

SPECIAL INTEREST ARTICLE

An update on newer pediatric supraglottic airways with recommendations for clinical use

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Summary

Supraglottic airways are an established part of routine and emergency pediatric airway management, including use in difficult airways and neonatal resuscitation. With the introduction of newer supraglottic airways in children, efficacy can only be determined by comparing these devices with those that are already well established (laryngeal mask airway Classic and laryngeal mask airway ProSeal). This narrative review aims to present the current literature on these newer supraglottic airways and give recommendations for their use in various clinical scenarios based on the existing evidence.

Introduction

Supraglottic airways (SGAs) may be pragmatically defined as a device that facilitates oxygenation and ventilation while sitting immediately outside the larynx to form a perilaryngeal seal. SGAs are an established part of routine and emergency pediatric airway management, including use in the difficult airway and neonatal resuscitation.

Supraglottic airways may be classified as first- or second-generation devices based on the presence of a gastric access channel (1). First-generation devices are simple airway tubes attached to a mask that rests over the glottic opening. Second-generation devices incorporate a gastric access channel that allows for gastric venting, and the option to place a gastric tube. Correct placement of an SGA results in the leading edge of the device to rest in the upper esophagus, creating a 'second seal' or hypopharyngeal seal. Second-generation devices typically provide a better 'second seal' which can support higher airway pressures than first-generation devices. The improved airway seal with the added gastric access channel helps reduce the risk of gastric insuffla-

tion, allows for more effective positive pressure ventilation (PPV), and offers some protection against unexpected regurgitation and aspiration (2,3).

Since the introduction of the first SGA 30 years ago, many variations of new first- and second-generation devices have been designed to improve ease of insertion, PPV, and facilitate tracheal intubation. This review aims to briefly present the evidence surrounding the use of established pediatric first- and second-generation SGAs: the laryngeal mask airway Classic, laryngeal mask airway Unique, and laryngeal mask airway ProSeal, which were introduced into clinical practice in 1987, 1997, and 2000, respectively; and to provide a more detailed critique of newer pediatric SGAs: the air-Q, laryngeal mask airway Supreme, i-gel, and Ambu Aura-i, which have the most evidence to support their use in the pediatric population. In addition, this review of the current literature will also provide a summary of recommendations for the use of these newer SGAs in clinical practice. Safety data are difficult to acquire and require extensive use of these devices in thousands of patients, which may bias clinicians against newer devices. As a result,

establishing safety data on newer SGAs can only be obtained over time as the use of these devices becomes more commonplace.

Established SGAs (laryngeal mask airway Classic, laryngeal mask airway ProSeal, laryngeal mask airway Unique): a brief overview

The laryngeal mask airway Classic is a first-generation device without a gastric access channel and is widely used in pediatric anesthesia. The laryngeal mask airway Classic has been shown to be superior to mask ventilation, even when used by inexperienced clinicians (4–7). The hemodynamic stress response associated with laryngeal mask airway insertion is less than that with laryngoscopy and tracheal intubation, and comparable to the insertion of an oral airway (7–10). In routine airway management by inexperienced personnel, the laryngeal mask airway Classic can be faster and easier to insert than a tracheal tube (TT) (4). However, increased technical difficulties and airway complications are noted with decreasing patient age (11,12). Complications include mask displacement, poor airway seal, gastric insufflation, and reflex activation of the airway (13). Despite these areas of concern, the laryngeal mask airway Classic has been safely utilized in pediatric practice.

The laryngeal mask airway Classic is constructed of silicone and designed to be reused up to 40 times. Despite proper sterilization, the risk of infection can remain because autoclaving fails to completely remove prions and protein deposits (14). An evaluation of 50 previously used and sterilized laryngeal mask airway Classics revealed residual protein after one use and increased protein load with each subsequent use (15).

The laryngeal mask airway Unique is a disposable version of the laryngeal mask airway Classic, made of polyvinylchloride (PVC) or silicone (in some countries), and was introduced in 1997. The laryngeal mask airway Unique performs similar to or better than the laryngeal mask airway Classic (16,17). The ease of insertion, combined with a disposable design, may potentially make the laryngeal mask airway Unique a good device for novice users and in out-of-hospital settings.

