Continuing Medical Education Article

The difficult tracheal intubation

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Tracheal intubation is a common procedure usually accomplished easily, but if the attempt proves unexpectedly difficult the patient may be seriously at risk. Early writings contain scant reference to the difficult intubation. During the past decade there has been increasing interest in the preoperative recognition of the patient who will be difficult to intubate with routine methods, and in the management of events that can be associated with a difficult intubation. The plan for this review includes anticipation of difficulties, attempts to overcome them, and the various possible outcomes of attempts at intubation.

Clinical history and examination

History
The scheduled procedure may indicate a likelihood of airway difficulties. The reason can be any disease – congenital, neoplastic and infective – or trauma, that exists in the vicinity of the path to be followed by the endotracheal tube. However, diseases and syndromes primarily affecting other parts of the body may have a component that makes intubation difficult. Space precludes listing all of these and only a supplement to the valuable review by Jones and Pelton[1] is included (Table I).

Examination
Careful clinical examination of the patient is very likely to reveal the signs of a potentially difficult intubation. Classic teaching is that a patient who exhibits one or more of the following will pose problems:

- Short muscular neck and full set of teeth.
- Receding mandible with obtuse mandibular angles.
- Protruding maxillary incisors and relative maxillary overgrowth.
- Poor mobility of the mandible.
- Long arched palate associated with a long, narrow mouth.

X-ray examination has been employed to analyse the anatomical features of small groups of patients who have proved particularly difficult to intubate and to identify predictive factors. Cass[24] confirmed the classic teaching and added that an increased alveolar-mental distance contributed to difficulty. In contrast White and Kinder[25] believed the posterior depth of the mandible was more significant and emphasized the importance of reduction in the distance between the occiput and the spine of the atlas vertebra, a distance that varies widely. This distance is the major factor limiting the extension of the head on the neck so desirable for ideal positioning during laryngoscopy. Van der Linde *et al.*[26] concluded that no single anatomical factor determines the ease of direct laryngoscopy but rather a combination of them. Thus *x*-ray examination is not a useful predictor of difficult intubation, even if it were an investigation suitable for routine patient management.

Supplementary studies have been done. If the fauces of a seated patient who was protruding his tongue could be visualised adequately exposure of the vocal cords by direct laryngoscopy could be achieved.[27] If only the palate could be seen, intubation was difficult. However, this test is unreliable if the patient is recumbent when examined. Another assessment requires measurement of the distance between the lower border of the chin and the thyroid notch, with the neck fully extended. A distance less than 6 cm suggests direct laryngoscopy will be impossible.[28]

These observations about intubation can be assembled to form a comprehensive plan for clinical examination. The general objectives are to determine the shape of the route that the endotracheal tube must follow, the likelihood that the vocal cords can be visualised with conventional laryngoscopic techniques, and the space available for manoeuvring laryngoscope blade, endotracheal tube, and ancillary devices. This examination can be conducted in the following series of steps (Figures 1–5).

- Viewing the patient from the lateral (Figure 1) and anterolateral positions.
- Viewing and palpating the neck anteriorly (Figure 2) and laterally.

