Supraglottic Airways:

Their Evolution as Tracheal Tube Introducers

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Anesthesiologists and emergency medicine providers encounter difficult endotracheal intubation in up to 6% of cases.[1-3]

The American Society of Anesthesiologists, which first developed guidelines for management of the difficult airway in 1992 and revised them in 2003, included the use of the laryngeal mask airway (LMA), a specific type of supraglottic airway (SGA), as a rescue device for ventilation and as a conduit for insertion of an endotracheal tube (ETT), either blindly or guided by a fiberoptic bronchoscope (FOB).[4]

Much has been written on SGAs over the past 20 years, mostly to extol their virtues as devices to be used in lieu of endotracheal intubation during elective surgery and as rescue ventilation in the setting of difficult airway management.

Since the advent of the intubating LMA Fastrach (Teleflex) in 1995, SGAs have also assumed the role of rescue intubation devices, a role that has expanded as a new generation of fiber-optic endoscopes, both traditional and video-enabled, has proliferated in the medical marketplace.

This article will discuss the recent evolution in the United States and international marketplaces of clinically available SGAs that serve as intubating conduits—that is, as true airway problem-solving devices. This article will also detail 2 methods of visualized tracheal intubation through a specific brand of SGA in order to illustrate the techniques needed for guided intubation through SGAs.

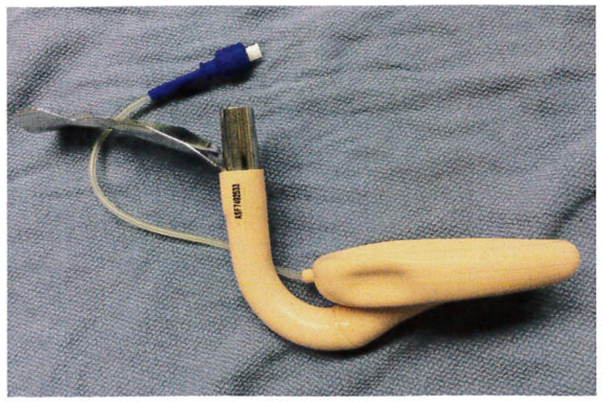


Figure 1. LMA Fastrach.

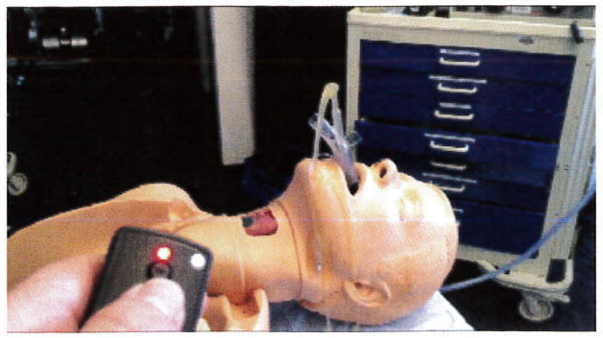


Figure 2. Demonstration of the function of a gastric drainage port on an LMA Supreme in a mannequin modified to flow simulated vomit using wireless radio control.

History

Archie Brain, MD, devised the LMA Fastrach (Teleflex; Figure 1) in 1995, as a tool to support ventilation and intubation. This particular SGA has since accumulated one of the largest bodies of literature to support its effectiveness and use in anesthesiology, emergency medicine, critical care, and pre-hospital medicine.

Devised as a tool that can effectively deliver a proprietary, soft-tipped tracheal tube using a blind technique, the LMA Fastrach has a proven track record. Although the blind method for the LMA Fastrach is easy to learn and implement, the consensus among physicians and allied health care workers who practice airway management has today evolved to the point where the use of imaging systems to guide the tracheal tube intubation is preferred.

Utilizing visualized guidance through an SGA obviates the need to learn specific techniques and maneuvers to enable blind intubation with a given SGA. A recently published theoretical article concerning in-water and underwater resuscitation explores the use of a fiber-optic stylet-visualized intubation through an SGA in a simulated setting, with the endoscopist in scuba gear immersed in the water-filled section of a special research hyperbaric chamber to a depth of 20 m.[5]

Indeed, the endoscopy system can be used to comprehensively set the stage for systematic examination of the SGA position within the patient's airway, readjustment of the SGA should that be deemed necessary to align its ventilation channel with the larynx, and guidance of the tracheal tube through the ventilation channel of the SGA. Utilization of a bronchoscopic port adapter with a flexible bronchoscope can furthermore permit the endoscopist the option of continuous ventilation during the intubation attempt, as the ventilation circuit can continue to deliver positive-pressure ventilation breaths throughout the endoscopy.

