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REVIEW ARTICLE/BRIEF REVIEW

Use of intubation introducers through a supraglottic airway to facilitate tracheal intubation: a brief review

Utilisation d'introducteurs d'intubation au travers d'un dispositif supraglottique pour faciliter l'intubation trachéale: article de synthèse court

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Abstract

Purpose *This article is a narrative review regarding the usage and effectiveness of introducers or catheters to facilitate tracheal intubation through a supraglottic airway (SGA) as an alternative intubation technique in normal and difficult airway management.*

Sources *Relevant articles were obtained through Medline (1948-July 2011). The articles were subsequently cross-referenced for additional literature, and only articles published in English were included.*

Principal findings *In this review, we consider 32 reports using the LMA Classic™, LMA Unique™, LMA ProSeal™, LMA Supreme™, AuraOnce™, and i-gel™ as SGA conduits for intubation. In 13 articles, the use of an Aintree Intubation Catheter was described as an intubation introducer and resulted in high success rates in both elective and emergent situations. Eight studies used a guidewire exchange catheter technique. Although blind intubation using a guidewire resulted in a high failure rate, these studies found that using a bronchoscope improved successful intubation. Ten studies showed that insertion of a gum elastic bougie with a bronchoscope as an intubation introducer has high success rates compared with blind bougie insertion. One article described the use of a small endotracheal tube as an intermediary for tracheal intubation.*

Conclusions *In failed intubation scenarios, supraglottic airways, such as the LMA Classic™ or LMA ProSeal™ can serve as a conduit for tracheal intubation. A number of techniques using introducers or catheters can facilitate the insertion of an adequately sized endotracheal tube, particularly guided by a bronchoscope. Usage of introducers or catheters through a supraglottic airway may be a useful alternative intubation technique in difficult airway management.*

Résumé *Objectif : Cet article est une analyse descriptive de l'utilisation et de l'efficacité des introducteurs ou cathéters pour faciliter l'intubation trachéale via un dispositif supraglottique (DSG) comme solution de rechange dans les cas de prise en charge de l'intubation trachéale normale ou difficile.*

Sources *Les articles pertinents ont été tirés de la base de données MEDLINE de 1948 à juillet 2011. Les articles ont ensuite fait l'objet d'un référencement croisé afin d'obtenir plus de sources et seuls les articles en anglais ont été inclus.*

Constatations principales *Dans cette analyse, nous considérons 32 comptes rendus où le LMA Classic™, LMA Unique™, LMA ProSeal™, LMA Supreme™, AuraOnce™, et i-gel™ ont été utilisés comme conduits supraglottiques pour l'intubation. Dans 13 articles,*

Author contributions *David T. Wong* was responsible for the conception of the review and writing the manuscript. *Jaisy J. Yang, Hannah Y. Mak,* and *Narasimhan Jagannathan* contributed to the analysis of the articles and writing the manuscript.

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l'utilisation d'une sonde d'intubation Aintree a été décrite comme introducteur d'intubation aboutissant à des taux élevés de succès aussi bien dans les situations d'urgence que dans les situations programmées. Huit études ont utilisé la technique d'échange du cathéter sur guide. Bien que l'intubation en aveugle au moyen d'une broche-guide ait abouti à un taux élevé d'échecs, ces études ont montré que l'utilisation d'un bronchoscope augmentait le nombre d'intubations réussies. Dix études ont montré que l'insertion d'un mandrin souple (gum elsatic bougie) avec un bronchoscope comme introducteur d'intubation avait des taux élevés de succès comparativement à l'insertion d'un mandrin à l'aveugle. Un article a décrit l'utilisation d'une petite sonde endotrachéale comme intermédiaire à l'intubation trachéale.

Conclusions *Dans les cas d'échec de l'intubation, des voies aériennes supraglottiques comme le LMA Classic™ ou le LMA ProSeal™ peuvent servir de guide à l'intubation trachéale. Un certain nombre de techniques faisant appel à des introducteurs ou à des cathéters peuvent faciliter l'insertion d'une sonde endotrachéale de taille adaptée, guidée en particulier par un bronchoscope. L'utilisation d'introducteurs ou de cathéters via un dispositif supraglottique peut être une solution de rechange dans les cas d'intubation trachéale difficile.*

In situations of failed intubation, a supraglottic airway (SGA), such as the LMA Classic™, may be inserted as a temporary lung ventilation device. Not uncommonly, the SGA is removed before an alternative intubation technique, such as bronchoscopic intubation, is attempted. Yet, subsequent intubation attempts may become challenging as the patient's airway is often soiled and bloodied from multiple intubation attempts. An alternative approach is to keep the SGA *in situ* and use it as a conduit for intubation so that secretions will be kept away from the path of intubation. However, not all SGAs allow the direct passage of an adequately sized endotracheal tube (ETT) to reach mid-trachea.[1-3] Therefore, introducers or catheters need to be utilized to facilitate intubation through SGAs. The same intubation technique through SGAs can also be employed in elective intubation situations. In this narrative review, we present a summary of techniques in which tracheal intubation may be accomplished through SGAs via introducers or catheters. We also briefly discuss the usage of SGAs as conduits for intubation in pediatric patients.