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TABLE I

Condition/syndrome	*Problem*	*Airway management implications*	*References*
Acromegaly	Decreased width of cricoid arch and enlarged tongue	Difficult exposure and restriction of size of tube passed	(2)
	Chondrocalinosis of larynx	Larynx could not be exposed	(3)
	Pharyngeal hypertrophy	Difficulty in visualizing larynx	(4)
Stylohyoid ligament calcification	Splinting of adjacent tissues	Difficulty in lifting epiglottis from the posterior pharyngeal wall	(5)
Cervical osteoarthritis	Large osteophytes on anterior surfaces of $C_{5,6,7}$ vertebrae	Difficulty in visualizing and reaching vocal cords	(6)
	Reduced neck movement	Difficulty in visualizing and reaching vocal cords	(7)
Cockayne's syndrome	Mandibular hypoplasia, large teeth and restricted mouth opening	Diminished accessibility to larynx	(8)
Cystic hygroma	Laryngotracheal lymphangioma in addition to primary diagnosis	Tube could not be passed down trachea	(9)
Familial osseous dysplasia (cherubism)	Mandibular enlargement with or without maxillary involvement	Difficulty in visualizing and reaching vocal cords	(10)
Fetal alcohol syndrome	Facial abnormalities	Maxillary and mandibular hypoplasia restricted access to larynx	(11)
Mucopolysaccharidoses	Short neck, high larynx, large tongue, and thickened soft tissue	Difficulty in visualizing and accessing vocal cords	(12, 13)
Eclampsia	Laryngeal oedema associated with eclampsia or labour	Obstructed laryngeal opening	(14)
Pharyngeal diverticula	Pharyngeal diverticulum	Nasopharyngeal tube passed into a blind ended pharyngeal pouch	(15)
Pseudoxanthoma "protein"	Protein clinical manifestation including laryngeal deformity	Difficulty in passing tube past a rigid and deformed epiglottis	(16)
Rheumatoid arthritis	Neck flexion and extension absent: cricoarytenoid cartilage calcification	Visualization of larynx impossible Restricted airway lumen	(17)
Temperomandibular joint impairment	Reduced mouth opening	Diminished accessibility to larynx	(18, 19)
Tracheobronchopathica osteochondroplastica	Numerous large submucosal cartilage bone protuberances within the lumen of the trachea and/or mainstem bronchi	Endotracheal tube could not be passed down trachea	(20)
	Prominent arch of first cervical (atlas) vertebra	Nasotracheal tube cannot be passed beyond the soft palate. A tear in posterior pharyngeal wall occurs easily	(21)
Tracheal agenesis	Varying degree of tracheal deficiency	Endotracheal tube could not be advanced beyond the vocal cords	(22)
Treacher Collins syndrome	Mandibular hypoplasia, macroglossia, glossoptosis, temperomandibular, gout abnormalities, and prominent maxilla or maxillary incisors	Difficult visualization and access to the larynx	(23)

- Extending the neck maximally (Figure 3).
- Flexing the neck maximally (Figure 4).
- Examining mouth opening, teeth, and oral cavity (Figure 5).
- Determining the patency of the nostrils.

The presence of positive findings means that the vocal cords will be unusually difficult to visualise when using a Macintosh laryngoscope blade, with the patient's head resting on a pillow about 7 cm high, neck slightly flexed and maximally extended at the atlanto-occipital joint. Some of these problems are illustrated in Figures 8–10. As few actual measurements are customarily made dur-

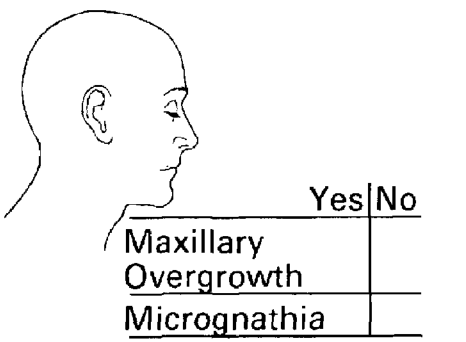


FIGURE 1 Lateral/anterolateral viewing.

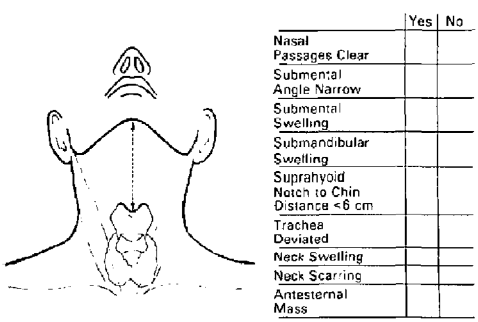


FIGURE 2 Anterior viewing and palpation of neck.

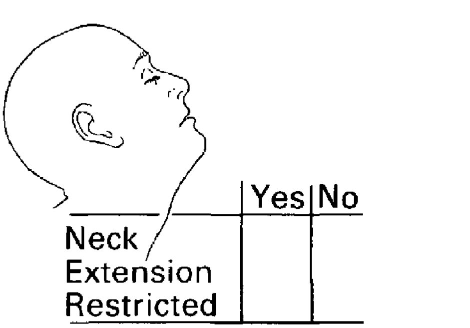


FIGURE 3 Neck extension.

ing a clinical examination, prediction of a difficult intubation is likely to remain a decision based on clinical judgement.

