Difficult Airway Management in the Intensive Care Unit: Alternative Techniques

M. S. T. LIM, J. J. HUNT-SMITH
Intensive Care Centre, St Vincent's Hospital, Melbourne, VICTORIA

ABSTRACT

Objective: *To review alternative airway management techniques and their suitability to the intensive care setting.*

Data sources: *A review of publications reported from 1975-2002 and identified in both the Medline and Pubmed databases on the products used in the management of a difficult airway. In addition new airway devices were identified by accessing the product catalogues of major manufacturers and third-party vendors. The publications were assessed for their relevance to the intensive care setting.*

Summary of review: *Many devices to manage the difficult airway have been designed for use in the controlled environment of an anaesthetic room rather than the intensive care unit. In addition, there is very little opportunity to evaluate and train with alternative techniques in real-life situations in the critical care setting. We review products that are considered as alternative airway devices to the standard endotracheal tube and include alternative intubating devices to the standard laryngoscope and devices to achieve a trans-tracheal airway. We also consider their suitability to the intensive care setting.*

Conclusions: *There is a wide range of techniques available to manage the difficult airway. Due to the limited opportunity to train in the use of alternative airway techniques, such techniques should ideally involve an extension of those skills commonly practised by intensivists (e.g. bronchoscopy). Ultimately, the most important features when choosing a technique to manage a difficult airway are the training, knowledge and experience of the practitioner.* (**Critical Care and Resuscitation 2003; 5: 53-62**)

Key words: Cricothyroidotomy, equipment: combitube; fibreoptic bronchoscope; light stylet; laryngeal mask airway, tracheal intubation: awake, direct vision, fibreoptic, retrograde, tracheostomy

There is a wide range of techniques available for the management of a difficult airway. This reflects both the lack of evidence demonstrating improved outcomes with any one technique, and the fact that no technique is universally successful in all situations.

Most devices that are currently marketed are designed for use in the relatively controlled environment of the anaesthetic room rather than for use in the intensive care unit. This review aims to give a brief overview of some of the techniques available to aid in the maintenance of a patent airway and techniques that will provide an alternative to standard laryngoscopy for intubation and discuss their use in the critical care setting.

ALTERNATIVE AIRWAY DEVICES

The laryngeal mask airway

The laryngeal mask airway (LMA) is now the most widely used alternative airway device in anaesthesia. It is designed to be inserted blindly into the pharynx and, with the balloon inflated, form a seal around the laryngeal inlet.[1] Whilst primarily used in spontaneously breathing patients undergoing elective anaesthesia, it has also worked well, with few complications, as a ventilatory device in patients who cannot be intubated or whose lungs cannot be ventilated with bag and mask techniques. It is effective even when used by practitioners who have limited experience[2] and has also

Correspondence to: Dr. M. Lim, Intensive Care Centre, St Vincent's Hospital, Fitzroy, Victoria 3065
(e-mail: michael.lim@talk21.com)

been useful as a conduit for endotracheal intubation.

In one review of anatomically normal patients the placement of the LMA was found to be clinically inadequate in only 0.4 - 0.6% and its insertion was found to be no more difficult in patients who had Grade I or Grade II compared with Grade III and IV laryngoscopic views.[3] When inserted by non-medical staff, it is also reported to provide an ability to ventilate the patient better compared with bag and mask techniques used by trained anaesthetists.[4,5] Even when radiologically shown not to be properly seated over the laryngeal inlet, it still often provides a clinically acceptable airway.

In a revision of the ASA guidelines for the management of a difficult airway (in light of the effectiveness of the LMA), Benumof[6] described several indications for the LMA, including its use:

- as an emergency airway in the patient whose lungs cannot be conventionally ventilated and whose trachea cannot be intubated,
- as a conduit for fibreoptic bronchoscopic intubation in the anaesthetised patient whose lungs can be ventilated but in whom the trachea cannot be conventionally intubated, and
- as a conduit for tracheal intubation in the anaesthetised patient whose lungs cannot be conventionally ventilated and whose trachea cannot be intubated.

In view of its widespread use, its ability to provide a better airway than bag and mask ventilation and the option for it to be utilised as a conduit for intubation, the LMA should be considered as a core component of most difficult airway management strategies.

The main problems associated with the LMA include:

- failure of insertion of the LMA (e.g. errors of inadequate anaesthesia or relaxation, failure to negotiate the 90° turn from the posterior pharynx to the hypopharynx and wrong choice of LMA size),
- lack of guaranteed airway protection,
- ineffectiveness in patients who have upper airway pathology (e.g. malignancy, haematoma, abscess, anaphylaxis), and
- need for adequate relaxation or anaesthesia (with attendant problems for airway protection and loss of ventilatory function).

