Airway management after major trauma

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Key points

The primary goal during early treatment of the severely injured patient is to provide sufficient tissue oxygen delivery to avoid organ failure and secondary central nervous system damage. 2–12% of major trauma victims have a cervical spine injury; 7–14% of these are unstable.

Advanced airway interventions are associated with significant complications and have the potential to cause harm and benefit.

Indications for immediate intubation are life-threatening hypoxaemia caused by airway obstruction not relieved by simple means, and inadequate ventilatory support because of an inadequate facemask seal.

In the emergency department, nearly 10% of intubations are described as difficult after rapid sequence induction.

The primary goal in the early management of the severely-injured patient is the provision of sufficient oxygen to the tissues to avoid organ failure and secondary central nervous system damage. The first priority is to establish and maintain a patent airway. With the addition of high-concentration oxygen and the presence of adequate tissue perfusion, this will enable sufficient spontaneous breathing or assisted ventilation to oxygenate the patient.

The possibility of an unstable cervical injury exists in patients exposed to significant blunt trauma; during airway interventions, neck movement must be minimized to avoid secondary harm to the spinal cord. Depending on the series, 2–12% of major trauma victims have a cervical spine injury and 7–14% of these are unstable. Approximately 10% of comatose trauma patients have a cervical spine injury.

Head injury with impaired consciousness and reduced pharyngeal tone is the commonest trauma-related cause of airway obstruction. The airway may also be soiled with blood or regurgitated matter. Blunt or penetrating injuries that obstruct the airway include maxillary, mandibular and laryngotracheal fractures, and large anterior neck haematomas. Significant partial and incipient airway obstruction are also potential causes of early death. Vigilant reassessment with immediate restoration and protection of airway patency is essential.

Prehospital airway management

All prehospital healthcare personnel should be capable of potentially life-saving basic airway interventions. Advanced interventions are associated with significant complications and potentially cause harm and benefit; they should be attempted only by those who have been trained adequately and assessed as competent.1,2

Having ensured scene safety, the initial approach to the trauma victim begins with an assessment of the patency of the airway and, if indicated, manual in-line stabilization (MILS) of the cervical spine. In unconscious patients, the head and neck should be maintained in neutral alignment. MILS may be replaced with a correctly sized hard cervical collar, lateral blocks and straps across the forehead and chin piece of the collar. Spinal immobilization prohibits head tilt. A jaw thrust may be more effective in relieving airway obstruction with decreased consciousness than a chin lift. However, a jaw thrust can cause significant movement of an unstable cervical spine. If tolerated, an oropharyngeal airway may maintain airway patency while exerting less force on the vertebrae. If an oropharyngeal airway is not tolerated or cannot be inserted, a nasopharyngeal airway may improve the airway. A suspected basal skull fracture is a relative contraindication; however, in extremis, gentle insertion may be life-saving. Subsequent assisted ventilation may be more successful if separate rescuers apply the jaw thrust, hold the facemask with both hands, and squeeze the reservoir bag.

Some indications for tracheal intubation in the prehospital scenario are listed in Table 1. Intubation normally requires drug assistance. The ability to intubate without drugs indicates a poor prognosis. The safe use of anaesthetic

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Table 1: Indications for intubation

<table>
<thead>
<tr>
<th>Indications for intubation</th>
<th>In both the prehospital and in-hospital scenarios</th>
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<tbody>
<tr>
<td>- Immediate (life-threatening hypoxaemia is likely in these circumstances)</td>
<td>life-threatening hypoxaemia caused by airway obstruction not relieved by simple means</td>
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<tr>
<td>- Urgent</td>
<td>inadequate facemask seal leading to insufficient ventilatory support</td>
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<td></td>
<td>to protect the lower respiratory tract from aspiration of blood or stomach contents</td>
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<td></td>
<td>to preserve the airway from anticipated occlusion by:</td>
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<tr>
<td></td>
<td>o oedema</td>
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<tr>
<td></td>
<td>o haematoma</td>
</tr>
<tr>
<td></td>
<td>o displacement of a laryngotraheal fracture</td>
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<tr>
<td></td>
<td>Typically, in the in-hospital scenario only</td>
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<tr>
<td></td>
<td>to regulate intracranial pressure by controlling CO2</td>
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<td></td>
<td>to provide a therapeutic ventilatory strategy for hypoxaemia after:</td>
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<td></td>
<td>o flail chest</td>
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<td></td>
<td>o pulmonary contusion</td>
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<td></td>
<td>to perform therapeutic and diagnostic procedures in uncooperative patients</td>
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drugs and neuromuscular blockers to facilitate intubation requires significant training. There is no firm evidence that prehospital intubation of trauma patients is beneficial, even by doctors highly skilled in rapid sequence induction (RSI). Blind nasal intubation in the field is unreliable and should not be attempted; complications include unrecognized oesophageal intubation, epistaxis, laryngospasm, and vomiting. If oxygenation can be achieved adequately with simple airway adjuncts and a bag-valve-mask device, expedient transfer may be more important than intubation.

