Supraglottic Airway Devices in the Ambulatory Setting

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Modern anesthesia practice was made possible by the invention of the endotracheal tube (ET), which made lengthy and complex surgical procedures feasible without the disastrous complications of airway obstruction, aspiration of gastric contents, or asphyxia. For decades, endotracheal intubation or bag-and-mask ventilation were the mainstays of airway management. In 1983 this changed with the invention of the laryngeal mask airway (LMA), the first supraglottic airway device (SGA) that blended features of the facemask with those of the ET, providing ease of placement and hands-free maintenance, along with a relatively secure airway.

In the United States, more than 75% of all surgical procedures are performed on an outpatient basis. This situation has created an ever-increasing demand for anesthetic agents and techniques that improve the efficiency and safety of anesthesia, aiming for faster induction, emergence and recovery, fewer and milder side effects, and earlier discharge of the patient. SGAs lend themselves particularly well to outpatient anesthesia, offering several advantages over the ET.

Insertion of an SGA may be less stimulating to the sympathetic nervous system than direct laryngoscopy and placement of a semirigid ET into the trachea, thereby decreasing the risk of adverse cardiovascular events in patients with coronary artery disease. The laryngeal mask airway (LMA) is also tolerated at lighter levels of anesthesia than an ET, potentially decreasing side effects and length of stay. While one study showed no differences between an LMA and an ET in average time to placement of the two airway devices or time from end of surgery to removal of the airway device, length of stay in the postanesthesia care unit and time to ambulation were significantly shorter in the LMA group, although there were no differences in the times to “home readiness.” Another study did demonstrate that LMAs reduce induction time when
compared with endotracheal intubation, although emergence times were again similar.\(^5\) For outpatients undergoing dentoalveolar procedures under general anesthesia, the LMA group did have a shorter procedure time than the ET group and had a significantly shorter recovery time.\(^6\) The incidence of postoperative sore throat is also significantly less in patients receiving the LMA.\(^4,7\) Another advantage is that an SGA typically does not require neuromuscular blockade, thereby avoiding any associated morbidity and side effects of the medication or its antagonists.

Following the success of the LMA, the last two decades have seen a proliferation of SGAs. To be suitable for clinical use, an SGA must bridge the oropharyngeal space efficiently, seal the upper airway during spontaneous and positive pressure ventilation, have low resistance to respiratory gas flow, provide some degree of protection of the subglottic airway from upper airway secretions and gastric contents, and have a low incidence of airway morbidity and adverse events. The success of any SGA in clinical practice depends on its accept/reject profile, which describes the potential for acceptance or rejection of a foreign body by the oropharynx.\(^8,9\) This profile depends on the device’s shape, material, cuff volume, and cuff position in the oropharynx.

The use of SGAs is limited to certain patient populations and surgical procedures. Compared with ETs, SGAs only partially protect against aspiration of gastric contents. This limitation precludes their use in patients with a full stomach or other risk factors for aspiration. Delivery of positive pressure ventilation is limited by the SGA’s airway leak pressure, which for many lies between 20 and 25 cm H\(_2\)O.\(^10,11\) Airway pressure above this range may result in gastric insufflation and increased risk for regurgitation and aspiration of gastric contents. Delivery of positive pressure ventilation may be inadequate in the presence of decreased lung and chest compliance. Thus, the utility of SGAs is limited in morbidly obese patients, in patients with restrictive and obstructive lung disease, or for laparoscopic surgery, especially when performed on a patient in steep Trendelenburg position. Newer SGA designs aspire to address these limitations and to expand the use of supraglottic ventilating techniques.

**SUPRAGLOTTIC AIRWAY DEVICES IN CLINICAL USE**

**LMA Classic (LMA North America, Inc)**

The LMA Classic may be the most important development in airway management in the last 25 years. This device became commercially available in Europe in 1988 and was approved by the Food and Drug Administration (FDA) for clinical use in the United States in 1992.

