Review Article

Emergency management of the airway outside the operating room

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Successful emergency airway intervention incorporates the anaesthetist's basic skills in airway management with the knowledge of the special nature of the clinical problems that arise outside the operating room. While a thorough but rapid evaluation of the key anatomical and physiological factors of an individual patient may result in an obvious choice for optimal management, clinical problems often arise in which there is not an evident "best approach." In these less clear-cut situations, the anaesthetist may do well to employ those techniques with which she/he has the greatest skills and experience. At times, however, some degree of creative improvisation is required to care for an especially difficult problem.

En situation d'urgence, le contrôle efficace de l'intégrité des voies respiratoires fait appel aux connaissances fondamentales de l'anesthésiste et exige en plus l'identification des problèmes particuliers qui ont précédé l'entrée en salle d'opération. Bien qu'une évaluation rapide des facteurs anatomiques et physiologiques essentiels propres à une condition spéciale puisse conduire à un choix évident pour une prise en charge optimale, des problèmes cliniques qui rendent ce choix moins certain se révèlent souvent leur apparition. Dans ces situations pour le moins douteuses, l'anesthésiste serait mal avisé de d'utiliser des techniques avec lesquelles il est moins familier. Cependant, occasionnellement, il devra faire usage de son imagination et improviser pour solutionner un problème particulièrement difficile.

Key words

AIRWAY: management, obstruction;
INTUBATION, TRACHEAL: technique.

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Infectious risks to the anaesthetist

The anaesthetist is called upon to manage the airway in a variety of different clinical environments unrelated to the performance of general anaesthesia. Optimal management of the airway in each of these situations requires insight into the disease processes which are present as well as an understanding of the implications of the therapeutic interventions. The acute management of the airway by the anaesthetist can be difficult and challenging because the clinical problems may differ considerably from those dealt with in the controlled environment of the operating room.

Emergency management of the airway

General considerations

The performance of tracheal intubation in the emergency room is not always simple. The complication rate is high and is not necessarily reduced when more experienced personnel are available.¹ The underlying diagnosis and condition of the patient on admission appear to be the most important factors relating to ultimate outcome.

A variety of clinical situations arises which necessitates an airway consultation. Assessment of the general level of consciousness, presence or absence of ventilatory drive, and patency of the airway are essential initial steps well known to the practicing anaesthetist. The results from these determinations will dictate the required urgency of action. It is important to note that intubation may not always be required because simple and basic airway manoeuvres may not have been tried by other health care professionals. Accordingly, initial intervention may include basic airway manoeuvres to rule out the presence of a foreign body or simple soft tissue upper airway obstruction, as well as bag and mask ventilation to assure airway patency. These may be accompanied by attempts to arouse the unconscious patient in an effort to stimulate ventilation. Failure of such manoeuvres should trigger an appropriate sequence to assure oxygenation, ventilation and airway protection. In the majority of these cases, tracheal intubation will be necessary. A complete review of the general approach to the airway is unnecessary. The well known principles of airway evaluation, compulsive preparation, monitoring, and technical procedures must be carefully applied when outside the operating room.²

The ability to manage the airway requires technical skills but is also strongly based on anticipating the potential consequences of the various manoeuvres on the cardiovascular system, intracranial pressure dynamics, and the respiratory system, thereby minimizing any adverse physiological sequelae. A variety of technical and pharmacological approaches must be considered rapidly in the treatment of each patient.

The philosophy of the approach to the airway outside the operating room is highly dependent on the local hospital situation. In our teaching hospital, residents answer emergency consultations and are strongly encouraged to manage the airway with local anaesthesia, minimal amounts of sedation and very infrequently, muscle relaxants. They are also encouraged to call for more senior help if the situation is extremely difficult and/or relaxants appear to be indicated. A second pair of educated hands may be beneficial in these situations. On the other hand, experienced clinicians may prefer to employ the classic rapid sequence approach to intubation in this setting. As in the operating room, it must be kept in mind that one may

be left with a patient whose lungs cannot be ventilated by mask and whose trachea cannot be intubated after relaxants have been given.³ Unlike the operating room, neither the people nor the equipment needed to manage this situation may be available. Overall, we believe that a conservative approach which spares the ability of the patient to breathe spontaneously is safest.

LOCAL ANAESTHESIA

Although airway anaesthesia may not be required in extremely obtunded patients, the ability to block sensation from the oropharynx and larynx is a skill which may be sufficient to permit intubation. Simple topical anaesthesia is applied effectively with a 10% lidocaine spray. Blockade of noxious sensory stimuli can blunt the hypertensive response and increase intracranial pressure often associated with laryngoscopy and intubation. A shortcoming of topical anaesthesia is the failure to anaesthetize the mechanoreceptors at the base of the tongue which are responsible for much of the gagging and discomfort during laryngoscopy. Bilateral glossopharyngeal blocks are helpful as they serve to interrupt both innervation of these mechanoreceptors as well as sensation over the tongue and pharyngeal mucosa.⁴ This block is performed bilaterally by injection of 2 ml lidocaine 2%, 0.5 cm lateral to the edge of the tongue where it forms the palatoglossal arch (Figure 1). With practice, this block can be performed rapidly and adapted for use in such emergency settings to provide blockade of deep pressure sensation in the tongue not provided by other glossopharyngeal block techniques. Laryngotracheal spray or translaryngeal anaesthesia is effective, rapid and easy to perform. The use of nebulized lidocaine may be effective if secretions are absent or have been controlled with antisialagogues.⁵ However, nebulization requires extra time and special equipment which may not be available. Other techniques of topical anaesthesia with slurries and gels require a high level of patient cooperation.

SEDATION

Intravenous sedation is often utilized as an adjunct for airway management, particularly in awake patients. Sedatives may blunt discomfort, airway reactivity and haemodynamic effects. No single medication is ideal for all situations.

Narcotics are a useful group of drugs for "out of operating room" airway management. They serve well to alleviate some of the pain associated with manipulation of the upper airway and larynx and also block cough reflexes elicited by intubation. The introduction of a short-acting agent, alfentanil, as well as the availability of antagonists such as naloxone, provide an element of safety not present with other drugs. Fentanyl is often used carefully in 25–50

FIGURE 1

μg increments with meticulous observation for possible adverse responses. However, it is important to recognize that narcotics may predispose the patient to the risks of pulmonary aspiration by means of their ability to blunt the laryngeal closure reflex.⁶

Benzodiazepines are effective anxiolytic drugs and have been used extensively for conscious tracheal intubation in the operating room. The introduction of a specific antagonist, flumazenil, may allow for more liberal use of these drugs in other situations. Anxiolysis and amnesia are less important in the urgent or emergency situation and these drugs are less effective and predictable at producing rapid sedation when compared with other drugs. It should also be noted that when benzodiazepines are combined with narcotics, dangerous degrees of sedation may be achieved. Although the combination does not result in any additional depression of ventilatory response to carbon dioxide than the opioid alone, more apnoea and hypoxia may occur than with either drug alone.⁷

The hypnotic drugs commonly used for anaesthetic induction are in a class of drugs whose use in a rapid sequence scenario is obvious. However, in small doses they may be useful in other settings. The careful titration of sedative doses further enhances their relative safety because of the rapid redistribution which characterizes the elimination of these drugs from the central nervous system. One must always balance the respiratory depression with the benefit from the anticipated sedative effects. Thiopentone, methohexitone, etomidate and propofol are

all equally useful. Individual differences between these drugs are undetectable when used in small sedative doses.

Ketamine also deserves some consideration because of its profound analgesic effects, maintenance of respiratory drive, and relative sparing of airway protective reflexes when used in small doses. Droperidol, though commonly used in the operating room environment for its ataractic effects, is rarely helpful and suffers from a lack of reversibility, long half-life, and high incidence of dysphoric reactions.

The use of any sedative demands attention to the possibilities of vomiting with subsequent pulmonary aspiration. Use of cricoid pressure may be considered but only with caution to avoid gagging as a result of excessive pressure on the larynx.

