Review article

The use of extraglottic airway devices in diving medicine – a review of the literature. Part 1: On-site (beach) management of near-drowned victims

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Key words
Extraglottic airway devices, oesophageal combitube, near drowning, resuscitation, review article

Abstract

(Acott CJ. The use of extraglottic airway devices in diving medicine – a review of the literature. Part 1: On-site (beach) management of near-drowned victims. *Diving and Hyperbaric Medicine*. 2006; 36: 186-94.)
On-site resuscitation for near-drowned (ND) victims has been limited to expired air resuscitation (EAR), bag mask ventilation (BMV) and intubation despite the development of the classic laryngeal mask airway (cLMA) and other extraglottic airway devices (EADs). Endotracheal intubation is the gold standard for airway control and ventilation during resuscitation; however, it requires a high degree of training, skill retention and additional equipment. In addition, BMV and EAR may be difficult because of the victim's physical characteristics and the need for an increased inspiratory pressure because of the pathophysiological effects of ND. BMV and EAR may also cause gastric inflation increasing the risk of regurgitation. A review of the relevant studies concerning the use of EADs in resuscitation and trauma was conducted to examine their suitability for use in resuscitation of ND victims. Those suitable were then compared with endotracheal intubation. The majority of the EADs reviewed lacked substantive data to support their use. However, the oesophageal tracheal combitube (OTC) and the cLMA are currently the only EADs with a Class lla recommendation from the American Heart Association. The risk of aspiration, gastric inflation and the inability to apply positive end expiratory pressure (PEEP) limits the use of the cLMA and other laryngeal masks (except the ProSeal™) in the emergency management of ND victims. Because the OTC protects the airway from aspiration, and permits gastric suction and the application of PEEP it is the EAD of choice in the management of adult ND victims (height > 117 cm).

Introduction

On-site resuscitation measures for near-drowned (ND) victims have been limited mainly to expired air resuscitation (EAR), bag mask ventilation (BMV) and intubation despite the development of the classic laryngeal mask airway (cLMA) and other extraglottic airway devices (EADs).[1] During cardiopulmonary resuscitation (CPR) the distribution of gas between the lungs and stomach during intermittent positive pressure ventilation (IPPV) in an unprotected airway has been shown to be determined by the victim's airway resistance, pulmonary compliance, lower oesophageal sphincter pressure and the peak inspiratory pressure required for ventilation.[2] The pathophysiological effects of ND of decreased lung compliance, pulmonary oedema and atelectasis will not only increase the magnitude of the intrapulmonary shunt but also increase the inspiratory pressure required during BMV, predisposing to gastric inflation and the risk of regurgitation.[3] Gastric distension limits ventilation and hence any resuscitative efforts should involve means to deflate the stomach. In addition, some of the victim's physical factors (a lack of teeth, the presence of a beard, an increased body mass index, a history of snoring or age greater than 55) may also make BMV and EAR difficult.[4] While endotracheal intubation remains the gold standard for airway control and ventilation during resuscitation, it requires a high degree of training, skill retention and additional equipment (a working laryngoscope and suction apparatus). Laryngoscopy and intubation in ND victims may also be difficult because of an obstructed view of the larynx by regurgitated gastric contents or pulmonary oedema fluid and, when attempted on the beach, environmental glare will add to the difficulty.

Resuscitative efforts to improve the victim's oxygenation will require all or some of the following:
- increase in the inspired oxygen fraction (FiO_2)
- application of IPPV with or without positive end expiratory pressure (PEEP) to decrease the magnitude of pulmonary shunt
- tracheal and oropharyngeal suction to clear some of the pulmonary oedema fluid to enable ventilation.[3]

A plethora of EADs have been marketed since the release of the cLMA (Table 1), some of which have been shown to be superior to BMV during resuscitation and CPR.[5,6] However, all are untried in the first-aid management of ND victims. Because there are no data concerning the use of the cLMA or any other EAD in the 'on-site' management of the ND victim a literature review of their characteristics

Table 1
Other extraglottic airway devices released for use since the classic laryngeal mask airway (cLMA)[5]