Articles reporting the use of SGAs with an introducer for tracheal intubation were obtained through Medline (1948-July 2011). Keywords used for an introducer were: "catheter", "Aintree", "guidewire", "bougie", "exchange catheter", "intubation catheter", or "introducer", while keywords used for SGAs were: "supraglottic airway", "supraglottic device", "extraglottic airway", or "extraglottic device". Only English articles were reviewed.

Supraglottic airway devices as conduits for tracheal intubation

There are a number of SGAs that allow direct passage of an adult-sized ETT, including the LMA Fastrach™, the LMA Classic Excel™, the LMA cTrach™ (LMA™ North America, Inc., San Diego, CA, USA), the Air-Q™ (Mercury Medical®, Clearwater, FL, USA), the Ambu® Aura-i™, the Ambu® AuraOnce™ (Ambu Inc. Glen Burnie, MD, USA), the i-gel™ (Intersurgical Ltd., Liverpool, NY, USA), and the Elisha airway device (Elisha Medical Technologies, Ltd., Katzrin, Israel).[4-9] An adult ETT can be placed directly into the trachea via these SGAs, either blindly or with bronchoscopic guidance. However, these SGAs designed for intubation may not be readily available in the operating room,[10] and many anesthesiologists are not familiar with using them as stand-alone airways or intubating devices.

There are other SGAs in which passage of an adult full-sized ETT into the trachea may be problematic, including the LMA Classic™, the LMA-Unique™, the double lumen SGAs (i.e., the LMA ProSeal™ and LMA Supreme™), and other SGAs. While they do not permit direct ETT intubation, these SGAs are readily available in the operating room and are commonly used as a stand-alone airway device. The small internal diameter (ID) of the airway lumen in these SGAs prevents an adult full-sized ETT (7.0 mm or larger) from passing through. In addition, the length of the ETT may be too short to reach mid-trachea (Fig. 1). This increases the risk of vocal cord compression and dislodging when the SGA is removed.[1-3,11,12] In this case, the use of introducers or catheters is necessary to achieve tracheal intubation. In this article, we review the use of the following devices: 1) an

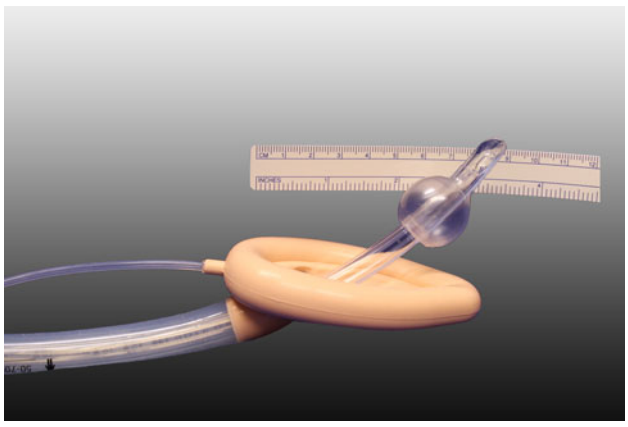

Fig. 1 Full insertion of an uncut 6.0-mm ETT through a size-4 LMA Classic™ The proximal extent of the ETT cuff is only 3-4 cm beyond the distal margin of the bowl of the LMA Classic™

Aintree Intubation Catheter, 2) a guidewire catheter, 3) a gum elastic bougie, and 4) a small ETT.

The Aintree Intubation Catheter

Use of the Aintree Intubation Catheter (AIC) (Cook Critical Care, Bloomington, IN, USA) was initially described by Atherton *et al.* in 1996.[13] The AIC is a semi-rigid hollow catheter that can facilitate bronchoscope-guided tracheal intubation. The device is 57 cm long with an ID of 4.7 mm, which allows the passage of a 4.5-mm bronchoscope through its lumen and leaves the distal 3-10 cm of the bronchoscope unsheathed for ease of manipulation.[14] The AIC has an outer diameter of 6.3 mm, which allows ETTs size 6.5 mm or greater to be inserted.[13] During tracheal intubation, the AIC is mounted over a bronchoscope (Fig. 2), and the bronchoscope/AIC assembly is inserted through the SGA into the trachea. After the bronchoscope and SGA are withdrawn, an ETT is railroaded over the AIC into the trachea. During this process, the AIC can also be used for interim ventilation through the use of a detachable Rapi-fit® connector (Cook Critical Care, Bloomington, IN, USA). [15]