Confirmation of intubation

Confirmation of tube placement within the trachea is important immediately following intubation. The numerous reports of undetected oesophageal intubation in the operating room under ideal conditions underscores the fact that correct tube placement is not trivial.⁸ The lack of reliability of the physical examination has led to the gradual acceptance of capnography as the "gold standard" for confirmation of tube placement. Such devices are usually not available in the emergency ward or in critical care units and thus one must rely on physical examination.

Direct visualization of the tube as it passes through the vocal cords is one of the best methods available but is less reliable if movement of the tube occurs before it is secured. Chest movement may be a helpful sign but its observation is hindered in the obese patient or in women with large breasts. Similarly, the barrel chest of chronic obstructive pulmonary disease obscures most of the chest expansion associated with ventilation of these patients. Indeed, there are reports of chest movement being observed when the oesophagus is intubated.⁹ Auscultation of breath sounds over the chest and the lack of sounds over the epigastrium are the most commonly employed techniques. Numerous cases have been reported where such measures have failed to identify oesophageal intubation, often because of extraneous noise which is in many areas in which such emergency airway intervention is required. The tactile sensation of the reservoir bag for the return of the expired tidal volumes can aid the experienced practitioner, while other signs such as condensation within the tube and palpation of the tracheal cuff in the neck may also be suggestive of proper placement.¹⁰ Used collectively, these methods can usually lead to the correct assessment. A slight degree of doubt may be helpful as it forces continued observation and reevaluation which may lead to prompt removal and replacement of the endotracheal tube if necessary.

FIGURE 2

FIGURE 3

A device has recently been described which is simple to use and can reliably differentiate oesophageal from tracheal intubations.^{11,12} A 60 ml catheter-tip syringe is attached to an endotracheal catheter mount which is fitted to a 15 mm right angle connector which readily attaches to the end of an endotracheal tube (Figure 2). Rapid aspiration on the syringe immediately following placement will meet with no resistance when the tube is properly placed within the respiratory tract. Oesophageal placement will lead to collapse of unsupported mucosa against the end of the tube and the sensation of resistance during aspiration of the syringe plunger. Such a device is portable and could be made available in numerous locations as well.

Whereas capnometers are stationary devices, there are commercially available carbon dioxide (CO₂) detectors that are battery powered and portable (Figure 3). These employ infrared detectors which are sensitive to expired levels of 2% CO₂ or greater. They may be carried to the site of an emergency intubation and utilized to confirm proper tube placement.¹³

FIGURE 4

Another device specific to carbon dioxide in expired gas is the colourimetric device manufactured by Nellcor (Easy Cap end-tidal carbon dioxide detector, Nellcor Incorporated, Hayward, CA)¹⁴⁻¹⁶ (Figure 4). It is packaged in an air-tight pouch and when opened produces obvious colour changes in the presence of CO₂. These changes occur relatively rapidly and provide a semiquantitative reading. The device attaches easily to the end of an endotracheal tube and, although it has a dead space of 38 ml, it can be left in place as an "elbow" for an indefinite time. The reliability of this monitor has recently been questioned.¹⁷ As with other portable CO₂ detectors, several caveats should be considered. First, previous mask ventilation or ingestion of a carbonated beverage or antacid may have led to the presence of carbon dioxide in the stomach and an oesophageal intubation could lead to the return of gas containing CO₂.¹⁸ As several breaths may be required to expel this gas, measurement following these initial breaths eliminates this potentially confusing variable. Second, extremely low cardiac output can lead to a low or absent level of CO₂ in the expired gas despite the correct placement of the tube. Finally, severe airway obstruction or malfunction of the detection apparatus can also lead to spuriously low CO₂ concentrations with a properly placed endotracheal (ET) tube.

Another method for reliable confirmation of intubation is the use of a fiberoptic bronchoscope, when available. Visualization of tracheal rings and the bifurcation at the carina provides absolute proof of correct positioning when seen through the ET tube.

Specific clinical situations

Upper airway obstruction

Occasionally, patients suffer airway compromise during a brief reversible event and can be managed with basic

airway manoeuvres or bag and mask ventilation. Examples include an epileptic seizure or a quickly treated ventricular dysrhythmia producing unconsciousness. Regardless of whether tracheal intubation is required, patients must be transferred to a nursing unit capable of providing close attention and supervision. Firm indications for ET tube placement include the need to assure airway patency and protection, to provide adequate ventilation and oxygenation, and control of secretions. Temporary airway management with bag and mask or other techniques when possible may allow more time to achieve optimal safe conditions for ET tube insertion.

Upper airway obstruction is a common indication for airway management consultation. The spectrum of causes ranges from foreign body or tumour to obstruction by existing tissues of the airway. Obstruction may be incomplete and present as noisy or laboured breathing which might be misdiagnosed as bronchospasm or it may be complete with paradoxical respiratory movements of the chest and abdomen. Actual respiratory arrest may follow shortly after development of complete upper airway obstruction.

The initial approach to intervening in the case of airway obstruction begins with examination of the airway to ensure the absence of foreign matter and basic manoeuvres to establish airway integrity. These latter manoeuvres include jaw thrust, chin lift or repositioning of the head if not contraindicated by the possible presence of cervical spine injury. Often the obstruction is primarily the result of posterior displacement of the tongue or soft palate in an obtunded patient and is quite responsive to these basic manoeuvres or the simple addition of an oral or nasal airway.

The airway may be obstructed extrinsically by abnormal swelling or enlargement of adjacent tissues or intrinsically by swelling of airway tissue. The latter often results from inflammation secondary to mechanical or thermal trauma, infectious agents, or an allergic reaction.

Extrinsic airway compression

A haematoma in the neck may be seen in the trauma patient and is common after thyroid and carotid artery surgery when it is a true emergency. Though the latter is often encountered in the recovery room, it is still a late possibility brought on by violent coughing or manipulation of a wound such as during drain removal. The obstruction is treated, when possible, by immediate removal of sutures in an attempt to allow escape of blood from the wound. Often this is not possible and urgent intubation is required prior to transfer to the operating room for re-exploration of the neck. Rapidly expanding haematomas may obliterate recognizable airway anatomy and precludes swift intubation by even the most skilled practitioners. In this case, the creation of a surgical airway may be necessary.¹⁹

Inflammatory causes of extrinsic airway obstruction include Ludwig's angina and retropharyngeal abscess. Ludwig's angina is classically defined as an infection, usually cellulitis, involving the submaxillary, sublingual and submental spaces with elevation of the base of the tongue. Any swelling in the suprahyoid space may cause extreme firmness of the tissues of the floor of the mouth and forces the tongue upwards and posteriorly to cause the obstruction. Laryngoscopy may be extremely difficult because of an inability to displace the tongue. Use of a Miller blade along the side of the tongue and manual deviation of the larynx posteriorly and to the side may allow visualization of the glottis. Usually, however, a tracheostomy is necessary when a mechanical airway is required.²⁰ A retropharyngeal abscess may obstruct the upper airway as well but does not pose as much difficulty for intubation prior to surgical therapy for the condition. The trachea should be intubated with the patient in a head down and lateral position to prevent aspiration of purulent material. When the situation is not immediately life-threatening, fiberoptic bronchoscopy can be used to establish the aetiology of the obstruction. An ET tube may then be passed over the scope should intubation be necessary.²¹

