trauma in India.[4] Sports-related injuries and industrial accidents are other causes of such injuries.

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Relevant Anatomy

An understanding of maxillofacial anatomy is essential for the proper management of maxillofacial trauma. The human skull is divided into two major parts:

- The calvaria, which encloses and protects the brain
- The facial skeleton, which is further divided into three regions
  - Upper face: Upper third consists of the cranium, frontal bone, and fronto-zygomatic processes.
  - Midface: The middle third is composed of the maxilla, zygomatic, and ethmoid bones, and bony orbital and nasal complexes.
  - Lower face: The lower third consists of the mandible (body, ramus, condyles, and coronoid processes) and temporomandibular joint (TMJ).

Pathophysiology

It is essential to know the mechanism of injury to assess the extent of damage and associated injuries. Maxillofacial injuries are caused by either blunt or penetrating trauma. The dispersion of kinetic energy during deceleration of a moving object produces the force that results in injury. The force generated is classified into high-impact or low-impact force depending on whether the force is greater or less than 50 times the force of gravity.[5] High-impact injuries cause pan facial fractures and may result in the compromised airway.[6] Low-impact injuries affect the nasal bone and zygoma and do not usually compromise the airway.

Classification and Presentation

Maxillofacial trauma involves injuries of the soft tissues and bony skeleton. Bony injuries are classified according to the part of the face involved:

Upper face fractures: Fractures involving the frontal bone and sinuses. One-third of the patients with frontal sinus fracture may have associated dural tear.[6]

Midface fractures: Fractures involving nasal bones, orbital floor, naso-ethmoid, zygomatic arch, and maxilla.

Le Fort described three patterns of maxillary fractures [Figure 1].[7]

Le Fort I: a horizontal fracture across the inferior aspect of maxilla separating the maxillary alveolus from the midface.
Le Fort II: a pyramidal or triangular fracture that separates the maxilla and medial orbit from the zygomatic arch and the skull.
Le Fort III: fracture line extends parallel to the skull base.

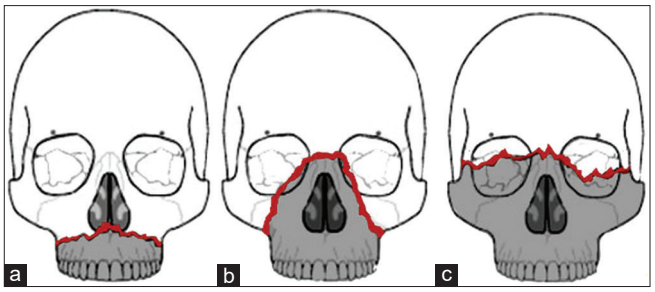

Figure 1: Le Fort fractures (a) Le Fort I; (b) Le Fort II; and (c) Le Fort III.

There is complete separation of the facial skeleton from the cranium suspended only by soft tissues and characterized by "dish-face" deformity.[8] They are frequently associated with damage to cribriform plate, skull fracture, and dural tears.
Le Fort IV: Maxillofacial fracture extending into frontal bone is frequently referred to as Le Fort IV with a clinical condition similar to Le Fort III injuries.[9]

Lower face fractures

The lower third comprises the mandible which is the third most frequently fractured facial bone.[10] Fractures of the mandible may be unilateral, bilateral, or comminuted. Unilateral is relatively stable; bilateral or comminuted fractures tend to be unstable.

Pan facial fractures

These fractures involve the upper, middle, and lower face.

Presentation: Facial fractures may present with edema, subcutaneous emphysema, mobility, and paresthesia of the respective regions with possible CSF rhinorrhea and epistaxis in Le Fort II and III fractures. Lower-face fractures may present with malocclusion of teeth and airway obstruction due to posteroinferior displacement of the fractured segment.

Diagnosis can be made by detailed history, physical examination, radiologic studies, and direct visualization techniques such as laryngoscopy, bronchoscopy, and esophagoscopy. However, the lack of definitive diagnosis should never delay the application of indicated emergent treatment.

Complications

Maxillofacial trauma may be associated with the following complications:

- Airway compromise
- Hemorrhage
- Trismus
- Cervical spine injury
- Pneumoencephalus
- Injury to esophagus
- Subcutaneous emphysema and pneumomediastinum.