As the LMA does not form a tight seal around the upper airway, it does not provide adequate protection against the aspiration of gastric contents. Furthermore, when used for positive pressure ventilation the risk of insufflation of air into the stomach increases as the usual LMA seal/pop-off pressure is 15 - 20 cmH_2O and the oesophagus may be included in the rim of the balloon. The application of cricoid pressure has also been shown to interfere with both the insertion and ability to ventilate the lungs with the LMA. If vomiting or gastric reflux occur, the LMA may block the passage of gastric contents past the larynx into the oropharynx.

Nevertheless, in one meta-analysis, the incidence of aspiration with the LMA was reported to be comparable with that for out-patient anaesthesia using a face mask or an endotracheal tube.[7]

The ProSeal®

The ProSeal® is a modification of the original LMA with an enlarged dorsal cuff and a ventral cuff. It is designed primarily to improve the seal around the larynx and to protect the airway from aspiration of gastric contents by incorporating a drainage tube which lies lateral to the airway and terminates at the distal end of the ventral cuff.[8] The drain allows the passage of an 18-French gauge tube for suctioning of regurgitated fluid, as well as aiding in the confirmation of the position of the device. By enlarging the ventral cuff and by the addition of a dorsal cuff (which pushes the ventral cuff forwards onto the periglottic tissues) the glottic seal is improved. Also the bowl of the ProSeal® is deeper than that of the standard LMA giving a better pharyngeal fit.

However, while the ProSeal® has been shown to allow ventilatory pressures up to 11 cmH_2O higher than the conventional LMA and offers a theoretical advantage for airway protection, the modifications have caused it to be more difficult to insert compared with the standard LMA.[9, 10] Accordingly, until the modifications of the ProSeal® have been refined, the LMA may remain a better option for the management of a difficult airway in the intensive care unit (ICU) setting.

The Combitube

This is double-lumen tube with the 2 lumens being arranged antero-posteriorly rather than side-by-side. One lumen is longer than the other and there is a distal and a proximal cuff. It is designed for blind insertion into the pharynx so that the distal lumen will be positioned either in the trachea or the oesophagus. When the distal lumen is positioned in the oesophagus (i.e. 98% of insertions), this is called the oesophageal obturator position. The distal cuff then blocks the passage of gastric contents up the oesophagus and the proximal lumen is used for ventilation. In the less common instance where the trachea is intubated by the distal lumen this lumen is then be used for ventilation.

The Combitube is commonly available in two sizes, 37 Fr for people less than 1.60 m in height and 41 Fr for taller individuals and it is inserted with the patient's head in a neutral, semi-flexed position. It is used widely

in the pre-hospital setting in North America where success rates by emergency medical technicians of up to 93% have been reported. It can also be used for positive pressure ventilation as Frass *et al*, [11] describe six patients who were ventilated in an ICU with the Combitube in the oesophageal obturator position for 2 - 8 hours.

To date, there has been only one report of the most obvious potential complication, oesophageal rupture, which necessitated operative repair.[12] However, when used in the pre-hospital setting, some complications, which may contribute to patient mortality, may be attributed to the patient's presenting condition and therefore may be under-reported.

While most anaesthetists would appear to favour the LMA over the Combitube, a study of paramedics in North America, showed a subjective preference for the Combitube,[13] suggesting a better insertion success rate in untrained hands compared with the LMA.

Cuffed oropharyngeal airway (COPA)

The cuffed oropharyngeal airway (COPA) is a modified Guedel airway with an inflatable cuff that is positioned in the pharynx and a 15mm connector that connects to the breathing circuit. Ideally, the cuff is inflated to displace the base of the patient's tongue, form an airtight seal within the pharynx and elevate the epiglottis from the posterior pharyngeal wall to provide a clear airway. When compared with the LMA during spontaneous breathing anesthesia, in one study the LMA had a clinically significant first-time successful insertion rate of 89%, compared with 81% for the COPA.[14] When the COPA was used, 30% required additional airway support (e.g. head tilt, chin lift, jaw thrust). However, the incidences of aspiration, regurgit-ation, laryngospasm, wheezing, oxygen desaturation (SpO_2 < 92%), failed use and other minor intraoperative problems were similar.

However, while the COPA, may be inferior to the LMA in the operating room, it may still offer advantages in the ICU, where staff may be more familiar with the Guedel airway compared with the LMA.

Glottic aperture seal airway (Augustine guide)

The glottic aperture seal airway[15] is similar to the LMA but differs in that the end over the larynx consists of a foam cushion with an inflatable balloon positioned on the posterior surface of the foam cushion. When inflated, the balloon presses against the posterior pharyngeal wall and pushes the ventilation hole and the foam cushion up against the laryngeal inlet.

The glottic aperture seal airway was developed in an attempt to improve ease of insertion, alignment with the laryngeal inlet, and provision of a high-pressure seal when compared with the LMA. The main advantage of the airway appears to be its ability to provide a better seal around the cuff and balloon when using higher airway pressures. In a study by Benumof,[15] the forced expiratory airway pressure reached up to 60 cmH_2O before a leak was detected.