- Pharyngeo-tracheal lumen airway (1984)
- Oesophageal tracheal combitube (1986)
- Flexible laryngeal mask airway (1991)
- Cuffed oral pharyngeal airway (1992)
- Intubating laryngeal mask airway (1997)
- Glottic aperture seal airway (1998)
- Laryngeal tube airway (1999)
- ProSeal laryngeal mask airway (2000)
- Airway management device (2000)
- Soft seal laryngeal mask, Portex™ (2002)
- Streamlined liner of the pharyngeal airway (2002)
- Laryngeal tube suction airway (2002)
- PAxpress oropharyngeal airway (2002)
- COBRA perilaryngeal airway (2003)
- Elisha airway device (2003)
- Easy tube (2003)

Table 2
Desirable characteristics of any airway device used for 'out of hospital' resuscitation of near-drowned victims

- Easy insertion by non-anaesthetists
- Blind insertion
- Used in difficult airway scenarios
- Minimal or no aspiration risk
- Negligible side effects (sore throat, dysphagia, hoarseness, blood contamination)
- Cricoid pressure friendly
- Easily converted to tracheal tube placement
- Minimal gastric inflation with IPPV
- Able to use PEEP
- Able to suction trachea
- Able to insert gastric tube and deflate the stomach
- Data confirming use in CPR
- Able to be secured once placed
- Paediatric size available

was conducted to predict their suitability for use in airway management of ND victims, particularly in clinical situations requiring endotracheal intubation which are or have been proven difficult.

Methods

A medical literature search was conducted for relevant studies of the EADs listed in Table 1 using the clinical criteria outlined in Table 2. These criteria were modified from the ideal airway device characteristics proposed by Charters.[7] The relevant data, comparison with endotracheal intubation and conclusions regarding each EAD's suitability for 'beach resuscitation' are tabulated in Table 3.

Review of the current extraglottic airway devices

THE CLASSIC LARYNGEAL MASK AIRWAY

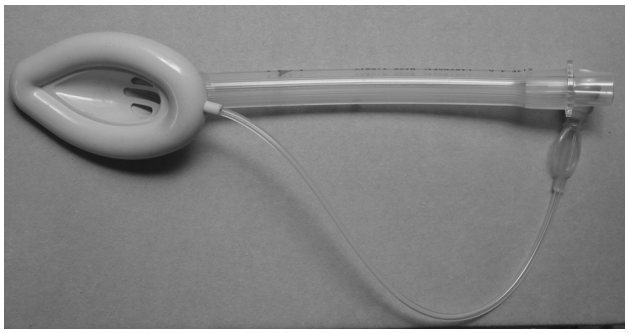
The cLMA (Figure 1) is a ventilatory device that provides a conduit from outside the lips to the laryngeal opening and has added a new dimension to airway control. The cLMA is easily inserted and secured. Since its commercial release in the United Kingdom in the 1980s, it has gained wide international acceptance in anaesthesia practice

Table 3. Comparison of various EADs to endotracheal intubation for use in 'beach' resuscitation (see text for full names of devices and other terms)

	cLMA	OTC	pLMA	SLIPA	LTA	ETT
Easy insertion	Yes	Yes	+/-	Yes	Yes	No
Blind insertion	Yes	Yes	+/-	Yes	Yes	No
Use in CPR*	Yes	Yes	Yes	Yes	Yes	Yes
Aspiration risk	Yes	No	No	No	No	No
Gastric inflation	Yes	No	No	+/-	No	No
Gastric tube insertable	No	Yes	Yes	No	No	Yes
CP friendly	No	No	No	Nd	No	Yes
IPPV	+/-	Yes	Yes	Yes	Yes	Yes
PEEP (up to +10 cm)	No	Md	Yes	Nd	Nd	Yes
CVS side effects	+	+++(+)	+	+	Md	+++(+)
Easily converted to ETT	No**	Yes	No**	No**	No**	—
Suction trachea	No	Yes	No	No	No	Yes
Securable once placed	No	Yes	No	No	No	No
Used in difficult airway	Yes	Yes	Yes	Nd	Nd	Yes
Paediatric size	Yes	No	Yes	No	Nd	Yes
Ease of training	Yes	Yes	+/-	Ld	Nd	No
Recommended	Y/N	Yes	Yes	Md	Md	

* includes manikin studies; ** bougie or fibrescope required, blind intubation through device occasionally successful
CP – cricoid pressure; Nd – no data; Ld – limited data; Md – more data and studies needed; Yes/No – better than BMV