Emergency management

Initial assessment

It is important to triage the patients appropriately for maxillofacial injuries. Airway evaluation should be thorough and as quick as possible. Life-threatening injuries must be identified and managed based on their clinical priority. A primary survey is done which includes a rapid and thorough evaluation of the patient according to the Advanced Trauma Life Support protocol, i.e., ABCDE.[11]

- A - airway management with cervical spine control
- B - assessment of breathing and ensuring ventilation
- C - checking circulation with hemorrhage control
- D - delineating disability or assessing the neurological status
- E - exposure and removing the patient from a harmful environment or chemicals.

Subsequently, a secondary survey is conducted. There is a significant association of maxillofacial trauma with traumatic brain injury (23–37%).[12] Patent and unobstructed airway remain the top priority while maintaining C-spine immobilization and preventing aspiration. A universal technique of airway management may not apply to all the patients. Hence, a high index of suspicion along with timely and skillful management is warranted. During attempts to secure the airway, precautions must be taken to protect against iatrogenic injuries.

According to Hutchison *et al*., there are six specific situations associated with maxillofacial trauma, which can adversely affect the airway.[13]

1. Posteroinferior displacement of the fractured maxilla may obstruct the nasopharyngeal airway (NPA).
2. Bilateral fracture of the anterior mandible or parasymphysial fracture may cause the tongue to fall back and block the oropharyngeal airway (OPA).
3. Foreign bodies such as fractural teeth, bone fragments, and blood or vomitus may block the airway.
4. Hematoma due to hemorrhage from major vessels or bleeding from open wounds may contribute to airway obstruction.
5. Soft-tissue edema resulting from trauma can cause delayed airway compromise.
6. Laryngotracheal trauma may cause edema and displacement of upper airway structures aggravating the risk of cervical airway obstruction.

Emergency airway management

Initial assessment:

1. Assessment of verbal response; if the patient responds appropriately, the airway may not be compromised.[14]
2. Examination of the mouth and pharynx for any bleeding or foreign body to be performed. All debris should be removed by suction/finger sweep/Magill's forceps as applicable.
3. All patients with maxillofacial trauma should be considered to have cervical spine injury unless proven otherwise.[15] C-spine immobilization by application of a hard collar/spine board should be maintained.
4. Periodic airway assessment is mandatory to prevent delayed airway compromise due to tissue displacement, hematoma, and edema.[16]
5. All trauma patients should receive a high flow of oxygen.[17]

Airway management and associated complexities

Airway management following maxillofacial trauma is challenging due to disarranged anatomy, soft tissue injury, edema, associated hemorrhage, and a full stomach. In addition to the enigma of anticipated difficult intubation and difficult mask ventilation, emergency situation and nonavailability of experienced personnel during odd hours compound the problem. In the case of midfacial fractures, significant hemorrhage remains a possibility due to the high vascularity of the head and neck region.[18] A patent airway may be established immediately in these cases, by placing the patient in the lateral position and pulling the mandible forward thus allowing the blood and secretions to drain out of oropharynx. Airway manager must ensure the availability of high-volume suction.[19] DuCanto *et al*. suggested a suction-assisted laryngoscopy and airway decontamination (SALAD) approach as a method to manage the soiled airway. In this technique, a rigid suction catheter is placed in the upper esophagus for continuous suction of contaminants and is then stabilized on the left of laryngoscope while intubating the trachea [Figure 2].[20]

Routine airway maneuvers like chin-lift and jaw thrust may not be possible due to distorted anatomy and poor patient cooperation, when conscious. Head-tilt and sniffing position are contraindicated in patients with C-spine injury to prevent inadvertent neurological injury.[16] Airway adjuncts such as OPA and NPA can be used to maintain airway patency. An OPA may induce vomiting and laryngospasm in a patient with an intact gag reflex. NPA is better tolerated in such patients but is not advisable in skull base fractures.[21] Patients with absent gag reflex are candidates for definitive airway. Preoxygenation is crucial in these patients to increase oxygen reserve and prevent the critical level of hypoxemia during apneic period.[22]

Bag mask ventilation (BMV) in facial trauma patients, preferably, should be a "two-person" technique in view of difficult mask

ventilation, though it may not provide effective ventilation.[23] In addition, positive pressure ventilation may worsen airway obstruction due to displacement of fractured fragments. Sometimes, the facemask may improve the situation by serving as a "splint" to stabilize fractured bones. Spontaneous ventilation is desirable while securing the airway in difficult airway scenarios and can be achieved by topical anesthesia or judicious sedation.[16,24]

Available options are:

- Orotracheal intubation
- Nasotracheal intubation: Blind/under the vision
- Surgical airway:
  - Cricothyroidotomy (Needle/Surgical)
  - Tracheostomy (Surgical/Percutaneous).