Current Tracheal Intubation–Capable SGA Systems

There are several commercially available SGA devices that represent the state of the art with regard to the ability to provide a conduit for visualized, guided intubation. Many of these SGA devices are categorized as second-generation SGA devices that possess the ability to divert passive regurgitated material away from the laryngeal inlet through dedicated guide channels or balloon-tipped catheters. The second-generation SGAs with tracheal-intubating capability do indeed represent the state of SGA-based tracheal intubation strategies, as these devices provide a margin of safety in patients in whom fasting is either not effective to prevent retention of stomach contents or, conversely, in patients who are not fasted prior to airway management, such as patients facing emergent airway management before emergency surgery.

To demonstrate the concept and function of a gastric drainage port, Figure 2 shows a geyser of simulated vomit emerging from the gastric drainage port of an LMA Supreme (Teleflex) second-generation SGA in an airway management training mannequin that has been modified to flow simulated vomit using wireless radio control (author's unpublished research).

All images courtesy of James DuCanto, MD

The expanding role of second-generation SGAs in resuscitation and emergency airway management is an important topic in pre-hospital medicine and emergency medicine. Stone et al noted that the incidence of regurgitation during cardiopulmonary resuscitation is as much as 4-fold greater in patients managed with the traditional bag-valve-mask as in those managed with an LMA.[6] Of relevance to anesthesiologists, multiple published case reports exist of the use of the LMA as an alternative airway device during cesarean delivery, including a large series of 3,000 cases by Halaseh et al that used the LMA ProSeal (Teleflex), a second-generation SGA.[7]

Description of Selected Intubation-Capable SGA Systems

The following list of clinically available SGA systems is not intended to be comprehensive, as most first-generation SGA masks based on the LMA design will support visualized intubation techniques with little or no modification to the mask itself (for example, cutting off the embedded 15-mm respiratory connector to permit the introduction of larger tracheal tube sizes in the LMA Classic or LMA Unique [both, Teleflex]). It has been estimated that globally, there are now more than 40 commercially available SGAs on the market.

Aura-i and AuraGain

The Ambu Aura-i is a first-generation SGA that features an anatomically curved airway device with an integral rigid plastic bite block built into the ventilation tubing, which also serves to place the airway. The Aura-i is intended as a general-use SGA that features convenient depth markings for monitoring correct position, as well as navigation marks for guiding flexible endoscopes in the event that it is used as a tracheal intubation introducer with fiber-optic visualization. The mask supports the placement of standard endotracheal tubes with flexible fiber-optic endoscopes.

A study of 120 pediatric patients looked at the ease of insertion, time of insertion and number of attempts at flexible fiber-optic insertion through the mask, comparing the Aura-i and the air-Q (Cookgas; distributed by Mercury Medical), and revealed no significant differences between these two SGA devices.[8] The Aura-i is manufactured in various sizes, from infant (sizes 1 and 1 ½) to pediatric (sizes 2 and 2 ½) to adult (sizes 3, 4, 5, and 6).

The Ambu AuraGain (Figure 3) is a second-generation SGA device, recently released in the US market, that is structurally similar to the Aura-i with respect to its shape, rigid bite-resistant airway insertion tubing and the contour of the mask; the AuraGain, however, has a dedicated gastric drainage channel. The mask supports the placement of standard endotracheal tubes with flexible fiber-optic endoscopes. Published clinical studies are not yet available, but the airway shows much promise as a general-use airway as well as an SGA to support flexible fiber-optic intubation. A simulation study in cadavers[9] assessed the effectiveness of AuraGain placement to facilitate intubation, and indicated that the mask performs well in its ability to seal and align with the upper esophageal sphincter.

i-gel

The i-gel (Intersurgical) is a second-generation SGA that uses a radically different construction from LMA-type SGAs, in that it is constructed with a soft medical-grade thermoplastic elastomer with a noninflatable cuff and has an integral gastric drainage channel that extends to its tip (Figure 4).

The mask was designed to create a noninflatable anatomic seal of the pharyngeal, laryngeal and perilaryngeal structures while avoiding the trauma that potentially can be caused by inflatable cuffs. Numerous published studies[10,11] detail the excellent alignment of the i-gel mask with the laryngeal inlet when visualized with a fiber-optic bronchoscope, and this SGA has been adopted by several international pre-hospital medical services, including the Sydney, Australia helicopter emergency medicine service, as a rescue ventilation and intubation airway (using the Ambu aScope—a portable video-driven endoscopy system).

The i-gel is available in a full range of pediatric and adult sizes, and is the only manufactured SGA that is also available for veterinary use (as the v-gel for cats and rabbits).

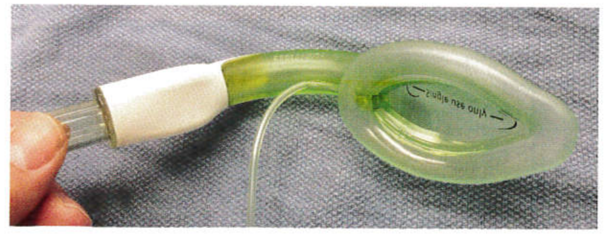


Figure 3. Ambu AuraGain.