ALTERNATIVE INTUBATING TECHNIQUES

The intubating laryngeal mask

The intubating laryngeal mask airway (ILMA) was developed as a better conduit for intubation compared with the LMA.[16] The main differences are that the ILMA has:

- *an anatomically curved, rigid airway tube*. The curve of tube is derived from head and neck sagittal MRI views with the head in neutral position. As it is a rigid tube, it is not required to bend over the chin to be secured and so is shorter, allowing easier passage of a tracheal tube through it. As the minimum internal diameter is 13 mm, it is able to accept a size 8.0 mm endotracheal tube, rather than a size 6.0 mm which is the maximum that can be inserted through a conventional LMA.
- *an integral guiding handle*. The integral stainless steel handle is welded to the tube to facilitate device manipulation and allow insertion without the clincian placing his or her fingers in the patient's mouth.
- *an epiglottic elevating bar replacing the mask bars*. The bars across the LMA aperture are replaced with a single central bar or epiglottic elevating bar attached only at the upper rim of the mask so that its free end can be moved out by the advancing endotracheal tube, pushing the epiglottis out of the way as it is inserted.
- *a guiding ramp built into the floor of the mask aperture*. This directs the tracheal tube anteriorly as it emerges from the mask aperture and if properly positioned, towards the laryngeal inlet.
- *a modified silicone tracheal tube*. After laboratory tests, the tracheal tube was manufactured from silicone as this allowed the appropriate level of flexibility. In addition, the midline position of the bevel has been designed to increase the chances of successful blind intubation.

In a multicentre trial involving 500 ASA grade 1 and 2 patients undergoing elective general anaesthesia, the ILMA was successfully inserted in all cases.[17] Ventilation via the ILMA was described as satisfactory in 475 (95%) cases, difficult in 20 (4%) cases and unsatisfactory in 5 (1%) cases. Ventilation via the ILMA was described as unsatisfactory during two of these cases but oxygenation still remained satisfactory. In 10% of

insertions, there was an initial reduction in ventilation which may have been caused by a down-folding of the epiglottis. This was resolved by partial withdrawal (approximately 5 cm) of the ILMA followed by its re-insertion.

Blind tracheal intubation through the ILMA was possible in 481 (96.2%) cases within three attempts, with success on the first attempt in 399 (79.8%) cases, second attempt in 62 (12.4%) cases and at the third attempt in 20 (4%) cases. Nineteen (3.8%) were not successfully intubated within the 3 attempts. Subjectively, all operators, who had at least 2 years anaesthetic experience, felt that the learning curve for the instrument was approximately 20 cases, as 17 of the 19 failures occurred during the individual operator's first 20 attempts. The operators assigned the following reasons for difficulty with insertion: difficult or poor dentition, limited mouth opening, obesity, small mouth and dry mouth.

Fibreoptic bronchoscopy

In anaesthesia, the use of the fibreoptic bronchoscope for an awake intubation is considered the gold standard for tracheal intubation in patients known or anticipated to be difficult intubations.[18] Both intensivists and ICU nurses will be familiar with fibre-optic bronchoscope and so it should a logical choice for difficult airway management in the ICU setting.

With appropriate local anaesthesia of the upper airway, it is well tolerated by most ICU patients and has all the attendant advantages of an awake intubation. It is a visually guided technique, so reducing the incidence of complications and allows concurrent airway control. Once the patient is intubated, it can then be used for verification of the position of the endotracheal tube. The probability of success is improved by having the patient in the sitting position as it may reduce respiratory distress and help separate the tongue from the posterior pharyngeal wall. The classic "sniffing-the-morning-air" position with cervical flexion and atlanto-axial extension during bronchoscopic intubation increases obstruction of the glottis by the epiglottis, and should be avoided.

However, once a patient is anaesthetised or comatose, then the loss of tone in the airway muscles and tongue usually produces a posterior movement of the tongue and epiglottis to cause airway obstruction. The loss of airway tone also reduces the diameter of the airway resulting in a greater likelihood that the lens of the bronchoscope will push up against the pharyngeal mucosa obscuring the view of the larynx. This includes the unexpected difficult airway, where, after the patient is anaesthetised and laryngoscopy attempted, the difficult airway is discovered. Even if the larynx can be seen it may not be possible to manipulate the bronchoscope into the glottis and once the fibrescope is inserted into the trachea, it may be difficult to advance a tracheal tube over the fibrescope because the endotracheal tube may be impeded by the epiglottis, arytenoids or pyriform fossae.[19] This may be offset, by using a smaller endotracheal tube. Koga *et al*,[19] even recorded a 10% incidence of oesophageal intubation with a 8.0mm diameter endotracheal tube, whereas a 6.0mm diameter endotracheal tube had 100% tracheal intubation success rate.

One disadvantage associated with fibreoptic bronchoscopic intubation includes the use of a nasal tube (as the nasal approach is easier than the oral approach). Whilst this may be advantageous for short-term endotracheal intubation, where an awake patient will tolerate the nasal tube better than an oral tube, in the long-term, there is an increased risk of sinusitis. Also a smaller sized endotracheal tube is often used, which can be a disadvantage in patients with ventilatory failure and excess pulmonary secretions.

