Supraglottic Airway Devices: Their Selection, Use, and Limitations

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“Dr Brain’s innovation is a gift of life to patients and anesthesiologists alike and has saved an untold number of lives since its introduction.”

—Andranik Ovassapian, MD

The Laryngeal Mask Airway (LMA, Teleflex) has dramatically changed practice for both elective and emergency airway management. More than 300 million patients all over the world have benefited from safer anesthetics, thanks to this brilliant airway device.1 The remarkable clinical success of the LMA was followed by the development of numerous other supraglottic airway devices (SADs) that serve a wide variety of clinical situations. The laryngeal masks (LMs) and non-LM SADs have constantly evolved, resulting in many improved and safer tools for airway management for adults and children. This review focuses on the clinical use of these SADs in adults.

Terminology
SAD is the term most frequently used to describe this group of noninvasive airway devices capable of delivering oxygen, or anesthetic gases, above the level of the glottis and sealing the pharynx. The acronym SGA (supraglottic airway) is used by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway.2 Extraglottic airway device is a broader term, introduced by Brimacombe in 20043 and more recently endorsed by Hernandez et al,4 to include “airways that do not violate the larynx” but have subglottic components (eg, SADs inserted in the esophagus but situated outside the glottis, such...
as the Combitube [Medtronic], Laryngeal Tube [LT; Ambu], etc). The downside of this term is that it is too inclusive, as it may include surgical airway devices, such as tracheostomy tubes. Alternatively, the terms periglottic airway device and supraglottic ventilatory device are used. Each commercially available SAD has been described by Hagberg in “Current Concepts in the Management of the Difficult Airway” in *Anesthesiology News*.¹

**Classification**  
**First- and Second-Generation SADs**

First-generation SADs have an airway tube for ventilation and oxygenation (eg, LMA Classic [Teleflex], LMA Unique [Teleflex], etc). Second-generation SADs are designed to reduce the risk for pulmonary aspiration (eg, LMA ProSeal [Teleflex], LMA Supreme [Teleflex], Laryngeal Tube Suction II [VBM Medizintechnik], i-gel [Intersurgical], Streamlined Liner of the Pharynx Airway [SLIPA; Hudson RCI], etc). The term third-generation SAD has been used to describe self-energizing sealing devices (eg, Baska Mask [Baska Versatile Laryngeal Mask Pty], air-Q Self-Pressurizing Disposable Masked Laryngeal Airway [Cookgas]) or devices designed to facilitate endotracheal intubation.⁵

Cook recently criticized the labeling of some SADs as “third generation,” arguing that it will do injustice to first- and second-generation SADs that allow either blind or fiber-optically guided endotracheal intubation.⁶ Cook proposed adding an “i” for SADs that enable intubation with a higher than 50% success rate, a “d” for direct/intubation, and a “g” for guided intubation.⁶

Based on their sealing mechanism, Miller classified the SADs into:
- cuffed perilaryngeal sealers (eg, the LMA);
- cuffed pharyngeal sealers (eg, the Combitube); and
- cuffless anatomically preshaped sealers (eg, the i-gel and SLIPA).⁷

