New Tools and Trends: Airway Rescue

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Introduction

Mastery of airway assessment and management remains a key area of knowledge and core skill for anaesthetists at all levels. The specialist anaesthesiologist is expected to have a commanding grasp of the majority of airway devices and techniques, and should be intimately familiar with dealing with airway emergencies. It is essential to become adept with the use of airway rescue devices and techniques in the non-emergency situation, before such skill is required in anger.

Airway equipment continues to develop along several themes, with new devices appearing with a regularity only matched by the paucity of good quality evidence about their clinical efficacy. Adequate comparative data frequently takes years to emerge. Anaesthesiologists, particularly those involved in equipment procurement, should familiarise themselves with the medical (not marketing) literature, and the suggested guidelines for device assessment.[1]

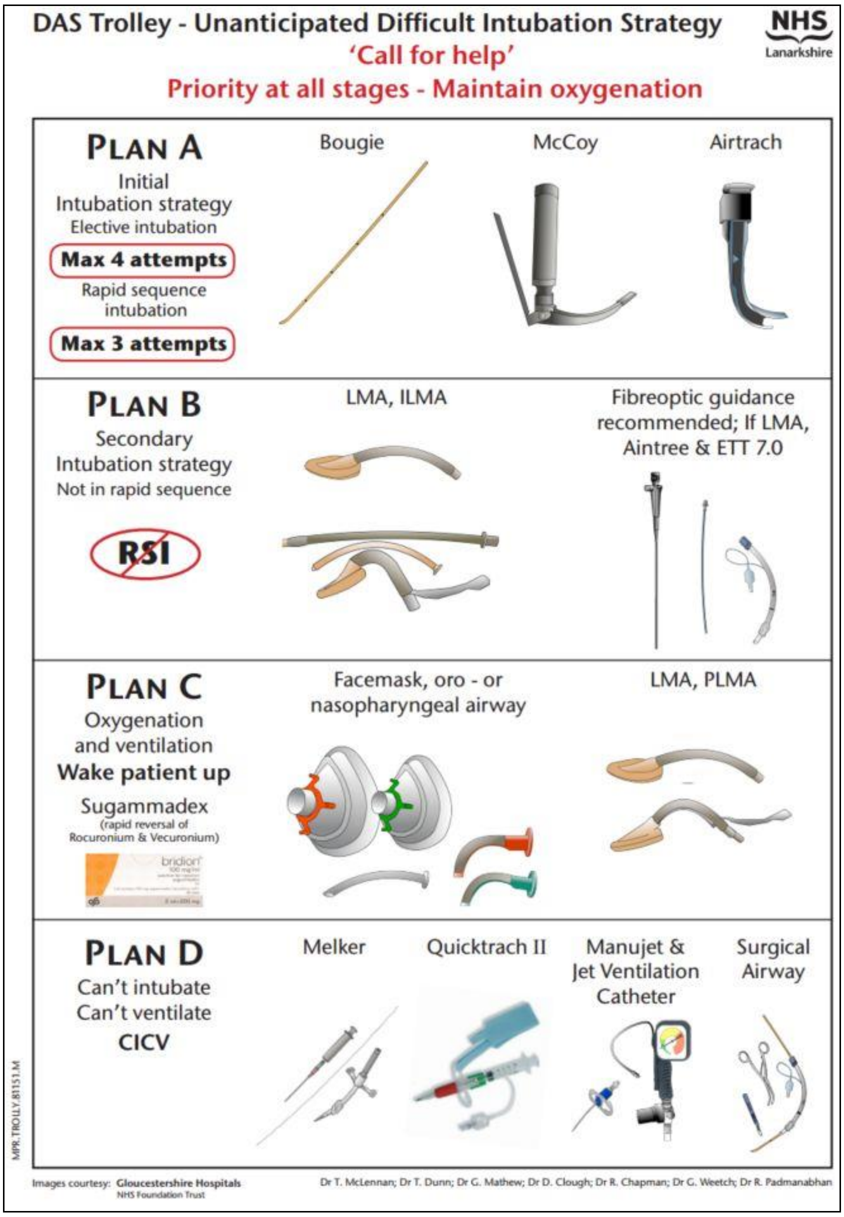
By the time you attend the Refresher Course, these notes will likely be out of date; by the time the exams arrive, the lecture will already be stale. Keeping in touch with the latest developments is a worthy challenge – but keep in mind your examiners have the same battle. OpenAirway.Org (www.openairway.org) is a free, open-access "meducation" (FOAM) resource dedicated to airway management, where you may find the latest information.