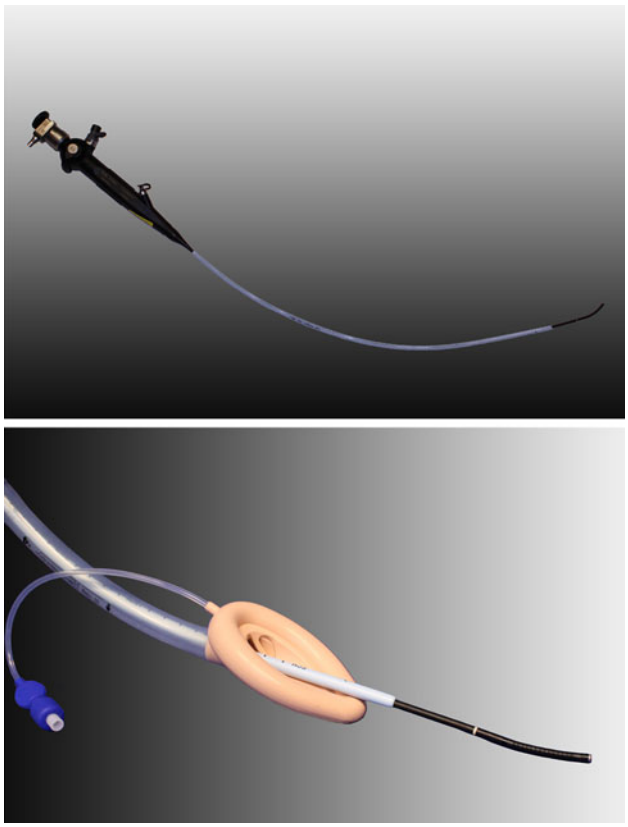

Fig. 2 Insertion of flexible bronchoscope and Aintree Intubation Catheter: Aintree Intubation Catheter is initially threaded over the flexible bronchoscope (top), and the assembly is then inserted into the LMA Classic™ (bottom)

Aintree Intubation Catheter/precursor with the LMA Classic™ (Table 1)

Use of AIC-aided tracheal intubation has mainly been described with the LMA Classic™ [16] but has also been documented in other SGAs, including the LMA Unique™, the LMA ProSeal™, the LMA Supreme™, the i-gel, and the AuraOnce. We identified two studies that examined the use of AIC-aided intubation through the LMA Classic™ in 54 patients, and the overall success rate was 98%.

The first study is a non-randomized prospective study in which Atherton *et al*. describe the successful use of a hollow "ventilation-exchange catheter", a precursor to the AIC, in 24 patients undergoing elective surgery.[13] As described above, the "ventilation-exchange catheter" was loaded on a bronchoscope and inserted through a LMA Classic™. The technique was performed by two anesthesiologists, one experienced and one inexperienced in bronchoscope-guided intubation. Mean insertion time (standard deviation) from induction of anesthesia to tracheal intubation was 360 (80) sec. The study identified a learning curve, derived from Cusum analysis, which plateaued after the fourth and sixth intubations for the experienced and inexperienced anesthesiologists, respectively.

The second study is a prospective consecutive patient series wherein Hammarskjold *et al*.[17] describe the use of a hollow catheter 66 cm in length with outer and inner diameters of 6.5 and 5.0 mm, respectively. The bronchoscope-catheter assembly was inserted through the LMA Classic™ as described above. The procedure was performed in 30 patients with normal airways by three anesthesiologists with bronchoscopic experience of 20, five, and zero years. Tracheal intubation was successful in 29/30 cases (97%). The time from LMA placement to ETT placement was less than two minutes in 17 patients, from two to five minutes in 11 patients, and ten minutes in one patient. Insertion time was largely dependent on the experience of the anesthesiologist.

In four case reports, endotracheal intubation with an AIC through the LMA Classic™ or LMA Unique™ was attempted in 16 patients (Table 1).[18-21] Overall, the tracheas of 14/16 patients (88%) were intubated successfully using an AIC through the LMA Classic™ or LMA Unique™.

In a randomized crossover mannequin study by Heard *et al.*,[22] bronchoscope/AIC intubation through an LMA Classic™ was compared with direct ETT insertion through an intubating LMA in a simulated difficult airway with 26 anesthesiologists as participants. Results showed that the AIC technique had a higher success rate and quicker intubation times than the intubating LMA approach. The success rate was 26/26 (100%) with the AIC and 5/26 (19%) with direct ETT insertion ($P < 0.0001$). The vocal cords were reached faster using the AIC technique than

Table 1 Studies and case reports for intubation using an Aintree Intubation Catheter through a supraglottic airway

Article	Type of Study	Subjects	Success rate	Other outcomes
LMA Classic™ or LMA ProSeal™				
Atherton *et al.* 1996[13] LMA Classic™	Prospective single device study	24 patients, Elective surgery	24/24 (100%)	Time from anesthesia to tracheal intubation:360 (80) sec
Hammarskjold *et al.* 1999[17] LMA Classic™	Prospective single device study	30 patients, No predicted difficult intubation	29/30 (97%)	Time from LMA placement to ETT placement: < 1 min: 13 patients 10 min: 1 patient
Higgs *et al.* 2005[18] LMA Classic™	Case series	9 patients, Failed intubation	8/9 (89%)	
Cook *et al.* 2007[19] LMA Classic™ or LMA ProSeal™	Case series	15 cases - failed intubation/ difficult airway - 2 cases not intubated with SGA	LMA ProSeal™:5/8 (63%) LMA Classic™:4/5 (80%) Success for both SGAs: 9/13 (69%)*	
Zura *et al.* 2005[20] LMA Classic™	Case report	1 patient, Failed intubation	Successful	No complications noted
Cook *et al.* 2005[14] LMA ProSeal™	Case report	1 patient Failed intubation	Successful	Time required: LMA ProSeal™ insertion = 15 sec FB/AIC technique = 60 sec
Doyle *et al.* 2007[23] LMA-ProSeal™	Case report	1 patient Failed intubation	Successful	
Farag *et al.* 2010[21] LMA Classic™	Case report	1 patient Difficult intubation	Successful	
Blair *et al.* 2007[16] LMA Classic™ *vs* LMA ProSeal™	Mannequin study	25 anesthesiologists, 2 intubations per device	LMA Classic™:46/50 (92%) LMA ProSeal™: 49/50 (98%)	Time from picking up AIC to ventilation: < 90 sec Experienced resistance to passage of AIC: LMA Classic™ = 12/50 LMA ProSeal™ = 9/50 Subjective negative comments: LMA Classic™ = 17 LMA ProSeal™ = 4
Heard *et al.* 2010[22] LMA Classic™	Mannequin study	26 anesthesiologists	AIC:26/26 (100%) ETT:5/26 (19%)	Time to reach vocal cords: AIC: 18 [14-20] sec ETT: 110 [70-114] sec Time to insertion: AIC: 93 [74-109] sec ETT: 135 (79-158)sec