Figure 4. i-gel.

Totaltrack VLM

The Totaltrack VLM (Figure 5; Medcomflow) represents a fusion of video laryngoscope technology within an SGA platform in a manner similar to the historically important LMA CTrach (Teleflex), with the addition of a distal suction channel in the tip of the mask, which thus qualifies this device as a second-generation SGA. The Totaltrack VLM uses disposable components with a reusable video camera and monitor, and relies on a tracheal tube within a dedicated channel to provide a seal for ventilation through the SGA mask. As such, the Totaltrack VLM can support continuous ventilation during intubation attempts without the use of flexible fiber-optic endoscopy equipment.

Figure 5. Totaltrack VLM.

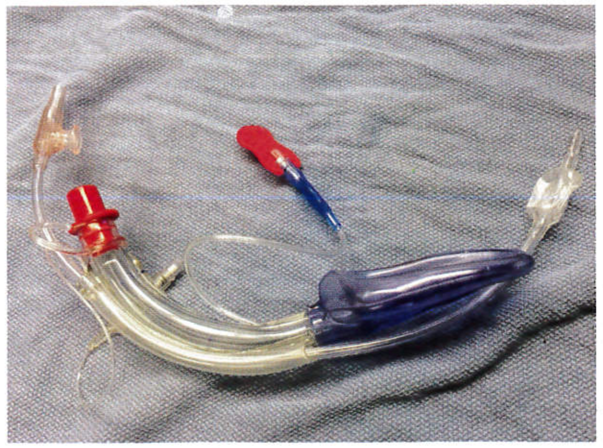


Figure 6. air-Q Blocker Disposable Laryngeal Airway

air-Q Blocker

The air-Q Blocker Disposable Laryngeal Airway (Figure 6; Cookgas, distributed by Mercury Medical) is a modification of the existing air-Q SGA, which permits the passage of a proprietary balloon-tipped suction catheter posterior to the mask in a simple guide channel positioned along the right side of the ventilation-insertion tubing. This balloon-tipped catheter has a spherical shape whose size can be appropriately adjusted for the patient with careful attention to the inflation balloon; each blocking catheter is sized appropriately for their respective airways. The air-Q Blocker is available in half sizes (2.5, 3.5, and 4.5), with the 4.5 intended for use on average-sized adult males, the 3.5 intended for use on average-sized adult females, and the 2.5 intended for use on small adult females or adolescent patients.

The air-Q mask itself is morphologically similar to the LMA Classic, but differs greatly with respect to the angle at which the ventilation tubing meets the mask and in the construction of the mask itself. The presence of a raised heel in later models allows the air-Q to achieve seal pressures similar to the LMA ProSeal (Teleflex), as this feature engages the base of the tongue in a way similar to that of the LMA ProSeal. The air-Q is available in a full range of neonatal, pediatric and adult sizes. Numerous studies in pediatrics and adults detail its utility as a conduit for tracheal intubation.[12-15]

Clinical Use: Description of 2 Intubation Methods Through the air-Q SGA and Removal Procedure

The following presentations are intended to familiarize medical professionals with the intubating capability of one specific brand of SGA. Should a clinician lack familiarity with endoscopic intubation techniques, I recommend that he or she receive specific, focused training from an expert colleague or at an appropriate airway management seminar. These techniques should be practiced first on airway intubating mannequins prior to clinical use. This information is presented solely for the purpose of medical education.

Patient safety is paramount, of course, so attention to oxygenation, ventilation, and airway decontamination (should emesis occur) is key. It is possible to perform these techniques with spontaneous ventilation under moderate to deep sedation if the clinician understands that the use of a topical local anesthetic will be necessary through the working channel of the endoscope. There are multiple drug regimens to produce moderate to deep sedation, the choice of which I leave to the judgment and experience of the clinician.

Three procedures will be discussed:

- Intubation through an SGA with a flexible fiber-optic bronchoscope;
- Intubation through an SGA with a video stylet; and
- Removal of the SGA with the air-Q removal stylet.

Procedure 1. Intubation Through an SGA With a Flexible Fiber-optic Bronchoscope

Step 1: Prepare the air-Q SGA for tracheal intubation

The patient is a 150-kg male and a 4.5 air-Q is used. This procedure is demonstrated with the use of general anesthesia and non-depolarizing muscle blockade, although it can also be performed with spontaneous ventilation (volatile anesthesia technique or total IV anesthesia [TIVA]) or with moderate to deep sedation in those cases in which the clinical scenario makes this necessary. Topical local anesthesia is necessary, which can be provided through the suction channel/working channel of the bronchoscope (Figure 7).