The LMA Classic (Fig. 1) consists of a “bowl-shaped” mask surrounded by an oval, inflatable, silicone cuff designed to seal around the laryngeal inlet. Two elastic bars across the bowl aperture prevent obstruction by the epiglottis. The bowl and aperture of the mask are continuous with a curved, wide-bore tube that can be connected to a self-inflating (eg, Ambu) bag or a ventilatory circuit. The LMA Classic, available in sizes 1 to 6, is designed to fit most airways, from neonates through large adults; it is reusable up to 40 times with steam autoclaving.

After placement in the oropharynx, the cuff of the LMA is inflated with enough air to yield an airway leak pressure between 20 and 25 cm H\(_2\)O. If the LMA is misplaced, it may result in a low airway leak pressure, but merely inflating the cuff with more air will not necessarily contain the leak, and may cause pressure ischemia of the pharyngeal mucosa and sore throat postoperatively. A low-pressure airway leak should be corrected by adjusting the LMA position (with gentle pushing or pulling or with jaw thrust) or by withdrawing and reinserting (Table 1).
The LMA Classic was originally developed for use during routine general anesthesia with spontaneous ventilation. The device can also be used with positive pressure ventilation at peak airway pressures not exceeding 20 to 25 cm H₂O or with pressure support ventilation. Although designed for elective airway management, it has been used successfully as an airway rescue device in emergencies, including resuscitation. The LMA Classic is now listed in the American Society of Anesthesiologists (ASA) Difficult Airway Algorithm and the American Heart Association 2000 Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care as a primary ventilatory device or as a conduit for the ET in pediatric and adult patients in whom ventilation with a facemask or intubation is difficult or impossible. The success rate for blind intubation through the LMA Classic varies, but the use of a fiberoptic scope for intubation through the LMA increases the success rate.

The LMA Classic remains the most widely used SGA. At present, about 30% to 60% of all general anesthetics are performed with an LMA, and it has been used in more than 200 million patients worldwide. The incidence of major complications and airway morbidity has been consistently low, and no apparent deaths have been attributed to its use. The LMA primarily substitutes for a facemask, making airway management “hands-free” during general anesthesia. The LMA is contraindicated for patients with decreased lung or chest compliance and increased airway resistance, glottic or subglottic airway obstruction, oropharyngeal anatomic abnormalities, or who are at high risk for aspiration.

The LMA Classic has been successfully used as a primary ventilatory device for laparoscopic cholecystectomy and laparoscopic gynecologic surgery. However, clinical studies of the use of the LMA for laparoscopic surgery have excluded patients at risk for failure or complications of the use of the LMA, including patients with a full stomach, those with a body mass index (BMI) of 30 kg/m² or more, those of ASA physical status III and above, or with a Mallampati score III or IV.

**LMA Unique (LMA North America, Inc)**

The LMA Unique was among the first single-use equivalents of the original, reusable SGAs. The development of this device was motivated by concerns about the transmission of infectious agents, especially prions, by residual proteinaceous
<table>
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<td>Inadequate anesthesia</td>
<td>Deepen anesthesia</td>
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<td>Poor fixation</td>
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<td>Overinflation of cuff</td>
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<td>Herniation of cuff</td>
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<tr>
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<td>Mask seated too high in pharynx</td>
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<td>Distal tip of mask pressing on glottic inlet with mechanical closure of vocal cords</td>
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<td>Place patient’s head/neck in sniffing position</td>
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<td>Try PPV or add PEEP</td>
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<td>Consider insertion of 1 size smaller LMA ProSeal</td>
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<td>Ensure correct cuff inflation pressures</td>
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<td>Distal tip of mask folded backward</td>
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<td>Mask seated to high in pharynx</td>
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<td>Migration/Rotation/Mask popping out of mouth</td>
<td>Overinflation of cuff</td>
<td>Check cuff pressure at start and periodically during case, especially if using nitrous oxide to ensure not &gt;60 cm H₂O</td>
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<tr>
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<td>Herniation of cuff</td>
<td>Confirm cuff integrity before use</td>
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<td>Distal tip of mask folded backward</td>
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<td>Incorrect placement in laryngeal vestibule</td>
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<td></td>
<td>Gross overinflation of cuff</td>
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**Abbreviations:** OG, orogastric; PEEP, positive end-expiratory pressure; PPV, positive pressure ventilation.