Table 1 continued

Article	Type of Study	Subjects	Success rate	Other outcomes
LMA Supreme™				
Joffe & Liew 2010[24] AIC *vs* Arndt Intubation introducer Set®	Mannequin study	20 anesthesiologists, Performed 1 insertion per method	AIC:18/20 (90%) Arndt: 20/20 (100%)	Time from picking up AIC to LMA Supreme withdrawal: AIC = 54 (21) sec Arndt: 98 (23) sec Rating for ease of passage: AIC = 2 (slightly difficult) Arndt = 1 (easy) Anesthesiologist preference: AIC = 50% Arndt = 50%
AuraOnce™				
Cattano *et al.* 2009[8] LMA Unique™ *vs* AuraOnce	Prospective single device study	50 patients, elective surgery	LMA Classic™:25/25 (100%) AuraOnce™:25/25 (100%)	Insertion time of SGA: -AuraOnce™: 20.0 (8.61) sec -LMA Unique™: 25.1 (13.57) sec AIC-ETT exchange time: -AuraOnce™: 31.9 (28.81) sec -LMA-Unique™: 41.5 (25.60) sec
i-gel™				
de Lloyd *et al.* 2010[15] LMA Classic™ *vs* i-gel™; FB alone *vs* FB/AIC	Mannequin study	32 anesthesiologists, Performed 2 intubations per method per device	FB alone in LMA Classic™:59/64 (92%) All other arms:100%	Time from picking up FB to ventilation: FB, LMA: 43 (24) sec FB, i-gel: 22 (9) sec FB/AIC, LMA: 46 (24) sec FB/AIC, i-gel: 37 (9) sec Subjective ratings: 1) Ease of railroading: Easier with i-gel 2) Device: 94% i-gel over LMA 3) Method: 84% FB over FB/AIC

Values are mean (standard deviation), median [interquartile range] or number of patients (%). *One failed LMA ProSeal™ attempt successfully managed with LMA Classic™; one failed intubation with LMA ProSeal™ & LMA Classic™. LMA = laryngeal mask airway; ETT = endotracheal tube; AIC = Aintree Intubation Catheter; SGA = supraglottic airway; FB = flexible bronchoscope

with direct ETT insertion, where median insertion time [interquartile range] for the AIC technique was 18 [14-20] sec *vs* 110 [70-114] sec for direct ETT insertion ($P = 0.008$). Median insertion time to first ventilation was also faster for the AIC technique at 93 [74-109] sec *vs* 135 [79-158] sec for direct ETT insertion ($P = 0.0038$).

Aintree Intubation Catheter and LMA ProSeal™

The efficacy of the LMA ProSeal™ as a conduit for tracheal intubation with an AIC was compared with the LMA Classic™. In three case reports, tracheal intubation with an AIC through the LMA ProSeal™ was attempted in ten patients with difficult or failed intubation (Table 1).[14,19,23] Seven of the ten cases were successful (70%). Of the three failed cases, the first failed case was subsequently managed by AIC-aided intubation through an LMA Classic™. The second failed case was managed with bronchoscope /AIC nasal intubation, and the third case was managed by percutaneous tracheostomy.

In a mannequin study by Blair *et al.* (Table 1),[16] 25 anesthesiologists with limited experience in this technique performed each procedure twice. The overall success rate was 95/100 (95%). There were four intubation failures with the LMA Classic™ (92% success) and one failure with the LMA ProSeal™ (98% success); this difference was not significant. The time from picking up the AIC to successful ventilation was under 90 sec in all cases, and no significant difference was identified between the two devices. Subjective ratings on the ease of AIC passage did not differ between the two devices, although there were significantly more negative comments regarding use of the LMA Classic™.

The modified design of the LMA ProSeal™, including a larger bowl, absence of aperture bars, and possible visualization of the larynx from further away, may better facilitate the use of the AIC.[16-19] However, due to the small sample size, case variability, and potential publication bias, further randomized trials are needed to make a complete assessment regarding the effectiveness of the LMA ProSeal™ as a conduit for intubation.

Aintree Intubation Catheter and LMA Supreme™

The bronchoscope/AIC technique may also facilitate ETT insertion through the LMA Supreme™. Joffe *et al.* described the technique in an AirSim™ airway mannequin using a size-4 LMA Supreme™ with 20 participants.[24] The study also compared the bronchoscope/AIC technique with the guidewire technique, described below. Greenland *et al.* identified a potential drawback, namely, the epiglottic fins of the LMA Supreme™ tended to trap the AIC in a sagittal plane, preventing maneuverability and insertion of the catheter.[25] This limitation may be prevented if the bronchoscope/AIC can be guided above the fins, which allows for greater range of movement.