Figure 1
The classic laryngeal mask airway (cLMA). When the cuff is fully inflated following correct insertion, the cLMA occupies the hypopharynx and rests against the upper oesophageal sphincter behind the cricoid cartilage. The cuff and bowl seal the laryngeal inlet. The cLMA's sides face the pyriform fossae and the epiglottis rests inside the bowl or under the proximal cuff at the junction of the cuff and airway tube.



both in routine cases and the management of the difficult airway.[6,8]

There are still reservations concerning the use of the cLMA for controlled ventilation and the prevention of aspiration.[8,9] Its role in trauma management is controversial; however, there are data suggesting better oxygenation and airway control than BMV.[6,8] Despite these reservations it has been reported to have provided an effective emergency airway in a variety of crisis situations and hence it is now considered a primary option for the management of the difficult airway by the American Society of Anesthesiologists (ASA),[10] the European Resuscitation Council,[11] and the British Difficult Airway Society.[12]

A meta-analysis of 10 studies containing 700 patients revealed that cricoid pressure (CP) not only impeded the insertion of the cLMA but also impeded ventilation after successful insertion of the cLMA. These data were applicable to any type of laryngeal mask.[6]

DISPOSABLE SOFT SEAL LARYNGEAL MASK

Portex™ released the soft seal LMA in 2002.[5] It differs from the cLMA in that it is made from polyvinyl, has a deeper bowl, blunter distal cuff, no aperture bars and a wider airway tube fused to a larger part of the bowl. There are contradictory data comparing it with the cLMA regarding ease of insertion.[13]

INTUBATING LARYNGEAL MASK AIRWAY

The intubating laryngeal mask (iLMA) functions in the same manner as the cLMA and hence offers inadequate airway protection. It was designed to facilitate either blind or fibreoptically assisted intubation in the difficult airway scenario.[14,15] Even inexperienced operators find the iLMA easy to insert and achieve ventilation.[16] One study suggested that the iLMA was inserted faster than the cLMA with a greater proportion achieving ventilation after their first attempt.[17] There are limited data on the use of the iLMA in CPR and only one study evaluating its use in children.[18] It may offer an advantage over the cLMA when a patient needs to be intubated. When used in the pre-hospital setting it will need to be replaced upon arrival at hospital, but at present the majority of hospital personnel are unfamiliar with it.

THE OESOPHAGEAL TRACHEAL COMBITUBE

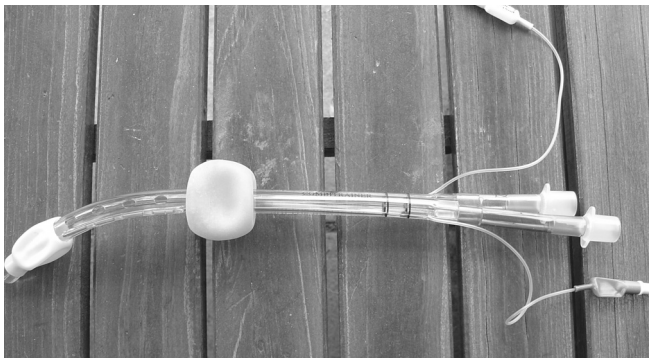
The oesophageal tracheal combitube (OTC) is a double-lumen, double-cuffed, polyvinyl EAD that can be used as the primary or as a secondary 'rescue airway' (Figure 2). It can function as an alternative ventilatory device to bag mask ventilation, the cLMA or endotracheal intubation.[19] The ASA,[10] American Heart Association,[19] and the European Resuscitation Council[11] have included the OTC in their guidelines as an emergency rescue airway device. The OTC is available in two sizes: 37F and 41F. The 37F is now recommended for use in the majority of patients greater than 117 cm in height. There is no paediatric size available at present.[20, 21]