Orotracheal intubation via direct laryngoscopy (DL) using rapid sequence induction (RSI) and manual-inline stabilization (MILS) remains the most rapid and preferred method when mouth opening is adequate.[25] However, nasotracheal intubation either blind nasal intubation (BNI) or fiber-optic (FOB) guided can be performed in patients with limited mouth opening in the absence of skull fractures. Importance of MILS while securing airway remains unclear. Some authors advocate that MILS may worsen the laryngoscopic view prolonging duration of laryngoscopy which, in turn, may cause hypoxemia[26] while others indicate that MILS may not be required as DL and intubation are unlikely to cause clinically significant neck movement.[27] In addition, safety and efficacy of traditionally recommended RSI and Sellick's maneuver have also been questioned by many studies due to worsening of laryngeal view.[28,29] Use of a McCoy laryngoscope with or without optimal external laryngeal manipulation may improve visualization with minimal movement of C-spine. Gum elastic bougie may be used for difficult endotracheal intubation.

Figure 2: SALAD technique

Airway devices enabling an indirect view of vocal cord

Video Laryngoscopes (VLS)

The Glidescope, C-MAC including hyperangulated D blade, McGrath, Kingvision, and Airtraq are new devices that enable an indirect view of epiglottis and vocal cords especially in patients with disruption of normal anatomy and edema at the base of the tongue. However, blood and secretions can obscure the view.[30,31] Availability of these devices in the emergency department is another limitation [Figure 3].

Bullard laryngoscope

It is a rigid indirect fiber-optic laryngoscope. Its anatomically designed blade permits glottis visualization in a neutral head position with minimal neck movement. Endotracheal intubation can be done over its dedicated stylet with simultaneous local anesthetic (LA) infiltration or oxygenation through a separate port. It requires a mouth opening of only 6 mm.[32]

Fiber-optic-guided

Although performing FOB-guided intubation under LA for achieving successful endotracheal intubation is one of the recommended methods in difficult airway scenario, the use of FOB is impractical in patients with maxillofacial trauma due to blood, vomitus, and secretions, which obscure the view and provide inadequate LA effect due to dilution. Patient cooperation is also desired, which is difficult in trauma patients.[33] Use of VLS and FOB along with a good suction can be combined for better results.[34]

Blind airway devices

Supraglottic airway devices (SAD)

When both mask ventilation and intubation are difficult, laryngeal mask airway (LMA) and intubating LMA (ILMA/Fastrack) can be used. These first-generation devices can be inserted blindly with minimum expertise. They are used as a bridging device to ventilate the patient until a definitive airway is achieved. ILMA can be used as a conduit for blind intubation when direct laryngoscopy fails with minimal movement at C-spine.

In the second generation version of SADs such as ProSeal LMA, LMA Supreme, I-gel, and so on, a separate gastric channel has

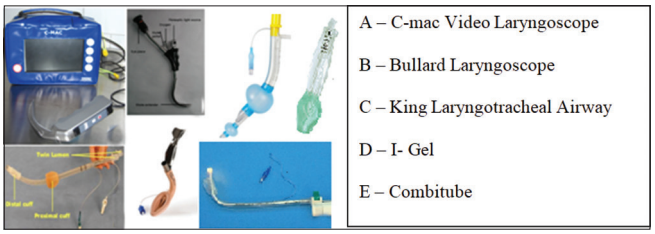

Figure 3: Airway devices

been incorporated which allows the passage of orogastric tube to decompress the stomach thereby reducing chances of aspiration. They are a better alternative than first generation because of separation of gastric and respiratory systems.[35]

Baska, Elisha, and 3Glm are third-generation SADs that additionally incorporate dynamic sealing mechanism avoiding problems of cuff overinflation.[36] The novel disposable intubating laryngeal tube suction offers the advantage of secondary tracheal intubation and is a potential device for use of inexperienced airway managers [Figure 4].[37]