### Table 1. Classification of SADs, Based on Sealing Mechanism

<table>
<thead>
<tr>
<th>Cuffed Perilaryngeal Sealers</th>
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<tbody>
<tr>
<td><strong>Laryngeal Mask Airways (LMAs)</strong> (Teleflex)</td>
<td>The reusable LMA Classic was developed by Dr Brain in 1981 and became commercially available in the United Kingdom in 1988 and the United States in 1991. LMAs are by far the most frequently used and studied SAD.</td>
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<tr>
<td><strong>Laryngeal Mask-type devices</strong></td>
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<tr>
<td></td>
<td>Ultra CPV family (AES)</td>
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<td></td>
<td>Ambu Aura family (Ambu)</td>
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<tr>
<td></td>
<td>Intubating Laryngeal Airway (LMA Fastrach, Teleflex)/air-Q Self-Pressurizing Disposable Masked Laryngeal Airway (Cookgas/Mercury Medical)</td>
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<tr>
<td></td>
<td>Shiley Laryngeal Mask (Medtronic)</td>
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<td></td>
<td>Soft Seal (Smith Medical)</td>
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<td></td>
<td>Solus Satin (Intersurgical)</td>
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<thead>
<tr>
<th>Cuffed Pharyngeal Sealers With Esophageal Cuff</th>
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<tbody>
<tr>
<td><strong>Combitube</strong> (Medtronic), <strong>EasyTube</strong> (Teleflex)</td>
<td>EasyTube is an improved version of the Combitube.</td>
</tr>
<tr>
<td><strong>Laryngeal Tube</strong> (Ambu)</td>
<td>Launched in the United States as “King LT,” LT and King LT are the same product, but King Systems named the device “King LT” for marketing reasons.</td>
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<tr>
<th>Cuffed Pharyngeal Sealers With Esophageal Cuff</th>
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<tbody>
<tr>
<td><strong>Cobra Perilaryngeal Airway</strong> (Engineered Medical Systems)</td>
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<tr>
<td><strong>Tulip Airway</strong> (Tulip)</td>
<td></td>
</tr>
<tr>
<td><strong>Anatomically Preshaped Noninflatable Supraglottic Airway Device</strong></td>
<td></td>
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<tr>
<td><strong>i-gel</strong> (Intersurgical)</td>
<td></td>
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<tr>
<td><strong>SLIPA</strong> (Hudson RCI)</td>
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<tr>
<td><strong>Baska Mask</strong> (Baska Versatile Laryngeal Mask Pty)</td>
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**CPV**, Cuff Pilot Valve; **SAD**, supraglottic airway device; **SLIPA**, Streamlined Liner of the Pharynx Airway
Cuffed pharyngeal sealers can be divided further, based on the presence (eg, the Combitube, EasyTube [Teleflex], LT) or absence of an esophageal cuff (eg, the Cobra Perilaryngeal Airway [Engineered Medical Systems], Tulip Airway [Tulip]) (Table 1).

Elective Surgery

The main advantages of the SADs over endotracheal tubes (ETTs) are easy insertion, easy use by inexperienced personnel, a short learning curve, decreased airway trauma, less hemodynamic changes at insertion, and high effectiveness as a rescue device. The desired features of a SAD are presented in Table 2.

SADs are being used increasingly for elective surgery during general anesthesia with spontaneous or positive-pressure ventilation. According to the “National Census of Airway Management Techniques Used for Anesthesia in the UK,” SADs are the most frequently used primary airway devices (56%) during general anesthesia, with the vast majority being LMs.8 Traditionally, SADs are indicated for airway management during general anesthesia for minor extraabdominal procedures in patients with no risk for aspiration. The improved design and safety profile of the second-generation SADs has enabled the expansion of the use of SADs to many other clinical areas (eg, laparoscopic surgery, thyroidectomy, obstetric procedures, prolonged airway management, etc).4

Improved oropharyngeal sealing pressure allows for safe positive-pressure ventilation. Increased airway pressure, exceeding the oropharyngeal sealing pressure, causes air leaks around the SAD, leading to hypoventilation. In addition, leaked gas into the stomach can cause gastric inflation, increasing the risk for regurgitation and aspiration. Table 3 summarizes oropharyngeal sealing pressures suitable for positive-pressure ventilation for some SADs, as reported in selected articles.9-17

This is optimally measured by using the manometric stability test.18 The manometric stability test is performed by closing the adjustable pressure-limiting valve of the anesthesia machine and recording the airway pressure at which equilibrium is achieved with a fixed gas flow (3-5 L/min).18 Changing the patient’s head and neck position can alter the oropharyngeal sealing pressure.14,19

Difficult Airway

SADs have a very well-established role as rescue devices in the management of the difficult airway. The American Society of Anesthesiologists and the Difficult Airway Society of the United Kingdom include the use