*Courtesy of LMA North America, Inc; with permission.*
material found on autoclaved airway management equipment.\textsuperscript{15,19,20} The LMA Unique is a disposable, sterile version of the LMA Classic, is available in 5 sizes, and has clinical applications and performance similar to those of the LMA Classic.

**LMA Classic Excel (LMA North America, Inc)**

The LMA Classic Excel (Fig. 3) improves on the LMA Classic with the addition of an epiglottic elevating bar and removable connector to facilitate introduction of an ET through the LMA after placement. The LMA Classic Excel is available in sizes 3 to 5 and accommodates ETs up to size 7.5; it is reusable up to 60 times.

**LMA Flexible (LMA North America, Inc)**

The LMA Flexible (Fig. 4) combines the original LMA cuff design with a narrower, longer, wire-reinforced flexible airway tube. Intubation through this device is impossible because of its longer and narrower airway tube, but because of its flexibility and extra length, it can be positioned away from the surgical field without cuff displacement. This feature makes it particularly useful for those procedures in which the surgeon and the anesthesiologist work in the same area, such as during
ear/nose/throat, maxillofacial, or dental procedures. The LMA Flexible is available in sizes 2 to 6 in both reusable and disposable versions.

**LMA ProSeal (LMA North America, Inc)**

The LMA ProSeal (Fig. 5) modifies the LMA Classic with a better airway seal and separate access to the gastrointestinal and respiratory tracts. These features improve the safety and efficacy of positive pressure ventilation, provide a means of gastric suctioning, reduce the risk of regurgitation and aspiration of gastric contents, and help confirm correct mask position (Fig. 6). The cuff of the LMA ProSeal has an additional chamber to form a tighter pharyngeal seal when the perilaryngeal cuff is pushed...
against the laryngeal inlet, permitting positive pressure ventilation up to 30 cm H$_2$O. A built-in esophageal drain opens at the esophageal tip of the mask and can accommodate a 14-F gastric tube (see Fig. 6). Because it is impossible to pass the gastric tube through an obstructed distal opening of the esophageal drain, a misplaced LMA (eg, folding the tip of the mask over backward) can be discovered quickly (see Table 1). The LMA ProSeal is available in sizes 1.5 to 5 and is reusable. The airway tube is wire-reinforced and fused with the esophageal drain at the incisor level by a built-in, silicone bite block.

In 2005, 59 controlled randomized trials or other clinical studies and 79 other publications from January 1998 to March 2005 were reviewed. Compared with the LMA Classic, the LMA ProSeal had an equal insertion success rate and 50% improvement in the airway seal. Because of the esophageal port, diagnosis of misplacement was prompt, gastric drainage was possible, gastric inflation was reduced, and regurgitated stomach contents could be vented. Evidence suggested, but did not prove, that a properly placed LMA ProSeal reduces aspiration risk compared with the LMA Classic. The LMA ProSeal also caused less coughing and sympathetic stimulation than an ET. Comparative trials of the LMA ProSeal and other SGAs demonstrated the superior performance of the LMA ProSeal during positive pressure ventilation, under conditions of both normal and elevated (ie, during laparoscopic surgery) intra-abdominal pressure. The ProSeal was also associated with less analgesic requirement in patients undergoing laparoscopic gynecologic surgery in the first six hours after surgery in comparison with intubated patients. Postoperative nausea and vomiting, analgesic requirements, and airway morbidity were also less in a similar study looking at both laparoscopic and breast surgery.

**LMA Supreme (LMA North America, Inc)**

Like the LMA ProSeal, the LMA Supreme (Fig. 7) has a modified cuff that achieves a 50% higher airway seal pressure than the Classic or the Unique, and a gastric drain to suction the stomach, vent regurgitated stomach contents, and confirm placement of the tip of the mask at the upper esophageal sphincter. A reinforced tip and molded distal cuff prevent folding. The curve and shape of the airway tube make insertion easier and placement more stable. The LMA Supreme is a single-use device, available in adult sizes 3 to 5; its clinical utility is similar to that of the LMA ProSeal.
LMA Fastrach (LMA North America, Inc)