Intrinsic airway compression

EPIGLOTTITIS

Acute inflammation of upper airway structures leading to obstruction is a well recognized clinical entity in paediatric practice. Though much more rare in adults, acute epiglottitis does occur.^{22,23} It is a disease of supraglottic structures capable of rapid progression to complete airway obstruction. Unfortunately, misdiagnosis and inappropriate treatment have resulted in a high mortality (approaching 6%) in adults.²⁴ Obstruction may occur as a result of laryngeal obstruction by the swollen epiglottis or laryngeal spasm secondary to secretions not excluded by a dysfunctional epiglottis. Respiratory arrest can occur secondary to fatigue if the process persists without intervention. Sore throat and dysphagia may be present before presentation and are out of proportion to findings on examination of the posterior pharynx. The voice is muffled but not hoarse. Respiratory distress may or may not be present. Diagnosis is best made by direct visualization. X-ray evaluation is insensitive and may be dangerous if the patient leaves the presence of personnel capable of managing the airway in the event of obstruction. Indirect laryngoscopy is probably safe though others may elect to perform flexible fiberoptic rhinolaryngoscopy which is better tolerated by most patients. The most conservative approach is immediate transportation to the operating room for performance of direct laryngoscopy. Positioning during transport is highly important since the supine

position may well result in obstruction. Intubation may be more difficult in the adult with epiglottitis than in a similarly affected child because of the sheer bulk of airway tissue. Conscious intubation represents the safest approach. Inhalational induction of general anaesthesia is possible although in adults may require a long time. Rapid sequence induction with the use of relaxants may be quite dangerous and may result in the need for the urgent creation of a surgical airway. Fiberoptic intubation requires a skilled practitioner to navigate around the swollen airway structures and thus may not be practical. A surgeon should be in attendance to perform a tracheostomy if necessary. Often, this latter option represents the soundest initial approach.

BURNS

Oedema of the upper airway structures in response to local and systemic injuries is another common cause of upper airway obstruction. Direct mechanical trauma is one obvious cause particularly when it involves upper airway structures directly. Burn trauma is more complex in that it represents more of a threat to the patient than is perceived on initial examination of the patient. Management of the airway in the burned patient requires extreme vigilance and an understanding of potential complications.²⁵ There are four causes of early respiratory compromise in such patients. *Carbon monoxide (CO) poisoning* is the most important to consider initially and must be suspected in all burned patients. Symptoms include headache, nausea and shortness of breath, while signs may include tachypnoea, irritability or delirium. Cyanosis will be masked by the cherry red colour of carboxyhaemoglobin. Carbon monoxide poisoning cannot be diagnosed by arterial blood gas measurements or by pulse oximetry.²⁶ Diagnosis requires direct measurement of carboxyhaemoglobin by a co-oximeter. Toxicity begins at a level of 15% and becomes lethal at about 50%. Therapy requires oxygen administration which should be started in all burned patients as soon as they are seen. Use of a nonrebreathing mask or delivery of 100% oxygen via an ET tube will reduce the half-life of CO unbinding to about 40 min from the approximately four hours required with room air.^{27,28}

Careful assessment of the adequacy of the upper airway is undertaken next to rule out the second major cause of respiratory compromise, *upper airway obstruction*. Obvious upper airway burns characterized by singed nasal or facial hairs, carbonaceous material in the mouth or pharynx, and burned skin on the face and neck may present with early airway compromise. Stridor or hoarseness are additional signs of such involvement. Immediate intubation is indicated in these cases. Less severe injuries, however, may be quite subtle and insidious in onset. In addition, oedema of the upper airway structures despite the

absence of direct thermal injury to the airway may occur as a side effect of the massive amount of fluid resuscitation which the patients require. Prudent management of the severely burned patient usually dictates the need for intubation early in the course of therapy regardless of the apparent adequacy of ventilation and oxygenation. Intubation also prevents the insidious development of upper airway obstruction. Too often oedema will develop, prevent adequate visualization of the larynx, and necessitate a surgical airway.

The other two causes of respiratory compromise in burn patients are *chest wall restriction* due to burn eschar and subglottic thermal or chemical burns which lead to *tracheobronchial damage* and subsequent respiratory failure. The former must be managed by surgical escharotomy which may dramatically improve ventilation. The problem of inhalation injury to the lungs is of great importance as it adds to mortality.²⁹ Diagnosis is based on clinical suspicion and examination. Admission chest x-rays, arterial PO₂, and auscultation are not helpful predictors of subsequent respiratory difficulty.³⁰ Early intubation (with a 7.5 mm or larger ET tube) facilitates fiberoptic bronchoscopy which allows for accurate diagnosis.^{31,32} Damage to the lower airway leads to oedema, bronchospasm, decreased pulmonary compliance and poor mucociliary clearance. Intubation provides therapeutic access to the respiratory tree for mechanical ventilation, delivery of aerosolized drugs and pulmonary toilet.

Other causes

Other causes of upper airway obstruction are less common but should be considered. These include bilateral vocal cord paralysis or severe laryngeal oedema, both of which are more likely in the postoperative patient, and laryngotracheal stenosis in patients with previous history of prolonged intubation.³³⁻³⁵ These conditions require placement of an appropriately sized ET tube as a short-term solution. Rarely a patient with severe hypocalcaemia will experience laryngospasm secondary to secretions or other noxious laryngeal stimulation which will require intervention. As in the operating room, this should be managed with positive pressure by mask for incomplete spasm and with the use of relaxants for total obstruction.

SECRETIONS/BLOOD

Secretions, and even more so blood, may impair the ability to ventilate and cause airway obstruction when present in large amounts. Upper gastrointestinal bleeding and haemoptysis may be initially indistinguishable in a patient in respiratory distress who is coughing or sputtering with blood in the airway. The approach to both is identical and involves removal of blood and secretions from the airway and provision of adequate ventilation and oxygenation.

Blind passage of an ET tube into either the oesophagus or trachea is a reasonable initial step if definitive visualization is impossible. Such a tube would stop or divert the escape of blood from the gastrointestinal tract and thereby allow the larynx to be visualized and the trachea intubated if necessary. Initial placement of the tube in the larynx would, of course, eliminate the need for passage of the oesophageal tube.

Uncontrollable haemorrhage from the respiratory tract is often fatal, even in the presence of tracheal intubation, unless the bleeding can be managed quickly by a manoeuvre such as endobronchial intubation of the uninvolved side. Other tools such as bronchial blockers, double lumen tubes, rigid bronchoscopes and the like are not readily available in settings outside of the operating room. Even when successful isolation of the affected bronchus is accomplished, results are often poor. Asphyxiation is the major risk and its treatment is often best accomplished with the largest single lumen tube available which provides the best means for removal of blood and secretions from the airway between breaths. If it is known from which bronchus the blood originates, the patient can be positioned with the bleeding lung dependent.

Pharmacological intervention, particularly neuromuscular relaxants, may be required to obtain control of the airway and facilitate tracheal intubation, but caution is advised. Whereas paralysis will stop active vomiting of blood from the stomach or lower oesophagus, it will not stop the flow of blood from the upper oesophagus or airway. Cricoid pressure may alleviate the oesophageal source of blood. Paralysis also removes the patient's ability to breathe and cough and may convert a precarious situation into a life-threatening one.

Bleeding from the upper airway, particularly the nasopharynx, should be considered as well. The diagnosis is more easily made and is usually known from the patient's history. Cessation of bleeding is often possible with nasal packing. Posterior nasal packing in the face of active bleeding is difficult and interferes with the patient's ability to protect the airway. While intubation is rarely necessary, it is important to realize that the patient may be at risk from aspiration, hypoxia and hypovolaemia. Posterior nasal packs and balloons may impair swallowing mechanisms, especially if improperly placed. In addition, it has been shown that such patients are at further risk of hypoxia and must receive supplemental oxygen.^{36,37} When intubation is necessary, it should be approached with at least one assistant and adequate equipment. Two powerful suction lines with appropriate attachments are suggested. The supine or Trendelenberg positions will keep blood away from the airway and provide some additional safety in the event of vomiting. When proper packing devices are not available, a nasal ET tube which is pulled back into the

nasopharynx with its cuff inflated may temporarily divert the flow of blood. Once oral intubation is accomplished, nasal packing may proceed with the assurance of adequate oxygenation, airway protection and with the added ability to sedate the patient.