First, begin with removal of the proprietary 15-mm connector to allow the insertion of a prelubricated standard tracheal tube to approximately 15-cm depth, so that the tracheal tube does not extend beyond the ventilation tubing and into the bowl of the SGA. Connect the tracheal tube to the ventilator breathing circuit utilizing an endoscopic port adapter to allow continuous oxygenation during the endoscopy and intubation.

Second, in order to permit continuous ventilation during endoscopy, a small amount of air can be added to the tracheal tube's cuff to seal the interior of the SGA, with the understanding that this small amount of air *must* be removed prior to advancement of the tracheal tube over the bronchoscope and into the trachea.

Step 2: The initial endoscopy through the tracheal tube and SGA mask

Insert (Figure 8) the flexible endoscope through the endoscopic port adapter and advance the endoscope past the tip of the tracheal tube into the bottom portion of the SGA mask. A wedge-shaped protrusion exists at the bottom of the ventilation tubing (designated as the "ramp" by the manufacturer of this SGA). In Ambu brand intubating airways, a small graphic is printed on the mask at this location, which is a visual cue to begin engaging the control lever of the bronchoscope into the flexion to look upward toward the larynx.

As the bottom of the ventilation tubing is reached, the endoscopist prepares to slowly and gently engage the control lever into flexion of the articulating distal tip of the endoscope.

Step 3: Flex the endoscopic control lever to visualize the larynx (Figure 9)

Step 4: Advance the flexible endoscope into the larynx

As the flexible endoscope is advanced into the larynx, the smooth portion of the interior of the thyroid cartilage is visualized. The endoscope tip is then extended through slow and careful manipulation of the control lever in order to align the tip of the endoscope with the posterior, caudal direction of the trachea (Figure 10).

As the control lever is extended, the bronchoscope is advanced down the trachea to the level of the carina or even the proximal right mainstem bronchus (Figure 11).

Step 5: Advance the endotracheal tube over the bronchoscope into the trachea

Important tips to ensure smooth advancement of the

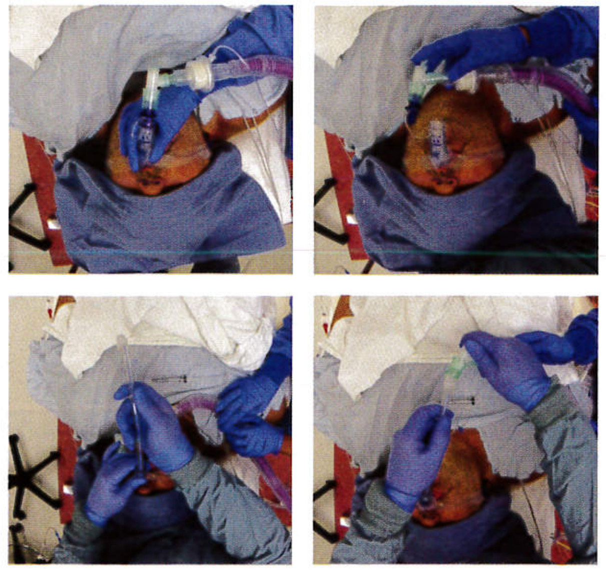


Figure 7.

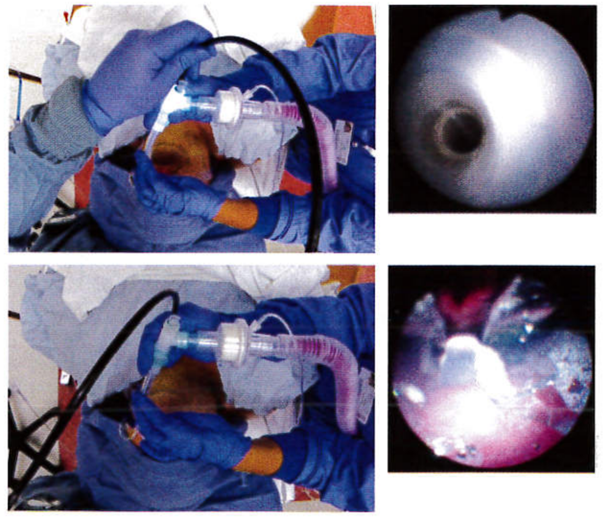


Figure 8.