Although the LMA Fastrach (Fig. 8) may function as a ventilating supraglottic airway, it is primarily an intubating tool and was designed as a conduit for placement of an ET in cases of anticipated or actual difficult direct laryngoscopy. Its rigid, anatomically shaped airway tube is wide enough to accommodate a size 8 ET and short enough for placement of the ET cuff below the vocal cords. The LMA Fastrach was intended for blind endotracheal intubation but also can be used with a fiberoptic bronchoscope, lighted stylets, or the Flexible Airway Scope; it is available in sizes 3 to 5 and comes with a specially designed, reusable, wire-reinforced LMA Fastrach ET (Fig. 9).

Fig. 7. Laryngeal mask airway LMA Supreme. (Courtesy of LMA North America, Inc; with permission.)

Fig. 8. Laryngeal mask airway LMA FasTrach. LMA ET Tube is placed in the airway tube. The tip of the ET tube protrudes under the epiglottic elevating bar. (Courtesy of LMA North America, Inc; with permission.)
**LMA CTrach (LMA North America, Inc)**

The LMA CTrach ([Fig. 10](#)) is an LMA Fastrach with built-in fiberoptics for real-time visualization during intubation of the trachea. Ventilation is possible during intubation attempts through the mask portion of the LMA CTrach.

**Other SGAs Similar To LMA Laryngeal Masks**

There are several laryngeal masks available for clinical use in the United States. Their design generally follows that of the LMA Classic and its later variants, with minor modifications depending on the manufacturer. Most of them are single-use devices. The list of the laryngeal masklike devices includes Sheridan Laryngeal Mask (Teleflex Medical), Portex Soft Seal Laryngeal Mask (Smiths Medical), Aura40 Reusable Laryngeal Mask, AuraStraight Disposable Laryngeal Mask, AuraFlex Disposable Laryngeal

![Fig. 10. Intubating laryngeal mask airway LMA CTrach. (Courtesy of LMA North America, Inc; with permission.)](image)

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![Fig. 10. Intubating laryngeal mask airway LMA CTrach. (Courtesy of LMA North America, Inc; with permission.)](image)
Mask, and AuraOnce Disposable Laryngeal Mask (Ambu, Inc), as well as Ultra CPV and UltraFlex CPV (AES, Inc).

OTHER SGA DESIGNS

**Combitube (Covidien)**

The Combitube (Fig. 11) is a disposable, double-lumen tube that combines the features of a conventional ET with those of an esophageal obturator airway. The Combitube has a large proximal oropharyngeal balloon and a distal esophageal (or tracheal), low-pressure small cuff, with eight ventilatory holes between the cuffs, and a single ventilatory port at the distal tip (Fig. 12). There is ventilation with the Combitube regardless of whether the distal tip is in the esophagus (common) (Fig. 13) or in the trachea (rare).26 In the latter case, the device functions like a conventional ET when the distal cuff is inflated. When the distal tip is in the esophagus, the distal cuff seals the esophagus against regurgitation of gastric contents, and a gastric tube can be placed through the esophageal lumen.

The Combitube has been used worldwide for more than 20 years as an emergency airway,27 chiefly in the prehospital setting. The Combitube is an easy-to-use device in a “cannot-ventilate-cannot-intubate” scenario that has been used in challenging situations.

**Fig. 11.** Combitube esophageal/tracheal double-lumen airway: 2 different sizes. (Courtesy of Covidien-Nellcor and Puritan Bennett, Boulder, CO; with permission.)
Fig. 12. Combitube esophageal/tracheal double-lumen airway. (Courtesy of Covidien-Nellcor and Puritan Bennett, Boulder, CO; with permission.)

Due to the material characteristics (e.g., texture) of the oropharyngeal cuff, the Combitube airway requires considerable force to dislodge, ensuring secure placement. \(^1\)

The robust distal cuff exhibits zero leakage around the cuff at 30 cm H\(_2\)O simulated gastric pressure. \(^*\)

*Results based on internal testing

Fig. 13. Combitube placement in esophagus. The tube is advanced until the 2 black depth marks are at the level of the teeth. The distal esophageal cuff is inflated with 10 mL of air to seal the esophagus. The proximal pharyngeal cuff is inflated with 80 mL of air, securing the tube in place and sealing off the oral and nasal cavity. The patient's lungs are ventilated through lumen 1 (pharyngeal lumen). (Courtesy of Covidien-Nellcor and Puritan Bennett, Boulder, CO; with permission.)
situations at accident sites, such as for individuals trapped in an automobile wreck where access to the airway is severely limited.