Drug overdose

A patient with acute drug intoxication may require tracheal intubation for protection and maintenance of the airway (especially during gastric lavage), control of secretions, and/or to provide mechanical ventilation. A decreased level of consciousness may blunt airway protective reflexes and place such patients at risk for aspiration pneumonia. Similarly, the use of therapeutic gastric lavage or emetic drugs to limit the gastric absorption of ingested drug may necessitate intubation for airway control. In the patient who is nearly or completely unresponsive, the trachea can be intubated with simple oral direct laryngoscopy. On the other hand, the alert patient may be observed for signs of deterioration in mental and/or respiratory status. The agitated, overdosed patient presents the greatest difficulty in airway management because he cannot cooperate during conscious intubation with local anaesthesia and is not sufficiently obtunded that intubation can be accomplished without further sedation or anaesthesia. Blind nasotracheal intubation may often be accomplished in the modestly uncooperative patient. Profound respiratory depression may impair the ability to perform blind nasal intubation easily because of the absence of airway sounds. Other techniques include the use of succinylcholine-assisted orotracheal intubation rather than repeated attempts with the blind nasal approach since the latter can be unsuccessful, time-consuming and result in epistaxis, vomiting, and aspiration. Succinylcholine-assisted intubation is more successful and is rapidly accomplished.³⁸ The decision to use succinylcholine is influenced by the ability to assess the airway and on the lack of contraindication to the drug. Success with relaxants in the emergency room is not always achieved.³⁹ Inability to intubate and a need to create a surgical airway has been complicated by vomiting and aspiration following the use of succinylcholine in such patients.⁴⁰ Fibre-optic, lighted stylet, and other techniques (retrograde, blind oral, tactile) for intubation are quite appropriate in these situations and may be safer than techniques requiring relaxants.

CARDIO-PULMONARY ARREST

Emergency airway interventions during cardiac arrest are usually straightforward. However, some patients with profound cardiovascular collapse may be rapidly resuscitated, regain consciousness and not require tracheal intubation. It may be possible to manage the airway with

basic manoeuvres to alleviate upper airway obstruction and assist ventilation by mask.

When intubation is required, the procedure can almost always be performed without the aid of muscle relaxants. The presence of hypoxia or the unconsciousness which accompanies a cardiac arrest usually provides conditions suitable for intubation without the administration of other drugs. This is fortuitous as it may be impossible to obtain a history and to rule out major contraindications to succinylcholine. Nondepolarizing relaxants are required rarely but their use precludes neurological assessment and other clinical indicators of successful resuscitation.

Cardiac arrest and active resuscitation make the management of the airway more difficult. The patient will be receiving chest compressions and the associated movement will introduce technical difficulties with visualization of the larynx caused by bed height, body positioning, or simply excessive motion. Aside from temporary cessation of compressions, not much can be done to facilitate intubation. The other major difficulty in these situations concerns confirmation of intubation. Adequacy and symmetry of breath sounds may be extremely difficult to determine and even sophisticated methods of carbon dioxide detection may be flawed by the lack of adequate cardiac output.

Trauma

HEAD INJURY

The patient with severe acute head injury requires airway intervention under most circumstances. Those patients who are awake and alert and have a Glasgow Coma Scale (GCS) score of 13 or higher will not require immediate attention but a small number will deteriorate later in their hospital course. In one series 3% of such "stable" patients required emergency craniotomy.⁴¹ Patients with an intermediate range of function (GCS 7–11) will often require tracheal intubation. Indications for airway intervention include the need for therapeutic hyperventilation to prevent or treat intracranial hypertension, the delivery of adequate supplemental oxygen and protection of the airway from aspiration or obstruction. Those patients with severe injury and extensive neurological dysfunction (GCS 3–6) require immediate tracheal intubation because hypercarbia and hypoxia places them at risk for secondary neurological injury from intracranial hypertension and local cerebral ischaemia.^{42,43}

Other airway management considerations in patients with head injury include the presence of facial fractures, cervical spine injury, basilar skull fracture and CSF leak as well as the status of the cardiovascular system and the quality of other vital signs. The incidence of cervical spine injury in these patients has been reported to be high but, in fact, is not different from that in the trauma patient without

head injury.^{44,45} Standard concerns in emergency patients such as full stomach and the possibility of unfavourable airway anatomy must always be considered.

A deeply comatose patient will require immediate therapy. There is little or no time to rule out cervical spine instability or basilar skull fracture, or for pharmacological manipulations. A prompt decision on the best approach for intubation is required. The most logical approach is oral intubation with manual in-line stabilization of the neck by a dedicated assistant. Mask ventilation should precede the attempts with some modification of usual manoeuvres to avoid excessive cervical motion. Head tilt and aggressive chin lift are unsatisfactory options but jaw thrust or modified chin lift appear to be quite safe. Cricoid pressure may be appropriate. Failure to intubate must be followed by establishing a surgical airway if ventilation is not possible. Mannitol should be considered and it may be started concomitantly with airway intervention to reduce brain water and hence ICP osmotically and possibly to reduce blood viscosity and increase free radical scavenging. Mannitol use may be contraindicated in fluid-overloaded patients or patients with renal failure and hyperosmolality. Hyperventilation, slight head elevation, intravenous mannitol, and diagnostic and therapeutic procedures should follow the airway intervention immediately.

It is the less severely injured patient with an intermediate GCS score that demands a thoughtful approach to airway management. These patients can be stabilized and observed while considering available options. Prevention of hypoxia and hypercarbia are important. Unrecognized upper airway obstruction in patients initially deemed stable is preventable. Irregular breathing patterns are also common and one must be alert for a sudden depression of central respiratory drive.⁴⁶ Many patients experience episodes of hypoxia immediately after arrival at the hospital because of ventilation-perfusion mismatch.^{47,48} Aspiration of gastric contents at the time of injury is not uncommon and may present as an increasing alveolar-arterial gradient later in the course of therapy.⁴⁹ Unrecognized neurogenic pulmonary oedema is also a possibility.⁵⁰ One cannot assume that oxygenation is adequate merely with the provision of supplemental oxygen and the presence of an ET tube.⁵¹ Continuous pulse oximetry monitoring should be utilized for these patients.

The effective approach to the patients with head injury necessitates an understanding of their particular risk factors. It is assumed that such patients have brain swelling and/or intracranial bleeding. Such conditions imply increased intracranial elastance (decreased compliance) and thus represent considerable risk factors for any manoeuvre which further increases intracranial volume. The determinants of intracranial volume involve the contribution of brain tissue, cerebrospinal fluid and cerebral blood volume. Hypoxia and hypercarbia initially

exert their adverse effects via increased cerebral blood volume but continued hypoxia will result in cytotoxic brain oedema as well.⁵² Precise control of blood pressure is important, particularly the prevention of acute increases in blood pressure during intubation. These may lead to sudden increases in ICP before cerebral autoregulation (if still intact) can compensate. Laryngoscopy alone may produce increases in ICP.⁵³ Gentle and skillful manipulation can reduce but not eliminate the increase in ICP. Pharmacological interventions are needed to blunt the effects of intubation. Thiopentone and lidocaine are the two most effective agents for this purpose.^{54,55} Etomidate may be particularly effective in the trauma setting as it would be less likely to decrease mean arterial pressure than thiopentone and cerebral perfusion pressure is better maintained.⁵⁶ Coughing and bucking on an ET tube may lead to pronounced ICP elevation by increasing the cerebral venous and CSF volumes and should be minimized.⁵⁷ Adequate sedation may accomplish this goal but often complete paralysis is necessary.

Much controversy surrounds the use of neuromuscular relaxants and their effect upon ICP, particularly in the patient who exhibits intracranial hypertension. Nondepolarizing relaxants have minimal or no effect on ICP but the delay required for their effects can lead to hypercarbia or hypoxia if ventilation is inadequate.^{58,59} In the emergency setting, succinylcholine facilitates intubation most expediently but can cause rises in ICP in the presence of increased intracranial elastance.^{60,61} It has been shown that pre-treatment with a nondepolarizer such as metocurine (2.0 mg *iv*) can blunt or eliminate this phenomenon but this required waiting 3–4 minutes.⁶² The choice of succinylcholine is made in an urgent situation where the anticipated mild and transient increase in ICP is clearly less of a concern than other potential problems facing the patient. Hyperkalaemia due to succinylcholine is not reported to occur in the acutely (<24 hr) injured patient.