Aintree Intubation Catheter and AuraOnce™

In a study by Cattano *et al.*, the AuraOnce™ was compared with the LMA Unique™ as a conduit for bronchoscope-guided AIC in 50 patients undergoing elective surgery.[8] Patients were randomized to either device. The tracheas of all patients were intubated successfully. Average insertion time was 20.0 (8.61) sec with the AuraOnce™ and 25.1 (13.57) sec with the LMA Unique™. The AIC-ETT exchange time was 31.9 (28.81) sec with the AuraOnce™ and 41.5 (25.60) sec with the LMA Unique™. A significantly higher incidence of postoperative hoarseness at two hours was found with the LMA Unique™ than with the AuraOnce™ (48% *vs* 20%, respectively; $P = 0.04$). While the difference in both times was not significant, the trend suggests that the insertion and AIC placement with the AuraOnce™ may be easier compared with the LMA Unique™.

Aintree Intubation Catheter and i-gel™

A single crossover study by de Lloyd *et al.* compared the i-gel to the LMA Classic™ as a conduit for tracheal intubation in a mannequin.[15] Intubations with bronchoscope alone *vs* bronchoscope/AIC were also compared for each device. Thirty-two anesthesiologists performed each procedure twice on the mannequin. There were 5/64 (8%) failures in the LMA Classic™ using bronchoscope alone. All other intubations were successful, including those using the LMA Classic™ with bronchoscope/AIC as well as those using i-gel with and without the AIC. The mean time required for intubation with and without the AIC was significantly shorter in the i-gel [37 (9) sec and 22 (9) sec, respectively] compared with the LMA Classic™ [46 (24) sec and 43 (24) sec, respectively]. Ninety-four percent of participants preferred the i-gel over the LMA Classic™, and interestingly, 84% preferred railroading the ETT directly over the bronchoscope rather than over an AIC.

Thus, the use of the AIC through various SGAs has shown a high success rate both in elective and emergency situations. Advantages of using the bronchoscope/AIC over blind or bronchoscope-guided intubation include a higher success rate, ability to insert larger-sized ETTs, and easy removal of the SGA. However, the multiple steps involved with the use of the bronchoscope/AIC may deter some anesthesiologists from incorporating this technique into practice. Furthermore, the study above found that only 50% of anesthetic departments in the UK had AICs available for use.[15] Training and ensuring the availability of the AIC may help overcome the learning curve and increase

familiarity with the technique. More research is required to ascertain the efficacy of the AIC as an aid to intubation in the LMA ProSeal™, LMA Supreme™, and i-gel in both normal and difficult airway scenarios.

The guidewire / exchange catheter

The second technique involves a wire-guided approach with or without an airway exchange catheter. This technique involves insertion of a bronchoscope through the SGA into the trachea followed by insertion of a guidewire through the bronchoscope. The bronchoscope is removed and an exchange catheter is railroaded over the guidewire. The SGA is then removed and an ETT is railroaded over the exchange catheter into the trachea.[26] Alternatively, the bronchoscope and SGA are removed after the guidewire is inserted into the trachea, and an ETT is then railroaded over the guidewire into the trachea.

The guidewire-catheter technique and the LMA Classic™ or LMA Unique™

In five case reports, the tracheas of 14 patients were intubated successfully using a bronchoscope with the guidewire/exchange catheter technique through the LMA Classic™ or LMA Unique™ (Table 2).[27-31] In the case report by John *et al.*, the lungs of a patient with a difficult airway were initially ventilated with a LMA Unique™.[31] An attempt to intubate with the bronchoscope/AIC technique failed due to the presence of the aperture bars.

The guidewire-catheter technique and the LMA ProSeal™ or the LMA Supreme™

The tracheas of ten patients were intubated successfully when the guidewire-exchange catheter technique was used with the LMA ProSeal™.[32] In the report by Joffe *et al.*, tracheal intubation with the AIC was compared with that of the Arndt Exchange Catheter Set®. Twenty experienced anesthesiologists performed each method once on an AirSim™ airway mannequin using a size-4 LMA Supreme™.[24] Successful intubation using an AIC was 90%, while successful intubation with the guidewire-exchange catheter was 100%; this difference was not statistically significant. However, faster intubation was achieved using the AIC technique, where insertion time was 54 (21) sec with the AIC and 98 (23) sec with the guidewire-exchange catheter ($P < 0.0001$). On the other hand, AIC passage into the trachea was rated as more difficult than with the exchange catheter, but preference for each method was 50%. As reported by Matioc, the method was also used successfully in three patients using the LMA Supreme™.[26] There are currently limited data regarding the efficacy of this device as an intubating conduit compared with other devices and in different clinical situations.

The guidewire-catheter technique for tracheal intubation has been shown to work in a number of case reports/series. It involves a large number of steps, and anesthesiologists must become familiar with the entire sequence to perform the technique well. The use of a guidewire without a catheter may also work, but the large size discrepancy between the small diameter wire and the much larger diameter ETT may result in ETT impingement at the arytenoid level.