The laryngeal mask airway ProSeal is a reusable second-generation device that was introduced in 2000. Pediatric-sized laryngeal mask airway ProSeals (1.0–2.5) became available in 2004. In addition to the gastric channel, there is a built-in bite block to prevent airway obstruction. A deep mask bowl improves the hypopharyngeal seal, which facilitates PPV. Compared with the laryngeal mask airway Classic, the laryngeal mask airway ProSeal has the same (18) or better (19) airway leak pressures with decreased rates of gastric insufflation

(2,18–24). Higher first-attempt insertion rates and higher leak pressures were also seen in neonatal resuscitation studies utilizing manikins with the laryngeal mask airway ProSeal when compared with the laryngeal mask airway Classic (25,26). The laryngeal mask airway ProSeal has been shown in a variety of clinical trials to outperform the laryngeal mask airway Classic, and can be an effective means for mechanical ventilation (2,18,20,22,23,27,28).

Key concepts

The airway seal of various first-generation SGAs and their leak volumes are largely dependent on the inflation status of the cuff, which has been shown to be less than the usual recommended range (<60 cmH₂O), for optimal performance (29–31). Lower cuff pressures have also been shown to be beneficial with the laryngeal mask airway Supreme (32). However, there is insufficient evidence to definitively recommend the best cuff pressure for optimal clinical performance with second-generation SGAs. Based on these studies, it is conceivable that a lower cuff pressure for newer SGA devices may be better airway sealing characteristics. In addition, the anatomic positioning of smaller sized SGAs does not necessarily correlate with the functionality of the SGA, and ventilation can be effective, despite significant downfolding of the epiglottis on fiberoptic examination (33,34). This is also true with the newer SGAs (35–38).

Both the laryngeal mask airway Classic and the laryngeal mask airway ProSeal have a strong evidence base supporting their use in children. Therefore, newer SGAs should be compared with these established standards when evaluating their efficacy (1).

Newer SGAs

First-generation devices

air-Q

The air-Q is an oval-shaped laryngeal mask with a shortened, wide, curved airway tube. The air-Q mask contains an elevated keyhole-shaped ventilating orifice designed to prevent epiglottic downfolding (Figure 1); however, epiglottic downfolding can still occur in smaller children (37,39).

The air-Q has three versions, and is manufactured as a reusable or single-use device:

1. Standard cuffed
2. Self-pressurized (air-Q SP; lack of an inflatable cuff)
3. air-Q with an esophageal blocker: a second-generation device which allows for evacuation of gastric contents; not yet available for children.

The air-Q SP performed well in a large observational study of several infants and small children (40). A randomized trial of children weighing 10–15 kg found higher airway leak pressures when the cuffed air-Q was used for routine anesthetic maintenance, as compared with the laryngeal mask airway Unique (35). The air-Q was also reported to have superior fiberoptic views of the larynx. Another randomized trial compared the air-Q SP with the laryngeal mask airway Unique in older children. The two devices performed similarly in terms of airway leak pressure, fiberoptic views, and complication rates (36). The cuffed air-Q was shown to be associated with higher airway leak pressures and superior fiberoptic views when compared with the flexible laryngeal mask airway in infants weighing less than 10 kg (41). Various studies have reported that leak pressures with the air-Q are similar (36) or higher (35) than the laryngeal mask airway Unique, but lower than the laryngeal mask airway ProSeal (42).

In addition to its use in routine anesthetic maintenance, the air-Q was also designed to assist tracheal intubation in both infants and children (37,39,43). Several reports suggest that the air-Q does offer advantages over traditional laryngeal masks and the Ambu Aura-i when used as a conduit for fiberoptic-guided tracheal intubation in children (39,41,44). Compared with the Ambu Aura-i, both devices performed well as conduits for tracheal intubation including similar success rates, time to tracheal intubation, and fiberoptic views (39). However, the utility of the Ambu Aura-i size 1.5 with cuffed TT was limited by its narrower airway tube, which could not accommodate the passage of the TT pilot balloons. The air-Q design has a shorter, wider airway tube to facilitate passage of cuffed TTs and

subsequent removal of the air-Q after tracheal intubation (37,39). The largest TT that can be accommodated by the air-Q is printed on the dorsal aspect of the airway tube. The removal process has been shown to be effective with low risk for inadvertent tracheal extubation when a removal stylet is used to stabilize the TT during air-Q removal (37,39,43,44).