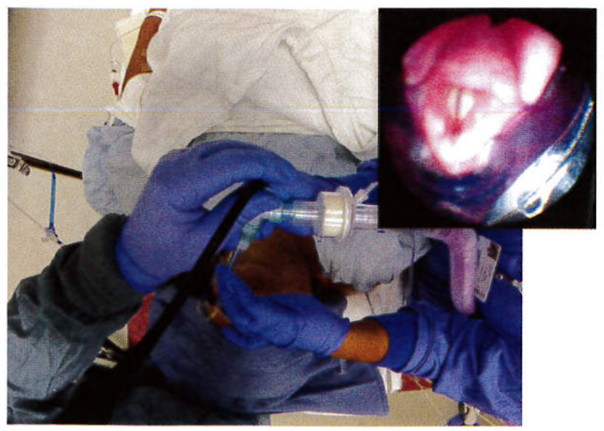


Figure 9.

tracheal tube through the SGA and into the larynx and trachea (Figure 12) include:

Turn the tracheal tube 90 degrees counterclockwise during advancement to minimize the gap between the tracheal tube and the endoscope at the level of the right corniculate cartilage (the most common site of tube hang-up). Should hang-up during advancement occur, *withdraw and turn the tracheal tube leftward (counterclockwise) to disengage the point of hang-up;* otherwise, this problematic step of the intubation process will continue to thwart laryngeal and tracheal intubation.

Gentle traction on the ventilation tubing of the SGA itself will flatten the angle of attack with respect to tracheal tube advancement as well by compressing the base of the tongue in a manner akin to a laryngoscope blade. This maneuver will also serve to straighten the course of the tracheal tube from the exit point of the SGA, as it is common that most SGAs are placed too deeply during initial insertion, and this causes a very acute angle from the point of view of a flexible endoscope exiting the SGA and passing through the larynx. It is important to withdraw the SGA slightly to reduce or eliminate this occurrence, as excessive force during this portion of the procedure will actually cause the bronchoscope to withdraw from the trachea and larynx and pass posteriorly into the esophagus.

If force is used during this phase of the intubation due to hang-up on the right corniculate cartilage or due to an acute angle between the bronchoscope and larynx, tracheal intubation will not be possible, and laryngeal trauma can occur.

Procedure 2. Intubation Through an SGA With a Video Stylet

Video stylet endoscopes are video-driven versions of optical stylets, which are devices that have been clinically available since the 1970s. This method of tracheal intubation through the SGA will be effective through an LMA Classic, LMA Unique, air-Q, and most clinical variants based on the LMA Classic design. Unfortunately, this technique will not function with SGAs that have rigid bite block portions such as the Ambu Aura-i, AuraGain, and the i-gel, as these SGAs will not allow a rigid preformed stylet to transit the airway around the base of the tongue to the ventilation outlet.

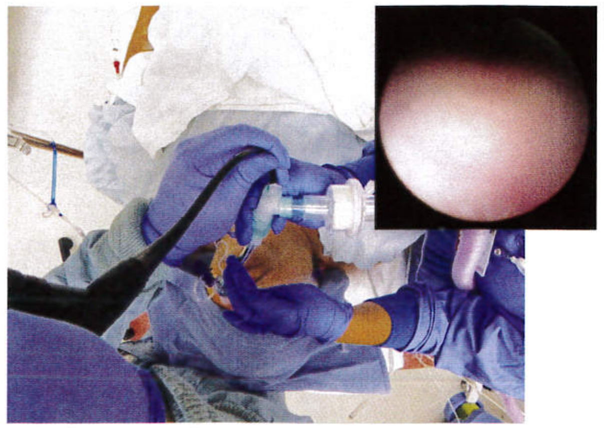


Figure 10.

Figure 11.

Figure 12.

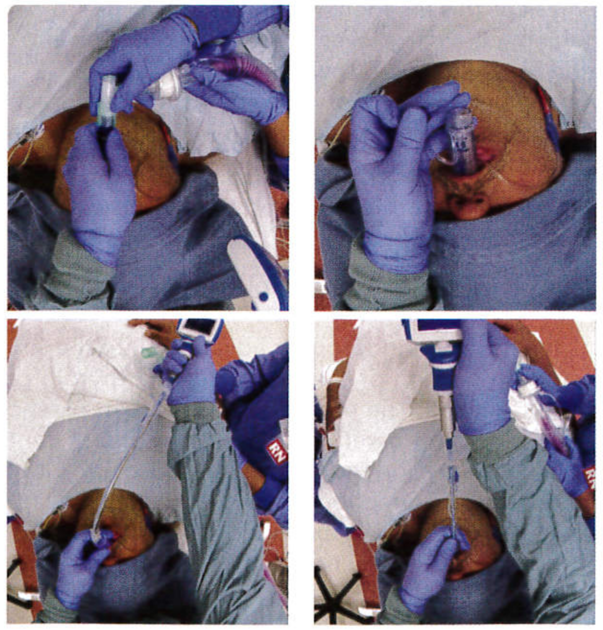


Figure 13.

This description uses the air-Q SGA (4.5 size) for convenience, as was the case in the previous procedure, as a larger tracheal tube was required to efficiently ventilate this patient (in this case, changed from 7.0 to 8.0). This procedure is demonstrated with the use of general anesthesia and non-depolarizing muscle blockade, although it can be performed with spontaneous ventilation (with volatile anesthesia technique or TIVA) or with moderate to deep sedation in cases should that be necessary due to the clinical scenario. Topical local anesthesia can be instilled with a variety of techniques through the ventilation tubing of the SGA if this technique is performed under sedation. The endoscope used in this procedure is a video stylet produced by UE Medical Devices.