The gum elastic bougie (bougie)

The third technique in which tracheal intubation can be achieved through the use of a SGA as a conduit is with the gum elastic bougie or bougie. Bougies are solid introducers 60-70 cm long with a 35-40° distally angulated (Coude) tip. They are easy to use, widely available, inexpensive,

Table 2 Case reports or series documenting insertion of a guidewire with or without an exchange catheter through a supraglottic airway

Article	Type of Study	Subjects	Supraglottic airway	Success rate
Guidewire with Catheter				
Joffe *et al.* 2010[27]	Case series	5 patients	LMA Classic™	5/5 (100%)
John *et al.* 2007[31]	Case report	1 patient	LMA Unique™	- FB/AIC failed-guidewire successful
Matioc 2009[26]	Case series	3 patients	LMA Supreme™	3/3 (100%)
Guidewire only				
Walburn *et al.* 2000[28]	Case series	5 patients	LMA Classic™	5/5 (100%)
Sartore *et al.* 1994[29]	Case report	1 patient	LMA Classic™	1/1 (100%)
Arndt *et al.* 1998[30]	Case report	2 patients	LMA Classic™	2/2 (100%)
Matioc *et al.* 2001[32]	Case series	10 patients	LMA ProSeal™	10/10 (100%)

FB = flexible bronchoscope; AIC = Aintree Intubation Catheter

and have been used as adjuncts to difficult direct laryngoscopy for many decades.[33] The Frova® intubation introducer is a similar device which comes in various lengths (35 or 65 cm) and diameters (1.6 or 3.0 ID). Unlike the bougie, it contains a lumen designed to allow oxygenation. Both blind and bronchoscopy-guided insertions of a bougie and Frova® intubation introducer through a LMA have been described. A nasogastric tube may be used to aid the placement of the bronchoscope and bougie. The bronchoscope is inserted into a nasogastric tube and advanced into the trachea. Upon removal of the bronchoscope, a bougie is inserted through the nasogastric tube into the trachea. Blind insertion of the bougie or Frova® intubation introducer is usually guided by tactile clicks as the device passes the cartilage rings of the trachea. After the bronchoscope and SGA are removed, an ETT can subsequently be railroaded over the bougie.

Blind insertion of the bougie

Three studies and three case series/reports were identified involving blind insertion of a bougie through a LMA Classic™ [34-39] (Table 3). The first study by Gabbott *et al*. examined the success rate of bougie insertion through a LMA Classic™ and investigated the role of cricoid pressure with manual in-line stabilization in 40 patients undergoing elective surgery.[34] The tracheas of 11(27.5%) of those patients were successfully intubated with the bougie. When cricoid pressure with manual in-line stabilization was applied, successful bougie insertion decreased to 9/40 (22.5%).

In the second study, Ahmed *et al*. compared the effect of head position on bougie insertion through the LMA Classic™ in 20 patients randomized into neutral *vs* sniffing head positions.[35] The overall success rate was 4/40 (10%), with 0/20 successes in neutral head position and 4/20 (20%) successes in the sniffing position. The difference was not significant and overall success was low.

The third study by Miller *et al*. examined the reliability of the bougie through a LMA Classic™ as a means of rescue intubation in six unembalmed human cadaveric models.[36] Nineteen emergency medicine residents and attending physicians participated. Successful intubations occurred in 59/114 (52%) cases. However, two cadavers had distorted laryngotracheal anatomy. Eliminating them from analysis increased the overall success rate to 63%. No significant difference in performance was found between the level of training of the residents or years of experience of the attending physicians.

Successful blind intubation using a bougie through a LMA Classic™ after failed direct laryngoscopy was also reported in 24/28 patients, at least three presenting with

Table 3 Studies and case reports for insertion of a bougie through the LMA Classic™ or the LMA Supreme™

Article	Type of Study	Subjects	Success rate
Bougie through LMA Classic™			
Blind			
Gabbott *et al*. 1996[34]	Controlled trial	40 patients; Elective surgery	11/40 (28%)
Effect of cricoid pressure			[+ cricoid pressure: 9/40 (23%)]
Ahmed *et al*. 2001[35]	Controlled trial	20 patients; Elective surgery	Neutral head position: 0/20 (0%)
Effect of head position: neutral *vs* sniffing			Sniffing head position: 4/20 (20%)
Allison & McCrory 1990[37]	Case series	25 patients	21/25 (84%)
Chadd *et al*. 1989[38]	Case report	2 patients; Difficult airway	2/2 (100%)
Murdoch 2006[39]	Case report	1 patient; Difficult airway, failed intubation	Successful
Miller *et al*. 2010[36]	Single device study	6 unembalmed human cadavers	59/114 (52%)
FB guided			
Allison & McCrory 1990[37]	Case series	25 patients	22/25 (88%)
Sarma 2006[40]	Case report	1 patient; Failed intubation	Successful
Bougie and alternatives through LMA-Supreme™			
Mathes *et al*. 2008[41]	Prospective single device study	8 patients	FB + bougie: 2/4 (50%)
FB + bougie *vs* FB in NGT with bougie			FB + bougie in NGT: 4/4 (100%)
Chu *et al*. 2012[42]	Case report	1 patient; Failed intubation	Successful

FB = flexible bronchoscope; NGT = nasogastric tube

difficult intubation characteristics.[37-39] One patient presented with ankylosing spondylitis, the second showed limited mouth opening, and the third had a severe fixed flexion deformity and required management after cardiorespiratory arrest. Thus, blind intubation with a bougie through a LMA Classic™ may be useful in some emergency and difficult airway situations; however, the overall success rate with blind insertion of the bougie is low.