The intubation attempt

The commonly used position for a patient who is to be intubated includes placing the patient's head on a small pillow and extending the neck at the atlanto occipital joint[29] (Figure 6). Some of the technical difficulties encountered cause the vocal cords to be anterior to the line of vision (Figures 7–10). A major objective in any attempt is to have the oral cavity, larynx, oropharynx and trachea in as straight a line as possible. If the result of this initial laryngoscopy is unsatisfactory the position of the laryngoscope blade should be checked to ensure that the blade is placed as far as possible to the right side of the mouth, thus reducing the distance to the vocal cords and altering the angle of approach. The tongue is pushed well out of the way, and any space between upper right molar teeth is utilised. External pressure by an assistant on the thyroid cartilage may be helpful, as may downward traction on the larynx.

Persistent difficulty can be countered by further flexion of the cervical spine. This manoeuvre can be particularly useful while slowly advancing the tube, because once it has been inserted between the vocal cords it is then less likely to impinge on the anterior wall of the trachea. If recourse is taken to one of the hazardous earlier positions advocated for laryngoscopy[29] in which the cervical spine and atlanto occipital joint are extended, then damage to bony and cartilaginous structures must be carefully avoided. It should be noted that vigorous attempts to improve visualisation by extending the cervical spine can bow it forward, thus lifting the larynx of some patients anteriorly and out of the line of view.[30]

The laryngoscope blade itself is an important feature of laryngoscopy. A popular model – the Macintosh – has a curved blade with a distal end designed to fit into the vallecula. The cross sectional depth of the blade at its proximal end is substantial. However, whatever model of blade the anaesthetist customarily uses, a change of blade may make the intubation possible. The factors considered are (i) the distance to the vocal cords, (ii) the need to compress tongue and soft tissues into the mandibular space, (iii) the need to avoid prominent upper incisor teeth, (iv) the need to improve blade manoeuvrability in a small mouth. Accordingly, the next blade selected will be on the basis of its length, degree and character of curvature, depth of step, and width. Commercially available blades have been reviewed elsewhere.[31] A selection adequate for most situations likely to be encountered comprises all sizes of the Macintosh, Miller, and Soper blades. There is no strict order in which the foregoing manoeuvres should be done, although many anaesthetists increase the degree of neck flexion early in their attempts to intubate the difficult patient. The most important axiom is that sequential attempts to intubate a patient are made in a rational fashion and in as atraumatic a manner as possible. The most common clinical difficulties encountered are that the larynx is far anterior to the anaesthetist's line of vision and the intra oral cavity provides minimal space for manipulation of the tube.

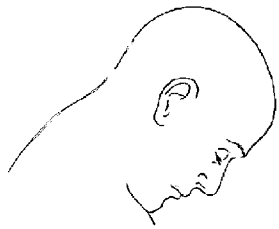
Some anaesthetists believe that blind nasotracheal intubation can be easily accomplished in those patients in which oral intubation under direct vision is particularly difficult. This may be true in the spontaneously breathing or apnoeic patient. However, nasal haemorrhage can be a complication of this technique. If this occurs in the unconscious or anaesthetised patient who still cannot be intubated a life-threatening situation exists. Thus in the patient proven difficult to intubate, before the nasal route is attempted the hazards must be considered with reference to the urgency for intubation.

Intubation assist devices

Fibreoptic instruments[28] have revolutionised the solution of difficult intubation problems as well as evaluation of airway pathology, but there are no strictly defined criteria for their use. However, if during the initial clinical examination existing signs of a potentially difficult intubation supplement a distance less than 6.0 cm between the lower border of the chin and the thyroid notch then fibreoptic laryngoscopy is indicated.[28] Though not as versatile as fibreoptic instruments, other simpler devices prove useful and their use may be accompanied by certain manoeuvres already mentioned. Most of these devices have obvious historic roots and include:

