Editorial III

Is it safe to artificially ventilate a paralysed patient through the laryngeal mask?

The jury is still out

The laryngeal mask airway (LMA®) was developed and introduced by Brain in 1983 with the intention of finding a compromise between a facemask and a tracheal tube. Since then it has undergone various modifications including: the flexible tube has been reinforced; a bigger size has been introduced (no. 5); a change in shape has been made for the intubating laryngeal mask (ILMA); and a different material has been used (silicon or polyvinyl chloride) for the disposable LMA. The LMA is now used by some practitioners during percutaneous dilatational tracheostomy in the intensive care unit; it has a firm place in the management of patients who are difficult to intubate; and, by decreasing the incidence of dysphonia and sore throat, it is contributing to patient comfort, especially after day case surgery. In future, pharyngeal oximetry with the LMA may be a more accurate means of monitoring the SaO₂ of unconscious patients than finger pulse oximetry. It is undoubtedly one of the major developments in anaesthesia in the last 20 years.

It may seem inappropriate to secure the airway with an LMA if the patient has received a neuromuscular blocking drug and is to be artificially ventilated. The main concern would be pulmonary aspiration of regurgitated gastric contents. How often does this occur? In a meta-analysis in 1995, Brimacombe and Berry looked at 547 LMA publications which used various anaesthetic techniques for evidence of pulmonary aspiration and found that the incidence was only two in 10 000 (0.02%). Most cases had predisposing risk factors for pulmonary aspiration; no deaths occurred.

It may be thought that the LMA is used predominantly in spontaneously breathing patients but a survey of its usage in the UK in 1996 revealed that 5236 of 11 910 patients (44%)...
underwent positive pressure ventilation through the LMA.\textsuperscript{11} It is not clear how many of these patients had received a neuromuscular blocking drug. This survey showed a very low rate of critical incidents associated with LMA use in conventional (0.16%) and non-conventional practice (0.14%). Non-conventional use of the LMA at that time included for operations such as abdominal hysterectomy (404 patients), gynaecological laparotomy (240 patients), laparoscopic cholecystectomy (65 patients), colectomy (14 patients) and even elective abdominal aortic aneurysm (seven patients). Ventilation was controlled in 77.4% of patients undergoing laparoscopy and 97% of patients undergoing laparotomy. Three cases of failed intubation were managed with a laryngeal mask. There were 44 (0.37%) critical incidents of which 18 were related to the airway. Regurgitation occurred in four patients (0.03%) and vomiting in two (0.017%), but proven aspiration of gastric contents occurred in only one patient (0.009%). Laryngospasm or bronchospasm (which could have been due to aspiration) occurred in 11 patients (0.095%). A slightly higher percentage of critical airway incidents occurred in patients undergoing positive pressure ventilation compared with spontaneous ventilation (0.21% vs 0.11%) through the LMA, but the difference did not reach statistical significance. How often would such adverse events have occurred during artificial ventilation using a cuffed tracheal tube in a paralysed patient? Few large prospective randomized comparisons exist.\textsuperscript{7} Undoubtedly, there is a need for further study in this area.

Innovation in anaesthesia is judged in the light of risk–benefit analysis. The risk of an adverse event associated with a new anaesthetic technique should be less than that in older, well accepted techniques and it should improve outcome. Is there any indication for positive pressure ventilation through the LMA or is it disadvantageous? Is it affected by the use of neuromuscular blocking drugs in combination with positive pressure ventilation?

**Advantages of the LMA**

In 1995, Brimacombe summarized the advantages and disadvantages of the LMA compared with tracheal intubation as derived from yet another meta-analysis.\textsuperscript{12} The advantages included: haemodynamic stability at induction compared with intubation, and during emergence compared with extubation; minimal increase in intraocular pressure after insertion; reduced anaesthetic requirements for airway tolerance; lower frequency of coughing during emergence; improved oxygen saturation during emergence; and a lower incidence of sore throat in adults. Ferranti and Goudsouzian have demonstrated that the use of a LMA in ex-premature infants and children with bronchopulmonary dysplasia undergoing second-stage vitreectomy as a daycase procedure produced less desaturation, coughing, wheezing and hoarseness than a tracheal tube.\textsuperscript{13} The children in the LMA group were discharged home earlier.