FACIAL TRAUMA

Trauma to the face which results in mandibular or maxillary fractures may have considerable airway management consequences. Blood loss may be large and may overwhelm the ability of awake patients to protect their airways. Unconscious patients often have aspirated large amounts of blood into their tracheobronchial trees. The presence of loose teeth must also be noted and considered as a potential risk for aspiration and subsequent complications. Upper airway obstruction may be due to posterior displacement of soft tissues which have lost their normal support from intact bony structures. Simple forward displacement of a fractured mandible or maxilla may temporarily relieve airway obstruction and improve ventilation.

Mandibular fractures are often associated with trismus

or pain which precludes adequate patient cooperation for visualization of the airway. The use of relaxants will alleviate trismus and allow sufficient mouth opening to permit intubation. However, mechanical prevention of mouth opening (e.g., by a fragment of bone) will not be relieved with the administration of muscle relaxants and a life-threatening situation may develop. If the mouth cannot be opened, the use of a relaxant should only be considered when measures to alleviate upper airway obstruction have been unsuccessful and when one is prepared to proceed to a surgical airway if necessary. The availability of good suctioning equipment is essential since the hypopharynx can be full of blood.

Maxillary fractures are less commonly associated with mechanical airway obstruction but bleeding is a major concern. Use of nasotracheal intubation is relatively contraindicated due to concerns about initiating bleeding. However, the presence of a cervical fracture occasionally leads one to consider the nasal route even in the presence of a maxillary fracture. Cricothyrotomy may be considered when the two injuries coexist, especially when the presence of a fracture considerably complicates the oral and nasal routes.⁶³ Also the possibility of basal skull fracture with loss of integrity of the cribriform plate must be considered. A nasal CSF leak may be difficult to detect in the supine patient. In the presence of basilar skull fractures nasogastric tubes and nasopharyngeal airways have been placed into the brain.^{64,65} Nasotracheal intubation can be safely accomplished in the face of basilar skull fracture, but should be attempted only if the alternatives are judged to be even more hazardous. The use of a soft red rubber catheter or fiberoptic bronchoscope as a flexible stylet and the correct horizontal and slightly caudad direction of insertion through the nose should allow the safe passage of an ET tube by the nasal route. Later development of sinusitis (or even meningitis) is a risk but should not preclude the nasal route for acute airway management. A nasal tube may later be changed to a tracheostomy or oral tube electively.³¹

CERVICAL SPINE INJURIES

Management of the airway in the traumatized patient can be difficult as some of the greatest concerns arise in the presence of real or suspected injury to the cervical spine. The cervical spine may be injured in any trauma patient though the overall incidence is less than 2%.^{66–68} Much is written about diagnostic techniques to rule out such injuries but there remain no completely effective and practical methods (clinical or radiological) to accomplish this goal.^{66,67–72} Indeed, there are numerous reports of injured patients with normal studies or missed diagnoses and some have suffered neurological damage following presentation to the hospital.^{69,73–75}

The aim of initial management is the prevention of

neurological injury from further movement at the site of cervical injury. It is important to know that the cervical spine immobilization techniques in common use are ineffective.⁷⁶ Even the best method utilizing bilateral sandbags and tape still allows 35% of normal extension. In addition, common airway manoeuvres can lead to undesirable motion and initial approaches may need to be altered.^{67,77-79} Motion of the neck occurring during laryngoscopy cannot be completely prevented. Axial traction may distract a fracture site and is not to be recommended as a means to stabilize all cervical spine injuries during intubation.^{78,79} In-line manual stabilization of the head and neck by an assistant is the approach most likely to minimize motion during any and all airway manoeuvres.

While these studies suggest that extreme danger is associated with airway interventions in the presence of spinal injuries, a number of other studies, as well as common sense, are more reassuring.^{66,80,81} Although there are many patients who have been injured by manipulation of the neck when an injury was unsuspected or missed, it is also true that a far greater number of patients has managed to escape such injury.^{66,71,80-83} Many authors suggest oral endotracheal intubation while the neck is stabilized by an assistant.⁸⁴⁻⁸⁷ Pharmacological agents such as hypnotics, sedatives or relaxants are very helpful but must be used judiciously in the hypovolaemic patient.⁸⁷ Two large series have failed to produce evidence of any adverse outcome when such an approach is undertaken in patients later shown to have been at risk for secondary neurological injury due to instability of the cervical spine.^{84,87} Oral intubation with stabilization of the spine and the possible use of pharmacological agents is the approach of choice in the traumatized patient in extremis due to apnoea, hypoxia or cardiac arrest. The use of relaxants in this situation has been debated. Some have argued that the cervical muscle spasm which accompanies a spinal injury is protective as it "splints" the unstable spine. A stronger argument can be made for the use of relaxants in those patients who are responsive enough to offer resistance to airway intervention.⁸⁸ Violent neck movements or forces leading to distraction of the splinted neck are possible in the patient who attempts to move in an effort to avoid intubation or in response to the noxious stimulation of intubation.

Other options should be considered when intubation is not an urgent need. A variety of other approaches is available. The goal will remain to minimize or eliminate cervical spine movement. *Conscious nasotracheal intubation* is a reasonable choice in the trauma setting. Relative contraindications include severe maxillofacial or basilar skull fractures, coagulopathy or anatomical abnormalities. Blind intubation is more difficult if spontaneous ventilation is not present and in the alert patient with intact

FIGURE 5

protective airway reflexes. Most practitioners find that neck manipulation greatly increases their success rate at nasal intubation and this, of course, is not an option in these patients. The use of an Endotrol tube[®] (Mallinckrodt Critical Care, Glens Falls, N.Y.) obviates the need for neck manipulation by providing a means to flex the tip of the nasotracheal tube and help direct it towards the larynx (Figure 5). O'Brien *et al.* reported a success rate of 95.7% with blind nasal attempts in their series of trauma patients while only 3 of 70 patients suffered a complication such as epistaxis or nasal mucosal contusion.⁸⁹ A portion of their success was credited to the extensive use of Endotrol tubes. The patients requiring intubation had reduced levels of consciousness and often lacked airway protective reflexes. Others have not been as successful at nasal intubation. Dronen and colleagues reported only a 65% success rate with nasal intubation in their population of obtunded patients and a very high complication rate. Epistaxis occurred in 69% of the patients and others experienced vomiting and aspiration.³⁸ While these were not trauma patients, their reduced levels of consciousness simulated the findings in the neurologically impaired trauma patients reported by O'Brien.⁸⁹ An intermediate complication rate is probably more consistent with the experiences of most anaesthetists. The lack of success by Dronen *et al.* may have been related to the unavailability of manoeuvrable tubes although differences in degrees of airway protective reflexes cannot be ruled out. Danzl and Thomas reported on 300 consecutive nasotracheal intubations in the emergency room and achieved a 92% success rate.⁹⁰ They made generous use of transalaryngeal topical local anaesthetic to obliterate airway protective reflexes, a practice which increases the patient's risk for aspiration if intubation is not accomplished rapidly.

Fibreoptic nasal intubation is perhaps the ideal tech-

nique in the trauma setting since it allows intubation without neck movement. Topical anaesthetics can be sprayed through the scope directly onto the vocal cords and into the trachea and can greatly facilitate the procedure. The increasing availability of these instruments and increased experience with their use may some day result in fiberoptic intubation becoming the treatment of choice. However, in most emergency facilities, a bronchoscope is not available. In addition, this is often a time-consuming approach in the hands of inexperienced operators. The presence of blood and secretions can interfere with or even prevent timely intubation.