One study compared the Combitube, the LMA ProSeal, and the Laryngeal Tube S (LTS) in 90 patients who underwent general anesthesia for minor gynecologic procedures. All patients were ASA physical status class I, II, or III, and had a BMI less than 35 kg/m². The Combitube was inferior for the technical aspects of ventilation (time to successful placement and ventilation, failure rate), produced the highest cuff pressures, and resulted in the highest incidence of airway morbidity.28 Increased airway morbidity with the Combitube compared with the LMA during routine surgery has also been demonstrated by another study,29 and airway management with the Combitube during routine general anesthesia is not recommended.28,29

King LT and King LTS (King Systems/VBM Medizintechnik, GmbH)
The Laryngeal Tube (LT) (Fig. 14) is a single-lumen, silicone tube with a large oropharyngeal and smaller esophageal, low-pressure cuff, two ventilation outlets between the cuffs, insertion marks, and a blind esophageal tip. Superficially it resembles a shorter Combitube. The LT is easy to insert and may offer some protection against aspiration. The reusable version may be used up to 50 times and is available in sizes 2 to 5. A disposable version is also available.

The Laryngeal Tube S (LTS) has a second lumen for placement of a gastric tube for drainage of stomach contents (Fig. 15). The LTS is available in reusable and disposable versions in sizes 3 to 5.

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**Fig. 14.** Supraglottic airway device King LT. (Courtesy of King Systems Corporation, Noblesville, IN; with permission.)
The LT and LTS can be used with a spontaneously breathing patient or with positive pressure ventilation. Their ventilatory seal characteristics are comparable with those of the LMA ProSeal. Since its introduction into clinical practice in 2002, several studies have compared the LTS with the LMA ProSeal.\textsuperscript{22,23,28,30} In three studies, the airway seal of the LTS was adequate during positive pressure ventilation, even under conditions of elevated intra-abdominal pressure during laparoscopy, but excluded from the studies were patients whose ASA physical status class was III or higher, whose BMI was greater than 35 kg/m\(^2\), or who were at a risk for aspiration. During laparoscopy, intra-abdominal pressure was limited to 18 cm H\(_2\)O, and Trendelenburg position did not exceed 15°. In a fourth study, the LTS was inferior to the LMA ProSeal with regard to insertion time and success, airway leak pressure, peak and plateau airway pressure, and ease of passage of a gastric tube.\textsuperscript{23} The incidence of throat soreness and dysphagia appeared to be lower with the use of the LMA ProSeal.\textsuperscript{22,28}

Overall, the data suggest that the LTS is a safe and effective airway device in adult patients whose lungs are mechanically ventilated.\textsuperscript{8}

**Cobra PLA (Engineered Medical Systems)**

The Cobra Perilaryngeal Airway (PLA) (Fig. 16) is a cuffed, disposable SGA. The Cobra PLA has a tapered, striated head, a large, circumferential pharyngeal cuff, and a breathing tube; it is available in eight sizes for use from neonates through large adults. The ventilatory opening at the junction of the tube and the head is protected from obstruction by the epiglottis by a soft “grill” on the anterior (laryngeal) aspect of the head. A size 8 ET can be advanced through Cobra sizes 4 to 6. Several
studies\textsuperscript{16,31–33} evaluated the Cobra during spontaneous and positive pressure ventilation in adults and children. Patients were ASA physical status class I or II, had a Mallampati score of I or II, BMI less than 30 kg/m\textsuperscript{2}, and no history of gastroesophageal reflux disease (GERD). In all studies, the Cobra was a suitable primary ventilatory device that provided a higher airway seal pressure than the LMA Unique. However, another study comparing the Cobra and the LMA Classic during anesthesia for elective surgery was terminated after pulmonary aspiration occurred in two patients with the Cobra PLA.\textsuperscript{34} This study excluded patients with a history of GERD, a difficult airway, or morbid obesity.

