The use of the laryngeal mask airway with mechanical positive pressure ventilation

Carrie Chmielewski, CRNA, MSN
Suzanne Snyder-Clickett, CRNA, MSN
Royal Oak, Michigan

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The purpose of this article is to discuss the benefits, safety, and efficacy of the laryngeal mask airway (LMA) and identify the risks and misconceptions associated with LMAs when used with positive pressure ventilation (PPV). Despite the abundance of supporting evidence that LMAs may be used successfully in a variety of age groups and surgical procedures using PPV, many anesthesia providers are still reluctant to choose an LMA when PPV is needed. This reluctance emerges from the misconception that when using an LMA with mechanical ventilation, there is an increased incidence of gastric insufflation, failed ventilation, and pulmonary aspiration. When compared to other airway adjuncts, however, the LMA is a safe, effective means of delivering ventilation under anesthesia.

Key words: Laryngeal mask airway, positive pressure ventilation, safe use of laryngeal mask airways.

Airway management is one of the most important skills to master in the anesthesia profession. Numerous devices have become available to secure a patient’s airway under anesthesia and assist in providing adequate oxygenation and ventilation during surgery. The laryngeal mask airway (LMA) is one airway device that has gained great popularity amongst anesthesia providers throughout the past decade.

The LMA has traditionally been used to secure the patient’s airway and maintain spontaneous ventilation during short outpatient surgical procedures in which general anesthesia is required.1 Although many short procedures may allow for the continuation of a patient’s spontaneous ventilation, instances arise in which positive pressure ventilation (PPV) or assistance to ventilation is required for brief periods of time. PPV may be needed when the depth of anesthesia must be increased or when continuous muscle relaxation is indicated for the procedure. The risks of failed ventilation, gastric insufflation, and aspiration are minimal. The goal of this paper is to discuss the benefits, safety, and efficacy of the LMA, and to discuss the risks and misconceptions associated with LMAs and PPV. When used properly, the LMA can be a safe, effective, and less invasive means of delivering general anesthesia.

Review of literature
The LMA was developed in 1981 at the Royal London Hospital by Archie J. Brain, MA, LMSSA, FFARCI. After nearly a decade of anatomical trials with the device, The US Food and Drug Administration approved the LMA in 1991 as a substitute for the face mask during elective anesthesia.2 Initially the LMA had very limited acceptance from anesthesia providers. By 1998, however, a survey by Rosenblatt et al reported that an increasing number of anesthesia cases were managed with the LMA.3

Indications for use of the LMA
Due to the safety and versatility of the LMA, the indications for its use are greatly expanding. LMAs are currently used for short outpatient procedures in the adult and pediatric populations. LMAs are used for a variety of routine general surgical procedures including gynecologic, orthopedic, urologic, and plastic surgeries. Many unconventional uses for the LMA also are being reported. For example, the use of the LMA has adopted a role in the new American Heart Association guidelines. The LMA is recommended as an alternative airway device to the bag-mask technique in basic life support training. The LMA may be considered a first choice resuscitation airway for basic life support providers who are not trained in endotracheal intubation.4 The uses of the LMA are numerous and discussions related to LMA use in the prehospital and critical care setting are impressive, but are beyond the scope of this paper.

Despite the myriad of uses, both conventional and unconventional, the use of the LMA device is contraindicated in certain patient conditions. Absolute contraindications to the use of LMAs as identified by Brimacombe et al include any risk of increased gastric contents (eg, full stomach, hiatal hernia, gastroesophageal reflux disease, intestinal obstruction, mor-
bid obesity, bowel surgery, and delayed gastric emptying, poor lung compliance (chronic obstructive pulmonary disease), high airway resistance, and glottic or subglottic obstruction and limited mouth opening. Since the LMA is not able to provide an impermeable seal to esophageal and gastric contents, the device should not be used in patients with increased gastric contents or increased risk of aspiration.