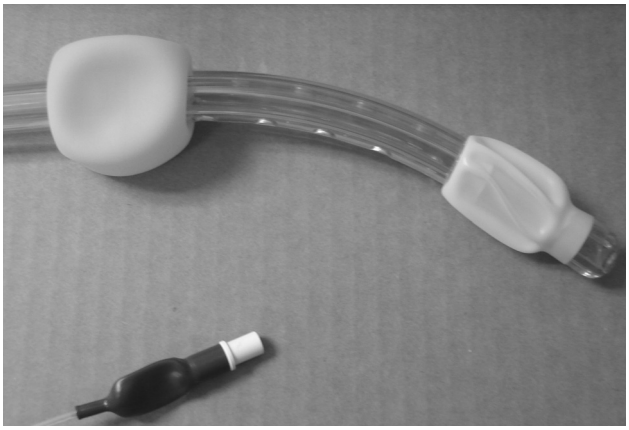
The two separated short, proximal, colour-coded tubes (numbered 1 and 2) unite to form one tube with a double lumen. These two proximal tubes each have a 15 mm connector and are of differing length (Figure 2a). The longer blue tube (numbered 1) is blind at the distal end but has eight small ventilatory side ports located midway along the joined single lumen (Figure 2b). The shorter clear tube (numbered 2) is open at its distal end and resembles an endotracheal tube (ETT). The double rings marked just distal to the junction of the two proximal colour-coded tubes should be at the level of the patient's teeth or alveolar margins when the OTC is correctly placed. The diameter of the 37F is 14 mm at its distal end (Size 8 ETT is 12 mm).[19–21]

The large proximal oropharyngeal latex cuff seals the upper airway while the smaller distal oesophageal-tracheal cuff will seal either the oesophagus when in the oesophageal position or the trachea when in the tracheal position. Various studies have been published concerning cuff volumes and pressures.[22] However, the potential risk of impaired oropharyngeal venous blood flow and swelling of the oropharyngeal soft tissues by the oropharyngeal balloon can be prevented by deflating the balloon to the minimum volume required for an airtight seal and routinely measuring cuff pressures.[20,22]

Insertion technique for the OTC is described in Table 4. During insertion there is little movement of the head and cervical spine and, therefore, it has been reported to be suitable for securing the airway in patients with either a fractured or abnormal cervical spine or difficult intubation. However, some insertions do require elevation of the chin

Figures 2a and 2b
The oesophageal tracheal combitube (OTC). Note the two cuffs, the larger pharyngeal cuff and the distal oesophageal (or tracheal) cuff, with the ventilating holes between.





and tongue.[23–25] Cricoid pressure cannot be applied while the OTC is being inserted, but insertion has been successfully performed in a vomiting patient without aspiration.[26] Contra-indications for use include patients with intact gag reflexes, known oesophageal pathology, following ingestion of caustic substances, supraglottic tumours or stenosis and unfamiliarity with its use.[19]

The OTC provides adequate ventilation and oxygenation in either oesophageal or tracheal positions even during CPR.[27] The oesophageal position is preferred and has been reported to occur in 89–95% of occasions. In this position ventilation occurs through the longer blue tube via the eight pharyngeal perforations, while in the tracheal position ventilation is via the shorter clear tube. Studies have shown there is almost 100% recognition by paramedic staff of oesophageal or tracheal placement.[28]

Patients ventilated with identical ventilatory parameters via an oesophageally placed OTC generated higher arterial oxygen partial pressures than patients ventilated with an ETT. This is probably due to a slower increase in inspiratory pressure and a positive end expiratory pressure effect of approximately 2 cm H_2O caused by the increased expiratory resistance associated with the perforations in the oesophageal limb of the OTC.[29] In the tracheal position the oropharyngeal cuff can be deflated; however, it is recommended that this cuff is inflated during transport to prevent dislodgement unless secured in another way.

Difficulty with ventilation has been recorded due to partial obstruction of the ventilatory perforations because of too deep an insertion of the pharyngeal tube in the oesophagus, or glottic obstruction due to downward displacement of the epiglottis by the inflated proximal oropharyngeal cuff. Withdrawing the OTC in increments of 2–3 cm can restore ventilation.[19,30]

Table 4
Insertion technique for the oesophageal tracheal combitube (OTC)