Trained rescuers may insert a supraglottic device that provides an airway and facilitates ventilation. The classic laryngeal mask airway (LMA), Combitube and Laryngeal Tube have proved useful in prehospital airway management. Some prehospital personnel are also trained to undertake surgical cricothyroidotomy. This is the intervention of choice when there is life-threatening hypoxaemia because of airway obstruction, tracheal intubation is impossible and a supraglottic airway device has failed or is inappropriate.

**Airway management in hospital**

In the resuscitation room, immediate availability of expertise and ‘difficult airway’ equipment enable optimal airway management. Intubation is difficult in nearly 10% of RSIIs undertaken in the emergency department. Some indications for intubation in the resuscitation room are listed in Table 1. Problems may be avoided by assessing rapidly for potential difficulties with mask ventilation, laryngoscopy, rescue techniques and surgical access to the airway before induction.

Facial hair, trauma and burns prevent effective mask application. Mechanical trismus may hinder supraglottic airway and laryngoscope insertion. Laryngoscopy becomes more difficult in the presence of airway oedema, blood or burns. MILS and cricoid pressure increase the incidence of Cormack and Lehane grade 3 laryngeal views to 20%. Blood, secretions and regurgitation may make fibreoptic-aided intubation impossible. Creating a surgical airway is harder with restricted neck extension, laryngotracheal disruption, subcutaneous emphysema or anatomical distortion by a penetrating injury or haematoma. Cricothyroidotomy, the standard emergency surgical approach to the trachea may become less advantageous than a tracheostomy performed by an experienced operator at a more accessible site. An emergency tracheostomy is recommended for laryngotracheal disruption with impending airway obstruction.

**RSI and intubation**

RSI comprises quick i.v. induction of anaesthesia and neuromuscular block, normally with succinylcholine, followed immediately by tracheal intubation. Cricoid pressure is applied to reduce the risk of pulmonary contamination with gastric contents. Ensure the patient is on a tipping trolley that enables head-down positioning to further protect the lower respiratory tract, if required. Check the ventilator, breathing system, laryngoscopes, tracheal tubes, suction and equipment for managing the difficult airway. An assistant familiar with this equipment is invaluable because time is often limited. All personnel involved in RSI should be trained in their roles (cricoid pressure, MILS, induction, cardiovascular management) and know the agreed plan of action if intubation and ventilation prove difficult. Routine monitors are applied; an intra-arterial cannula enabling continuous pulse and blood pressure monitoring is also useful. In shocked patients, pulse oximetry and non-invasive blood pressure readings may be unreliable and ECG electrodes may be difficult to secure.

In a patient with a potential unstable cervical spine injury undergoing RSI, an assistant, crouched beside the intubator, applies MILS by holding the patient’s mastoid processes firmly down on the trolley. MILS can be provided from in front of the patient but this interferes with the application of cricoid pressure and formation of a surgical airway. MILS must oppose the force generated by direct laryngoscopy which rotates the occipito-atlanto-axial complex. After odontoid peg fracture, this joint complex can extend outside its normal range with potential impingement of the cord and its vascular supply. Do not apply traction; it may cause cord injury.

After MILS is applied, remove the hard collar. Hard collars limit mouth opening, jaw thrust, application of cricoid pressure, laryngeal manipulation and LMA insertion, and increase the proportion of Cormack and Lehane grade 3 or 4 laryngeal views. The posterior component of a collar may be left in situ if single-handed cricoid pressure is used and, in a cadaver study, single-handed cricoid pressure produced negligible vertebral movement as assessed by lateral cervical spine radiographs. Bimanual cricoid pressure may prevent cervical flexion and give a better laryngeal view; however, it requires another assistant to pass equipment to the intubator.

Before induction, give high flow oxygen to the patient through a close-fitting mask for 3 min or, in extreme emergency, with four vital capacity breaths. Do not remove the mask until laryngoscopy. Efficient pre-oxygenation may be impossible because of poor mask seal, patient confusion, maxillofacial trauma and airway obstruction. Apply gentle cricoid pressure (10 N) before induction—this relies on identification of the cartilage which may be difficult after anterior neck trauma. If there is laryngotracheal damage, cricoid pressure may be ineffective, obstruct the airway and worsen the injury.

For induction, inject a pre-determined dose of induction drug through a dependable i.v. cannula connected to a running infusion followed immediately by succinylcholine. Ensure that suction is functional and in easy reach beforehand. The choice of induction drug is dictated by experience, and pharmacodynamic characteristics. The dose depends on the patient’s physiological condition. If there is evidence of a high spinal cord injury (e.g. neurogenic shock, disproportionate bradycardia), an anticholinergic given minutes before laryngoscopy will oppose vagal
reflexes that may cause asystole. Succinylcholine may cause life-threatening acute hyperkalaemia after cord injury but is thought safe up to 48 h after trauma.