Double-lumen laryngeal devices

Combitube

It can be inserted blindly, even by paramedics in prehospital settings. The combitube is a dual lumen, dual cuff tube which can be inserted blindly in the esophagus. Both the cuffs are inflated. The proximal cuff seals off the oropharynx and distal is placed into the esophagus. Ventilation is accomplished through perforations between two cuffs. In case of inadvertent placement of combitube into the trachea, ventilation can be performed via another lumen. It can be left *in situ* while performing direct laryngoscopy and endotracheal intubation. It is difficult to insert combitube in patients with distorted anatomy. Serious complications such as false track, tongue edema, vocal cord injury, tracheal, and esophageal injuries can occur.[38]

King LTS is also an extraglottic device and works on the same principle as combitube.

Limitations

- SADs do not protect the airway from the risk of aspiration.
- Can get displaced if the patient moves or during transfer.
- Patients with facial trauma have minimum space in the mouth, which restricts the use of these devices.

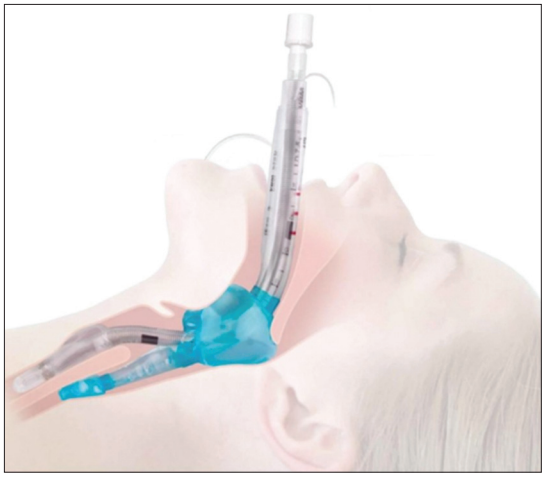

Figure 4: Intubating laryngeal tube suction D

Hence, an attempt to establish the definitive airway should be made as soon as possible as these devices can only be used as rescue measures.

Lighted stylet

The lighted stylet is another option in a patient with maxillofacial surgery. The stylet is inserted blindly into hypopharynx, and intubation is guided by its glow in the midline with minimal C-spine movement.

Surgical Airway

Surgical airway performed under LA is the procedure of choice when other measures of airway management fail. In an emergency, available options are as follows.

Cricothyroidotomy

The relative ease in locating the cricothyroid membrane makes it a preferred site for emergent and expedient airway management. In addition, it is less vascular and associated with low complications rate.[39]

Needle cricothyroidotomy

Available options for needle cricothyroidotomy are as follows:

Commercial kits: There are now commercially available cricothyroidotomy sets that allow the introduction of a dedicated small, cuffed tube using a technique similar to cannula cricothyroidotomy [Figure 5].

Indigenous: If the above kits are not available, then readily available assembly can be used for the same purpose. A 14 G cannula is inserted through the cricothyroid membrane. Oxygen can be delivered via a three-way stopcock @ 15 L/min. Inspiration is provided for 1 s with three way in the closed position, while it is opened for 4 s to allow expiration. The oxygen flow is reduced to 2 L/min if there is obstruction of the upper airway to avoid barotrauma to lungs. The third port of stopcock can be used for attaching the $EtCO_2$ monitor. Alternatively, the jet ventilator may be attached to cannula working on the same principle [Figure 5].

Possible complications:

- Lung hyperinflation
- Subcutaneous emphysema
- Hypercapnia
- Provides oxygenation only for a limited period.