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**Table 2. Desired Features of a SAD**

<table>
<thead>
<tr>
<th>Feature</th>
<th>SADs</th>
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<tbody>
<tr>
<td>Disposable</td>
<td></td>
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<tr>
<td>Latex free</td>
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<tr>
<td>Easy to use even by inexperienced personnel</td>
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<tr>
<td>High success rate of first-attempt insertions</td>
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<tr>
<td>Short learning curve and high retention of skills</td>
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<tr>
<td>Prevention of regurgitation and pulmonary aspiration</td>
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<tr>
<td>Conduit for endotracheal intubation</td>
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<tr>
<td>High sealing pressure to allow mechanical ventilation</td>
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<tr>
<td>Minimal airway trauma</td>
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<tr>
<td>Low incidence of postoperative sore throat, hoarseness, dysphagia, dysphonia</td>
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**Table 3. Oropharyngeal Leak Pressure in Paralyzed Patients**

<table>
<thead>
<tr>
<th>Supraglottic Airway Device</th>
<th>Oropharyngeal Leak Pressure (cm H2O)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMA Classic (Teleflex)</td>
<td>19±6</td>
<td>Lu et al9</td>
</tr>
<tr>
<td>LMA ProSeal (Teleflex)</td>
<td>29±4</td>
<td>Lu et al9</td>
</tr>
<tr>
<td>LMA Supreme (Teleflex)</td>
<td>28±5</td>
<td>Lee et al10</td>
</tr>
<tr>
<td>AuraGain (Ambu)</td>
<td>24±7</td>
<td>Shariffuddin et al11</td>
</tr>
<tr>
<td>i-gel (Intersurgical)</td>
<td>27±6</td>
<td>Shin et al12</td>
</tr>
<tr>
<td>Combitube (Medtronic)</td>
<td>32±2</td>
<td>Gaitini et al14</td>
</tr>
<tr>
<td>EasyTube (Teleflex)</td>
<td>34±5</td>
<td>Gaitini et al13</td>
</tr>
<tr>
<td>Laryngeal Tube Suction-Disposable (VBM Medical)</td>
<td>30±4</td>
<td>Park et al14</td>
</tr>
<tr>
<td>Cobra Perilaryngeal Airway (Engineered Medical Systems)</td>
<td>25±1</td>
<td>Yaghoobi et al15</td>
</tr>
<tr>
<td>SLIPA (Hudson RCI)</td>
<td>30±5</td>
<td>Miller and Camporota16</td>
</tr>
<tr>
<td>air-Q (Cookgas)</td>
<td>30±7</td>
<td>Galgon et al17</td>
</tr>
</tbody>
</table>

**SLIPA Streamlined Liner of the Pharynx Airway**
of a SAD early in the process of a difficult airway, after limited failed attempts to intubate the trachea. The algorithm developed by the Difficult Airway Society, focusing on the unanticipated difficult airway, favors the use of second-generation SADs based on evidence that pulmonary aspiration is the most common cause for significant airway complications. No more than 3 attempts at supraglottic ventilation are allowed. Cricoid pressure should be transiently released to facilitate successful placement.

There is, by far, more data to support the LMA or LM variants as rescue devices for cases of unanticipated difficult airways. Parmet et al reported successful use of the LMA in 94% of cases of unexpected difficult mask ventilation and tracheal intubation. The intubating LMA (also known as the LMA Fastrach [Teleflex]) should be given high preference, as it is specifically designed to serve as a conduit for endotracheal intubation. Other non-LM SADs, with a different design, may succeed in cases of LM failure. The choice of the SAD is dictated mainly by availability, user proficiency, and preference.

Algorithms are very important strategic tools for managing expected and unexpected difficult airways. However, they are very complex, and, so far, there is no evidence of improved outcomes to favor one algorithm over another.