Bougie insertion under bronchoscopic guidance

The bougie and bronchoscope are inserted in parallel through the SGA and advanced in tandem. One operator steers the bronchoscope while the second operator steers the bougie under bronchoscopic guidance into the trachea.

Insertion of a bronchoscope in conjunction with a bougie through a SGA can potentially increase the intubation success rate (Table 3, Fig. 3). Allison and McCrory reported successful tracheal intubation in 22/25 patients (88%)[37]; a bougie was successfully inserted into the trachea under bronchoscope guidance through a LMA Classic™. All failures were associated with poor SGA placement. A suggested way to improve the passage of the bougie is to point the flex tip anteriorly followed by a 180° rotation after passing the aperture bars. In a case report, Sarma described a 56-yr-old patient with failed direct laryngoscopy.[40] Two attempts to insert an ETT through a LMA Classic™ were unsuccessful. Under bronchoscope guidance, a bougie was then successfully introduced through the LMA Classic™ into the trachea, and a 7.0-mm ETT was subsequently railroaded over the bougie into the trachea. Thus, bronchoscope-guided bougie insertion can potentially increase the success rate compared with blind bougie insertion, and it may be a valuable alternative in difficult or failed intubation situations.

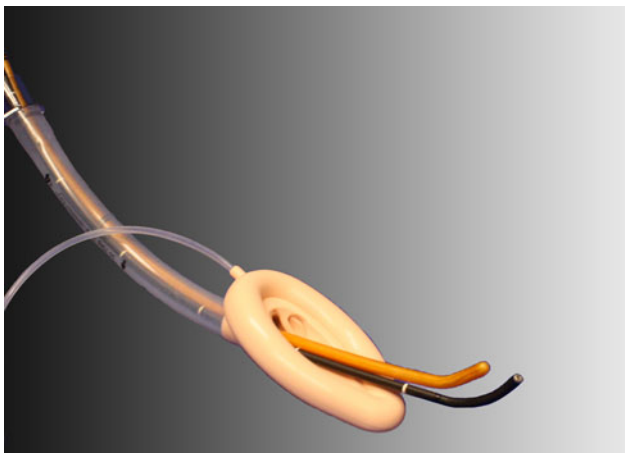

Fig. 3 Insertion of flexible bronchoscope and bougie through the LMA Classic™

Use of bougie through the LMA Supreme™

The use of a bougie through the LMA Supreme™ has recently been investigated. Mathes *et al.* studied eight patients undergoing elective surgery.[41] A gum elastic bougie in conjunction with a flexible bronchoscope was inserted through the airway lumen of the LMA Supreme™ in four patients with normal airways undergoing elective surgery. In the other four patients, a nasogastric tube was used as an adjunct for intubation through the LMA Supreme™. In both cases, an ETT was railroaded over the bougie after removal of the SGA and bronchoscope. The success rate with bronchoscope and bougie was 2/4 (50%) due to the inability to maneuver the bougie tip into the trachea through the LMA Supreme™. However, tracheal intubation with the addition of a nasogastric tube increased the success rate to 4/4 (100%). Recently, Chu *et al.* described the insertion of a LMA Supreme™ in a "cannot intubate, cannot oxygenate" difficult airway situation. After rescue ventilation was obtained, a bougie was inserted under bronchoscopic guidance into the trachea and a full-size ETT was successfully railroaded over the bougie into the trachea.[42]

In summary, the success rate of blind bougie insertion through a SGA into the trachea is quite low and cannot be recommended. Parallel insertion of bronchoscope- and endoscopic-guided insertion of a bougie through a SGA into the trachea has a high success rate. However, this technique involves a coordinated effort of two skilled operators to achieve tracheal intubation.

Small ETT

Lastly, a small ETT (< 6.0 mm ID) can be used to facilitate endotracheal intubation.[43,44] Carron *et al.* described its use in a patient with three failed laryngoscopic intubation attempts.[44] A size-4 LMA Supreme™ was first inserted for ventilation, and a small ETT (6.0 mm ID) was then mounted over a bronchoscope and inserted through the LMA Supreme™ into the trachea. The bronchoscope and LMA Supreme™ were withdrawn, and a 4.0-mm Cook Airway Exchange Catheter was inserted into the small ETT. The small ETT was subsequently removed and a 7.5-mm ID ETT was railroaded in.

Supraglottic airways as conduits for tracheal intubation in pediatric patients

Use of a SGA as a conduit for tracheal intubation for the pediatric difficult airway is less well documented than in adult patients. Most occurrences are documented in case

reports/series rather than in clinical trials.[45-52] In children, the conduit most often used for tracheal intubation is the LMA Classic™ or the LMA Unique™. The main modalities to access the pediatric trachea with use of a bronchoscope are: 1) use of a traditional ETT directly via the SGA, 2) use of an airway exchange catheter over a bronchoscope, and 3) use of a guidewire through the working channel of the bronchoscope.