Surgical cricothyroidotomy

It is considered the most appropriate choice for emergency airway control.[40] Recently published DAS guidelines recommend scalpel cricothyroidotomy as the fastest and most reliable method

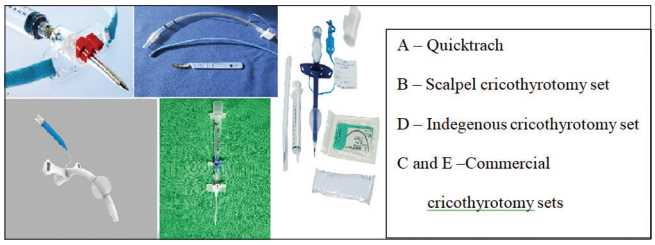

Figure 5: Cricothyroidotomy sets

of securing the airway in "cannot ventilate cannot oxygenate" situations.[41] It is advantageous over needle cricothyroidotomy as it allows the introduction of a cuffed endotracheal tube.
Advantages:

- Protects the airway from aspiration
- Provides a secure route for exhalation
- Allows IPPV using the standard breathing system
- Permits $EtCO_2$ monitoring
- Once the patient is stabilized, a formal tracheostomy can be performed to prevent subglottic stenosis. In an emergency scenario, tracheostomy is not the preferred technique as it is time consuming and difficult to perform in patients with maxillofacial trauma.[17]
  Difficult airway management algorithm [Figure 6].[42]
  Airway management for semielective surgeries
  Early definitive surgery for maxillofacial fractures and soft-tissue injuries should be done electively after stabilization of life-threatening situations as excessive delay may result in malunion or infections resulting in a poor outcome.

Preoperative evaluation

Preoperative assessment should include inspection of-

- Mouth opening
- Mallampatti grading
- Nasal patency
- Dentition, edema
- Radiological investigations to ascertain the extent of an injury including flail-chest, head, and cervical spine injury
- Other comorbid conditions

Limited mouth-opening may be due to TMJ injury or pain. The latter can be improved after sedation and analgesia. Relevant biochemical investigations and blood availability are essential as they are long procedures associated with significant blood loss.

Preoperative preparation

The risk of airway-related complications remains throughout the perioperative period in patients with maxillofacial trauma. Hence, a proper airway management plan should be chosen based on the patient's injuries, the status of the airway, and anesthesiologist's experience. A detailed

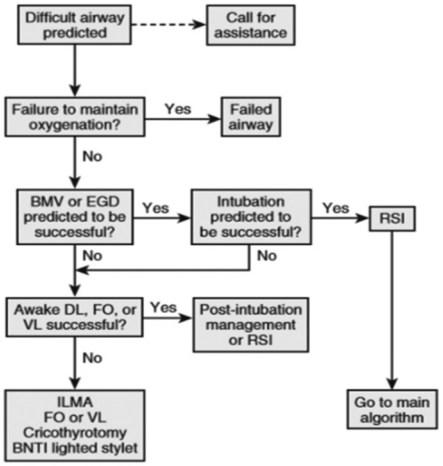

Figure 6: Difficult airway algorithm. BMV: Bag-mask ventilation; BNTI: Blind nasotracheal intubation; DL: Difficult laryngoscopy; EGD: Extraglottic device; FO: Fiber-optic; ILMA: Intubating laryngeal mask airway; RSI: Rapid sequence intubation; VL: Video laryngoscopy. (From Walls RM. Manual of emergency airway management. ed 3. Philadelphia 2008. Lippincott Williams and Wikins.)

discussion with surgical team is necessary regarding the route of surgery, intubation, and need for postoperative maxillo-mandibular fixation. A fully equipped difficult airway cart including cricothyroidotomy and tracheostomy sets should be available.

Available options for securing airway are:

1. Awake vs Anesthetized
2. Orotracheal vs Nasotracheal intubation
3. Direct/VLS/BNI/FOB-guided intubation
4. Antegrade vs Retrograde intubation
5. Transtracheal jet ventilation (TTJV)
6. Surgical airway, cricothyroidotomy, and tracheostomy

Awake Intubation: LA of upper airway is essential for awake oral/nasal intubation.

Indications: Anticipated difficult airway, cervical spine injury. It can be FOB-guided or blind nasal in c/o restricted mouth opening.

Drawbacks:

- Limited success rate with BNI
- Trauma to airway.

Intubation after induction of general anesthesia

Indications: If airway not difficult or for uncooperative patients. Oral or nasal intubation may be needed depending on the requirement of surgery.

Direct laryngoscopy with orotracheal intubation is the technique of choice with immobilization of the cervical spine.[5] Normal PVC, armored tube, or south-pole tube can be used.

VLSs are helpful in difficult airway situations as they improve visualization of vocal cords with minimal manipulation of neck, e.g., glidescope, Cmac, and McGrath, etc.