As with all artificial airway devices, aspiration is a legitimate and important concern that should be addressed and minimized during each administered anesthetic. In current trends of practice, the endotracheal tube (ETT) is generally chosen over the LMA when PPV and/or muscle relaxation is needed. Misconceptions that make anesthesia practitioners reluctant to choose an LMA over an ETT when PPV is needed stems from a belief that there is an increased incidence of gastric insufflation with mechanical ventilation leading to a greater risk for pulmonary aspiration. Additionally, the proposed risk is believed to increase when muscle relaxation is needed. Many anesthesia providers are under the impression that the LMA is contraindicated with muscle relaxants and ventilatory use. The aforementioned beliefs can be dispelled by the abundance of supporting evidence that PPV and muscle relaxation can be safely used with the LMA. This will be discussed at length in the following paragraphs.

The LMA compared to the ETT

In order to successfully emphasize the advantages of the LMA in practice, the risks and benefits of its use must be compared to other airway adjuncts, specifically the ETT. Endotracheal tubes have been a proven standard of care for adults undergoing general anesthesia. Brimacombe conducted a meta-analysis to determine if any advantages existed in using an LMA over the ETT. The analysis demonstrated that the LMA may have an advantage over ETTS in terms of increased speed and reliability of placement, maintenance of hemodynamic stability at induction and emergence, decreased incidence of coughing during emergence, and increased patient satisfaction by decreasing the incidence of postoperative sore throat and voice alterations. The author identified that the literature frequently discussed gastric insufflation and air leak as common disadvantages to the LMA, but that this was dependent upon proper placement and positioning of the LMA. An improperly placed device may lead to unnecessary complications. When inserted properly and when used with PPV at volumes less than 10 mL/kg, no episodes of gastric dilation were noted in nearly 12,000 anesthetics delivered via the LMA with the use of PPV.

Additional support for LMAs has been shown through a meta-analysis of several million cases worldwide that the risk of aspiration and gastric insufflation with an LMA is the same as that for the ETT. In a randomized clinical trial, Graziotti studied the effects of PPV on gastric insufflation comparing the LMA to the ETT. To measure the amount of gastric insufflation sustained, he used a nasogastric tube and the aspiration technique. After aspirating the gastric tract with a lavage technique, he found that there was no significant difference in insufflation volumes between the LMA and the tracheal tube. Similarly, Heinrichs et al conducted research on gastric insufflation and oropharyngeal pressures comparing the safety of the LMA, face mask, and ETT in conjunction with PPV. The researchers concluded that for the LMA, the mean for gastric insufflation pressure was 28 cm H2O and that the mean oropharyngeal leak was 31 cm H2O. They suggested that the margin of safety with an LMA in regard to gastric insufflation (with PPV) was essentially comparable to that of the face mask but inferior to the ETT. However, the incidence of overall complications with the PPV/LMA technique may be less than the PPV/ETT technique. The latter technique can be associated with complications such as sore throat, vocal cord paresis, endobronchial intubation, bronchospasm, and increased adrenergic activity upon placement of the ETT. This may be detrimental to patients with underlying cardiovascular or reactive airway disease.

In a randomized, multicenter trial comparing the LMA to the ETT in ambulatory surgery, the anesthetic requirements, recovery times, and postoperative side effects were compared. Anesthesia was maintained with a volatile anesthetic, nitrous oxide, oxygen, narcotics (fentanyl), and propofol. The results showed that in the LMA group, there was a decreased intraoperative fentanyl requirement, a decrease in the duration of the postanesthesia care unit stay, and shorter time to ambulation. There were no differences in the incidence of nausea and vomiting and the need for rescue antiemetics. The incidence of postoperative sore throat, however, was significantly greater in patients receiving the ETT. With proper training, appropriate patient selection, and proper insertion techniques, the associated risks of LMAs can be greatly reduced. When comparing the risk-to-benefit ratio of the airway devices, the LMA may offer a safer alternative to general anesthetic airway management.