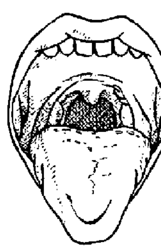
- Malleable stilettes and bougies to place in the endotracheal tube or thread the tube over.
- Forceps to alter the direction of the tip[32] (e.g., Magill forceps).
- Tubes that incorporate a tip moving device.[33]
- Stilette with a mobile tip.[34]
- Malleable stilettes incorporating a light.[35,36]
- Tongue forceps to increase the size of the intra oral cavity.[28]
- Malleable tongue retractors to increase the size of the intra oral cavity.[28]
- Oropharyngeal airways through which the endotracheal tube may be directed in the direction of the larynx.[37,38]
- Endotracheal stethoscope.[39]

The malleable stilette and Magill forceps are the most widely used because the commonest difficulty is to direct the tip of the tube between the vocal cords that are



	Yes	No
Neck Flexion Restricted		

FIGURE 4 Neck flexion.



	Yes	No
Mouth Opening Limited		
Width of Mouth Narrow		
Intra-oral Cavity Small		
View of Fauces Poor		
Tongue Large		
Cleft Lip/Palate		
Teeth Long		

FIGURE 5 Viewing of mouth, teeth, and oral cavity.

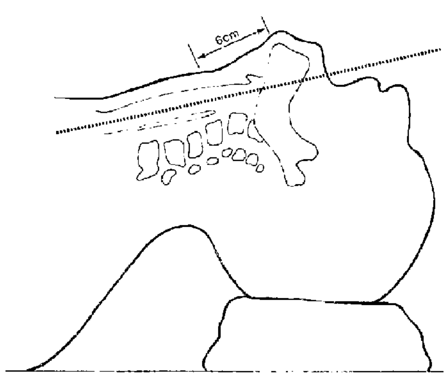


FIGURE 6 Ideal situation.

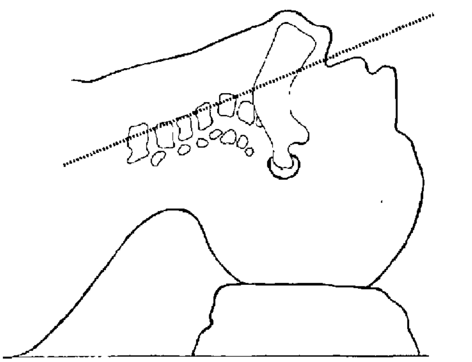


FIGURE 7 Temperomandibular joint limitation.

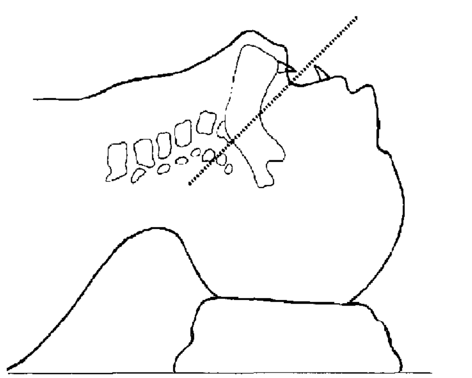


FIGURE 8 Prominent teeth.

located anterior to the line of vision and these simple devices usually solve this problem. Some of the other devices have a similar function or help the anaesthetist to know where the tip of the endotracheal tube is.

Newer plastics and wires have facilitated development of an alternative intubation technique whereby a catheter or guidewire is inserted through the cricothyroid membrane and passed in retrograde fashion through the larynx and mouth so that it can be attached to the tip of the endotracheal tube. The tube is then pushed and guided down through the larynx.[40–45] This technique has been successfully used in patients of all ages and can be a valuable alternative to fibreoptic endoscopy. A distressing complication is inadvertent dislodgement of the tube when the translaryngeal guidewire is removed, or discovering afterwards that the tube is partially obstructed. A support such as a fibreoptic scope is useful to stabilize the tube once it has passed the cords[46] and the endotracheal tube selected should be able to remain in its tortuous resting place, without kinking when its support has been removed.

These catheter and guidewire techniques are rarely necessary, but are particularly useful if the patient has very severe and complex anatomical difficulties.