The air-Q may be a useful tool in small children, as it was shown to require fewer maneuvers to optimize the fiberoptic glottic view for tracheal intubation when compared with a traditional free-handed fiberoptic intubation in children with normal airways (45). The air-Q has also been used successfully in children with anticipated and unanticipated difficult airways (46–53), while allowing for the use of cuffed TTs. A retrospective evaluation of anticipated and unanticipated difficult airways found that the air-Q was used successfully as a conduit for intubation in all cases (47). A case series showed that in children with craniofacial abnormalities (limited mouth opening), the air-Q provided adequate ventilation even when downsized, and was still an effective conduit for fiberoptic-guided tracheal intubation with an appropriately sized cuffed TT (44). This ability to facilitate tracheal intubation with larger cuffed TT even with a smaller air-Q may be an advantage over the laryngeal mask airway Classic. The air-Q has also been used to successfully relieve upper airway obstruction during rapid sequence fiberoptic intubations (53) as well as facilitate oxygenation while performing fiberoptic tracheal intubations in children with predicted difficult airways (44,47,49,53).

In addition, the air-Q may prove to be beneficial in neonatal resuscitation. In a neonatal manikin resuscitation study, novices found the air-Q easier to use than the Soft Seal laryngeal mask for emergency airway management during chest compression (54). Table 1 summarizes the studies performed with the air-Q in children.

Second-generation devices

The most established second-generation device is the laryngeal mask airway ProSeal, and it is associated with a long history of safety and efficacy for various procedures in children (1,55). Newer second-generation devices include the laryngeal mask airway Supreme and the i-gel. A recent survey of 240 anesthesiologists in the United Kingdom showed that adoption of second-generation devices for use in children has been slow, with 88% preferentially using first-generation devices (56) and citing safety concerns as the determining factor. The choice of SGA was also largely influenced by departmental preference and personal choice.



Figure 1 Supraglottic airways, from left to right (all devices are size 2.0): laryngeal mask airway ProSeal, i-gel, laryngeal mask airway Supreme, air-Q, Ambu Aura-i, and laryngeal mask airway Unique.

Laryngeal mask airway Supreme

The laryngeal mask airway Supreme is a single-use, second-generation device made of PVC. It was designed to combine features of the laryngeal mask airway ProSeal (gastric access and high airway leak pressures) and the laryngeal mask airway Fastrach (curved, rigid airway to facilitate easy insertion). The airway tube of the laryngeal mask airway Supreme also incorporates a bite block at its proximal end, and has a drain tube that travels through the center of the device and exits out of the leading edge of the mask (Figure 1). The ventilating orifices are located on either side of the mask bowl with overlying epiglottic fins to prevent epiglottic trapping. The proximal portion of the laryngeal mask airway Supreme mask is also relatively larger than the laryngeal mask airway ProSeal.

The laryngeal mask airway Supreme has been evaluated in a number of studies performed in children. These are summarized in Table 2. Several randomized trials

comparing the laryngeal mask airway Supreme with the laryngeal mask airway Unique have shown that the laryngeal mask airway Supreme provided good gastric access, and had reduced rates of gastric insufflation with similar (32) or higher airway leak pressures (57). Compared to the i-gel, the laryngeal mask airway Supreme was shown to have lower airway leak pressures (58). However, no differences in the overall clinical performance were noted, including the ability to provide PPV. In a study simulating a difficult airway scenario, the laryngeal mask airway Supreme was associated with higher airway leak pressures than the i-gel. The laryngeal mask airway Supreme was also associated with higher first-attempt success rates and faster times for successful insertion (59). A study comparing the laryngeal mask airway Supreme with the laryngeal mask airway ProSeal showed the laryngeal mask airway Supreme to be easier to insert, and associated with less pharyngeal injury (60). In addition, another study comparing the laryngeal

Table 1 Summary of studies performed on the pediatric air-Q

Author	Study population; device size(s)	Type of study; device(s)	Primary findings	Secondary findings
Jagannathan <i>et al.</i> (40)	352 children; 69 infants; all pediatric sizes	Observational: air-Q SP	99% insertion success rate	No difference in complication rates in infants vs older children
Whyte <i>et al.</i> (42)	110 infants and children; all pediatric sizes	Observational: air-Q cuffed	Ventilation was adequate in 108 of 110 cases	Fiberoptic view of the vocal cords was obtained in 102 of 110 cases
Komasawa <i>et al.</i> (54)	24 novice doctors on a neonatal manikin	Observational: air-Q Soft Seal laryngeal mask airway	Insertion time during chest compressions was faster with the air-Q than the Soft Seal ($P < 0.05$)	n/a
Sinha <i>et al.</i> (43)	20 infants; sizes 1.0, 1.5	Observational: air-Q cuffed for tracheal intubation	Tracheal intubation successful in 19 of 20 patients	Mean time to device insertion was 13 s; mean time to intubation was 96 s
Jagannathan <i>et al.</i> (35)	50 children; sizes 1.5, 2.0	RCT (crossover design): air-Q vs laryngeal mask airway Unique	Mean leak pressure was higher with the air-Q: 19 vs 16 cmH ₂ O ($P = 0.01$)	Better fiberoptic views of glottis with air-Q
Jagannathan <i>et al.</i> (36)	60 children; size 2.0	RCT: air-Q SP vs laryngeal mask airway Unique	No difference in initial leak pressure and leak pressure measured at 10 min	Median time to successful insertion was faster with the air-Q SP: 12 vs 14 s ($P = 0.05$); no differences in fiberoptic view of glottis and complication rates
Jagannathan <i>et al.</i> (39)	120 infants and children; sizes 1.5, 2.0	RCT: air-Q vs Ambu Aura-i for tracheal intubation	No differences in time to tracheal intubation or overall intubation success	Mean leak pressure was higher with air-Q in infants; pilot balloon could not pass through the size 1.5 Ambu Aura-i
Darlong <i>et al.</i> (41)	50 infants weighing less than 10 kg	RCT: air-Q vs Flexible laryngeal mask airway	Mean leak pressure was higher with the air-Q: 21 vs 17 cmH ₂ O ($P = 0.02$)	Better fiberoptic views of glottis with air-Q (good view in 84% vs 48% ($P = 0.0016$))