The LMA with PPV

In 1998, Keller and colleagues evaluated patient outcomes comparing positive pressure versus sponta-
neous ventilation in nonparalyzed adults with the LMA. Tidal volumes of 6 to 8 mg/kg and peak airway pressures limited to 15 cm H2O were used. Respiratory rates were adjusted to keep end-tidal carbon dioxide levels within normal limits. The data concluded that similar patient outcomes were reported when comparing PPV with an LMA device to spontaneous ventilation in nonparalyzed adults. No cases of gastric insufflation were noted in the research. Interestingly, ETCO2 was higher during spontaneous ventilation and SpO2 was higher during PPV. The increased ETCO2 during spontaneous ventilation was attributed to the respiratory depressive effects of the inhalation agents. The aforementioned research studies consistently demonstrate that PPV can be safely and effectively used with the LMA. The majority of data shows that maintaining tidal volumes of less than 10 mL/kg can adequately ventilate patients with the device. Leaks are generally noted at an average airway pressure of 17 cm H2O. Devitt et al conducted a study that demonstrated similar results. They also noted that the incidence of gastric insufflation was similar to using intermittent PPV via a face mask. The authors did note that this phenomenon warrants further study and validation. It was concluded that LMAs may be used for PPV in patients with normal airway resistance and compliance that do not require higher than normal tidal volumes (which are generally greater than 10 mL/kg).

The LMA and pressure control ventilation
Pressure control ventilation (PCV) is widely discussed as the method of choice for delivery of PPV through an LMA. PCV helps to maintain constant ventilation pressures with less pressure variability than volume control ventilation. Additionally PCV adjusts for any leak from the device by continuing to deliver gas flow during inspiration until the set pressure limit is met. PCV also may enhance the effectiveness of ventilation in patients with high airway pressures. Natalini et al concluded that the greater the increase in airway pressure with volume control ventilation, the greater the decrease in pressure when PCV was used.

Another study by Natalini et al compared pressure-controlled ventilation and volume-controlled ventilation with the LMA. The study demonstrated that the use of PCV during general anesthesia with the LMA reduced the peak airway pressure compared with volume control ventilation at the same tidal volumes and inspiratory times. Peak airway pressures were measured at the airway opening, as values recorded at the ventilator would be higher due to the resistive load of the inspiratory line. The increase in resistance of the respiratory system can be related to patient characteristics such as chronic obstructive pulmonary disease, obesity, patient positioning (Trendelenberg or prone), or due to the surgery itself (laparoscopy). These conditions are probably the main indication for the use of PCV during mechanical ventilation with the LMA according to the researchers. Peak airway pressures greater than 20 to 30 cm H2O have large impacts on the air leak from the LMA. Clinical consequences of high airway pressures and LMA use may include hypoventilation, gastric insufflation, and operating room pollution. To decrease the incidence of air leaks and high peak airway pressures with the LMA, PCV should be employed when mechanical ventilation is needed during anesthesia delivery.

Children and the LMA
A comparison study also demonstrated that LMAs provided adequate airway management in 90% of infants and children. No differences in complication rates with laryngospasm, bronchospasm, or hypersalivation were noted when compared with an ETT. There was a lower incidence of coughing and breath holding in the LMA group. Additionally, measurement of abdominal girth was performed, and no differences between the 2 groups were noted. Ventilatory parameters such as rate, tidal volume, peak pressures, and mean pressures were comparable in each group. These findings further support the use of PPV with LMAs in a variety of age groups.

LMA compared to other airway devices
The LMA also has proven to be an effective means of delivering PPV when compared to other airway adjuncts such as the laryngeal tube airway (LTA), which is a variation of the combitube, and the ETT. Brimacombe et al compared the 2 devices for use with spontaneous ventilation and PPV. This study concluded that the LMA was superior to the LTA in most areas of airway management during PPV. The advantages included higher success rates, a more effective seal, fewer adjustments in ventilatory parameters, less airway obstruction, and less variability in expired tidal volume with head and neck movement. Pressure control ventilation was used as the method of positive pressure delivery. Two patients with the LTA were found to have gastric distention during leak pressure testing secondary to malpositioning of the device. No incidences of gastric insufflation were noted in the LMA group.

A study in 2001 comparing the LMA Classic to the ProSeal LMA (PLMA) resulted in similar conclusions. The research showed that both devices, when used in
healthy female patients with PPV, were equally effective when properly inserted and used with tidal volumes of 8 to 12 mL/kg.  