Anaesthetic conditions for intubation

Crucial to the patient's welfare is avoidance of acute life-threatening situations and so the prudent anaesthetist will plan the anaesthetic conditions under which intubation will be attempted, with particular reference to the hazards for the patient if the intubation process is prolonged or unsuccessful. A patient should not be rendered apnoeic if there is any doubt about satisfactory artificial ventilation using a face mask, or rapid tracheal intubation. Similarly if there is a possibility of regurgitation, vomiting or bleeding into the pharynx the patient should not be rendered unconscious nor apnoeic. Intubation while awake can be made more tolerable by light intravenous sedation with a narcotic and an antiemetic. Topical application of local anaesthetic is useful unless there is bleeding into the mouth and pharynx. Other manoeuvres include bilateral block of the superior laryngeal nerve at the apex of the greater cornu of the hyoid bone, which blocks the vagal distribution to the larynx and trachea. Injection of local anaesthetic through the cricothyroid membrane into the trachea produces anaesthesia below the vocal cords.

Outcomes of attempted intubation

The satisfactory outcome is an atraumatic placement of the endotracheal tube. Less fortunate events are failure to intubate, airway obstruction, and trauma that may be manifest at the time or later.

Failure to intubate

If the anaesthetist is unfortunate enough to render a patient apnoeic and then be unable to intubate there are various courses of action. Assuming that the surgery will be short and the anaesthesia can be safely conducted without intubation, artificial ventilation is continued with the use of an oropharyngeal airway and spontaneous breathing is ultimately restored. If believed necessary, regurgitation is prevented by inserting a cuffed endotracheal tube into the top third of the oesophagus and inflating the balloon or by having cricothyroid pressure maintained by an assistant. The value of an oesophageal obturator or oesophageal gastric airway under these circumstances is as yet unproven. If the surgery will be protracted and need not be started at once, the wisest course is to artificially ventilate the patient until spontaneous respiration has been restored and elective intubation can be done when consciousness has been regained. If surgery must continue or an obstetric procedure done another plan of action[47] is as follows:

1 Maintain cricoid pressure.
2 Put patient head down and on left side (request surgeon and OR nurse to help).
3 Oxygenate by IPPV: it may be difficult – try different positions and sizes of Guedel airway – get someone else to artificially ventilate the patient if necessary. Aspirate larynx as required.
4 If obstruction persists, try effect of releasing cricoid pressure.
5A If ventilation and oxygenation easy – ventilate with nitrous oxide, oxygen and inhalational agent and establish surgical anaesthesia with spontaneous ventilation using the facemask.
6A Pass wide-bore stomach tube through mouth – aspirate – instil 30 ml sodium citrate – withdraw tube and clear pharynx.
7A Level table and place mother supine with lateral tilt and buttock wedge (for Caesarean sections). Allow operation to proceed using inhalational anaesthesia with a facemask. Ask for an experienced paediatrician to be present at delivery.
5B If oxygenation difficult, allow succinylcholine to wear off and let patient wake up.
6B Empty stomach as in 6A.
7B Use local or regional analgesia or consider undertaking an inhalational induction and continuing as in 7A with spontaneous respiration.

Acute respiratory obstruction

On rare occasions acute respiratory obstruction occurs during attempts to intubate and recourse to mechanical measures is necessary. These are:

- Percutaneous cricothyroidotomy employing a tube with a lumen adequate for temporary spontaneous breathing or artificial to and fro ventilation. (Internal diameter >3.0 mm.)
- Percutaneous transtracheal or transcricothyroid membrane ventilation via a tube or tubes having lumens insufficient to permit to and fro respiration or ventilation (14 gauge).
- Surgical tracheostomy.

Percutaneous cricothyroidotomy is similar to a routine tracheostomy and its function, management, and complications are well understood. Various devices have been described for use in emergency situations.[48,49] However, smaller lumened catheters are more conveniently introduced percutaneously and their availability has created

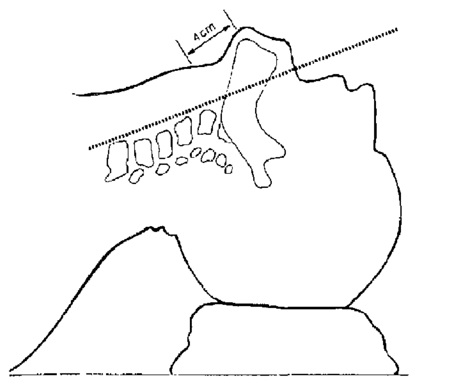


FIGURE 9 Reduced chin–suprahyoid notch distance.