RCT, randomized clinical trial.

Table 2 Summary of studies performed on the pediatric laryngeal mask airway Supreme

Author	Study population; device size(s)	Type of study: device(s)	Primary outcome	Secondary outcomes
Trevisanuto <i>et al.</i> (63)	40 clinicians Neonatal manikin	Observational: laryngeal mask airway Supreme laryngeal mask airway ProSeal laryngeal mask airway Classic	Maximal inflation pressure and quality perceived by the operator are higher with Supreme than with laryngeal mask airway Classic and laryngeal mask airway ProSeal	Time to effective ventilation with the laryngeal mask airway Supreme is superior to laryngeal mask airway ProSeal
Jagannathan <i>et al.</i> (88)	100 patients; sizes 1.0, 2.0, 3.0	Observational: laryngeal mask airway Supreme	First-time insertion success rate was 97%; overall insertion success rate of 100%	Gastric tube placement was possible in 98% of patients; mean leak pressure was 22 cmH ₂ O
Jagannathan <i>et al.</i> (57)	50 patients; size 2 device	RCT: laryngeal mask airway Supreme laryngeal mask airway Unique	Median leak pressure was higher with laryngeal mask airway Supreme: 20 vs 15 cmH ₂ O ($P = 0.01$)	Laryngeal mask airway Unique was faster to insert; less gastric insufflation with laryngeal mask airway Supreme
Jagannathan <i>et al.</i> (61)	60 patients; size 2.0	RCT: laryngeal mask airway Supreme laryngeal mask airway ProSeal	No difference in median leak pressure: 19 vs 18 cmH ₂ O	No differences in ease and success of insertion, fiberoptic views, or complication rates
Jagannathan <i>et al.</i> (58)	168 patients; sizes 1.5, 2.0, 2.5, 3.0	RCT: laryngeal mask airway Supreme i-gel	Mean leak pressure was higher with i-gel 20 vs 17 cmH ₂ O ($P = 0.001$)	The i-gel required a greater number of airway manipulations to maintain a patent airway
Jagannathan <i>et al.</i> (31)	180 patients; sizes 1.5, 2.0, 2.5	RCT: laryngeal mask airway Supreme laryngeal mask airway Unique	No differences in leak pressure between devices at an intracuff pressure of 40 cmH ₂ O vs 60 cmH ₂ O	Less rates of gastric insufflation with the laryngeal mask airway Supreme during positive pressure ventilation
Kus <i>et al.</i> (59)	60 patients with simulated difficult airway; size 2.0	RCT: laryngeal mask airway Supreme i-gel	Mean leak pressure was higher with laryngeal mask airway Supreme: 21 vs 19 cmH ₂ O ($P = 0.019$)	Laryngeal mask airway Supreme was faster to insert with higher success rate in simulated difficult airway scenario
Aydogmus <i>et al.</i> (60)	80 patients; size 3.0	RCT: laryngeal mask airway Supreme laryngeal mask airway ProSeal	Blood staining on removal of device was higher with the ProSeal: 10 vs 3 ($P = 0.034$) and associated with pharyngeal injury	Laryngeal mask airway Supreme was faster to insert
Hosten <i>et al.</i> (62)	60 patients; size 2.0	RCT: laryngeal mask airway Supreme laryngeal mask airway ProSeal	No difference in leak pressure between devices	Laryngeal mask airway Supreme was faster to insert with no difference in overall insertion success rates between devices

RCT, randomized clinical trial.

mask airway Supreme with the laryngeal mask airway ProSeal did not show any differences in airway leak pressures, or the overall clinical performance of either device (61). Some studies have also demonstrated that the laryngeal mask airway Supreme is faster to insert than the laryngeal mask airway ProSeal (60,62).