Other techniques to consider are retrograde intubation and *light wand-guided oral or nasal intubation*. Riou *et al.* demonstrated that retrograde intubation can be performed in the setting of trauma and suspected cervical spine injury.⁹¹ Initially this technique was chosen after failure of conventional intubation techniques or because of a contraindication to nasal intubation. Later in the series, however, *retrograde intubation* was utilized as the initial approach when potential difficulty was anticipated.⁹² The procedure begins with puncture of the cricothyroid membrane and insertion of a wire (Seldinger technique) or catheter (through the needle technique) in a cephalad direction. It is retrieved through the oropharynx. Patients with large amounts of blood or secretions in the mouth are best approached using a catheter as air can be injected through the catheter to facilitate visualization of the tip. Bubbles will be seen to emanate from beneath the oropharyngeal fluids. Once the line is retrieved it is used to guide an endotracheal tube into the airway (Figure 6). The drum catheter CVP (Drum-Cartridge Catheter, Abbott Laboratories, North Chicago, IL) or a standard epidural needle and catheter can be used for either technique. Both contain wires within the catheters which provide for strength but can be removed if necessary for injection of air.

Use of the lighted stylet for the purpose of intubation is a technique which we recommend in the trauma setting.^{93,94} It does not require spontaneous ventilation and can be performed without manipulation of the neck. Most often it is accomplished orally although its use for nasotracheal intubation has been reported.⁹⁵ The nasal approach should employ the light wand designed for nasal use (Tube Stat[®], nasotracheal intubation stylet, Concept Incorporated, Clearwater, FL). Fox *et al.* reported a high degree of success and showed that intubation could be accomplished in one third of the time that it took for nasal intubation.⁹⁶ The technique was easily learned and was less traumatic than blind nasal intubation. After inserting the light wand into an endotracheal tube (cut to 26 cm length with the 15 mm connector removed), the bright tip is observed in the midline and the endotracheal tube is slid off into the

FIGURE 6

FIGURE 7

trachea (Figure 7). Forward traction on the tongue is helpful as is a darkened room. Stone has reported the use of a fiberoptic bronchoscope in place of a light wand.⁹⁷ In a case of attempted fiberoptic intubation deemed impossible due to impaired visualization by blood or secretions, the lighted tip of the bronchoscope may be left in place at the end of a standard length ET tube and used just as one would a light wand.

Another option which allows for intubation with minimal movement of the neck is *blind tactile intubation*.^{98,99} This works best in a patient lacking a gag reflex and without teeth. In addition, long fingers are essential and this may limit the number of individuals who can accomplish a digital intubation.

The final option to consider for the patient with suspected cervical injury is *cricothyrotomy*.¹⁰⁰⁻¹⁰² The American College of Surgeons recommends cricothyrotomy to be used only after failure to intubate but some clinicians recommend its more liberal use.¹⁰³ Too often cricothy-

rotomy is used as a last resort following a severe hypoxic insult. Brantigan and Grow were the first to show that the procedure can be performed safely and noted that its use in emergency situations did not lead to a higher likelihood of problems.¹⁰⁴ They reported a 6.1% complication rate in 655 procedures in the operating room or at the bedside. One quarter of their complications were due to bleeding which was relatively easy to control with a suture. Infections were rare. There were some cases of transient hoarseness and a few of late stricture as in any series of intubated patients. Unfortunately, the application of this technique to the trauma setting has not always been so successful. McGill *et al.* reported 14 immediate complications in 12 patients and this represented 32% of their studied population requiring an emergency surgical airway.¹⁰⁵ Late difficulties increased the complication rate to 39%. They reported very serious complications including incorrect siting or unsuccessful tube placement, severe haemorrhage and procedure time exceeding three minutes. It must be remembered that this technique may be more difficult than anticipated and must be initiated without hesitation when its use is required. In addition, while the technique avoids flexion or extension of the neck, it may involve more than a modicum of force and therefore is not entirely without risk of posterior displacement of the spine. Vertical and transverse incisions have been suggested with most surgeons favouring the latter.¹⁰¹⁻¹⁰³ As long as the incision is correctly placed over the cricothyroid membrane and not the trachea, the type of incision is unimportant as it does not need to be longer than a few centimeters. A 6.0 endotracheal tube will fit within the cricothyroid space in almost all patients but a smaller paediatric tube will suffice if difficulty with a larger tube is encountered.¹⁰²

LARYNGOTRACHEAL INJURY

Trauma to the larynx is a relatively unusual injury. Penetrating trauma is an obvious cause. Motor vehicle accidents involving deceleration may result in crushing of the larynx against the dashboard or steering wheel.¹⁰⁶ Motorcyclists or snowmobile riders may injure their airways by striking a clothesline or similar object. Hyperextension injuries may also disrupt the airway. Other portions of the airway, particularly the trachea and bronchi, can be disrupted by both blunt and penetrating traumatic episodes.¹⁰⁷ Laryngotracheal trauma can present diagnostic and therapeutic dilemmas. The condition may be immediately life-threatening or subtle and non-acute. The latter often leads to complacency on the part of physicians and may lead to improper care with resultant laryngeal damage and lifelong disability. Failure to recognize a subtle injury may allow cicatrization and airway narrowing or obstruction to occur at a later date.¹⁰⁸ Successful outcome

demand a prompt and skillful response from those involved early in the care of these patients.^{107,109}

Signs of laryngotracheal damage include subcutaneous emphysema, haemoptysis, hoarseness, inspiratory stridor, visible contusion or ecchymosis, and acute respiratory distress. Symptoms commonly encountered include localized pain and tenderness with palpation, as well as difficulty with breathing or swallowing.¹¹⁰ Pneumothorax commonly occurs with distal airway injuries.¹⁰⁷ A high index of suspicion results from knowledge of the circumstances of injury. Diagnosis relies on direct visualization of structures and radiological studies.¹¹¹

Most seriously injured patients require immediate airway intervention. It is also important to remember that there may be a concurrent cervical spine injury in these patients.¹⁰⁶ The correct approach to the injured airway is uncertain. Some argue that the damaged larynx should be avoided and that an emergency tracheostomy should be performed.¹¹²⁻¹¹⁴ Such a procedure will avoid further damage to injured mucosa and avoid compromising an already tenuous airway. Cricothyrotomy cannot be considered as it involves the larynx itself.¹¹⁵ Others argue for careful orotracheal intubation and claim the morbidity and mortality of emergency tracheostomy is too great.¹¹⁶⁻¹¹⁸

Orotracheal intubation is an acceptable approach in many circumstances but depends on the skills of the personnel. Intubation must proceed carefully and the use of a small ET tube is encouraged. The placement of a soft stylet or fiberoptic bronchoscope through the ET tube may help prevent disruption of mucosa or creation of a flap of airway tissue with a subsequent false passage. Unnecessary force should be avoided. Tracheostomy should follow if attempts at intubation are unsuccessful and cricothyrotomy should be used only as a last resort. Tracheostomy is a logical first approach in cases of obvious severe laryngotracheal disruption or penetrating injuries exposing a large opening in the trachea through which a tube could be placed. In a life-threatening situation, an externally visible tear can be enlarged as a direct access to the airway.¹⁰⁷ A large mucosal tear seen during laryngoscopy would also be an indication for establishing a surgical airway. Early consultation with ENT and chest surgeons should be sought.

Further evaluation of the injury with radiological techniques and direct operative visualization will follow early in the post-resuscitation phase of injury. Early repair when possible leads to better long-term results.

