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## INTRODUCTION

The laryngeal mask airway (LMA), introduced in 1988, revolutionised airway management by providing an attractive alternative to tracheal tube or face mask. The LMA rapidly became popular in the elective, fasted day surgery population, where it provided a clear airway while avoiding the trauma, stress response and need for neuromuscular block associated with tracheal intubation. With greater experience of the LMA in simple, spontaneously breathing cases, there has also been an increase in its use for more controversial applications, such as in extended laparoscopies and in the prone position. Some of these more controversial uses will be reviewed.

The original reusable LMA has been further developed into a wide variety of variants, including single use, disposable devices, the intubating LMA (iLMA) and the ProSeal. The role of some of these developments in day surgery will also be reviewed. In addition, a great many manufacturers now produce their own versions of the laryngeal mask in both reusable and single-use versions. While it is often assumed that these devices will perform similarly to the original LMA, this assumption is rarely supported by data. This review will highlight some areas where performance has been compared.

Finally, the success of the LMA has spurred the development of numerous other supraglottic airways. These are often marketed after minimal clinical evaluation with little or no published evidence to support the claims for their performance [1]. While a comprehensive evaluation of all the new airways is beyond the scope of this review, some of the more prominent devices will be discussed and, where possible, compared to the LMA.

## CONTROVERSIAL USES OF THE LMA

### SIMPLE LAPAROSCOPY

Using the LMA for gynaecological laparoscopy has been controversial in the past, as the risk of aspiration was thought to be increased by the pneumoperitoneum and by head down tilt. It is now recognised that these manoeuvres actually *increase* the barrier pressure protecting against regurgitation, since both increase lower oesophageal pressure to a greater extent than intragastric pressure. Continuous oesophageal pH monitoring confirms a low incidence of significant gastroesophageal reflux when using the LMA for laparoscopy, and adverse events appear rare in practice. In one evaluation of the LMA for laparoscopy in which 20% of the patients were obese and 14% had reflux, regurgitation was observed in only 1% overall and no patient aspirated [2].

The pneumoperitoneum, absorption of $CO_2$ and adverse patient positioning all compromise ventilation during laparoscopy and statistically significant changes in end-tidal carbon dioxide tension and arterial pH develop if patients are permitted to breath spontaneously. These are small in magnitude, however, and correct rapidly once the intraabdominal gas is released. In practice, spontaneous ventilation through the LMA does not appear to increase adverse events and is probably acceptable during short gynaecological laparoscopic procedures. In this context, “short” has been suggested to be operating times of 15 minutes or less with less than 15 degrees of table tilt and intraabdominal pressures below 15 mmHg. As longer and increasingly complex laparoscopic surgery is being performed, the adverse mechanics of spontaneous ventilation become unacceptable and the overall safety of the LMA is largely unknown.

### Laparoscopic cholecystectomy

Laparoscopic cholecystectomy is increasingly being performed as a day case procedure and the use of an airway which is less invasive than tracheal intubation is an attractive prospect. In addition, the procedure generally requires a head-up tilt, which is more mechanically favourable for the LMA compared to pelvic laparoscopy. However, the longer duration of the procedure and greater disturbance of the upper gastrointestinal almost certainly increase the risk of aspiration. Bile reflux is a distinct possibility and may produce especially severe pulmonary damage when aspirated. In addition, bile reflux will increase gastric volume, making regurgitation more likely. Controlled ventilation using either a LMA or tracheal tube resulted in comparable oxygen saturation, expired $CO_2$, airway pressures and surgical conditions during laparoscopic cholecystectomy and there have been other small series which have confirmed the effectiveness of the LMA for this procedure [3]. However, there is far too little published evidence to establish the safety of the LMA for laparoscopic cholecystectomy and at least one case of aspiration pneumonia has been reported. Many would consider the LMA to be contraindicated for laparoscopic cholecystectomy.

The ProSeal® LMA (Intavent Orthofix Ltd, Maidenhead, UK) is designed to permit better drainage of gastric contents while affording greater protection against aspiration through a higher seal pressure. This LMA variant would appear to be a better choice for laparoscopic cholecystectomy and, indeed, has been shown to result in better ventilation following the establishment of a pneumoperitoneum than that which could be achieved through a standard LMA [4]. In addition, a gastric drainage tube could be readily placed in all patients, 78% of whom were found to have residual gastric fluid which was bile stained in almost half the cases [4]. This finding tends to support the notion that pulmonary aspiration may be more likely with this procedure. While the ProSeal is probably the more effective form of LMA for laparoscopic cholecystectomy, there is again insufficient evidence to confirm that its safety is comparable to tracheal intubation and it cannot be relied upon to prevent aspiration.