1 Bend the portion of the OTC between the cuffs in order to augment the preformed curve and maintain this bend as long as possible prior to insertion (a modified Lipp manoeuvre).
2 Blind insertion in the midline in a caudal direction along the tongue; avoid pushing against the hard palate and posterior pharyngeal wall. A laryngoscope can also be used to assist insertion.
3 Head preferably in the neutral position.
4 The OTC is inserted until the patient's teeth or alveolar margins lie between the double rings distal to the junction of the two proximal tubes.
5 The oropharyngeal cuff is inflated first with 50–85 ml of air followed by the oesophageal/tracheal cuff with 8–10 ml.
6 Attach a ventilating bag to the longer blue tube 1 and confirm chest ventilation by auscultation of the chest listening for bilateral lung sounds and epigastrium confirming an absence of gastric insufflation. In addition an oesophageal detector device, capnometry and colorimetric breath indicators can be used to verify the position of the OTC.
7 Ventilate via the colourless shorter tube 2 if there is an absence of chest breath sounds, a failure to detect carbon dioxide via capnometry, or gastric inflation.
8 In the absence of ventilation via either tube check the position of the teeth or alveolar margins in relationship to the two proximal rings, deflate cuffs and adjust accordingly.
9 The most common insertion problem is too deep an insertion. A failure to ventilate after adjustment requires a further cuff deflation and withdrawal of the OTC in increments of 2–3 cm checking ventilation each time until it is achieved.

Several studies have shown that the skill retention required to insert the OTC is easier to retain over time when compared with the cLMA and endotracheal intubation. However, the period of time required before retraining has varied in different studies and is more likely to be related to the airway skills used on a daily basis by paramedics.[6,31]

The OTC is primarily intended for emergency use and should not be left in situ for more than eight hours. Complications of the OTC, such as oesophageal and pyriform fossa tears, haematomas, dysphagia and sore throat occur infrequently.[30,31] The reported increase in airway morbidity may be explained by the unphysiological high cuff pressure, which may be prevented by deflating the cuffs to the minimum volume required for an airtight seal and routinely monitoring intra-cuff pressures.[22,32]

Intubation can be performed with the OTC in place protecting the airway from aspiration. If it is in the tracheal position an exchange catheter bougie technique is used with an appropriately sized bougie to enable it to be placed in the OTC's tracheal lumen. If the OTC is in the oesophageal position the oropharyngeal cuff is deflated, and the OTC pushed to the left followed by laryngoscopy and intubation; the distal cuff is left inflated until intubation is achieved.[19–21]

THE EASY TUBE

The Easy tube (EzT) was released in Europe in 2003. It is a double-lumen tube similar to the OTC but is latex free. Ventilation is via a single large orifice situated between the oropharyngeal and oesophageal cuffs and allows the passage of a fibreoptic scope, bougie or suction catheter.[33] There are two sizes (28 and 41) for use in patients greater than 90 cm in height. The tip of the size 41 is the same as that of a standard 7.5 mm ETT, and the tip of the size 28 as for a standard 5.5 mm ETT. The tip of the EzT resembles the end of an endotracheal tube and is less bulky than the OTC. There are limited data on its use at present. A recent study has shown it to be effective in the 'difficult airway' scenario in either anaesthesia or the pre-hospital setting.[33]

PROSEAL LARYNGEAL MASK AIRWAY

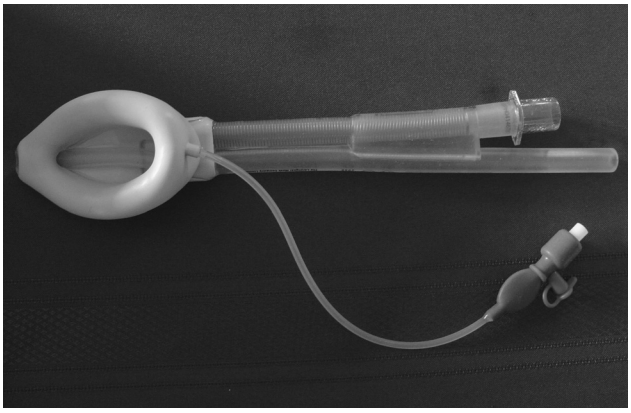
The ProSeal (pLMA) is a major advance in airway control compared with the cLMA. It allows ventilation at higher airway pressures, protects against gastric insufflation and aspiration, allows insertion of a gastric tube and has a built-in bite block (Figure 3).[34] It has four main components: a bowl-shaped mask, pilot balloon inflation line, an airway and drainage tubes. The airway tube is shorter and narrower than that of the cLMA (9 mm) and hence has a 20% greater airway resistance. The drainage tube traverses the floor of the mask opening at the mask tip.[34,35] There are paediatric sizes available.