Bronchospasm

Management of the asthmatic patient with acute bronchospasm is seldom in the domain of the anaesthetist. At times, however, these patients will require tracheal intubation for acute respiratory failure. While intubation

will enable mechanical ventilation to decrease the work of breathing and the delivery of an increased oxygen concentration, it may aggravate the bronchospasm.¹¹⁹ Intubation is indicated for depression of consciousness, fatigue with impending respiratory failure, deterioration of arterial blood gases, and in cases characterized by obvious progression of symptoms despite aggressive treatment. Therapeutic measures usually include hydration, inhaled and systemic steroids and sympathomimetics, and intravenous aminophylline. In addition, anticholinergics have become an important element of therapy. Ipratropium bromide is a commonly used anticholinergic and is delivered by metered dose inhaler. It rarely achieves optimum therapeutic levels in the bronchi as its delivery is hampered by the small delivered dose and the poor airflow present in these patients. Glycopyrrrolate can be given in large doses (up to 2 mg) by nebulizer but also accumulates in the oropharynx unless given via an endotracheal tube. It is important to block the vagal efferent effects on the bronchial tree completely and 1 mg glycopyrrrolate *iv* (or the equivalent atropine 2 mg *iv*) will accomplish this goal.¹²⁰ In patients with severe bronchospasm, intravenous administration may be required until the bronchospasm lessens sufficiently to allow effective inhaled administration. Despite systemic side effects, the therapeutic effects of these large doses are warranted. Lidocaine and fentanyl may also be used during intubation in an attempt to block airway reflexes which worsen bronchospasm.¹²¹ Sedative drugs may also be considered unless the patient is already severely obtunded. Ketamine has been used in this situation as it is capable of mild sympathetic nervous system activation. Whether or not this stimulation would be therapeutic in the presence of prior interventions is unclear. Nevertheless, the drug is helpful for its sedative and analgesic qualities without significant respiratory depressant effects when used in small doses (10–20 mg boluses). Extremely severe bronchospasm in the intubated patient needs to be evaluated to ensure that carinal stimulation or right mainstem intubation have not occurred. The use of magnesium sulfate infusions is becoming more common and may have the additional advantage of decreasing the incidence of adrenergically mediated cardiac arrhythmias associated with standard antiasthmatic regimens.^{122,123} The use of PEEP and muscle relaxants may help when the situation is life-threatening.¹²⁴

Coronary artery disease

Patients suffering from complications of ischaemic coronary artery disease may require tracheal intubation. This usually occurs in the presence of cardiac decompensation with congestive heart failure and pulmonary oedema. Intubation and use of positive pressure ventilation improves oxygenation and may improve cardiac output by

decreasing left ventricular afterload.¹²⁵ Controlled or assisted ventilation diminishes the metabolic demands associated with the work of breathing and thereby also lessens cardiac demands. The goals for airway intervention for these precarious individuals involves the avoidance of myocardial depression from the use of adjunctive drugs. Ketamine is the only sedative/hypnotic drug which results in stimulation of the sympathetic nervous system. Low doses of ketamine, up to 1 mg · kg⁻¹, are not likely to produce hypotension but can cause tachycardia in high-risk patients.¹²⁶ Etomidate in doses of 0.1 mg · kg⁻¹ is an effective sedative/hypnotic which is virtually devoid of haemodynamic side effects and has mild coronary vasodilating properties.¹²⁷ Lidocaine and incremental low doses of fentanyl can also be used to facilitate intubation in the setting of significant myocardial dysfunction.

At other times, patients without frank cardiac decompensation but with known coronary artery disease will require intubation for other reasons. Manipulation of the airway is a potent stimulus and is capable of significantly increasing systemic and myocardial oxygen consumption.^{128,129} Therefore, it is clear that attenuation of haemodynamic responses (especially tachycardia), maintenance of adequate cardiac output, reduction of anxiety and stress responses and, finally, maintenance of arterial oxygenation are necessary goals during laryngoscopy and intubation.¹³⁰ The level of anaesthesia necessary for tracheal intubation has been documented by Yakaitis to be approximately 30% greater than that needed for surgical incision.¹³¹ Roizen has shown that anaesthetic levels 50% greater than MAC are needed to block adrenergic response.¹³² Clearly the use of adjunctive drugs will be necessary in most of these patients with cardiac disease.

When intubation may be approached without urgency, intubating conditions and patient comfort can be improved. The use of sedative/hypnotic drugs is very helpful. Thiopentone in small sedative doses of 25–75 mg will cause brief unconsciousness allowing time for intubation without undue myocardial depression in most circumstances. Usually a larger dose is chosen to intentionally blunt the responses seen with intubation.¹³³ Propofol may produce less myocardial depressant effect than thiopentone, but is more likely to cause hypotension via vasodilation of both capacitance and resistance vessels.^{134,135} The use of these agents can partially block the hypertensive responses but rarely blunt tachycardia and also place the patient at risk for hypotension prior to intubation. The most effective approach is often to combine these drugs with other agents.

Benzodiazepines are useful to allay anxiety and blunt the responses to tracheal intubation. The safety of midazolam and diazepam, even with the use of large doses, has been documented in patients with ischaemic heart dis-

ease.¹³⁶ Care must be taken when these drugs are used together with opioids as supra-additive effects leading to hypotension have been reported.¹³⁷ The addition of benzodiazepines to narcotic anaesthetics decreases baroreceptor reflexes and circulating catecholamine levels even when used in small doses and can result in undesirable hypotension.¹³⁸⁻¹⁴⁰

Narcotics are extremely effective agents in this setting. Haemodynamic stability regardless of dose is a hallmark of narcotic sedation/anaesthesia.^{138,140,141} Adverse haemodynamic responses are attenuated by doses as low as $1.5 \mu\text{g} \cdot \text{kg}^{-1}$ of fentanyl in geriatric patients.¹⁴² Higher doses in the range of $3-8 \mu\text{g} \cdot \text{kg}^{-1}$ of fentanyl are even more effective.¹⁴³⁻¹⁴⁵ The use of fentanyl for urgent intubations outside the operating room has also been shown to be free from adverse haemodynamic effects.¹⁴⁶ The duration of fentanyl analgesia is helpful as it continues to blunt sympathetic responses to the tracheal tube which persist after the completion of laryngoscopy.¹⁴⁷ Alfentanil in a dose as low as $10 \mu\text{g} \cdot \text{kg}^{-1}$ has been shown to have the efficacy of a fentanyl dose of $2.5 \mu\text{g} \cdot \text{kg}^{-1}$.^{148,149} Doses of alfentanil of $30 \mu\text{g} \cdot \text{kg}^{-1}$ blunt heart rate and blood pressure responses.¹⁵⁰ The pharmacokinetic profile of alfentanil may at times be helpful as it has a more rapid onset of action than fentanyl and a shorter half-life.¹⁵¹ Large doses of narcotics, while extremely effective, may cause chest wall rigidity which will be problematic if relaxants are not used.¹⁴¹

Intravenous lidocaine has been used to blunt the haemodynamic response to intubation in the operating room and it may be considered for this purpose in the ICU.¹⁵² Intravenous administration of lidocaine is clearly better than topical administration and, in fact, systemic absorption may be the responsible mechanism for the purported effects of topically applied lidocaine.¹⁵³⁻¹⁵⁶ Timing is important with an interval of three minutes reportedly being optimal between dosing and intubation.¹⁵⁷ It should be noted, however, that this property of lidocaine has been questioned.¹⁵⁸⁻¹⁶¹ While the diminution of adverse haemodynamic effects by lidocaine is equivocal at best, there is no doubt that it will be helpful in decreasing the incidence of ventricular extrasystoles associated with intubation.^{142,155} In the setting of cardiovascular disease, this anti-arrhythmic potential of lidocaine may be important.