Fibreoptic intubation via the LMA

The LMA has been recommended by the ASA as conduit for difficult tracheal intubation as it has the advantage of allowing ventilation whilst preparing for intubation. The intubation may be performed blindly by passing the endotracheal tube through the lumen of the LMA, using a gum-elastic bougie (inserted into the trachea through the LMA then exchanging it for an endotracheal tube) or by using the LMA as a conduit for a fibreoptic bronchoscope previously loaded with a endotracheal tube, which is then "rail-roaded" over the fibreoptic bronchoscope into the trachea. A 6.0 mm diameter endotracheal tube can be inserted through a size 3 or 4 LMA and a 7.0 mm diameter endotracheal tube can be inserted through a size 5 LMA. A fibreoptic bronchoscope may also be used in conjunction with an intubating LMA which would allow a larger diameter endotracheal tube to be used (e.g. 8.0 mm). The success rate of the various methods using a LMA[20] are shown in table 1.

When the LMA has a perfect central position (i.e. 45 - 60%), then blind insertion will have a good chance of being successful. However, when the LMA is off-centre, laryngopharyngeal injury may occur if there is persistent blind insertion of the endotracheal tube or bougie against the larynx or pharynx. The use of cricoid pressure may further decrease the chance of passing an endotracheal tube blindly. As the LMA directs a fibreoptic bronchoscope towards the laryngeal inlet this technique avoids the problems of airway trauma associated with blind insertion. In most instances, the laryngeal inlet is readily visible immediately the

bronchoscope exits the LMA tip and the procedure can be performed easily and rapidly.

Table 1. The success rate of a laryngeal mask airway as a conduit for tracheal intubation

Method	*Success rate*
Blind	Lower than with bougie
Bougie	25%
Fibreoptic	95%

However, the difficulties that may be encountered when using this technique include, the cuff of the endotracheal tube might be above or over the vocal cords on first visualisation, the small endotracheal tube required may not allow adequate ventilation, and extubation with removal of the LMA.

In a bronchoscopic study, the mean distance between the grille of the LMA and the vocal cords was 3.6 cm (range 2.5 - 4.7 cm) in males and 3.1 cm (range 2.0 - 4.2 cm) in females,[21] suggesting that the cuff of an uncut 6.0 mm tracheal tube would often lie between the vocal cords if this tube is fully inserted through a LMA. When either neck extension or flexion is required there may be further displacement of the endotracheal tube cuff. To avoid this, the tracheal tube must protrude more than 9.5 cm beyond the grille of the LMA. Prior to attempting to pass an endotracheal tube through the LMA it is necessary to test that it will actually pass freely through the LMA and that the endotracheal tube will protrude the required distance beyond the grille.

When the LMA is used during surgery, once the endotracheal tube has been inserted through the LMA, both are left in situ until the end of the surgical procedure. However, this is not ideal for the prolonged intubation often required in the ICU and is particularly unsuitable with the ILMA, with its prominent handle and hard tube. Therefore, before the LMA is removed, the airway should be secured by either inserting a gum-elastic bougie or an airway exchange catheter and equipment for a rapid difficult re-intubation should be close at hand when the LMA is removed.

The Aintree catheter

This is a ventilation-exchange bougie which has an internal diameter and length designed to be a close fit over an adult fibreoptic laryngoscope whilst leaving the manoeuverable tip free to allow manipulation into the trachea.[22] After using the LMA as a conduit for the fibreoptic bronchoscope, the bronchoscope is removed leaving the Aintree catheter in the trachea. The LMA can then be removed and an endotracheal tube railroaded over the Aintree catheter. This device is designed to by-pass most of the problems associated with passing the endotracheal tube directly over the fibreoptic bronchoscope through the LMA as described above.

Retrograde intubation

Waters first described this technique, nearly 40 years ago in Nigerian patients with cancrum oris, a nutritional disease deforming the jaw.[23] It involves a cricothyroid puncture, followed by passing a guidewire cephalad into the oro- or naso- pharynx which is then used to guide the passage of an endotracheal tube. Once the endotracheal tube is in the trachea, the guidewire is withdrawn.

This technique offers the advantages of combining a Seldinger technique, with which all intensivists are familiar, with a relatively atraumatic cricothyroid puncture. The technique can be used in conjunction with direct laryngoscopy, fibreoptic bronchoscopy or LMA.