The laryngeal mask airway Supreme has also performed well as a resuscitation device in neonates. One study utilizing neonatal manikin models demonstrated

faster insertion times and higher airway leak pressures with the laryngeal mask airway Supreme when compared with the laryngeal mask airway Classic and laryngeal mask airway ProSeal (63).

i-gel

The i-gel is a single-use, second-generation SGA that contains a noninflatable laryngeal mask made of a gel-like thermoplastic elastomer. The semi-rigid cuff does

not require or allow for inflation or adjustment of intra-cuff pressures. Instead, the airway seal is designed to improve as the device warms to body temperature. The noninflatable cuff design has the potential advantage of faster insertion time and reduced morbidity related to cuff hyperinflation (64). Easy and rapid insertion of an SGA may be especially important for emergency situations, difficult airways, or out-of-hospital scenarios. Additional features of the i-gel include a built-in bite block, an epiglottic rest to prevent downfolding, and a gastric access channel (size 1 has no gastric channel) (Figure 1).

Among the newer SGAs, the i-gel has the greatest evidence base, and several observational, randomized studies and meta-analyses evaluating the performance of the i-gel in children are summarized in Tables 3 and 4. An observational study on older children (65) found that the i-gel was easy to insert, and had a mean airway leak pressure of 25 cmH₂O. Studies show similar (66) or higher (67–69) leak pressures to the laryngeal mask airway ProSeal, and higher leak pressures when compared with the laryngeal mask airway Supreme (59) or laryngeal mask airway Classic (67,68). Two studies demonstrated no difference in the airway leak pressures between the laryngeal mask airway Classic and i-gel, but found that the i-gel was faster (64) and easier (70) to insert in infants, a population historically at higher risk for mask displacement during anesthetic maintenance with the laryngeal mask airway Classic.

Compared with the Ambu AuraOnce, the i-gel was associated with higher airway leak pressures, longer insertion times (71), and a tendency to slide out of the mouth after insertion. Spontaneous dislodgement of the i-gel was noted by several authors (58,71–73),

and may be attributed to a relatively wider conical mask compared with other traditionally designed laryngeal masks. Although the design of the i-gel includes an elliptically shaped tube to prevent axial rotation and increase stability, it has been reported to require positional adjustments during the anesthetic course to maintain airway patency (61). These adjustments were more common when the i-gel was used in smaller children. There was an observed outward displacement of the i-gel that often necessitated downward traction and fixation with tape to maintain a good airway seal (71).

Two recent meta-analyses (38,76) included nine RCTs comparing the i-gel with various SGAs in children. The i-gel was found to have higher airway leak pressures and superior fiberoptic views compared with other SGAs in children, including the laryngeal mask airway ProSeal. However, there were no differences between the SGAs in terms of rates of successful insertion, insertion times, or overall complications. Higher airway leak pressures may be clinically advantageous in settings requiring increased ventilating pressures such as prone positioning, obesity, and lung disease. Table 4 summarizes the RCTs performed on the i-gel.

Supraglottic airways as conduits for tracheal intubation

Supraglottic airways are ideal conduits for tracheal intubation in children who cannot be intubated by direct laryngoscopy, and are recommended in difficult airway algorithms (76,77). Advantages include the option for continuous oxygenation during intubation, hands-free operation, and relief of upper airway obstruction in children with difficult airways (53,79,80). Evidence for the

Table 3 Summary of observational trials with the pediatric i-gel

Author	Study population; device size(s)	Primary findings	Secondary findings
Beringer <i>et al.</i> (72)	120 children; sizes 1.5, 2.0, 2.5	Median insertion time was 14 s. Manual ventilation was possible in all cases. Median (IQR [range]) leak pressure was 20 (16–26 [8–30]) cmH ₂ O	Fiberoptic inspection through the i-gel revealed a clear view of the vocal cords in 40 of 46 cases (87%)
Abukawa, <i>et al.</i> (89)	70 children; sizes 1.5, 2.0, 2.5	Overall first-attempt success rate was 94%. Gastric tube insertions were easy in all patients. The overall mean leak pressure was 23 cmH ₂ O	Complication rates were higher in size 1.5 group
Hughes <i>et al.</i> (73)	154 children; sizes 1.2, 2.0, 2.5	First insertion attempt was successful in 93.5% of patients. Gastric tube placement was successful in 90% of cases. Minor complications occurred in 20% of cases	Considerable vigilance is required when securing the device
Beylacq <i>et al.</i> (65)	50 children; size 3.0	Overall first-attempt success rate was 100%. The mean seal pressure was 25 cmH ₂ O	There was no gastric insufflation. Gastric tube insertion was achieved in all cases