Bronchoscopic use must be emphasized when considering SGA-guided tracheal intubations, as the incidence of epiglottic downfolding is very high in smaller children despite adequate ventilation parameters with the SGA.[53,54] The use of airway exchange catheters and guidewires requires a series of additional steps that may be impractical in smaller children who physiologically show lower cardiopulmonary reserve than older children and adults.[55] In addition, the AIC is not available for pediatric patients. For these reasons, direct access to the trachea with an ETT loaded onto a bronchoscope is usually a more practical choice than the use of these adjuncts. Nevertheless, there are a few reports where a Cook Airway Exchange Catheter or ureteral dilators are used to perform tracheal intubation via the SGA in children.[45] Finally, the successful use of an ETT via the SGA requires some modification of equipment, particularly if cuffed tracheal tubes are needed[56] and/or when SGA removal is desired after tracheal intubation.[57] The unique consideration in smaller pediatric patients is that the airway tube of the SGA can be as long or even longer than the ETT used for tracheal intubation, making it difficult to maintain control of the ETT while removing the SGA. Several techniques that decrease the likelihood of accidental extubation of the ETT during removal of the SGA have been devised and reported in the literature. These techniques include the use of a long ETT[3] or a double ETT assembly[60] and shortening the shaft of the SGA.[58]

The use of an exchange catheter or guidewire to access the trachea in children is similar to the techniques in adult patients, as described above. When choosing to place an airway exchange catheter over the bronchoscope (functionally similar to AIC), the clinician is limited by the ID of the exchange catheter relative to the external diameter of the bronchoscope. A Cook Airway Exchange Catheter (11 Fr) with an ID of 2.3 mm allows the passage of a 2.2-mm bronchoscope through its lumen and can accommodate an ETT with a 4-mm ID or larger. The size 14 Fr (3.0-mm ID) exchange catheter allows passage of the same size bronchoscope and accommodates ETTs with a 5-mm ID or larger. The 19 Fr (3.4-mm ID) exchange catheter allows passage of a 3.1-mm bronchoscope through its lumen and accommodates ETTs with a 7-mm ID or larger. The clinician must cut these exchange catheters to an appropriate length to expose the distal articulating portion of the bronchoscope to allow for ease of manipulation. The use of an exchange catheter may have some advantages, as seen with AIC in adult patients: 1) the position of the exchange catheter is confirmed under direct vision; 2) the potential for dislodgement of the ETT during removal of the SGA is minimized; and 3) the increased rigidity of the exchange catheter minimizes the potential for inadvertent malpositioning of the distal tip of the smaller diameter bronchoscope when the ETT is advanced. Malpositioning may lead to esophageal intubation, a common problem seen with use of guidewires and a smaller diameter bronchoscope.[59,60]

In the case of the guidewire, the clinician may choose to railroad an ETT directly over the guidewire or may choose to place an exchange catheter over the guidewire, which can then be used to accommodate the ETT. Commonly used guidewires are 145-170 cm in length and 0.035-0.038 inches (approximately 1 mm) in diameter. Therefore, these guidewires will fit into the working channel of a pediatric-sized bronchoscope or within an exchange catheter. However, because of the small diameter and softness of the guidewire, railroading an ETT may displace the guidewire and lead to esophageal intubation. We recommend a two-stage ETT insertion. First, an exchange catheter (11, 14, or 19 Fr) is loaded onto the guidewire to increase the diameter and stiffness of the introducer, and second, an ETT is then railroaded over the exchange catheter into the trachea.

In summary, tracheal intubation in pediatric patients can be performed without the use of guidewires or exchange catheters, a practice commonly performed in adult patients. However, when attempted, the use of a bronchoscope is highly recommended, and some modifications of equipment are usually required to overcome some of the limitations associated with use of a LMA Classic™ for tracheal intubations. With these appropriate precautions, the clinician will have a greater degree of success with tracheal intubation through the LMA Classic™ in pediatric patients.

Conclusion

In a patient with failed direct laryngoscopic intubation and a bloodied airway, alternative intubation techniques, including bronchoscopic intubation, may be a major challenge. In this situation, a SGA can serve both as a ventilatory device and as a conduit for tracheal intubation. Supraglottic airways have become virtually universal in the operating rooms across the country, and previous studies have suggested that anesthesiologists tend to use devices with which they have the most experience. Direct tracheal intubation through the SGA may be challenging due to limitations in the size and depth of penetration of the ETT. The techniques that can facilitate the insertion of an

adequately sized ETT are: 1) an AIC, 2) a guidewire and airway exchange catheter, 3) a bougie, and 4) a small ETT.

Although there is insufficient evidence to recommend one technique over the others, in the authors' opinion, the AIC technique is preferable. The AIC coupled with a bronchoscope can be inserted under endoscopic guidance through a SGA into the trachea by one operator in a single step. In contrast, the guidewire technique involves more steps and often more than one operator. The blind bougie technique has a low success rate, while a parallel bougie/bronchoscope insertion necessitated a coordinated effort of two operators. Usage of introducers or catheters through a SGA to facilitate intubation may be a useful alternative intubation technique in difficult airway management.

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