Keller and Brimacombe demonstrated that the LMA impairs mucociliary clearance, as measured by mucus transport velocity, less than a tracheal tube.\textsuperscript{14} The authors postulated that this may have implications for reducing the risk of retention of secretions, atelectasis and pulmonary infection. A cost analysis study proved that the LMA was the most cost-efficient airway choice if it is reused 40 times, and each anaesthetic lasted for >40 min.\textsuperscript{15}

Thus there appear to be advantages in using an LMA instead of a tracheal tube, mainly in reducing the minor morbidity associated with anaesthesia. Are there disadvantages?

**Disadvantages**

The main complications of using a LMA relate to the airway seal pressure of its cuff. The LMA cuff seal pressure is the inflation pressure above which gas can escape around the cuff. This is lower than with a tracheal tube, so there is a greater risk of gastric insufflation, gastro-oesophageal reflux and aspiration of regurgitated gastric contents when using an LMA.\textsuperscript{12}

**Gastric insufflation**

The lower seal pressure of an LMA might cause difficulties in patients unexpectedly requiring high airway inflation pressures for adequate oxygenation; this is pertinent when pressures reach 19–33 cm H\textsubscript{2}O.\textsuperscript{16} Devitt and colleagues studied gastro-oesophageal insufflation in 48 patients who received neuromuscular blocking drugs and controlled ventilation through the LMA.\textsuperscript{17} Gastro-oesophageal insufflation and gas leak were assessed by a single investigator, blinded to the ventilating pressures, by placing a stethoscope over the stomach and neck respectively during artificial ventilation. Gastro-oesophageal insufflation occurred in only 2.1% of patients at inflation pressures of 15 cm H\textsubscript{2}O but increased to 35.4% at 30 cm H\textsubscript{2}O.

A lower frequency of gastro-oesophageal insufflation was found by the same group of workers in a study of 60 artificially ventilated patients using the LMA or a facemask; in the LMA group, it occurred in one patient at an inflation pressure of 20 cm H\textsubscript{2}O and in three patients at 30 cm H\textsubscript{2}O.\textsuperscript{18} Keller and colleagues looked at 164 unparalysed patients during either spontaneous or positive pressure ventilation who underwent peripheral musculoskeletal surgery.\textsuperscript{19} Peak airway pressure was limited to 15 cm H\textsubscript{2}O. No gastric insufflation was detected using the same clinical method as Devitt and colleagues, i.e. epigastric auscultation. As there are limitations to this technique, Weiler and colleagues used an epigastric microphone, which could detect as little as 2 ml of air entering the stomach.\textsuperscript{16} In this study, eight of 30 patients (27%) experienced gastric insufflation at inspiratory pressures between 19 and 33 cm H\textsubscript{2}O.

A size 5 LMA can provide a better seal for positive pressure ventilation and reduce the incidence of air leak.\textsuperscript{20,21}
Brimacombe investigated the safety and efficacy of a size 5 LMA in 179 patients undergoing positive pressure ventilation using a neuromuscular blocking drug. He demonstrated that none of the patients had gastric insufflation at tidal volumes of 8 ml kg\(^{-1}\) and an oropharyngeal leak only occurred in 0.7% of patients. He suggested that positive pressure ventilation with the size 5 LMA is safe and effective. A low failure rate (3%) was seen even in patients who were moderately obese (body mass index >30 kg m\(^{-2}\)). There was no correlation between the incidence of complications, leak pressure and body mass index.

Maltby and colleagues recently investigated the incidence of gastric distension during laparoscopic cholecystectomy in 101 patients paralysed and ventilated through an LMA in 179 patients undergoing positive pressure ventilation with the size 5 LMA is safe and effective. A low failure rate (3%) was seen even in patients who were moderately obese (body mass index >30 kg m\(^{-2}\)). There was no correlation between the incidence of complications, leak pressure and body mass index.