### The LMA in the prone position

The use of the LMA in the prone position is still considered controversial. The main concern seems to be that the airway may fall out or become dislodged while the patient is face down with “disastrous consequences”. No such event appears to have been reported, however, and case reports and a few small series support the simplicity and effectiveness of using the LMA in prone patients. If the patient is adequately supported with sufficient clearance under the abdomen, spontaneous breathing is usually quite effective. A reinforced LMA gives greater protection against kinking of the tube, although a conventional LMA is usually acceptable. It is the author’s practice to induce anaesthesia conventionally and then turn the patient prone once the airway is secure. However, others have the patient position themselves in a comfortable face-down position and then induce anaesthesia while prone, turning the head slightly to facilitate LMA insertion [5]. This obviously reduces the amount of manual handling and minimises the risk of patient (or staff) injury. The fact that the LMA can readily be inserted with the patient prone shows that it would be quite possible to replace an airway in the unlikely event that it was dislodged during surgery. Contrast this with the difficulties in trying to reintubate a paralysed prone patient in whom a tracheal tube had become unintentionally displaced.

## The LMA “family”

The main developments of the conventional LMA have been the ProSeal and the intubating LMA. The ProSeal has already been discussed in relation to laparoscopy. Its revised cuff design increases seal pressure, while an integral conduit facilitates gastric drainage. It is probably the LMA of choice for controlled ventilation (although in the author’s experience, spontaneous ventilation through a conventional LMA is usually satisfactory), but is more difficult to insert and cannot be relied upon to protect against aspiration [6].

The intubating LMA (iLMA) acts as a conduit for tracheal intubation. Minor trauma and cardiovascular stimulation may be reduced, but at the expense of less successful first time intubation and the risk of serious oesophageal injury [7]. One novel use of the iLMA is to facilitate vocal cord biopsy during suspension laryngoscopy, the wide diameter of the tube giving adequate access for a flexible bronchoscope, biopsy forceps and laser fibre [8].

## Alternative and disposable LMAs

A large number of manufacturers now produce their variation of the laryngeal mask airway. While these bear a close resemblance to the original LMA, the aperture bars of the latter, intended to prevent obstruction by the epiglottis, are still protected by patent and so are not a feature of the alternative devices. It is still not clear if this difference will affect performance, as detailed comparisons of the numerous devices have rarely been performed. However, it should not be assumed that everything which looks like a LMA will perform like one.

Both the original LMA Company and several other manufacturers produce disposable LMAs designed for single use. Unlike the silicone cuff of the reusable models, these are generally made of PVC to reduce costs. One of the more extensively studied is the Portex Soft Seal, which appears to be associated with a higher seal pressure, but also an increased incidence of throat soreness [9]. The LMA Unique, from the manufacturer of the original LMA, appears less traumatic and is easier to insert with better final position [9,10]. One of the main drivers towards disposable LMAs has been the fear of possible transmission of prion diseases. The magnitude of this theoretical risk appears to have reduced greatly with significantly reduced estimates for the "worst case" incidence of new variant Creutzfeldt-Jakob disease, questioning the need for single-use airways which generally have poorer performance than their reusable counterparts [9].

## Alternative airway devices

The LMA has been an enormous clinical and commercial success which many inventors and manufacturers have attempted to replicate. This is a tough challenge, since the LMA is easy to use, provides a reliable airway and is relatively atraumatic. Desirable improvements would be a lower incidence of throat soreness and protection against aspiration, although the latter has rarely been a claim for alternative supraglottic airways.

The variety of available supraglottic airways is overwhelming. Airways are subject to the regulations which govern medical devices, which are more concerned with manufacturing materials and standards, rather than efficacy [1]. In contrast to new drugs, novel airways can be marketed with little if any published comparative trials to substantiate the claims of their manufacturers. Furthermore, these devices are frequently modified, often without obvious notification, rendering previous comparative data useless. As a consequence, new airways are often launched in a blaze of glory, only to be withdrawn a few years later when problems become evident or unimpressive performance results in poor sales. One example is the cuffed oropharyngeal airway (COPA) which, according to the manufacturer's literature, offered "improved airway management in spontaneous ventilation". In practice, it was difficult to choose the correct size of COPA and, compared to a LMA, was more difficult to insert and resulted in a poorer airway [11]. The COPA was finally withdrawn in 2003.

### The Airway Management Device

The Airway Management Device (AMD) is another example of a device marketed with claims of safe airway maintenance and minimal soft tissue trauma, unsupported by clinical literature. The original design, comprising a silicone tube with two inflatable cuffs, was found to be not very effective in practice and modifications were subsequently made to the cuff design. Despite these modifications, first time successful insertion was still only possible in 70–83% of cases and, more importantly, the airway became obstructed in 19–22% of patients [12,13]. Although some of these cases could be resolved by manipulation of the airway, in many the AMD failed to provide an adequate airway and had to be replaced by an alternative device [12,13]. It is believed that the AMD has subsequently been withdrawn.

### The laryngeal tube

The laryngeal tube consists of an airway tube with a small distal cuff at the tip and a larger, interconnected cuff in the central part; ventilation occurs through an opening between the cuffs. Since its original conception (intended as an emergency form of airway), the device has been modified and is now available in a number of variants, some of which have themselves undergone modification. The two basic designs are the laryngeal tube (LT) with a single lumen and blind distal cuff and the laryngeal tube-suction (LTS), which incorporates a second channel opening beyond the distal cuff to facilitate the placement of a gastric tube. Both devices are currently available as reusable devices, with a silicone cuff, and as single use disposables.