Increase cricoid pressure (30 N) at loss of consciousness. Correct application of cricoid pressure is a skill. Excessive pressure may worsen the laryngeal view and make intubation more difficult. Airway obstruction, chest injury, or both may render the patient hypoxaemic before induction and rapid desaturation may occur. Pulse oximetry lags behind the in vivo value. If necessary, maintain arterial oxygen saturation by gentle ventilation while waiting for paralysis. With correct cricoid pressure, careful ventilation should not cause gastric inflation and may prevent life-threatening hypoxaemia.

Anticipate haemodynamic instability after induction. Hypovolaemia and positive pressure ventilation may cause circulatory collapse; treat this with rapid i.v. fluid, inotropic/vasoconstrictor drugs, or both. Significant hypertension and hypoxaemia worsen the outcome of traumatic brain injury. In the absence of intra-arterial pressure monitoring, diagnose haemodynamic instability by palpitating the pulse, observing the ECG and setting a non-invasive blood pressure monitor in ‘stat’ mode. During hypotension, a pulse oximeter may alarm because of failure to detect a signal rather than hypoxaemia. Hypertension after laryngoscopy and intubation may be treated judiciously with more induction drug, a rapidly acting opioid, or both. A judicious propofol infusion is often used to maintain anaesthesia.

Attempt laryngoscopy and intubation after complete paralysis. Inability to insert the laryngoscope, or clear the airway sufficiently with suction or forceps to obtain an adequate laryngeal view, are indications to proceed directly to a surgical airway while attempting to maintain oxygenation by bag–valve–mask ventilation. This scenario is associated typically with severe maxillofacial trauma.

During MILS and cricoid pressure, the laryngeal view with a McCoy blade will be equivalent or better than with the same size Macintosh blade. Backward, upward and rightward pressure on the thyroid cartilage may also improve the view. If the laryngeal view is Cormack and Lehane grade 3 or 4, a gum elastic bougie may aid intubation. Laryngoscopy with a Miller straight blade may produce less vertebral movement than an equivalent Macintosh or McCoy blade. However, transmitted force from the laryngoscope to the cervical spine may also be reduced by using the least force required to obtain a grade 2 view and inserting a bougie. Railroading a tube over a bougie is easier if the laryngoscope is left in the mouth and the tube is rotated 90° anticlockwise. Small internal diameter (7.0 mm) intubating LMA (ILMA) or Mallinckrodt reinforced tubes are easier to railroad but restrict the passage of larger suction catheters. Good indirect laryngeal views may be obtained with minimal neck movement using a flexible fiberoptic intubating laryngoscope, rigid fiberoptic Bullard laryngoscope and angulated video-intubating laryngoscope provided their optical systems remain clean. However, successful use of these instruments may take time and requires training.

Intra-tracheal tube insertion may be established laryngoscopically. Six similar consecutive breaths should be observed on a capnograph to rule out gastro-oesophageal origin of CO2. Their amplitude may be small with a low cardiac output. Insert a tube of appropriate length. If facial oedema is anticipated, cut the tube well beyond the lips. Inflate the tube-cuff to loss of tracheal leak and hand-ventilate the lungs while confirming correct placement with a stethoscope. Bilateral breath sounds in the axillae without sounds over the stomach suggest intra-tracheal positioning but chest trauma and a noisy environment make auscultation difficult. When the tube is placed correctly remove the cricoid pressure.

Secure the tube firmly; in cases of head injury, tapping the tube in place, rather than tying it, may facilitate jugular venous outflow and benefit intracranial pressure control but adhesive tape may be ineffective after facial trauma or burns. Replace the hard collar, lateral blocks and straps before releasing MILS.

Failed intubation

A failed intubation drill involving waking the patient after spontaneous breathing returns, so that an alternative plan can be tried, is rarely appropriate for patients with severe injuries. If an RSI is undertaken because of inadequate airway patency, ventilation and oxygenation, it is unlikely that waking will be advantageous.

If oxygenation is adequate, further efforts to intubate the trachea may be possible but multiple attempts may lead to awareness and hypoxaemia. If airway trauma is incurred, subsequent attempts may be more difficult and airway obstruction precipitated. Cricoid pressure cannot be maintained reliably for more than 5 min and airway reflexes return after rapid metabolism of succinylcholine. The Difficult Airway Society of the UK has suggested that no more than four intubation attempts are warranted under normal circumstances and that it is difficult to justify the use of the same laryngoscope more than twice. If optimal external laryngeal manipulation, an appropriate length McCoy laryngoscope blade and a gum elastic bougie have been used unsuccessfully at the first attempt, a more experienced intubator may make a difference.