Step 1: Preparing the air-Q SGA for tracheal intubation

Begin (Figure 13) with the removal of the proprietary 15-mm connector to allow the insertion of the prelubricated standard tracheal tube, which has been loaded onto the video stylet (lubricate the tracheal tube and video stylet prior to the procedure).

Using the natural curved shape of the video stylet, follow the curve of the SGA around the base of the tongue until the tip of the tracheal tube and stylet endoscope approaches the bottom portion of the SGA.

Step 2: Identify the ventilation outlet at the bottom of the mask

At the bottom of the air-Q SGA is a wedge-shaped protrusion (Figure 14). At the bottom of the mask, the rigid video stylet is now in position to lift and rotate through a cephalad arc that will bring the tip of the tracheal tube and stylet endoscope up and into alignment with the larynx.

Step 3: Lift and rotate cephalad the stylet through the SGA into the larynx

This maneuver (Figure 15) has been called the "one-armed bandit," as it resembles the pulling of the lever on a slot machine. Using the one-armed bandit maneuver will rotate the tip of the tracheal tube through the body of the SGA anteriorly in a natural motion that follows the contour of the airway up into the larynx. The motion mostly occurs in the elbow, and not the wrist. This maneuver is also useful in tracheal tube delivery with hypercurved video laryngoscopes, such as the GlideScope (Verathon) and the C-MAC D-Blade (Karl Storz Endoscopy), when a rigid stylet is used, such as the GlideRite (Verathon) stylet.

Step 4: Rotate the tracheal tube and stylet into the larynx and identify the interior of the larynx (Figure 16)

Step 5: Advance the tracheal tube off the stylet with a subtle caudad-posterior tilt to align the tip of the tracheal tube and video stylet with the long axis of the trachea

As this technique (Figure 17) leads with the edge of the tracheal tube itself, it is much less prone to hanging

Figure 14.

Figure 15.

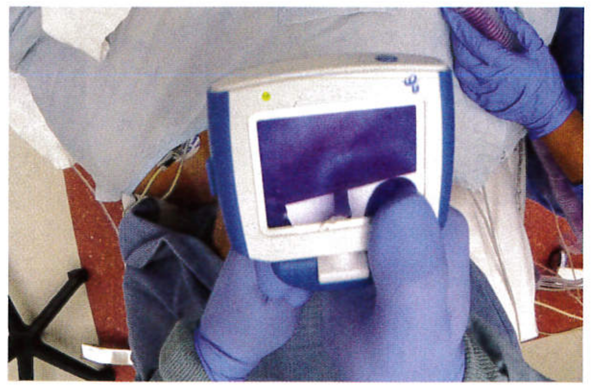


Figure 16.

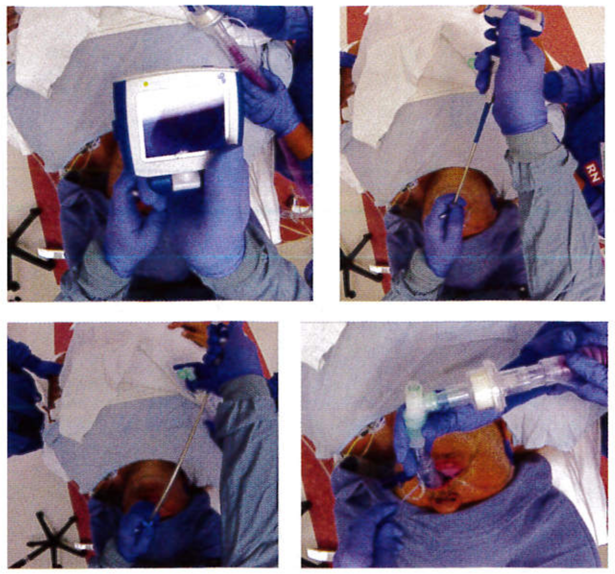


Figure 17.

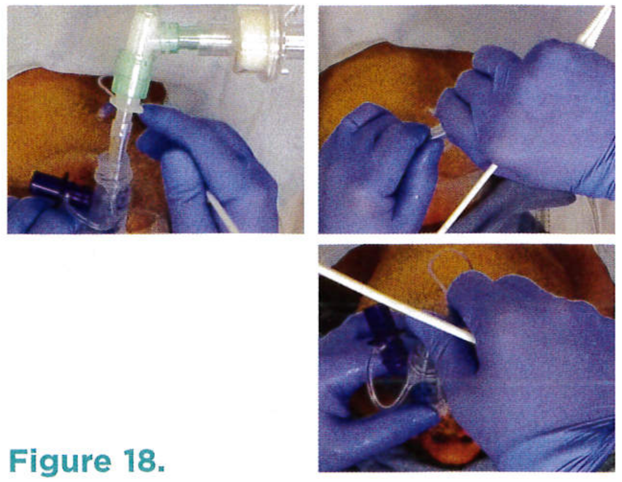


Figure 18.