Insertion of the LT is generally described as easy and a satisfactory airway can be obtained in most cases [14]. Most comparative studies have evaluated the LT during controlled ventilation. Despite minor differences, leak pressures and ventilatory parameters have been found to be broadly similar to those achieved with either the standard or ProSeal LMAs. There have been far fewer evaluations of the LT during spontaneous ventilation; one early report found it to be quite unsatisfactory, although the device has been modified since then. However, airway obstruction does seem to be a consistent problem with the LT, with a reported incidence ranging from 2–40% and a greater requirement to adjust its position compared to the LMA [14].

Although versions of the LT for use in children are produced, there is only limited evidence from the paediatric population, where the performance seems to be somewhat less satisfactory than in adults. Similarly, evaluation of the LTS is incomplete, with rather variable results being obtained. It is currently not clear how the performance of the disposable LT and LTS compares with that of their reusable counterparts. At present, it would appear that the LT approximately shares the indications and contraindications of the LMA, with similar ease of insertion and comparable degrees of trauma and throat soreness. However, it does not appear to produce as consistently clear an airway and it has not been extensively evaluated in spontaneous ventilation, where the LMA is already well established. Other variants of the LT may yet find a useful role following further evaluation, possibly in the management of the difficult airway, but it is hard to see any clear advantage of the LT over the LMA in routine day surgery.

### The streamlined pharynx airway liner (SLIPA)

SLIPA is both an abbreviation of streamlined pharynx airway liner and a descriptive term for this boot (or slipper) shaped device. The SLIPA is a disposable device moulded from soft plastic into a hollow shape which lines the pharynx. Because the SLIPA is specifically shaped to fill the pharynx, it requires no cuff to achieve a seal, although it is necessary to match the size of the device to that of the patient [15]. This necessitates a wide range of sizes, currently there are six intended for adults.

The SLIPA was developed by a South African anaesthetist and initially marketed in that country in 2002. It was launched in Europe at the 2004 ESA by Hudson Medical, but an acquisition shortly after that meeting ensured that only established products were marketed and the SLIPA returned to its original distributor. It is currently available in much of Europe, although it does not seem to be very actively promoted. There is still relatively little published experience with the SLIPA and even less which is independent of its inventor. Insertion generally appears to be easy and comparable to the LMA, although a small failure rate has been observed, even in experienced hands [15,16]. In use, the device appears to give a good seal and a reliable airway. There is currently conflicting evidence as to whether the SLIPA is any more traumatic than the LMA and on the comparative incidence of throat soreness.

One interesting claim for the SLIPA is that, in the event of regurgitation, "there would be less risk of aspiration than with other similar devices."* This is based on the hollow design of the airway, which could theoretically act as a reservoir for regurgitated material, preventing it from reaching the trachea. This claim is supported by a laboratory study, which showed that the SLIPA prevented any simulated aspiration with "regurgitated" volumes of up to 50 ml [16]. This was comparable to, or slightly better than the ProSeal (depending on the rate of regurgitation) and superior to the LMA. However, these tests were performed on a specially designed pharynx model which had been constructed around the template of a SLIPA airway. There is much less evidence of how the SLIPA would perform in the more variable anatomy of the clinical pharynx, and the airway is still recommended only for fasted patients [16].

At present, there is still too little evidence to fully assess the possible role of the SLIPA. While it may provide somewhat greater protection against aspiration, this has yet to be proven in practice. Any worthwhile protection, as well as optimal performance in controlled ventilation and during low flow anaesthesia, is likely to require a precise fit and it will be quite a challenge to reliably choose the correct size of SLIPA on every occasion.

### $PA_{Xpress}$

The $PA_{Xpress}$ comprises an anatomically curved tube with an inflatable cuff in the mid-section, a conical tip with gill-like protrusions and an airway opening between these. Although commercially available, it has undergone limited evaluation which has demonstrated slower and more traumatic insertion, a high incidence of sore throat and an unacceptably high incidence of failures and minor complications [17,18].

### Cobra

The Cobra is a single-use, silicone tube with an inflatable cuff near to a tip which is flattened into a smooth surface pierced by a parallel series of grilles. Intended for both controlled and spontaneous ventilation, the device is available in the USA and Europe. Evaluation is still rather limited, but insertion is reported to be easy, but with a high incidence of minor trauma and throat soreness in up to 50% [19,20]. Of greater concern is that one study was prematurely halted after two unexpected cases of aspiration with the Cobra which the authors suggest may be related to the design of the airway [20].

## Summary

Undoubtedly, inventors will continue to produce alternative airway devices and some will be marketed. While these new designs may appear attractive, we should greet them with caution until their efficacy and safety have been properly evaluated. While the LMA is not a perfect airway, few alternatives have yet demonstrated clear advantages (especially in day surgery anaesthesia) and none share its long history.

## Conflict of interest

None

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