Barriot and Riou[24] reported their experience with 19 trauma patients with either maxillofacial trauma or cervical spine fracture who were orotracheally intubated over a retrograde guidewire. In 13 patients, conventional techniques failed and in 6 patients, the initial method of choice was a retrograde technique. In all patients, the retrograde technique succeeded on first attempt. In another study where retrograde intubation was used after multiple failed attempts at direct laryngoscopy in patients undergoing open heart surgery, it was associated with significantly less haemodynamic disturbance compared with the laryngoscopy attempts.[25]

Although there may be many potential complications, few have been reported. The most serious include pneumomediastinum[26] and pretracheal abscess (caused by a mixed oral flora growth suggesting that the guidewire should be removed orally, to prevent contamination of the paratracheal tissues and to consider prophylactic antibiotics in immunocompromised patients).[27] Haemorrhage has also been reported in most studies of retrograde intubations[25,28] but these have not been life-threatening.

The lighted stylet (light wand)

This consists of a stylet with a bright light at its distal end. After the endotracheal tube is loaded onto the stylet, it uses the principle of transillumination of the soft tissues of the neck to allow the operator to identify the position of the tip in the pharynx. When the tip enters the glottic opening, there is a well-defined circumscribed glow in the anterior neck slightly below thyroid prominence. If the tip is in the oesophagus the transmitted glow is diffuse. If the tip is placed in the vallecula (i.e. anterior to the epiglottis) the light glow is slightly above thyroid prominence and is also diffuse.[29,30]

Whilst the lighted stylet has been effective in several studies, including patients with known grade III and grade IV laryngoscopy,[31] it is a blind technique and so contraindicated in patients with obstructive lesions in the upper airway (e.g. tumour, abscess). The main cause of failure reported when using the instrument is an excess of fatty tissue in the neck (preventing transillumination of the tip), so the light wand would appear to be of limited use in obese patients.

Lighted stylets, like rigid fibreoptic laryngoscopes, are specialised techniques and most intensivists will often have insufficient time to gain experience to justify their use in the emergency situation. Therefore, they would appear to have a limited role in difficult airway management in the ICU.

The transtracheal airway

There are certain instances (particularly in patients with an upper airway mass) where it will be impossible to oxygenate the patient through the laryngeal inlet and where alternative airway devices (e.g. LMA) will also fail to oxygenate the patient. The only alternative left in these circumstances will be to provide a transtracheal airway.

This procedure should be familiar to the intensivist due to the experience commonly gained when performing elective percutaneous dilational tracheostomies. When it is clear that the patient is becoming progressively hypoxic and will not be able to be intubated via the laryngeal route or managed by the LMA a transtracheal airway should be established as soon as possible.

An urgent transtracheal airway other than a formal tracheostomy) can only be temporary measure while a more definitive procedure for the airway management is performed. The transtracheal airways include a needle cricothyrotomy, cricothyrotomy with large cannula (internal diameter > 4 mm) and surgical or percutaneous tracheostomy.

Most emergency transtracheal methods go through the cricothyroid membrane as it is relatively avascular, does not calcify, is reasonably superficial and the cricoid ring maintains an open airway. The method is contraindicated in the presence of an obstructive laryngeal lesion where a subcricoid puncture is required.

Needle cricothyrotomy

This is technically the easiest of the techniques with oxygenation often being provided by jet ventilation through the cannula. However, if complete upper airway obstruction exists it has the disadvantage of not allowing adequate exhalation. The side effects of this technique include, pneumothorax, pneumomediastinum, surgical emphysema and even oesophageal perforation, and are more likely to occur if the cannula is displaced from the tracheal lumen.

There is also an incompatibility of the cannula's luer lock connector with the standard breathing system, although several temporary connection systems have been suggested (e.g. using a 7 mm internal diameter endotracheal tube connector inserted into the top of the barrel of a 2 mL syringe which can then be connected to the top of the cannula). The ENK oxygen flow modulator system is specifically designed to connect the standard wall-mounted oxygen flowmeter to a luer lock connection.

Cricothyrotomy with large cannula (internal diameter > 4 mm)

This is a reasonably simple procedure and allows connection to standard breathing circuits and a lower pressure ventilation. Exhalation, and therefore CO_2 excretion, can occur if the expiratory time is 4 seconds or more. The *Mini-Trach*® is one such product that creates a large cannula cricothyrotomy. It is often used as an aid to suctioning in patients with sputum retention and ICU staff are familiar with its use. Other products include the *Quicktrach* (a needle over a cannula technique) and the *Melker* (a Seldinger and a dilational technique). Products that use the Seldinger technique provide the best compromise between safety and delay in establishing an airway. The *Melker* has the additional advantage of providing a cuffed version.

Tracheostomy

Elective insertion of a percutaneous dilational tracheostomy is now commonly performed in most ICU's, and has been used in the management of a patient with an upper airway obstruction caused by a laryngeal carcinoma.[32] However, the technique of an urgent percutaneous tracheostomy is a specilalised one and should only be undertaken by an experienced intensivist. It would seem prudent to stabilise the patient with a cricothyroid puncture first, then the tracheostomy performed as a semi-elective procedure by staff who are experienced in the technique. A single pass dilatational technique (eg. the Ciaglia Blue Rhino technique or guide-wire dilational technique) would be preferable in this circumstance.