Maltby and colleagues recently investigated the incidence of gastric distension during laparoscopic cholecystectomy in 101 patients paralysed and ventilated through an LMA or a tracheal tube. The incidence and degree of gastric distension was similar in both groups. However, importantly, these investigators noted that their randomized controlled study was too small to determine the risk of aspiration pneumonitis when using an LMA.

Regurgitation into oesophagus

Regurgitation and aspiration with the LMA are more commonly associated with periods of light general anaesthesia, or placing the patient in the Trendelenburg or lithotomy position. El Mikatti and colleagues used methylene blue to detect regurgitation in patients receiving an LMA. They demonstrated that one of 30 patients in the Trendelenburg or lithotomy position had regurgitation, but none experienced it in the supine position. Valentine and colleagues investigated the incidence of reflux during positive pressure ventilation through the LMA or a tracheal tube in 20 paralysed patients undergoing cataract surgery. All patients were ventilated to normocapnia and tidal volumes adjusted to maintain a peak inflation pressure of 16 cm H\(_2\)O. Four out of 10 patients in the LMA group and one out of 10 patients in the tracheal tube group had mid-oesophageal reflux during anaesthesia. The incidence of reflux after antagonism of residual neuromuscular block was even higher in the LMA group but none of the patients had any clinical evidence of adverse sequelae. Reflux was measured with a pH electrode placed in the mid-oesophagus.

Brain and colleagues have suggested that the LMA seal interferes with upper oesophageal sphincter tone, and this tone may also be affected by insertion of a pH electrode into the oesophagus or by the return of muscle power to the larynx and pharynx during antagonism of residual neuromuscular block. Agró and colleagues studied oesophageal pH values associated with the LMA and positive pressure ventilation in 82 paralysed, supine orthopaedic patients. Neuromuscular block was allowed to wear off spontaneously. There were no reflux events into the oesophagus (pH <4.9) during any phase of anaesthesia. Agró and colleagues stated with 95% confidence that the probability of gastro-oesophageal reflux is less than 4.6% when the LMA is inserted by skilled users. Bapat and Verghese came to a similar conclusion in a study of the incidence of regurgitation during gynaecological laparoscopies, when the patients were given a small dose of atracurium and artificially ventilated through the LMA; they suggested that the probability of regurgitation is <4.1%. Owens and colleagues compared the incidence of gastro-oesophageal reflux in 55 patients breathing spontaneously through the LMA or facemask. They observed reflux episodes in the LMA group in 53.6% of patients into the mid-oesophagus and 21.4% into the upper oesophagus; there were multiple reflux episodes in 28.6%. In each instance, the incidence of reflux was greater in the LMA group than in the facemask group, but there was no clinical evidence of pulmonary aspiration of gastric contents.

Aspiration of gastric contents

Regurgitation and aspiration occasionally occur in all types of anaesthetic practice. Warner and colleagues investigated the Mayo Hospital database of 215 488 general anaesthetics given between 1985 and 1991 (not involving the use of the LMA) for clinically significant events of pulmonary aspiration during the perioperative period. Fifteen aspiration episodes occurred during 13 427 anaesthetics (0.11%) in patients undergoing emergency surgery and 52 occurred in 202 061 anaesthetics (0.025%) in patients undergoing elective surgery. The complications occurred either during artificial ventilation with the facemask, preceding tracheal intubation, or after extubation. None occurred when the trachea was intubated. Of the 66 patients who aspired and survived surgery, 13 required ventilatory support postoperatively, three of whom died.

How often do such events occur with the LMA? Such a large, retrospective study including the LMA does not yet exist. Although not as useful as a prospective randomized comparison with tracheal intubation, it would provide interesting, evidence-based information.