Table 4 Summary of randomized trials with the pediatric i-gel

Author	Study population; device size(s)	Comparison device(s)	Primary outcome: mean leak pressure (cmH ₂ O)	Secondary outcomes: ease and success of insertion, fiberoptic views, complications
Theiler <i>et al.</i> (71)	208 patients; Sizes 1.5, 2.0, 2.5, 3.0	Ambu AuraOnce	Higher with i-gel: 22 vs 19 ($P < 0.01$)	Time to successful insertion faster with the Ambu AuraOnce The i-gel was more likely to slide out of the mouth after insertion
Goyal <i>et al.</i> (67)	120 patients; size 2.0	Laryngeal mask airway ProSeal laryngeal mask airway Classic	Higher with i-gel: 26 vs 23 (ProSeal) and 22 (Classic) ($P < 0.01$)	No differences
Das <i>et al.</i> (69)	90 patients; size 2.0	Laryngeal mask airway ProSeal laryngeal mask airway Classic	Higher with i-gel: 27 vs 22 (ProSeal) and 23 (Classic)	No differences
Mitra <i>et al.</i> (68)	60 patients; size 2.5	Laryngeal mask airway ProSeal	Higher with i-gel: 27 vs 22	No differences
Lee <i>et al.</i> (64)	99 patients; sizes 1.5, 2.0, 2.5	Laryngeal mask airway Classic	No difference	The i-gel had faster insertion times and better fiberoptic views of glottis compared with the laryngeal mask airway Classic ($P = 0.001$)
Gasteiger <i>et al.</i> (66)	51 patients; size 2.0	Laryngeal mask airway ProSeal	No difference	No differences
Fukuhara <i>et al.</i> (82)	134 patients; sizes 1.5, 2.0, 2.5, 3.0	Laryngeal mask airway ProSeal	No difference	Fiberoptic views were significantly better with the i-gel than with the laryngeal mask airway ProSeal ($P = 0.002$), especially in larger children
Jagannathan <i>et al.</i> (58)	168 patients; sizes 1.5, 2.0, 2.5, 3.0	Laryngeal mask airway Supreme	Higher with i-gel 20 vs 17 ($P = 0.001$)	The i-gel required a greater number of airway manipulations to maintain a patent airway
Kim <i>et al.</i> (70)	54 infants; sizes 1.0, 1.5	Laryngeal mask airway Classic	No difference	First insertion success rate higher with i-gel (100% vs 88%); i-gel easier to insert (96% of patients) compared with the laryngeal mask airway Classic (69% of patients). No differences in insertion times, fiberoptic views of glottis, or complication rates

successful use of SGAs in difficult airway scenarios is based on reports from case series and observational studies (80).

Two new SGAs specifically designed to facilitate tracheal intubation are the air-Q (discussed earlier) and the Ambu Aura-i. The Ambu Aura-i is a newer model of the Ambu AuraOnce, and is specifically designed for tracheal intubation with fiberoptic guidance in children. The mask bowl of both of these devices resembles the laryngeal mask airway Classic, but without aperture bars (Figure 1). The airway tube has a 90° angle for easy insertion. Compared to the i-gel and air-Q, the Ambu AuraOnce offers similar fiberoptic views of the glottis (39,71), although it should be noted that the Ambu Aura-i size 1.0 and 1.5 does not permit the passage of cuffed tube. A study evaluating the use of SGAs as a conduit for diagnostic and therapeutic bronchoscopy

found that PVC-based devices, including the Aura Once, were associated with more resistance during bronchoscope manipulation than silicone-based SGAs (81).

The i-gel offers equal or better fiberoptic views of the glottis compared with the laryngeal mask airway Classic or laryngeal mask airway ProSeal (64,66,82). The favorable fiberoptic views may suggest a role for the i-gel as a conduit for tracheal intubation; however, no formal pediatric study has been performed to date.