The LMA with muscle relaxation

Successful placement of the LMA device also is dependent on depression of upper airway reflexes at the time of insertion. Adverse responses to insertion of an LMA, such as gagging, coughing, and laryngospasm, make correct positioning of the LMA difficult and predispose the patient to hypoxic conditions. Yoshino et al studied the use of the rapid onset, short-acting neuromuscular blocking drug, succinylcholine, during LMA insertion and assessed the optimal dose needed to provide satisfactory conditions for LMA insertion.  

Low-dose succinylcholine (given randomly to patients in doses of 0.25 mg/kg or 0.50 mg/kg) was administered after induction of anesthesia with thiopental, 5 mg/kg, and LMA insertion took place 1 minute later. The researchers concluded that the incidence of coughing and gagging on insertion was significantly lower in the group that received succinylcholine, 0.5 mg/kg, compared to the group that received 0.25 mg/kg. There were no significant differences in the incidence of postoperative myalgia between the groups after succinylcholine administration. The findings also suggested that residual upper airway reflexes, which may cause coughing and gagging, were a major cause of failed LMA insertion in the study. These adverse effects were almost completely suppressed by low-dose succinylcholine (0.5 mg/kg) but not by succinylcholine, 0.25 mg/kg.  

The use of low-dose mivacurium to facilitate insertion of the LMA also was studied. The findings suggested that low-dose mivacurium, 0.04 to 0.08 mg/kg, before LMA insertion decreased the incidence of swallowing, coughing, movement and laryngospasm, and increased the ease and success of LMA insertion. The LMA insertion was graded as “easy” in 88% of patients who had mivacurium compared to 50% of patients who had propofol alone. Chui and Cheam concluded that low-dose mivacurium facilitated LMA insertion and decreased the incidence of postoperative sore throat.  

Muscle relaxants have shown to increase the ease of LMA insertion and should be used upon induction of anesthesia if there are no patient contraindications present.

Discussion

Despite the abundance of literature supporting the safe use of LMAs with PPV, current practice trends continue to demonstrate that anesthesia providers are reluctant to use PPV with the device during their anesthetic delivery. Many providers continue to reserve LMA use for short outpatient procedures in which the patient is able to maintain spontaneous ventilation. As numerous studies have eluded, the LMA has consistently proven to be a safe and effective means of anesthesia delivery when inserted correctly and when used under the appropriate conditions. In certain circumstances, the LMA has been identified as superior to the ETT when the risk/benefit ratio is weighed. The reasons associated with underutilization of the LMA device are unclear. The current literature available fails to identify why such practice patterns exist and what factors may be influencing current trends. It is possible that geographic location, age of practitioner, and lack of continuing education on the uses of the LMA may influence practice. The majority of literature obtained for this paper was found in medical anesthesia journals, possibly indicating a lack of distribution of adequate information to nurse anesthetists. Research related to the lack of use of PPV with LMAs and universal practice patterns with the LMA device would be useful and should be considered in future studies.

Summary

In conclusion, the LMA device has rapidly gained popularity and has become a commonly used airway adjunct in anesthesia practice. The scope of its use continues to expand. LMAs may be used successfully in a variety of age groups and in a vast array of surgical procedures. The LMA offers distinct advantages in certain patient populations related to its rapid placement, maintenance of hemodynamic stability during placement and removal, and decreased incidence of coughing and sore throat postoperatively. These advantages may be attributed to the lack of invasiveness and make the LMA an appealing alternative to the ETT. Clearly, an abundance of literature is available to support the LMA and its use with PPV, with or without muscle relaxation. When used correctly, this method of anesthesia delivery can enhance the care provided by Certified Registered Nurse Anesthetists while simultaneously improving patient outcomes and patient satisfaction.

REFERENCES


AUTHORS
Carrie Chmielewski, CRNA, MSN, is a staff anesthetist at William Beaumont Hospital, Troy, Michigan.

Suzanne Snyder-Clickett, CRNA, MSN, is a staff anesthetist at William Beaumont Hospital, Royal Oak, Michigan.