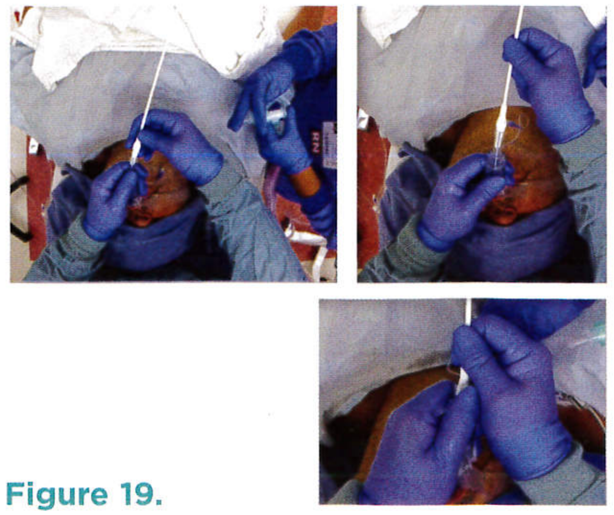


Figure 19.

up on the larynx; however, due to the anterior arc of this intubation method, it must be stressed that after the tracheal tube enters the larynx, a problem in tube advancement may occur if the tip of the tracheal tube and stylet are not rotated forward to change the direction of the tracheal tube away from the anterior wall of the thyroid cartilage.

The video stylet is rotated out of the tracheal tube and SGA as the tracheal tube is advanced off the stylet. This is a very easy and smooth maneuver, especially if proper lubrication of the stylet and tracheal tube is accomplished before the procedure.

Procedure 3. Removal of an SGA With the air-Q Removal Stylet

Step 1: Prepare the tracheal tube to receive the removal stylet by twisting it free from its connection with the tracheal tube (Figure 18).

Step 2: Firmly connect the air-Q removal stylet with the proximal tracheal tube with a 90- to 120-degree clockwise twist to permit the locking grooves/serrations to engage the plastic of the tracheal tube with a secure purchase (Figure 19).

Step 3: Begin to remove the air-Q SGA over the removal stylet-tracheal tube combination by maintaining constant positioning of the tracheal tube (with pressure exerted inward toward the trachea) and with gentle pressure on the SGA to ensure its removal (Figure 20).

Ensure that the endotracheal tube's pilot balloon follows the tracheal tube through the ventilation tubing of the SGA.

Step 4: Rotate the bowl of the SGA mask (posteriorly) to grasp the proximal portion of the tracheal tube and the locking portion of the removal stylet (Figure 21).

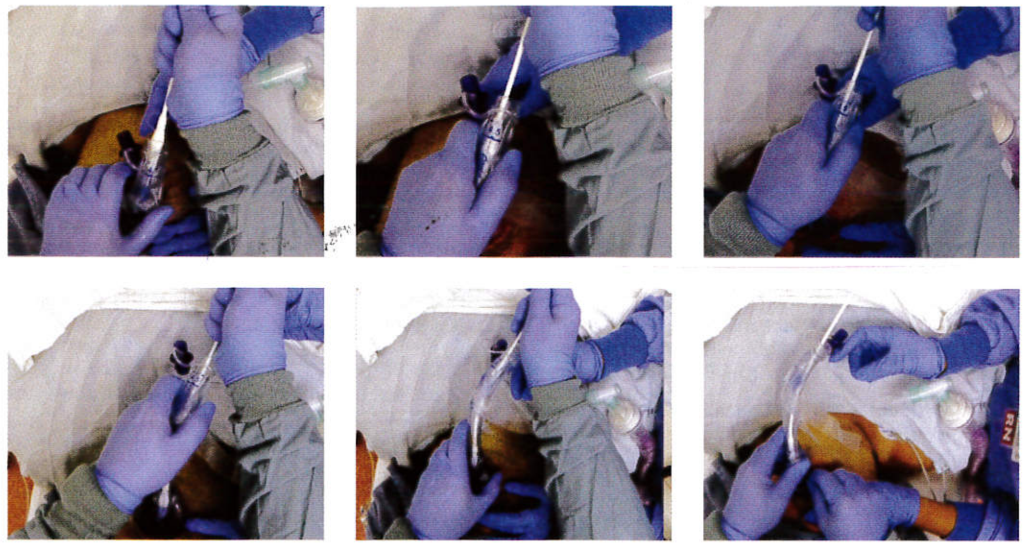
Ensure that the pilot balloon of the tracheal tube has followed through the ventilation tubing of the SGA. Finish removing the SGA.