A small bolus of a direct vasodilating drug may be very effective in avoiding hypertension concomitant with intubation. Nitroprusside in a dose of $1-2 \mu\text{g} \cdot \text{kg}^{-1}$ administered 15 sec prior to laryngoscopy can effectively block severe increases in blood pressure.¹⁶² Though the risk of hypotension is present, the short half-life of nitroprusside would be a forgiving variable should an overdose be administered. Nitroglycerine (NTG) is effective when administered nasally in a dose of 0.75 mg and given 60 sec

before intubation.¹⁶³ The safety of this route of administration is apparent from a similar study which showed efficacy without side effects and involved the use of a dose of 60 mg of NTG, fully 80 times larger than the former study's dose.¹⁶⁴ Prophylactic infusions of NTG in cardiac surgical patients have been shown to decrease hypertensive responses to intubation.¹⁶⁵ The effectiveness of NTG has been questioned when given intravenously in non-cardiac patients.¹⁶⁶ Efficacy of *iv* NTG will depend on volume status and the individual variability of sensitivity to the drug. Nitroglycerine has the attractive property of increasing coronary blood flow and this reason alone may well be an indication for its use during intubation of the patient with ischaemic heart disease. While this beneficial effect is difficult to document, there is some suggestive evidence for its existence in a study showing a lower incidence of wall motion abnormalities during intubation when NTG was given at $1 \mu\text{g} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$.¹⁶⁷ Sublingual nifedipine, in a dose of 10 mg administered ten minutes prior to laryngoscopy, will also blunt hypertensive responses to intubation.¹⁶⁸ All of these drugs, fail to block the increase in heart rate which accompanies airway intervention and which result in myocardial ischaemia in this patient population.^{162,166,168}

Myocardial ischaemia can occur following intubation in patients undergoing general anaesthesia.¹⁶⁹ The pre-operative use of beta blocking drugs has been shown to decrease the incidence of this ischaemia.¹⁷⁰ Additionally, studies showing the blockade of hypertensive responses to intubation often reveal a lack of effect on heart rate responses.^{157,162,164,166,168} Given the relationship between heart rate and myocardial oxygen supply-demand ratio every effort should be made to block tachycardia resulting from the airway manipulation of patients with known coronary artery disease. Esmolol is an ultra short-acting cardioselective beta blocker which is ideal for use in this situation. It has a distribution time of two minutes and an elimination half-life of only nine minutes. Doses of 100 to 200 mg given approximately 90 sec before intubation will attenuate the heart rate response to intubation.¹⁷¹⁻¹⁷⁶ Blood pressure is not affected by these doses in most circumstances.¹⁷¹⁻¹⁷³ Therefore, the use of esmolol is ideally suited for concomitant use with a drug which blocks hypertensive responses.

The best approach is often the judicious use of hypnotic and sedative drugs with the addition of topical local anaesthetics to prepare the airway. Glossopharyngeal tongue blocks, superior laryngeal nerve blocks or simply the nebulization of lidocaine may accomplish the desired goal of blunting responses to intubation.² Caution with respect to drug dosing is mandatory, especially in the face of reduced cardiac output. Patients in shock or a low output state are at higher risk for seizures as well as

cardiac depression from initial doses of local anaesthetics due to the higher concentration that results from a decreased volume of distribution.¹⁷⁷ Cumulative toxicity may result from diminished hepatic blood flow.¹⁷⁸

The technique of intubation is also relevant. Stoelting has shown that the duration of laryngoscopy affects the haemodynamic consequences of intubation.¹⁷⁹ Others have suggested fiberoptic techniques as being less stressful.¹⁸⁰ This may be related to the skillful use of topical agents or to the nasal route of intubation. A study of oral fiberoptic intubation did not result in any major difference compared with standard intubation with direct laryngoscopy.¹⁸¹

The ventilatory status of the patient may also influence the airway management choice. Dyspnoeic and tachypnoeic patients with "air hunger" are well suited to blind oral and nasal techniques, thus sparing the additional stress associated with the use of a laryngoscope. It is helpful to have an assistant watch closely for changes in vital signs and particularly for the development of myocardial ischaemia. The demands of an intubation may distract attention long enough to miss early desaturation or cardiovascular trends. Changes may occur suddenly and can often be more effectively treated if recognized early. The anaesthetist must keep this in mind while distracted by the demands of an intubation in otherwise unfamiliar territory.

Neurological diseases

Some patients with acute and chronic non-traumatic neurological diseases will require airway intervention at some time during their hospital course. The most frequent indication is for airway protection in a stuporous patient. Other indications may include the need for therapeutic hyperventilation or sedation to control ICP or the need for oxygenation and airway protection during a seizure.⁴⁶ The relevant physiological variables affecting ICP have been discussed in the section on head trauma.

Barbiturates, propofol and etomidate are the most effective of the available sedative hypnotics useful for ICP reduction.^{55,56,182} Their mechanism of action is mainly due to cerebral vasoconstriction secondary to a decrease in cerebral metabolic rate. Propofol decreases mean arterial pressure relatively more than thiopental leading to a net decrease in cerebral perfusion pressure.¹⁸² Etomidate causes minimal haemodynamic effects but may block steroidogenesis for 24 hr and also may rarely produce seizures in a patient predisposed to such events. Lidocaine decreases mean arterial pressure minimally and effectively blunts ICP responses to intubation and suctioning of the airway.⁵⁴ Fentanyl has no direct adverse effect on cerebral haemodynamics and will blunt the rise in ICP by decreasing any rise in blood pressure.¹⁸³ Other drugs which blunt this hypertensive response (hydralazine, calcium channel

blockers) may have concomitant vasodilating actions which can cause deleterious increases in ICP. Nitroglycerine and nitroprusside have been demonstrated to increase ICP.¹⁸⁴⁻¹⁸⁹ Esmolol and labetalol are useful agents that do not dilate the cerebral vessels. Neuromuscular blocking drugs facilitate intubation and eliminate the patient's ability to cough and strain on the tube and thereby dangerously raise their intracranial pressure.⁵⁷ The use and choice of neuromuscular relaxant is determined by the factors discussed in the head trauma section. Notably, as these non-traumatic problems may be subacute or chronic in nature, the possibility of succinylcholine-related hyperkalaemia must be carefully considered.

Hepatic failure

With the increasing success and availability of hepatic transplantation, more patients in hepatic coma require support in intensive care units. A sudden and massive variceal haemorrhage will require tracheal intubation for airway protection during stabilization and treatment. Progressive coma secondary to hepatic encephalopathy demands attention aimed at airway protection, but carries some caveats. Increased intracranial pressure is often present in these patients and intubation must proceed in a fashion which will minimize changes in ICP.^{190,191} Coagulopathy invariably is present and contraindicates nasal intubation. Ascites with increased intraabdominal pressure, decreased gastric and intestinal motility, and a lower gastric fluid pH combine to place the patient at increased risk for regurgitation and significant aspiration. Anaesthetic requirements are reduced in these patients who tend to have low systemic vascular resistance and hyperdynamic circulations. Nevertheless, thiopentone can be given in usual induction doses as in the normovolaemic patient without danger and will serve to blunt potential ICP responses. Hypovolaemia requires a reduction in dosage or the substitution of etomidate to avoid harmful vasodilation. A final caveat in the approach to these patients is their tendency to develop hypoxia.¹⁹² Ascites and pleural effusions cause atelectasis and a reduction in lung volumes, particularly functional residual capacity. The hyperdynamic circulation or possibly the presence of pulmonary arterio-venous shunts allows deoxygenated blood into the left side of the circulation. Portal to pulmonary venous connections, if present, contribute to the decrease in arterial saturation.¹⁹²

Infectious risks to the anaesthetist

The personnel who provide airway management care may be at considerable additional risk of contracting infectious diseases from blood borne, as well as respiratory pathogens.¹⁹³ Eye and mucous membrane protection are as essential as gloves. Such advice, though offered in all

universal precaution warnings, often goes unheeded. Masks may also serve to diminish the inhalation of respiratory pathogens which are becoming a more important threat given the rise in prevalence of tuberculosis in the various populations of immunocompromised patients in our hospitals.¹⁹⁴ It is strongly suggested that each patient be approached as a potential source of disease so that careful habits are developed. Safe practice will provide the additional benefit of enhanced patient safety as the patients are also at risk from the physician with regards to nosocomial respiratory infections.¹⁹⁵⁻¹⁹⁷

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