New trends

Algorithms for airway rescue and the management of anticipated difficulty continue to be developed and renewed. The major national and professional anaesthesia societies release updated algorithms in a roughly 5 year cycle, which are usually to be found on their respective webpages. The Difficult Airway Society (DAS)[2] and Vortex[3] (see below) guidelines are useful for study and reference in theatre. The 2015 DAS guideline update is anticipated in November 2015. SASA's most recent version was published 2014 and distributed in March 2015.[4] It includes lists of recommended equipment for all levels of care. Significantly trends in the various guidelines include:

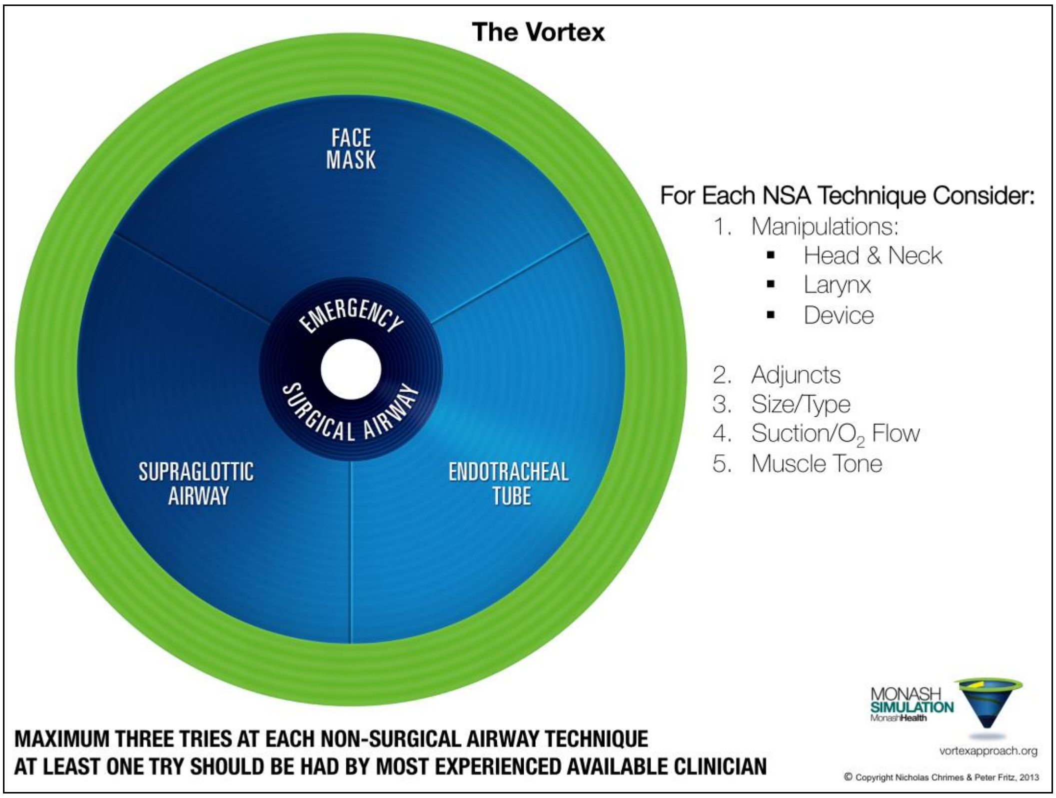
- Early use of video laryngoscopes where suitable skill exists
- Including the use of VL as an initial plan in anticipated difficulty
- Emphasis on supraglottic airways (SGAs) as rescue devices in failed intubation
- SGAs for cardiac resuscitation to minimise interruptions of chest compressions
- A move from referring to CICV (can't intubate, can't ventilate) to the more focused CICO (can't intubate, can't oxygenate) nomenclature
- Planning of multiple strategies (Plan A, B, C etc.) before commencing airway management.

An updated collection of airway algorithms from various sources (ASA, DAS, Vortex, SASA, etc.) can be found at www.openairway.org/algorithms



1. Example of cognitive aid to sequential plan for management of a difficult airway.
http://scottishairwaygroup.co.uk/wp-content/uploads/2013/11/ART_NHS_Lanarkshire.pdf

Increasingly, **cognitive aids** for airway emergencies are being developed in recognition of the frequency of human factor errors in airway emergencies. One popular (and useful) example is the Vortex Approach, which encourages the practitioner to move through the three main non-surgical options (mask, supraglottic and endotracheal tube) in any sequence, with optimisation techniques at each stage. This helps to avoid the task-fixation that can occur with failed intubation.



2. Vortex Approach. Open access from http://www.vortexapproach.com/Vortex_Approach/Vortex.html

Recent studies of **paediatric airway** anatomy have shown that our traditional understanding of the round, 'funnel-shaped' airway based on cadaveric research was mistaken.[5] *In vivo* investigation using measurements from video bronchoscopy and MRIs in sedated children demonstrate the glottis to be the narrowest section. Furthermore, the cricoid is elliptical, not circular. This has increased the motivation for cuffed endotracheal tubes in children, provided they are of the high volume, low pressure (HVLP) design. As the cricoid cartilage ring cannot expand, it is still the most common site of post-intubation tissue ischaemia and fibrosis. Cuffed tubes should be chosen ½ size smaller than the traditional uncuffed ETT (age/4 + 3.5), and a leak with the application of no greater than 20 cm$H_2$0 pressure should be elicited with the cuff deflated. Ideally, a cuff pressure manometer should be used with all cuffed ETTs to limit the cuff pressure to <20cm $H_2$0; a similar recommendation is made for cuffed supraglottic airways in children.