Critical incidents from LMA usage

In 1990, Griffin and Hatcher reported the case of a 26-year-old woman weighing 60 kg with no previous medical history who underwent elective cholecystectomy. After induction of anaesthesia, neuromuscular blockade was established with vecuronium 6 mg and a size 3 LMA inserted. Anaesthesia was maintained with enflurane in nitrous oxide and oxygen. The patient was ventilated with a tidal volume of 430 ml and a peak inspiratory pressure of no more than 1.5 kPa (15 cm H\(_2\)O). The duration of surgery was 1.5 h. Spontaneous ventilation was allowed to return without antagonism of residual neuromuscular block, which may be a significant factor. At the end of surgery, the patient was placed in the left lateral position to carry out intercostal nerve blocks. The LMA was removed after bile-stained fluid was noted within the LMA tube lumen. A chest X-ray...
showed left-sided aspiration pneumonia. The patient was closely monitored on the intensive care unit but did not require artificial ventilation. She made a good recovery.

In 1992, Nanji and Maltby described a critical incident in a 74-year-old man who underwent an arthroplasty for fracture of the femoral neck. He had Alzheimer’s disease and a history of peptic ulcer for which he had required oesophageal dilatation, but he had not had any symptoms of reflux, as far as could be ascertained, for more than 20 years. A size 4 LMA was inserted after induction of anaesthesia with thiopental and fentanyl, and anaesthesia was maintained with isoflurane, with the patient breathing spontaneously. The patient was placed in the right lateral position for surgery, which continued uneventfully until the femoral head was pulled from the acetabulum. At that time, the patient took several deep breaths and the femoral head was pulled from the acetabulum. At that time, the patient took several deep breaths and the SaO₂ decreased from 98% to 85%. Gastric content was observed at the corner of the patient’s mouth. After immediate tracheal intubation, auscultation did not reveal any wheezing or decreased air entry, although gastric contents were observed in the anaesthetic circuit. The patient vomited again around the tracheal tube at the end of surgery. Bronchoscopy did not show any particulate matter. Nevertheless, the patient required artificial ventilation for 4 days after surgery with an \( F_iO_2 \) of 1.0 and positive end-expiratory pressure. He subsequently recovered and was discharged to the ward.

In 1996, Ismail-Zade reported a case of regurgitation and aspiration of gastric contents in an asthmatic child anaesthetized for elective orthopaedic surgery using an LMA. Ten minutes after induction, brown fluid was noted in the LMA tube and the patient’s arterial oxygen saturation decreased from 96% to 86%. Tracheal intubation was effected and brown fluid was also noted in the tracheal aspirate. Bronchospasm developed which worsened after surgery. Chest X-ray revealed patchy consolidation of the right upper lobe. After antibiotic and bronchodilator therapy, the patient made a good recovery.

Would these patients have regurgitated and inhaled gastric contents if a tracheal tube had been used? Is the number of such reports small because they are no longer considered new (and therefore interesting)? Or is the incidence of such critical incidents truly low? Representatives of the Medical Defence Union could not confirm any incidents, but the NHS Litigation Authority have received a complaint arising from a critical incident associated with the ILMA (personal communication, J. Mead).

A concluding paradox

Thus, evidence from studies undertaken in relatively small numbers of patients (mainly by experts in LMA insertion), and the small number of critical incidents reported, suggest it is safe to ventilate a patient artificially through an LMA. But consider further the findings of Verghese and Brimacombe in relation to anaesthetic practice in the UK.

The incidence of proven aspiration using the LMA in Verghese and Brimacombe’s retrospective study was 0.009%. If about four million anaesthetics are given in the UK each year, this would amount to about 360 such incidents. Warner and colleagues reported that three of the 66 patients who aspirated and survived surgery in the Mayo clinic study died. Thus one might expect about 16 deaths each year in the UK from aspiration of gastric contents when using the LMA (3 x 360/66). This would equate with one death in each region of the UK each year. Such considerations are reminiscent of determining the risk of spinal haematoma after epidural anaesthesia in patients on heparin, or hepatitis after exposure to halothane. They are rare. But we suggest that the time has not yet come to pass when we can appreciate fully the risks of artificially ventilating a patient through an LMA.

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