Recently, the Vortex concept was developed by Chrimes as a visual cognitive aid for difficult airway management. The Vortex graphical representation of “looking down into a funnel” (Figure 1A-B) symbolizes the rapid and progressive deterioration of an airway crisis, toward the “blue zone,” representing the life-threatening situation of a can’t intubate/can’t oxygenate scenario. Failure to obtain a patent airway after 3 optimal attempts with each of the nonsurgical airway tools (face mask ventilation, SAD, or ETT) prompts immediate establishment of a surgical airway (front of neck access). The “green zone” of the Vortex is reached by reestablishing airway patency, offering the opportunity to reorganize and make a plan. Figure 2 summarizes the best efforts to optimize use of a SAD.

**Exchange of a SAD for an ETT**

Although it is possible to maintain an airway with a SAD for longer periods of time, an exchange to an ETT is often necessary, as dictated by clinical need. Several techniques to facilitate tracheal intubation through a SAD have been described, including blind intubation or facilitation by light wands, optical stylets, or a fiber-optic bronchoscope.

Ferson et al reported successful insertion of the intubating LM in 100% of patients with expected difficult airways, after a maximum of 3 attempts. Blind insertion of an ETT through the intubating LMA was successful in 97% of patients, and fiber-optically guided intubations were successful in 100% of patients. Berkow et al reported a 93% success rate for exchanging the LM for an ETT using an Aintree Intubation Catheter (AIC; Cook Medical) and a fiber-optic bronchoscope.

The air-Q Intubating Laryngeal Airway (Cookgas/Mercury Medical) can be used both as a primary airway device and a conduit for endotracheal intubation. Karim and Swanson reported successful blind intubation through the air-Q after 2 attempts in 77% of patients, and in 95% of patients after the third fiber-optically guided intubation. In a large multicenter study, Ruetzler et al reported a blind intubation success rate of 78% in patients ventilated with the air-Q Self-Pressurizing Disposable Masked Laryngeal Airway.

The Combitube can be replaced with an ETT using direct and indirect laryngoscopy. Alternatively,
fiber-optically guided airway exchange, by inserting the fiber-optic bronchoscope alongside the Combitube, has a success rate of 90% in spontaneously breathing patients.\textsuperscript{34} The LT can be exchanged by indirect visualization with a C-MAC video laryngoscope (KARL STORZ), a fiber-optically guided intraluminal or extraluminal approach, or using an Arndt Airway Exchange Catheter (Cook Medical).\textsuperscript{35,36}

Moore et al reported a 100% success rate of fiberoptic intubation through the i-gel, using a Parker Medical ETT.\textsuperscript{37}

The intubating Laryngeal Tube Suction-Disposable (VBM Medical), a new SAD designed as a conduit for endotracheal intubation, was reported by Bergold et al to have been used successfully to intubate the trachea in 30 patients with normal airways.\textsuperscript{38}

**Prehospital Use of SAD**

Popularity of the SADs in the prehospital area is increasing for both primary airway management and as rescue devices. SADs generally require less training, are easier and quicker to insert even by inexperienced personnel, and require less interruptions in chest compressions during cardiopulmonary resuscitation.

Diggs et al analyzed the 2012 National Emergency Medical Services Information System for airway management outcomes.\textsuperscript{39} They reported 74,993 endotracheal intubations, with an overall 85.3% success rate, and 21,990 “alternate airways” uses, with an overall success rate of 79.6%. The LT had the highest success rate (89.7%). The Combitube was the most frequently used “alternate airway,” with a success rate of 79%. Of note, the LM was successfully used in 66% of cases.

Hubble et al, in a meta-analysis of prehospital airway control techniques analyzing 35 studies that included 10,172 patients, found that the LT had the highest insertion success rate (96.5%), followed by the LM (87.4%) and the Combitube (85.4%).\textsuperscript{40}

For prehospital airway control, when inserted by well-trained emergency physicians, Timmermann et al reported a 100% success rate of ventilation and endotracheal intubation with the intubating LMA.\textsuperscript{41}

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**Figure 2.**

For each lifeline tried, the Vortex Approach requires a “best effort” that considers manipulations, adjuncts, size and type, suction and oxygen flow, and muscle tone. Here, the best efforts for a supraglottic airway.