Digital insertion is recommended with the head in the intubating position (neck flexed, head extended) using either a metal introducer or a gum-elastic bougie-guided technique.[34–6] The pLMA is more difficult to insert digitally than the cLMA because of the larger cuff, which leaves less room in the mouth for the index finger; however, this difficulty is eliminated when the metal introducer or the bougie-guided technique is used (both these techniques have the advantage that a finger is not placed in the patient's mouth).[37] Using the introducer made insertion of the pLMA easier than that of the cLMA in patients with manual in-line neck stabilization.[38] Haemodynamic responses to insertion (whatever the method) are similar to those seen with insertion of the cLMA with an increase in mean arterial pressure and heart rate of about 20%.[5]

The pLMA is an improvement on the cLMA for controlled ventilation and can be used effectively for the application of 10 cm H_2O PEEP during IPPV without any detectable gas leak or gastric inflation.[39] The improved airway seal is thought to be due to the larger wedge-shaped ventral cuff, deeper bowl with the dorsal cuff pushing the ventral cuff firmly into the periglottic tissues.[35,37] A correctly positioned pLMA theoretically protects the airway from aspiration; however, comparison of the proposed increased safety of the pLMA with that of the cLMA in a patient with an aspiration risk will probably remain unproven. Therefore, it is important to identify the correct position of the pLMA by the performance of a series of simple tests.[34,40] The drainage tube allows insertion of a gastric tube for drainage of the stomach. Failure to insert a gastric tube via the drainage tube can be due to malpositioning, inadequate tube lubrication or herniation of the dorsal cuff compressing the drainage tube in the bowl.[41]

There are no clinical case reports of the use of the pLMA in the trauma setting but it has been reported as a rescue device after failed intubation during rapid-sequence intubation.[42]

Figure 3
The ProSeal laryngeal mask airway (pLMA). The pLMA differs from the cLMA in that it is bulkier and has a gastric drainage tube passing through the bowl. This drainage tube allows the passage of an oral-gastric tube for drainage of the stomach.



Manikin studies comparing various laryngeal masks with tracheal intubation, OTC, laryngeal tube suction airway (LTSA) or BMV during simulated CPR showed that the pLMA functioned as well as the tracheal tube, OTC or LTSA but better than BMV or the other laryngeal masks (cLMA, iLMA and the disposable LMA).[5,35]

The pLMA is not designed to replace the ETT in patients who are at risk of aspiration but it offers several important advantages over the cLMA:

- it isolates the gastrointestinal tract from the airway[34,35]
- when correctly positioned its design makes gastric inflation unlikely and a gastric tube can be inserted to aspirate or deflate the stomach[34,42]
- it has a built-in bite block[34]
- its airway sealing pressure is 50% greater (10.8 cm H_2O) than the cLMA[34,42]
- up to 10.0 cm H_2O PEEP can be applied without gastric inflation[39]
- a wider bowl without aperture bars makes the view of the glottis with a fibrescope easier and allows for easier intubation[35,42]
- malposition of the pLMA can be detected by a series of simple tests.[5,34,40]

LARYNGEAL TUBE AIRWAY AND LARYNGEAL TUBE SUCTION AIRWAY

The laryngeal tube airway (LTA) is a single-lumen, silicone tube with two, low-pressure cuffs (oropharyngeal and oesophageal) and a ventilation port between these two. It is autoclavable and can be used up to 50 times. Six sizes are available (from neonates to large adults) but usually a size 4 is adequate for adults. The cuffs are inflated by a single pilot balloon either via a cuff inflator or with a 100 ml syringe with marks for the recommended volumes for each size of the LTA. The single ventilation orifice is positioned between the two cuffs and when correctly positioned lies behind the larynx. The orifice is large enough to allow for fibreoptic bronchoscopy and suctioning. A disposable version is now available. [43]

It is inserted in the midline until resistance is felt; the patient's head can be in either the neutral or intubating position. The cuffs are then inflated. When correctly placed, the LTA lies along the midline of the tongue with the distal tip in the hypopharynx. The proximal non-latex cuff seals the upper pharynx and the distal cuff the oesophagus.[43] Studies show that it prevents aspiration, is atraumatic and can be used for IPPV; however, it is not a satisfactory device for spontaneous ventilation.[44] There are no data concerning the application of PEEP. When used by experienced personnel, the LTA is comparable to the cLMA and pLMA in ease and time of insertion.[45] Studies comparing the cLMA with the LTA have shown that the incidence of complications was similar but the LTA required more adjustments to obtain a clear airway.[43] Exchange for an ETT using an exchange catheter and a fibreoptic bronchoscope has been reported.[43]

It is as effective during CPR as a bag mask or endotracheal intubation,[46] but there are only limited reports (five cases) of the successful use of the LTA in out-of-hospital CPR.[47] There are no data concerning its use in trauma or in children.