Step 5: Unlock the removal stylet connection with the proximal tracheal tube using a leftward or counterclockwise twist and replace the 15-mm connector on the tracheal tube (Figure 22).

Verify tracheal tube placement with capnography and with auscultation of breath sounds. Note the depth of tracheal tube placement on the centimeter markings.

Conclusion

Simplified algorithms for difficult airway management, such as the Vortex algorithm,[16] suggest an expanded and early use of SGA devices for both ventilation and tracheal intubation. Although the use of SGAs for airway management in routine cases has begun to eclipse the use of tracheal intubation in elective surgery worldwide, knowledge and experience with techniques to employ them as tracheal tube introducers is still a relatively new topic in anesthesiology, and currently is a hot topic in the specialty of emergency medicine. Continued research, simulation, and academic as well as clinical studies of these techniques are vital to the future of modern airway management preparedness.



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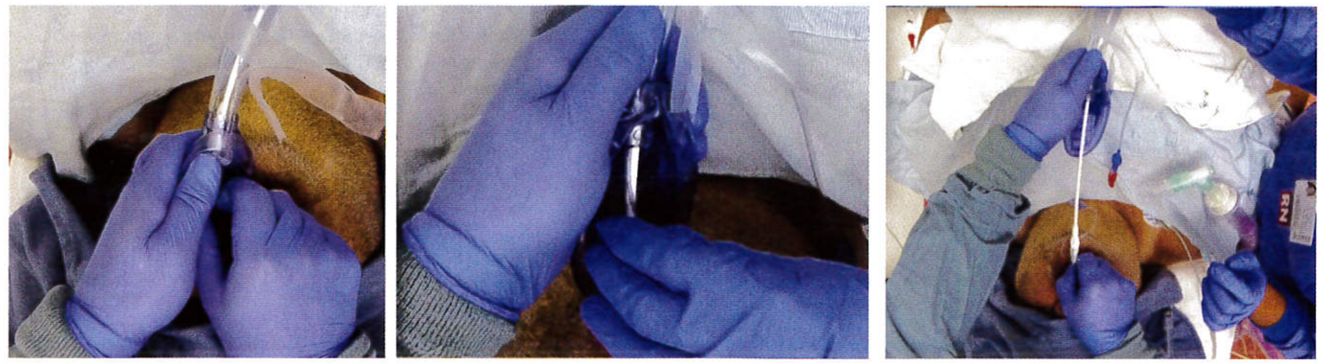

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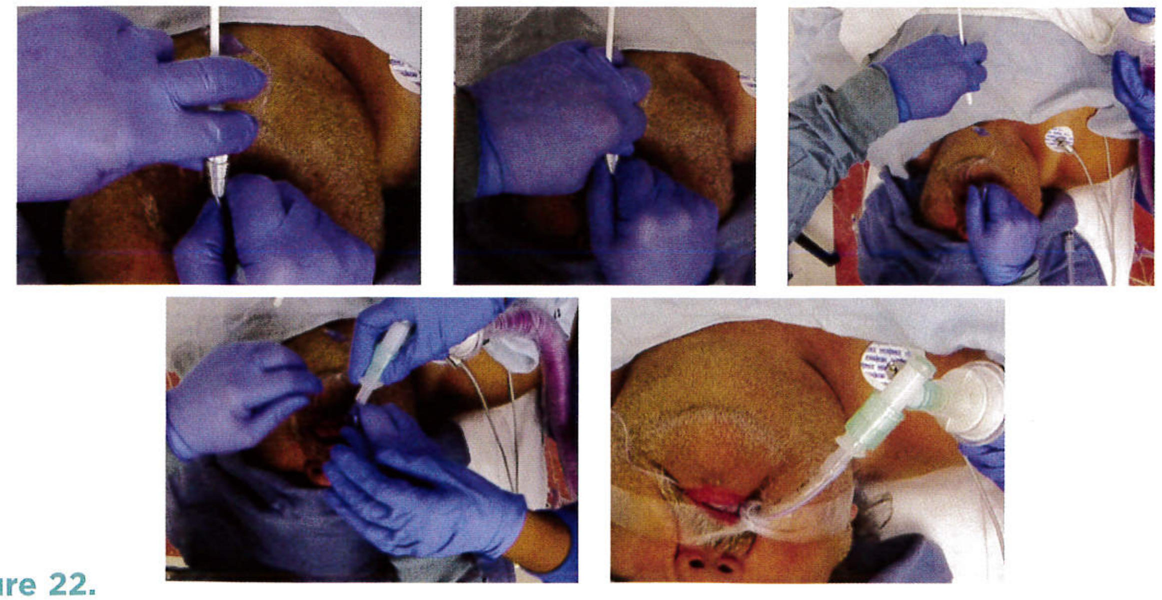

Figure 22.

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