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Correct cuff inflation and insertion depth are necessary to provide an adequate seal. Insufficient cuff inflation causes hypoventilation, whereas overinflation can cause damage to the surrounding tissues. Downfolding of the epiglottis during insertion of the SAD results in serious malfunctioning.49 The LMA has 2 bars across the ventilation aperture to prevent obstruction by the epiglottis. However, the protective role of the mask aperture bars has been questioned by Van Zundert et al, who showed no anatomic evidence of contact of the epiglottis with the bars.50

Suboptimal position of a SAD can be corrected by adjusting the head/neck position, applying jaw lift, changing depth of insertion, changing the SAD size, reinserting the device using a railroading technique (bougie, orogastric tube), or laryngoscopically facilitated repositioning/insertion.49,51,52

Limitations

SADs are difficult or impossible to insert in patients with small mouth openings, anatomic abnormalities, upper airway edema, or obesity. In a retrospective review of 14,480 patients ventilated with the LMA Classic, LMA ProSeal, LMA Fastrach, LMA Supreme, or i-gel, Saito et al reported an incidence of 0.5% difficult ventilation with a SAD and a 0.2% failure of the SAD to provide an effective airway.53 Ramachandran et al reported a 1% failure to provide adequate ventilation as a primary airway with the LMA Unique in patients undergoing elective surgery.54 Patients with a failed LMA Unique insertion presented a 3-fold increased incidence for difficult mask ventilation.

Even though second-generation SADs provide superior safety in airway protection, they are not replacements for the ETT, and should not be considered as absolutely safe for preventing aspiration. The LMA Protector (Teleflex) has been designed to minimize the risk for aspiration by channeling the gastric content away from the airway. It has a pharyngeal chamber, dual gastric channels to channel away fluids from the airway, and an integrated cuff pilot.

A SAD may be left in place for several hours, but the length of time of safe ventilation is still being investigated.

Complications

Excessive filling of the cuff can predispose the SAD to malfunctioning and the patient to pharyngeal/esophageal tissue injury. The pharynx, a fibromuscular cavity, is capable of accommodating a large, expandable SAD. However, excessive cuff pressure may cause injury by compressing part of the pharynx against rigid structures, such as the hyoid bone or cervical vertebrae.

Intracuff pressure exceeding the pharyngeal mucosa capillary perfusion pressure can lead to mucosal perfusion impairment with consequent tissue ischemia. Manufacturers often recommend not to exceed an intracuff pressure of 60 cm H2O.55 The incidence of postoperative sore throat after general anesthesia with SADs for airway management can be as high as 49%.56 The...
incidence and severity of sore throat depends on intracuff pressure throughout the procedure, technique, and choice of SAD. Frequent monitoring and adjustment of the intracuff pressure using a manometer helps reduce the incidence of postoperative sore throat, hoarseness, and dysphagia.66 The AES Ultra Cuff Pilot Valve (CPV), a relatively new SAD similar to the LMA, presents an integrated CPV that provides continuous monitoring of the intracuff pressure.57

Overinflation of the esophageal balloon of the Combitube can lead to esophageal injury.58 Cranial nerve injuries, such as lingual, recurrent laryngeal, hypoglossal, glossopharyngeal, inferior alveolar, and infraorbital nerve injury, have been described after SAD use.59

### References


### Conclusion

Proper SAD selection, atraumatic insertion, and maintenance of an intracuff pressure no higher than 60 cm H2O are crucial for safe and efficient use of a SAD. Among the numerous available SADs, the choice should be determined by availability and user proficiency, while giving preference to second-generation SADs.

It is difficult to imagine how we provided everyday anesthetics before the LM era, or how we could manage a difficult airway without an intubating LM. In February 1983, the LMA was used for the first time to rescue an airway. Since then, many more lives have been saved thanks to the LM and other SADs.

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