Concern about the blind distal end causing an oesophageal rupture during regurgitation led to the LTSA being developed. The LTSA has two tubes, one for ventilation and the other to allow the passage of a gastric tube for gastric decompression and suction.[43] The efficacy of the LTSA has yet to be determined.

GLOTTIC APERTURE SEAL AIRWAY

The glottic aperture seal airway (GASA) was introduced in 1998.[5] It is not easy to insert but is reported to incur less gastric inflation compared with the cLMA when used for IPPV.[48] Insertion requires the use of a broad semi-flexible retractable blade to elevate the epiglottis anteriorly while the GASA is passed behind the blade until resistance is felt. The blade is then removed and the foam cuff allowed to align itself with the glottic inlet.[5] The foam cushion seals behind the epiglottis and arytenoids. Insertion is more traumatic than with the cLMA.[48] At present this airway is not readily available and there are limited data concerning its use.

COBRA PERILARYNGEAL TUBE

The cobra perilaryngeal airway (COBRA) consists of a tube, a standard 15 mm adaptor at one end, an inflatable cuff (which requires deflation prior to insertion) and a softened distal end (shaped like a Cobra's head). The distal end has slotted openings on one side which, when correctly positioned in the hypopharynx, are opposite the laryngeal opening.[5,49] The appropriate size for the patient's weight is marked on the tube. It is inserted blindly along the midline of the tongue. A recent study was abandoned because of lung aspiration of gastric contents in two subjects.[50]

STREAMLINED LINER OF THE PHARYNGEAL AIRWAY

The streamlined liner of the pharyngeal airway (SLIPA™) is a new, inexpensive, disposable EAD designed to seal the airway without the use of an inflatable cuff and has features designed to reduce the aspiration risk. Shaped like a hollow boot, it is made of soft plastic and hence flexible, allowing it to be 'squeezed' between the teeth in limited opening situations. Insertion is easy but requires the flat side to face the patient's back, the jaw to be lifted forward and the device lubricated. Once inserted the flatter hollow portion (which consists of the heel, toe and bridge sections) faces the laryngeal inlet. The 'central' bridge fits into the pyriform fossae at the base of the tongue. The toe of the chamber slips easily into the entrance of the oesophagus where it seals against the crico-pharyngeal sphincter. The heel anchors the SLIPA™ in position.[5,51]

Comparative study of 120 patients by Miller and Light demonstrated that the SLIPA™ compared favourably with the cLMA in ease of insertion, ventilatory capacity, post-extubation morbidity, haemodynamic changes associated with insertion, and prevention of aspiration if secretions or blood accumulated in the pharynx or if regurgitation occurred.[51] Airway seal equalled the cLMA but gastric inflation is possible with IPPV if too small a size is used. There are six adult sizes. The size is estimated by measurement of the patient's translaryngeal diameter and its comparison with the SLIPA's diameter.[51] At present it is not readily available and more studies are needed.

PHARYNGO-TRACHEAL LUMEN AIRWAY

The pharyngo-tracheal lumen airway (PTLA) is a double-cuffed, double-lumen tube which allows ventilation following placement in either the oesophagus or trachea. The operator inflates the two cuffs orally. It has been used successfully in pre-hospital CPR and as a method of emergency airway management. The PTLA is not readily available and has limited data supporting its use.[5,52]

PHARYNGEAL AIRWAY EXPRESS

The pharyngeal airway express (PAxpress) was released recently and has few data concerning its efficacy and safety. It consists of an anatomically curved polypropylene tube, an inflatable midsection circular cuff and a non-inflatable gilled conical cuff at the distal end. It is easily inserted, is atraumatic to the upper airway, allows effective IPPV with a low risk of gastric inflation but is haemodynamically stressful during insertion.[5,53] Only one size, for adults greater that 40 kg, is manufactured, and it is not readily available.