A surgical tracheostomy performed under local anaesthesia in an awake patient, should also be considered in the management of a patient with an upper airway obstruction unable to be managed by an endotracheal access, particularly in the absence of a specialist intensivist experienced in the insertion of a percutaneous dilational tracheostomy.

Table 2. Comparison of selection and use of alternative ventilation devices in the intensive care unit

	LMA	*Combitube*	*COPA*	*GAS airway*
Educational considerations				
Initial training requirements to obtain proficiency	+++	+++	+++	+++
Frequency of use required to maintain proficiency	+++	+++	+++	+++
Mannikin, cadaver, animal, or virtual reality model for additional practice	++	+	++	++
Success rates of infrequent users in critical situations	++	++	++	++
Potential for supervisor assistance and targeted feedback	+++	+++	+++	+++
Secondary educational benefits	+	-	+	-
Clinical considerations				
Time to correct insertion among infrequent users	++	++	+++	++
Oxygenation and/or ventilation concurrent with use	---	---	---	---
Potential for significant complications	+++	+	+++	+++
Immediate confirmation of correct tube placement	+	+	++	+
Airway examination/inspection	--	---	--	--
Use with distorted anatomy	-	+	+	-
Use with secretions, blood, vomitus	+	++	-	+
Option for use in non-paralysed patient	+++	-	+++	+++
Option for use with patient in sitting position	++	+	++	++
Integration with current clinical practice	+++	+	-	-
Logistical considerations				
Initial purchase price and/or per-use expenses	+++	-	++	+
Setup and preparation time/labour	++	+++	+++	++
Resterilisation time/labour	--	+++	+++	--
Maintenance/cleaning requirement	-	+++	+++	-
Mobility/manoeuvrability	+++	+++	+++	+++
Cable connection required to light source and/or electrical supply	+++	+++	+++	+++
Breakage risks	++	++	+++	++
Backup unit availability	+++	++	+++	++
Additional considerations specific to ventilation devices				
Time to oxygenation/ventilation	++	++	++	++
Adequacy of oxygenation/ventilation	++	++	+	++
Aspiration protection	-	++	--	-
Option to convert to endotracheal intubation	+++	---	+	+
Ability to oxygenate/ventilate when oral route and/or hypopharynx obstructed	--	-	---	--

LMA = Laryngeal mask airway, COPA = Cuffed oropharyngeal airway, GAS = Glottic aperture seal

PRACTICAL CONSIDERATIONS

All of the published guidelines stress the importance of tailoring techniques and strategies used in the management of a difficult airway to the training, knowledge and experience of the practioner.[1,13,18] The most commonly used alternative airway device used in current practice is the LMA. It is easy to insert with a minimum of training[33,34] and has the additional advantage in the ICU of oxygenating the patient whilst simultaneously acting as a conduit for alternative intubating techniques.

Two of these techniques (e.g. fibreoptic bronchoscopy via LMA and retrograde intubation) may be suited to the ICU setting as they involve extensions of skills familiar to most intensivists and use equipment that is often readily available.

Factors to be considered when selecting the appropriate devices for use in the ICU for management of the patient with a difficult airway (adapted from Levithan *et al*[35]) are summarised in tables 2, 3 and 4.

"Difficult airway" trolley

All published guidelines concerning the management of a patient with a difficult airway recommend having a "difficult airway" trolley in an area where patients will be intubated. Most agree that the trolley should include equipment in the following categories:

- Alternative laryngoscope blades
- Stylets, gum-elastic bougies and airway exchange catheters
- Alternate airway devices
- Alternate intubating devices
- Transtracheal airways

However, there are disadvantages to having too much equipment in the trolley including making the trolley unnecessarily large and cumbersome, more difficult to locate the required equipment and confus-

Table 3. Comparison of selection and use of alternative intubation devices in the intensive care unit

	ILMA	*FOB*	*FOB via LMA*	*RI*	*LS*
Educational considerations					
Initial training requirements to obtain proficiency	+	---	++	+	--
Frequency of use required to maintain proficiency	+	---	++	-	--
Mannikin, cadaver, animal, or virtual reality model for additional practice	+	+	+	--	-
Success rates of infrequent users in critical situations	+	--	++	+	+
Potential for supervisor assistance and targeted feedback	+	++	+	-	+
Secondary educational benefits	++	+++	+++	++	-
Clinical considerations					
Time to tracheal tube placement among infrequent users	++	---	+	+	+
Oxygenation and/or ventilation concurrent with use	++	+	+	++	--
Potential for significant complications	-	+++	+++	-	--
Immediate confirmation of correct tube placement	--	+++	+++	-	++
Airway examination/inspection	--	+++	+++	--	--
Use with distorted anatomy	---	+++	++	++	---
Use with secretions, blood, vomitus	--	---	++	+++	--
Option for use in non-paralysed patient	++	+++	+++	+++	+
Option for use with patient in sitting position	-	+++	++	++	---
Integration with current clinical practice	++	+++	+++	++	+
Logistical considerations					
Initial purchase price and/or per-use expenses	-	--	-	++	--
Setup and preparation time/labour	++	--	-	-	--
Resterilisation time/labour	---	---	---	+++	--
Maintenance/cleaning requirement	-	---	---	+++	--
Mobility/manoeuvrability	+++	---	---	++	+++
Cable connection required to light source and/or electrical supply	+++	---	---	+++	+++
Breakage risks	++	---	---	+++	--
Backup unit availability	++	--	--	+++	--