The laryngeal mask airway ProSeal and laryngeal mask airway Supreme may be used as conduits for tracheal intubation, but their narrower airway tubes preclude the ability to directly pass an adequately sized TT through these devices. Therefore, the use of an airway exchange catheter, an intubation introducer (Aintree exchange catheter: for size 3 and larger), or a guidewire technique is required. A two-step technique involves first

passing an exchange catheter through the SGA with subsequent removal, followed by insertion of the TT over the exchange catheter, with or without a guidewire (83). Another potential advantage of the SGAs (air-Q) with larger diameter airway tubes is the ability to directly pass a cuffed TT through the device, thus avoiding an additional step and the need for an intubation introducer (53).

Recommendations for clinical use

While the older SGAs have the largest evidence base and are already established in pediatric use, the availability of high-quality data on newer SGA devices suggests the potential benefit of a specific device in certain clinical situations. While the choice of the device used should ultimately be based on experienced clinical judgment, the authors have the following recommendations for the clinical use of newer pediatric SGAs.

Spontaneous ventilation

The existing data suggest that the use of the laryngeal mask airway ProSeal, laryngeal mask airway Supreme, air-Q, and i-gel for spontaneous ventilation in small infants is not associated with the same increased risk for complications as seen with the laryngeal mask airway Classic. However, due to limited number of studies in infants, there is insufficient evidence to recommend one SGA over another in spontaneously ventilating patients. In older children, the evidence base is larger, and all newer SGAs have demonstrated successful efficacy. Therefore, in children, the clinician should choose the device with which he/she has adequate experience.

Positive pressure ventilation

Supraglottic airway use in PPV must take into account higher airway pressures and associated risks for gastric insufflation and aspiration. The air-Q and Ambu Aura-i are both first-generation devices with similar or lower leak pressures compared with the laryngeal mask airway ProSeal, and therefore offer no significant advantage in the setting of PPV for routine anesthesia. The i-gel may be a useful alternative to the laryngeal mask airway ProSeal for PPV, as they both have comparable leak pressures and gastric access capabilities. The i-gel has the added advantage over the laryngeal mask airway ProSeal in that it is disposable and therefore has lower risk for infection transmission. The laryngeal mask airway Supreme has been shown to provide effective PPV as well, but more widespread use of this device is needed to make definitive conclusions.

The difficult airway: conduit for tracheal intubation and rescue device for failed intubation

The role of SGAs for rescue ventilation in the pediatric failed intubation scenario is increasingly being recognized. Most of the evidence to date consists of case reports/series using the laryngeal mask airway Classic. Newer devices such as the i-gel and air-Q have also been utilized for this purpose.

The ability of the air-Q and Ambu Aura-i to accommodate cuffed TTs may offer a genuine advantage over the laryngeal mask airway Classic, especially as cuffed TTs are now routinely being utilized in children. The air-Q has been shown to be effective in the difficult airway population for this purpose. The i-gel may be a suitable conduit for tracheal intubation; however, no formal studies have been conducted yet.

Pediatric/neonatal resuscitation

Insufficient evidence exists to recommend the use of a specific SGA in the setting of pediatric cardiac arrest. Further studies are necessary to compare the advantages and limitations of SGAs over conventional methods currently used in pediatric resuscitation.

Supraglottic airways may also be used to provide ventilation in neonates when bag-mask ventilation and intubation have failed. The American Heart Association and the European Resuscitation Council's incorporation of SGAs into the guidelines for neonatal resuscitation reflects support for this use. In addition, studies have shown that initial resuscitation with an SGA is both feasible and safe (5,25,26,84–87). Some studies appear to show some advantage to using an SGA over tracheal intubation during neonatal resuscitation, including lower rates of failure, and reduced time to secure the airway (5). Even though newer devices have been shown to be useful, there is insufficient evidence to recommend a particular device at this time.

Emergent airway management

Although tracheal intubation is the preferred method for establishing an airway in emergent situations, SGAs may be used when tracheal intubation may be difficult to perform, such as out-of-hospital emergencies or inter-hospital transport. SGAs are relatively easy to insert blindly, and may provide improved ventilation compared to bag-mask ventilation by inexperienced personnel, which could be a useful intermediate step until a definitive airway can be secured. Second-generation devices may have the added benefit by allowing drainage of gastric contents. However, there is not enough evi-