AIRWAY MANAGEMENT DEVICE

The original airway management device (AMD) was released in 2000. It was similar in appearance to the LTA with a blind distal end but had two pilot balloons for cuff inflation. It is inserted in a similar manner to the LTA. Studies concerning its use, however, were unfavourable – tongue congestion, airway obstruction following insertion and regurgitation being reported.[54] It has subsequently been modified, the sizes have changed making it easier to choose an appropriate size for an adult, and the inflated cuffs have been modified in size and shape. A direct comparison with other EADs is needed but a recently published study of 50 patients showed that the modified AMD was easy to insert, atraumatic, and provided a reliable patent airway that could be suitably used in anaesthesia.[55] More studies are required in the pre-hospital and CPR situations.

Discussion

The majority of the EADs reviewed:

- failed to meet the criteria outlined in Table 2
- lacked substantive data concerning their use in CPR, trauma and anaesthesia and/or
- had small patient numbers in published studies.

The OTC, SLIPA™, pLMA and LTSA have limited data to support their use in resuscitation; however, the OTC and cLMA are the only EADs with a Class lla recommendation from the American Heart Association (the weight of evidence/opinion is in favour of its usefulness/efficacy).

The problems associated with the use of the cLMA and other laryngeal masks in emergency management – the lack of airway protection from aspiration, conflict with the use of CP, the risk of gastric inflation with IPPV, particularly if high inspiratory pressures are needed, and the inability to apply PEEP and decompression or suction of the stomach – are not associated with the pLMA. Its design isolates the respiratory tract from the gastrointestinal tract and allows IPPV with PEEP without a substantial airway leak or gastric inflation and allows the passage of a gastric tube to decompress the stomach. Few complications have been reported in association with its use but it needs securing once positioned and it is not easily replaced with an ETT. There are also other potential limitations for the use of the pLMA for resuscitation: it is more complex to understand, more difficult to insert and must be correctly positioned for it to be used safely. In addition, there are no data, at present, on its use in resuscitation. Its main use is that it acts as a 'bridge' between the use of a cLMA and endotracheal intubation and if the user is trained and skilled then it is potentially a very useful EAD in the trauma/resuscitation situation.

Gastric suction and deflation of the stomach cannot be performed if the SLIPA™ is used and there are no data concerning its ease of replacement with an ETT or the use of PEEP. There are no data on the use of the LTSA with PEEP and once positioned it needs to be constantly monitored to ensure that it remains correctly placed. More data are needed before the SLIPA™ and LTSA are routinely recommended for use in CPR or trauma and hence they are not recommended for beach resuscitation of the ND victim.

The OTC compares favourably with the use of an ETT in the emergency setting. The main limitations to the use of the OTC are a lack of any paediatric sizes (although it can be used in patients of a height greater than 117 cm – a 9- or 10-year-old child), the latex oropharyngeal cuff, the intra-cuff pressures and its reported rare complications of oesophageal and laryngeal damage. It is important to realise that the efficacy of the airway seal obtained with the OTC may vary with the individual's laryngopharyngeal anatomy and, therefore, using a fixed cuff inflation value is not recommended. The cuffs should be inflated until an acceptable airway seal is obtained and intra-cuff pressure monitoring should become routine when available. The ease of insertion, the lack of the need of any additional equipment, protection of the airway from aspiration, the ability to deflate the stomach in either the oesophageal or tracheal positions, and the ability to apply IPPV and probably PEEP make the

OTC the first choice in the resuscitation of ND victims with a height greater than 117 cm.

Recommendation of a particular EAD for the resuscitation of ND children is difficult. Several choices are available, none fulfilling all requirements. If the operator is skilled in the use of the pLMA then this would be the EAD of first choice. The LTSA has merit but more data on paediatric patients are needed. If the clinical situation dictates that the only choice is between using the cLMA and BMV then the cLMA should be used because it does offer some airway protection and better oxygenation than the BMV.

Conclusions

Environmental circumstances, victim size and operator experience all dictate which airway device can be used for resuscitation of the ND victim. This review indicates that the OTC and pLMA are suitable. More data on the LTSA are needed. The OTC is the EAD of choice in teenage or adult ND victims while the pLMA can be used in adults or children if the resuscitator is suitably trained and skilled.

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