\textbf{SLIPA (SLIPA Medical Ltd)}

The Streamlined Liner of the Pharynx Airway (SLIPA) (Fig. 17) is a noncuffed, single-use SGA, made of soft plastic in the shape of a pressurized pharynx. The SLIPA has a hollow, boot-shaped chamber, with a toe bridge that seals at the base of the tongue and a heel that anchors the device in place between the esophagus and the nasopharynx (Fig. 18). The hollow chamber can store up to 50 mL of regurgitant gastric liquid. The SLIPA is available in six adult sizes, 47 to 57, that match the width of the thyroid cartilage and are equivalent to LMA sizes 3 to 5.5.

The SLIPA is intended as a primary airway device during general anesthesia of short duration. Its efficacy and complication rate are comparable to those of the LMA Classic.\textsuperscript{31,35,36} The SLIPA is not recommended for patients placed in positions other than supine or when the risk of aspiration is increased. Even though the SLIPA includes a chamber to capture regurgitant gastric contents, more clinical evidence is needed to demonstrate that it confers protection against aspiration.
Fig. 17. SLIPA supraglottic airway device. (Courtesy of ARC Medical, Inc, Tucker, GA; with permission.)

Fig. 18. SLIPA supraglottic airway device placement in the oropharynx. (Courtesy of ARC Medical, Inc, Tucker, GA; with permission.)
Fig. 19. i-gel supraglottic airway device. (Courtesy of i-gel Intersurgical Ltd, Wokingham, Berkshire, UK; with permission.)

Fig. 20. Placement of the i-gel supraglottic airway device in the oropharynx. (Courtesy of i-gel Intersurgical Ltd, Wokingham, Berkshire, UK; with permission.)
**Intersurgical i-gel (Intersurgical Inc)**

The i-gel (Fig. 19) is the latest addition to the SGA arsenal. The i-gel is a single-use device that has an integral bite block, a gastric tube channel, and a soft, noninflatable cuff that adapts to the hypopharyngeal anatomy after blind placement (Fig. 20). The i-gel was found to be safe and effective during positive pressure ventilation in adults with a BMI less than 35 kg/m²,37,38 and in nonobese children,39 but another study looking at 280 uses of the i-gel yielded three cases of regurgitation, with one resulting in nonfatal aspiration.40

**SUMMARY**

Supraglottic airway devices have become prevalent in the ambulatory setting because they typically are more user-friendly than a face mask and avoid many of the problems associated with endotracheal intubation. The LMA Classic and the LMA ProSeal have an established record of safety and efficacy for routine cases in healthy adult and pediatric patients with no significant comorbidities such as morbid obesity, pulmonary disease, or aspiration risk. While this reputation has resulted in a tendency to expand the use of supraglottic airway devices to laparoscopic surgery and to procedures in morbidly obese or pregnant patients, these practices remain controversial. The LMA ProSeal may provide a better airway seal and protection against aspiration than the LMA Classic, although the latter claim has not been definitively demonstrated. Often, disposable LMAs match the performance of the reusable devices.

Over the last two decades, the enormous success of the LMA has been followed by the proliferation of other supraglottic airway devices, each claiming advantages over devices already in use. The Laryngeal Tube and the Laryngeal Tube S are somewhat inferior to the LMA and the LMA ProSeal, respectively, in terms of airway morbidity and delivery of positive pressure ventilation, but they are suitable for routine use. The Combitube should not be used for routine airway management during anesthesia because its incidence of airway morbidity is higher than that of other supraglottic airway devices. Recently developed noninflatable devices, the SLIPA and the i-gel, await more clinical trials to establish their suitability in either the outpatient or the inpatient setting. While more research and development are indicated, SGAs are already proven to be indispensable in the ambulatory setting.

**ACKNOWLEDGMENTS**

The authors wish to thank Sally Kozlik for editorial help, and Susan Yager and Sandra Nunnally for technical assistance in preparing this article.

**REFERENCES**