Table 5 Summary of supraglottic airway devices available for children

Devices	Approximate cost per single unit (US dollars) ^a	Pediatric sizes; recommended weight range	First or second generation	Ease of insertion: first-attempt insertion rate; overall insertion success rate	Leak pressures (reported range) (cmH ₂ O)	Use as a conduit for fiberoptic (FO)-guided tracheal intubation	Areas of potential concern
Established SGAs							
Laryngeal mask airway Classic	\$80–200 (reusable up to 40 uses)	1.0: <5 kg 1.5: 5–10 kg 2.0: 10–20 kg 2.5: 20–30 kg 3.0: 30–50 kg	First	91% (first attempt) 99–100% (overall)	15–23	Most widely used for fiberoptic intubation; may be difficult to remove when cuffed tracheal tubes (TT) are utilized	Higher complication rate and lower leak pressures in small infants; potential for gastric insufflation
Laryngeal mask airway Unique	\$7–10 Single use	1.0: <5 kg 1.5: 5–10 kg 2.0: 10–20 kg 2.5: 20–30 kg 3.0: 30–50 kg	First	89% (first attempt) 100% (overall)	15–18	No formal studies evaluating use as a conduit for tracheal intubation; FO views inferior to air-Q	Potential for gastric insufflation
Laryngeal mask airway ProSeal	\$100–250 (reusable up to 40 uses)	1.0: <5 kg 1.5: 5–10 kg 2.0: 10–20 kg 2.5: 20–30 kg 3.0: 30–50 kg	Second	94% (first attempt) 75% (overall)	22–23	Requires two-step technique for larger TTs	Size 1.5 associated with difficult insertion; narrow airway tube requires smaller TT or exchange catheter technique
Newer SGAs							
air-Q	\$7–10 Single use	0.5: <4 kg 1.0: 4–7 kg 1.5: 7–17 kg 2.0: 17–30 kg 2.5: 30–50 kg	First	99% (first attempt) 99–100% (overall)	19–25	High success rates and accommodates cuffed TTs; FO views superior to laryngeal mask airway Unique	Potential for gastric insufflation
Ambu Aura-i	\$5–8 Single use	1.0: <5 kg 1.5: 5–10 kg 2.0: 10–20 kg 2.5: 20–30 kg 3.0: 30–50 kg	First	93% (first attempt) 98% (overall)	16–22	High success rate; FO views similar to air-Q and i-gel	Size 1 and 1.5 cannot accommodate pilot balloon of cuffed TTs; potential for gastric insufflation
Laryngeal mask airway Supreme	\$10–20 Single use	1.0: <5 kg 1.5: 5–10 kg 2.0: 10–20 kg 2.5: 20–30 kg 3.0: 30–50 kg	Second	97% (first attempt) 100% (overall)	17–20	No formal studies evaluating use as a conduit for tracheal intubation; requires two-step technique for larger TTs; similar FO view compared with laryngeal mask airway ProSeal	Narrow airway tube requires smaller TT or exchange catheter technique
i-gel	\$10–20 Single use	1.0: 2–5 kg 1.5: 5–12 kg 2.0: 10–25 kg 2.5: 25–35 kg 3.0: 30–60 kg	Second	91% (first attempt) 93% (overall)	20–27	No formal studies evaluating use as a conduit for tracheal intubation; superior FO view compared with laryngeal mask airway Classic and laryngeal mask airway ProSeal	Spontaneous dislodgement observed in smaller sizes; size 1.0 lacks gastric access

FO, fiberoptic; TT, tracheal tube.

^aReflects approximate cost in US dollars per single device. Cost may differ depending on distributor and country.

dence to suggest the use of a particular device in such emergency situations.

Conclusion

A variety of new SGAs for use in children have emerged since their introduction into clinical practice over 30 years ago. As new devices are introduced into clinical practice, assessing the potential advantages and limitations of each device through thorough clinical evaluations remains important. Table 5 summarizes the SGAs discussed and outlines potential areas of concern.

Despite the many new devices, the laryngeal mask airway Classic, laryngeal mask airway ProSeal, and laryngeal mask airway Unique remain the most ubiquitous devices in pediatric use, and still provide excellent conditions in a wide variety of situations with only a few specific exceptions. For healthy children undergoing routine anesthesia with spontaneous ventilation, the laryngeal mask airway Classic and laryngeal mask airway Unique are suitable devices, except in infants where the laryngeal mask airway ProSeal, air-Q, or i-gel may be

preferable for their relative stability during anesthetic maintenance. For PPV, the best options are either the established laryngeal mask airway ProSeal or the newer i-gel for their higher airway leak pressures, and gastric access. When used as a conduit for tracheal intubation, the air-Q and Ambu Aura-i were designed for this purpose and may better facilitate the tracheal intubation and device removal process when compared with the laryngeal mask airway Classic. For use in emergency situations such as failed intubation and cardiac arrest, a lack of data suggests that pragmatic choices must be made, as both established and newer devices have all been used successfully.

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Conflict of interest

No conflicts of interest declared.

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