If rapid or severe hypoxaemia develop and successful intubation is not imminent, the attempt must be abandoned and ventilation of the lungs re-established. The priority is to maintain adequate oxygenation. The airway may require reopening with basic airway manoeuvres and adjuncts. Poorly-applied cricoid pressure may aggravate airway obstruction; a trial of relaxing cricoid pressure during positive pressure ventilation may be indicated, with suction to hand. If sufficient oxygenation cannot be restored quickly, a ‘cannot intubate—cannot ventilate’ situation has arisen. A back-up plan must be initiated immediately.
A trained practitioner may insert a supraglottic airway device depending on availability, familiarity and the failed intubation plan. Release cricoid pressure temporarily when inserting an LMA as it prevents correct positioning over the larynx. Replacement of cricoid pressure will be unnecessary if a ProSeal LMA (PLMA), Combitube, or Laryngeal Tube Suction (LTS) has been sited correctly. These devices contain oesophageal drainage tubes which may reduce the risk of airway contamination by preventing gastric inflation and diverting emerging gastro-oesophageal contents away from the larynx. The PLMA produces a better seal with the larynx than a cLMA, facilitating higher positive pressure ventilation, which may be useful in patients with thoracic injury.

All these devices will protect the larynx and the distal lens of a flexible fibreoptic bronchoscope from bleeding arising from above. If they provide an adequate airway and stable oxygenation, they may also act as a conduit for blind or fibreoptic-aided tracheal intubation. Blind intubation through a cLMA is unreliable. Fibreoptic-guided intubation is more successful but the physical constraints of cLMA length, connector diameter and aperture bars make it difficult. Fibreoptic-guided tracheal insertion of a bougie or Aintree intubation catheter to railroad a tube after cLMA removal is easier. The reliable fibreoptic laryngeal view from the large bowl of the PLMA may make this device more suitable.

The ILMA facilitates blind and fibreoptic-guided tracheal intubation, provided the operator has sufficient experience. The ILMA has been used as an airway and intubating conduit after RSI in trauma victims. While MILS may make cLMA insertion difficult, the ILMA is reliably and quickly inserted in this position. However, cervical flexion and posterior vertebral displacement by pressure on the cervical spine from the ILMA may occur. This pressure may also produce pharyngeal oedema if the ILMA is left in situ; therefore, remove it once intubation is accomplished. Although LMAs and other supraglottic airway devices are useful in maintaining a difficult airway after failed intubation in trauma patients, use them only if difficulties are anticipated or encountered.

A reliable surgical airway must be created rapidly if sufficient oxygenation cannot be maintained using simple manoeuvres, basic airway adjuncts or a supraglottic airway device. Re-oxygenation requires effective ventilation. Do not reserve a surgical airway for the peri-arrest scenario—it is part of a decisive management plan. Although Seldinger techniques may have a place in forming a surgical airway, the two universally accepted methods of emergency surgical access to the trachea are cannula and surgical cricothyroidotomy. Their safety and efficacy rely on accurate identification of the relatively avascular cricothyroid membrane.

For cannula cricothyroidotomy, a purpose-made kink-resistant device wide enough to enable exhalation (≥4.0 mm ID) is desirable. Confirm intra-tracheal placement by aspiration and secure the cannula before connecting a high-pressure ventilation system. Barotrauma is less likely if the pressure is initially limited to 4 kPa. Standard 14 G i.v. cannulae are not wide enough to enable exhalation, which is then dependent on a patent upper airway. A supraglottic airway device may be useful to facilitate this patency. However, if the upper airway is open, a 400 kPa source is needed to inflate the lungs. If cannulation is slow, ineffective or causes respiratory complications, surgical cricothyroidotomy is indicated.

A simple surgical cricothyroidotomy consists of a horizontal stab incision through the skin and cricothyroid membrane followed by blunt enlargement of the wound to pass a 6.0–7.0 mm ID cuffed tracheal tube. Retraction of the wound edges facilitates intubation as may prior insertion of a bougie to railroad the tube. Surgical cricothyroidotomy should produce little vertebral displacement. Exclude endobronchial intubation after intra-tracheal placement.

**Summary**

Establishing and maintaining a patent airway is the first priority in severely injured patients. Basic airway manoeuvres and simple adjuncts will often enable sufficient oxygenation and ventilation until personnel skilled in RSI and tracheal intubation are available. Patients with significant blunt trauma are treated as they have unstable spinal injuries until formal clearance procedures have been completed. Induction of anaesthesia, laryngoscopy and intubation of these patients is challenging and should be attempted only by those with appropriate training and competency.

**References**

1. Nolan JP. Prehospital and resuscitative airway care: should the gold standard be reassessed? *Curr Opin Crit Care* 2001; 7: 413–21

Please see multiple choice questions 25–27.