ILMA = Intubating laryngeal mask, FOB = Fibreoptic bronchoscope, LMA = Laryngeal mask airway, RI = Retrograde intubation, LS = Lighted stylet.

ing the practitioner with excessive choices. The equipment selected from each of the above categories should be chosen according to local experience and the type of personnel staffing the ICU. If there is a requirement to use the "difficult intubation" trolley outside the ICU, the techniques chosen and the design of the trolley should facilitate its portability. The equipment should also be arranged by technique (eg a drawer for transtracheal techniques, drawer for alternative airway devices etc).

Conclusion

The most important factor in the choice of an alternative airway technique should be the training, knowledge and experience of the practitioner and, in most instances, the LMA would often be used as the first alternative. However, intensivists who have more experience with Seldinger techniques, may decide to consider cricothyrotomy, percutaneous tracheostomy and fibreoptic bronchoscopy in their personal difficult airway management strategies. Nevertheless, due to the wide variety of clinical situations in which intensivists often find themselves, they should be familiar with more than one alternative intubating technique.

Received: 30 December 2002
Accepted: 25 February 2003

REFERENCES

1. Brain AIJ. The laryngeal mask - a new concept in airway management. Br J Anaesth 1983;55:801-804.
2. Verghese C, Brimacombe JR. Survey of laryngeal mask airway usage in 11,910 patients: safety and efficacy for conventional and nonconventional usage. Anesth Analg 1996;82:129-133.
3. Mahiou P, Narchi P, Veyrac P, Germond M, Gory G, Bazin G. Is the laryngeal mask easy to use in case of difficult intubation? Anesthesiology 1992;77:A1228.
4. Martin PD, Cyna AM, Hunter WAH, Henry J, Ramayya GP. Training nursing staff in airway management for resuscitation. A clinical comparison of the facemask and laryngeal mask. Anaesthesia 1993;48:33-37.
5. Burgoyne L, Cyna A. Laryngeal mask vs intubating laryngeal mask: insertion and ventilation by inexperienced resuscitators. Anaesth Intensive Care 2001;29:604-608.
6. Benumof JL. Laryngeal mask airway and the ASA difficult airway algorithm. Anesthesiology 1996;84:686-99.

Table 4. Comparison of selection and use of trans-tracheal airway devices in the intensive care unit

	Needle cricothyrotomy	Cricothyrotomy with large cannula	Tracheostomy
Educational considerations			
Initial training requirements to obtain proficiency	++	+	--
Frequency of use required to maintain proficiency	++	+	--
Mannikin, cadaver, animal, or virtual reality model for additional practice	+	+	+
Success rates of infrequent users in critical situations	++	+	---
Potential for supervisor assistance and targeted feedback	+	---	+++
Secondary educational benefits	++	-	+++
Clinical considerations			
Time to tracheal tube placement among infrequent users	++	+	--
Oxygenation and/or ventilation concurrent with use	--	---	---
Potential for significant complications	--	--	---
Immediate confirmation of correct tube placement	---	-	++
Airway examination/inspection	---	---	---
Use with distorted anatomy	+++	+++	+++
Use with secretions, blood, vomitus	-	+	+++
Option for use in non-paralysed patient	+++	+	--
Option for use with patient in sitting position	+	-	---
Integration with current clinical practice	-	--	+++
Logistical considerations			
Initial purchase price and/or per-use expenses	-	--	+
Setup and preparation time/labour	+	--	---
Resterilisation time/labour	++	++	++
Maintenance/cleaning requirement	+++	+++	+++
Mobility/manoeuvrability	+++	++	++
Cable connection required to light source and/or electrical supply	+++	+++	+++
Breakage risks	+++	+	++
Backup unit availability	+	+	+++
Additional considerations specific to ventilation devices			
Time to oxygenation/ventilation	+++	++	-
Adequacy of oxygenation/ventilation	-	+	+++
Aspiration protection	---	+	+++
Option to convert to endotracheal intubation	+	+	N/A
Ability to oxygenate/ventilate when oral route and/or hypopharynx obstructed	+	++	+++