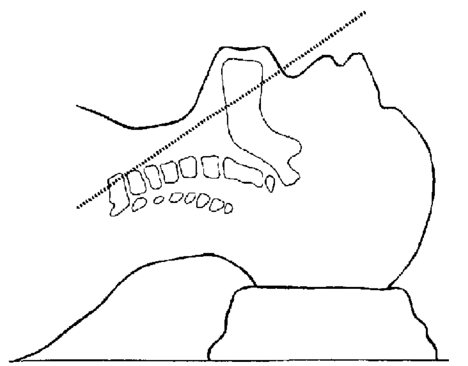


FIGURE 10 Rigid cervical spine.

increased interest in insufflation, jet ventilation, and high frequency ventilation.

In 1956[50] interest was revived in the insertion of an 18-gauge needle through the cricothyroid membrane, or the first 2–3 cm of the trachea, and giving oxygen through the needle at a rate of $4\,L\cdot min^{-1}$. Animal and clinical investigation confirmed its value. The technique has been further developed[51–60] and used in emergencies and during elective surgery for patients of all ages (Table II). Although the presence of a small bore needle or catheter is the basis of transtracheal ventilation, gases can be delivered in different ways and many factors influence the results. These include:

- Physical characteristics of gas flow (volume, waveform, density and viscosity).

TABLE II Transtracheal ventilation techniques

Size of catheter or needle inserted	*Site of gas release*	*Reported characteristics of the gas glow*	*Reported adverse respiratory effects*	*References*
18 gauge	Approximately 5 cm below crycothyroid membrane	Continuous 4 $L \cdot min^{-1}$	Respiratory acidosis	(49)
16 gauge	The carina	Intermittent gas at 344.5 kPa, 12–16 BPM, inspiratory phase 1–1.5 sec delivered by Bird Mk2 ventilator	None	(50)
16 gauge	Below cricothyroid membrane	Intermittent gas jet, 10 BPM, inspiratory phase 1 sec	None	(51)
14 gauge	Approximately 5 cm below cricothyroid membrane	Intermittent gas at 345 kPa from a bronchoscope injector		(54, 55)
14 gauge	Approximately 5 cm below cricothyroid membrane	Manual ventilation using a 344.5 kPa Venturi-Saunders insufflator at 60 $cycles \cdot min^{-1}$	None	(56)
13 gauge	Approximately 7 cm below cricothyroid membrane	HFJV system, minute volume 250 $ml \cdot kg^{-1}$, ventilator driving pressure 101–304 kPa, inspiratory expiratory ratio 1:2, frequency rate 150 Hz	Occasional respiratory acidosis	(58)

- Site of gas release in the respiratory tract.
- Presence of any spontaneous respiratory efforts by the patient.
- Pulmonary compliance and resistance.
- Port of egress for expired air or gas.

Early techniques appear to have depended largely on diffusion oxygenation. Physiological results have been reviewed by Holmdahl[61] and more recently by Frumin *et al.*[62] and Smith *et al.*[63] Alternatively, jet ventilation has been employed whereby the lungs themselves are inflated intermittently. Another technique, high frequency ventilation, has also been used for similar clinical situations. Results with diffusion oxygenation (Table II) show that elimination of carbon dioxide has proved to be a greater problem than oxygenation. Whatever the value of transtracheal ventilation may be, it also has dangers. If catheter placement is incorrect or the exit route for exhalation is inadequate, mediastinal emphysema, pneumothorax, or pneumoperitoneum can occur very rapidly. The monitoring of the patient must be conducted in such a fashion that a developing dangerously high intrapulmonary pressure is detected at once.