Nasal: Commonly preferred in patients with maxillofacial surgery[43] but is contraindicated in nasal fractures and basilar skull fractures. However, Bracken has described it to be a safe alternative in such patients.[44] North-pole tube is a useful device for this purpose.

Techniques when oral and nasal intubations are not feasible

Retromolar intubation

Retromolar intubation is a useful alternative avoiding invasive technique for securing the airway when both oral and nasal intubations are not advisable as in Le Fort II fracture.[45] After performing routine orotracheal intubation with a reinforced tube, the ETT is pushed into retromolar space and stitched at the angle of mouth. Suitability of the patient for retromolar intubation can be judged preoperatively by asking the patient to close the mouth with his/her index finger placed in retromolar space. The main advantage is minimal interference in the surgical field and the achievement of optimal intraoperative dental occlusion. Retromolar intubation can also be used for postoperative ventilation [Figure 7].

Bonfils: Retromolar intubation can also be performed with the Bonfils.[46]

Submental intubation

In this technique, after standard orotracheal intubation with an armored tube, a small incision is made in the submental region medial to lower border of the mandible and a tunnel is made through the muscular layers up to the oral mucosa using a blunt dissection technique. Later, a tube is taken out through the tunnel and secured with sutures. After surgery, submental intubation should be converted to orotracheal intubation as it is contraindicated for long-term intubation. This technique is not possible in maxillofacial trauma with restricted mouth opening.[47] Interference with the surgical field and the need for tracheostomy are avoided with this approach.

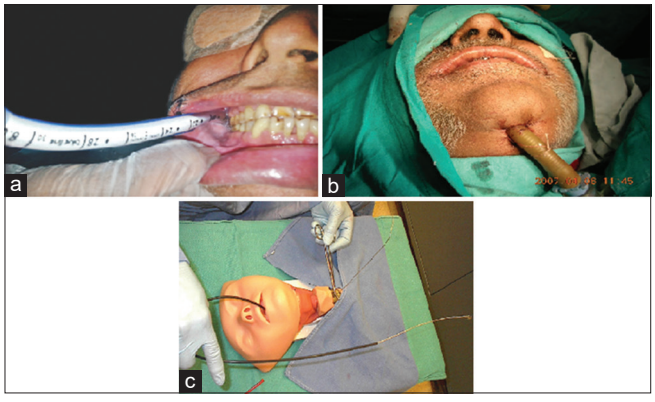

Figure 7: (a) Retromolar intubation; (b) Submental intubation; and (c) Retrograde intubation

Retrograde intubation

Though associated with minimal neck movement, retrograde intubation is not a desirable option in patients with maxillofacial trauma as passing the guidewire cephalad and bringing it out through the oral/nasal cavity may be difficult.[48]

Transtracheal jet ventilation (TTJV)

TTJV can be life-saving in "cannot intubate-cannot oxygenate" scenario in the presence of inexperienced anesthesiologist and surgeon.

Postoperative management

Extubation is anticipated to be difficult in postoperative patients of maxillofacial trauma. Strategy for extubating the trachea should be planned appropriately keeping in mind the duration of surgery, secondary airway edema, use of maxillomandibular fixation, comorbid conditions, and associated injuries of the patients. Removal of throat pack commonly placed during the surgery should be ensured at the end of the procedure. We prefer to extubate a fully awake patient in OR. NPA can be a useful option to maintain the unobstructed airway in the postoperative period. To avoid reintubation in at risk patients, extubation over airway exchange catheter through oro/nasotracheal route may be planned with due care.[49] Cuff leak test can be performed prior to extubation in patients where laryngeal edema is anticipated. O_2 therapy and steroid may be continued in the postoperative period along with adequate analgesia. In the case of planned delayed extubation, the patient is shifted to either high dependency unit or intensive care unit. Wire cutter should be readily available at the bedside for emergency intervention and the staff should be trained regarding its use.

Conclusion

Successful airway management of a patient with maxillofacial trauma depends on the expertise of the anesthesiologist and his/her familiarity with airway equipment. Multiple options exist for securing the airway, but direct laryngoscopy and orotracheal intubation is still considered the technique of choice in an emergency. Good communication between surgeon and anesthesiologist is warranted for planning definitive surgical management. The clear backup plan should be in place well in advance.

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Conflicts of interest

There are no conflicts of interest.

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