7. Brimacombe JR, Berry A. The incidence of aspiration associated with the laryngeal mask airway: a meta-analysis of published literature. J Clin Anesth 1995;7:297-305.
8. Brain AI, Verghese C, Strube PJ. The LMA 'ProSeal'--a laryngeal mask with an oesophageal vent. Br J Anaesth 2000;84:650-654.
9. Brimacombe J, Keller C. The ProSeal laryngeal mask airway: A randomized, crossover study with the standard laryngeal mask airway in paralyzed, anesthetized patients. Anesthesiology 2000;93:104-109.
10. Evans NR, Gardner SV, James MF, et al. The proseal laryngeal mask: results of a descriptive trial with experience of 300 cases. Br J Anaesth 2002;88:534-539.
11. Frass M, Frenzer R, Mayer G, Popovic R, Leithner C. Mechanical ventilation with the esophageal tracheal combitube (ETC) in the intensive care unit. Arch Emerg Med 1987;4:219-25.
12. Klein H, Williamson M, Sue-Ling HM, Vucevic M, Quinn AC. Esophageal rupture associated with the Combitube. Anesth Analg 1997;85:937-939.
13. Rumball CJ, MacDonald D. The PTL, Combitube, laryngeal mask, and oral airway: a randomized prehospital comparative study of ventilatory device effectiveness and cost-effectiveness in 470 cases of cardiorespiratory arrest. Prehospital Emergency Care 1997;1:1-10.
14. Greenberg RS, Brimacombe JMB, Berry A, Gouze V, Piantadosi S, Dake EM. A randomized controlled trial comparing the Cuffed Oropharyngeal Airway and the Laryngeal Mask Airway in spontaneously breathing anesthetized adults. Anesthesiology 1998;88:970-977.
15. Benumof JL. The Glottic Aperture Seal Airway. A New Ventilatory Device. Anesthesiology 1998;88:1219-1226.
16. Brain AI, Verghese C, Addy EV, Kapila A. The intubating laryngeal mask. I: Development of a new device for intubation of the trachea. Br J Anaesth 1997;79:699-703.
17. Baskett PJF, Parr MJA, Nolan JP. The intubating laryngeal mask. Results of a multicentre trial with experience of 500 cases. Anaesthesia 1998;53:1174-1179.

18. Rose DK, Cohen MM. The airway: problems and predictions in 18,500 patients. Can J. Anaesth 1994;41:372-383.
19. Koga K, Asai T, Latto IP, Vaughan RS. Effect of the size of a tracheal tube and the efficacy of the use of the laryngeal mask for fibrescope-aided tracheal intubation. Anaesthesia 1997;52:131-135.
20. Gabbott DA, Sasada MP. Tracheal intubation through the laryngeal mask using a gum elastic bougie in the presence of cricoid pressure and manual in line stabilisation of the neck. Anaesthesia 1996;51:389-390.
21. Asai T, Latto IP, Vaughan RS. The distance between the grille of the laryngeal mask airway and the vocal cords. Is conventional intubation through the laryngeal mask safe? Anaesthesia 1993;48:667-669.
22. Atherton DPL, O'Sullivan E, Lowe D, Charters P. A ventilation-exchange bougie for fibreoptic intubations with the laryngeal mask airway. Anaesthesia 1996;51:1123-1126.
23. Waters DJ. Guided blind endotracheal intubation. Anaesthesia 1963;18:158-162.
24. Barriot P, Riou B. Retrograde technique for tracheal intubation in trauma patients. Crit Care Med 1988;16:712-713.
25. Casthely FA, Landesman S, Fyman PN, Ergin MA, Griepp R, Wolf GL. Retrograde intubation in patients undergoing open heart surgery. Can Anaesth Soc J 1985;32:661-664.
26. Bowes WA 3rd, Johnson JO. Pneumomediastinum after planned retrograde fibreoptic intubation. Anesth Analg 1994;78:795-797.
27. Beebe DS, Tran P, Belani KG, Adams GL. Pretracheal abscess following retrograde tracheal intubation. Anaesthesia 1995;50:470.
28. Guggenberger H, Lenz G. Training in retrograde intubation. Anesthesiology 1988;69:292.
29. Rayburn RL. "Light wand" intubation. Anaesthesia 1979;34:677-678.
30. McCoy EP, Mirakhur RK. The levering laryngoscope. Anaesthesia 1993;48:516-519.
31. Hung OR, Pytka S, Morris I, Murphy M, Stewart RD. Lightwand intubation II. Clinical trial of a new lightwand for tracheal intubation in patients with difficult airways. Can J Anaesth 1995;42:826-830.
32. Griggs WM, Myburgh JA, Worthley LIG. Urgent airway access--an indication for percutaneous tracheostomy? Anaesth Intensive Care 1991;19:586-587.
33. Martin PD, Cyna AM, Hunter WAH, Henry J, Ramayya GP. Training nursing staff in airway management for resuscitation. A clinical comparison of the facemask and laryngeal mask. Anaesthesia 1993;48:33-37.
34. Burgoyne L, Cyna A. Laryngeal mask vs intubating laryngeal mask: insertion and ventilation by inexperienced resuscitators. Anaesth Intensive Care 2001;29:604-608.
35. Levitan RM, Kush S, Hollander JE. Devices for difficult airway management in academic emergency departments: results of a national survey. Ann Emerg Med 1999;33:694-698.