Unrecognised oesophageal intubation

Few things can be more difficult than establishing with certainty in every patient that the end of the endotracheal tube is in the trachea. The only reliable criterion is to have seen the distal end pass between the vocal cords and know that no subsequent movement of the tube or larynx has dislodged it. Unfortunately sometimes this is impossible. End-tidal carbon dioxide measurement is at present perhaps the most reliable means under all circumstances of determining proper tube position.[64] However, it is unlikely that this information will be routinely available in situations where patients are intubated, for very many years to come. In circumstances when an oesophageal intubation has gone unrecognised, the anaesthetist has usually been misled by relying on positive findings that have on occasion been shown to be fallible. Prudent anaesthetists are aware of these and they are as follows:[64,65] (i) Equal bilateral breath sounds. (ii) Symmetrical bilateral hemithorax elevation. (iii) Epigastric auscultation and observation. (iv) Reservoir bag compliance and refilling. (v) Presence of tidal volumes with respiratory effort. (vi) Endotracheal tube cuff palpation in the neck. (vii) Quality of air sound escaping around tube. (viii) Persistence of adequate vital signs for two or three minutes following the insertion of the tube. (ix) Radiography. Thus available information about accidental oesophageal intubation indicates that if the tube was not seen to pass between the vocal cords and known to have remained there and the patient cannot spontaneously ventilate or be ventilated in a fashion similar to that prior to intubation then the tube should be assumed to be in the oesophagus. Only end-tidal carbon dioxide measurements consistent with adequate ventilation can overwhelm this assumption.

Intra oral and nasal haemorrhage

Haemorrhage from mouth, larynx, or pharynx is unlikely to occur during careful attempts at transoral intubation under direct vision, unless the patient is already traumatised. However, even an apparently gentle intranasal manipulation may produce severe bleeding into the pharynx. Materials for the immediate control of such haemorrhage include small bore catheters with inflatable balloons and packing. These should be readily available.

Damage to the oesophagus and related structures
Perforations of the pharynx or oesophagus are rare, but well documented.[66–72] These soft structures are easily damaged and injury may not be immediately obvious. Characteristically symptoms of cervical pain, dysphagia and sore throat occur later when the patient is in the recovery room or ward. There may also be signs of subcutaneous emphysema or swelling. Thus complaints of this nature by a patient for whom there have been intubation difficulties must be taken very seriously. It is worth noting that in reported cases the delay between injury and diagnosis has been up to fourteen days.[70]

Other complications
The complications described above are major threats to a patient's well being. There are a wide variety of others that will be taken seriously by the patient and are usually avoidable. They include trauma to lips, tongue and pharynx, dental damage, penetration and dissection of mucosa, nerve damage, temperomandibular joint dysfunction, and trauma to the joints of the cervical spine. Of particular interest is that pulmonary oedema may develop following relief of respiratory obstruction by endotracheal intubation.[73–74]

Conclusion

A careful history taking and physical examination will identify most patients who will be difficult to intubate. This anticipation enables the anaesthetist to plan conditions under which the intubation will be attempted and the technique that will be employed. Unfortunately an unexpectedly difficult situation may still be met or the technique selected may be unsuccessful. In the interest of good patient care it is useful if a tray containing devices necessary to supplement oropharyngeal airways, laryngoscope blades, endotracheal tubes, stilettes, and facemasks is customarily kept in induction or operating rooms. This protects all concerned from the frustration caused by an uninformed person gathering unfamiliar things from unfamiliar places. The items that should be in the tray are: (i) A malleable stilette with a light at the distal end to indicate the position of the endotracheal tube. (ii) A gum elastic bougie over which an endotracheal tube can be guided. (iii) A cuffed flexometallic endotracheal tube to place in the oesophagus and prevent regurgitation into the pharynx. (iv) A scalpel. (v) A cricothyrotomy cannula with adaptor to connect it to a breathing circuit. (vi) Two 12-gauge plastic intravenous catheters with stilettes for direct insertion into the trachea or via the cricothyroid membrane and an adaptor to connect to the source of gases. (vii) An epidural catheter (20 gauge) with wire stilette introducer. (viii) A 0.021 extra long flexible tip guidewire.[42] (ix) A Tuohy needle (18 gauge). (x) Two Foley catheters to occlude nasal bleeding.

Finally, anecdotal reports show a need for what may be considered a motherhood statement. The more difficult an endotracheal tube has been to insert the more reluctant the anaesthetist (or other personnel) should be to remove the tube, until it is absolutely safe for the patient to have it removed.

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