Simulation training in airway management is becoming more and more common. The fidelity of training models and especially immersive simulation systems and environments is continuously increasing. Participants find simulation very enjoyable after initial misgivings. A recent systematic review found simulation training at least as good as other forms of instruction, with greater participant enjoyment and satisfaction, and effects on process behaviour.[6] Data is not yet conclusive that this leads to enhanced patient safety, however.

Pre-oxygenation and oxygen delivery: NODESAT, ApOx, DSI and THRIVE

Recent attention in the anaesthesia and emergency medicine literature has focused on effective pre-oxygenation in critically ill patients, and the prevention of desaturation during airway interventions (particularly emergency intubation). These patients are at much greater risk than those undergoing elective surgery die to the presence of lung pathologies, decreased level of consciousness, reduce innate airway protection, increased metabolic demands, reduced oxygen carrying capacity and often decreased respiratory drive as they near the point of decompensation. Strategies to increase effective pre-oxygenation and decrease the likelihood and rate of desaturation (the so-called 'NODESAT' philosophy[7])in this patient cohort include:

- Pre-oxygenation with CPAP or assisted ventilation to increase mean airway pressure – this can be achieved with the use of a bag-valve-mask-reservoir (eg. Ambu® Bag) with a PEEP valve, by manually assisting ventilation on a circle system, or by using non-invasive ventilation (NIV) by face mask (many ICU and anaesthesia ventilators can do this in pressure support mode).[8] Nasal cannula oxygen, especially using high-flow systems, also provides a degree of CPAP.[9]
- Apnoeic oxygenation ('ApOx') during intubation attempts[10] – ideally, this is achieved by the use of specifically designed high-flow nasal cannula (eg. using the THRIVE system - Transnasal Humidified Rapid-Insufflation Ventilatory Exchange[11]), but normal nasal cannulae at flow rates of 10-15 L/min for short periods are effective and well tolerated.[12, 13] This has also been described in paediatric patients at risk of desaturation.[14] A laryngoscope modified to deliver oxygen is also a proposed option.[15]
- Delayed Sequence Intubation (DSI) – A strategy for the patient who is delirious or combative due to the effects of the presenting medical condition and/or hypoxia, and is therefore challenging to pre-oxygenate. A dissociative dose of ketamine is used to optimise compliance without causing apnoea, and therefore improve pre-oxygenation; it can be thought of procedural sedation, where the procedure in question is adequate pre-oxygenation. While the utility is obvious to any anaesthetist familiar with the use of ketamine in critically ill patients, the evidence is still limited to one prospective but observational trial which showed improved oxygenation without complication.[16]

Laryngoscopes

Without doubt, the greatest area of development of new airway rescue tools over the last decade has been in the field of indirect laryngoscopy. Although several novel and effective optical laryngoscopic devices exist (eg. the AirTraq and Bonfils), the rapid improvement and decrease in cost of miniature video camera chips and LED light sources (fuelled by the smartphone industry) has led to an explosion of video laryngoscopes (VLs). At least 13 manufacturers exist at the time of writing:

- Glidescope – various iterations (original, GVL, AVL, Ranger, Cobalt, Titanium)
- Storz C-MAC – numerous blades available (MAC 2-4, MIL 0-2, D-blade)
- McGrath – Series 5, McGrath MAC with multiple blades
- King Vision – disposable ducted and plain blades
- AirTraq – Optical laryngoscope now offering a video attachment
- TrueView – Optical laryngoscope which has a camera attachment
- Pentax AWS – ducted VL with disposable blades
- Intubrite VLS – VL with LEDs designed to cause fluorescence of the vocal cords
- VividTrac VL – 'Plug&Play' disposable USB VL, not yet supported in SA
- CoPilot VL – Not yet supported in SA
- AP Advance VL – Not yet supported in SA
- Coopdech VLP – Not yet supported in SA
- Anatech Disposable VL – Not yet supported in SA
- Numerous other rather dubious copies and untested devices are available online…

The most recent devices in the South African market are the King Vision, McGrath MAC and Intubrite VL. The Glidescope Titanium series blades may be available before the end of 2015.

It is beyond the scope of these notes to try and compare the features and evidence behind all these devices. The Glidescope, C-MAC and AirTraq have the best breadth and depth of literature describing their use. However, it is helpful for the practitioner to understand the fundamental principles and function of the major classes of VL. If the optical/video stylets are omitted, there are 3 basic blade shapes, which determine the strengths, weaknesses and appropriate technique for each VL. Blades can either be traditional deeply curved/hyper-angulated or feature a tube guide channel/duct and close to 90° bend. The following table describes the important considerations.

Blade shape	Traditional	Hyper-angulated	Channelled/Ducted
Examples	Storz C-MAC Glidescope Direct TrueView Intubrite VL	Glidescope AVL Glidecope Titanium C-MAC D blade	Pentax AWS AirTraq King Vision
Insertion technique	Right side of mouth with subsequent tongue sweep (traditional technique)	Mostly in midline Devices with flange (C-MAC D) allow tongue sweep	Midline
Ideal uses	Routine VL use Anticipated difficulty without abnormal anatomy (eg. obesity) Teaching intubation	Anticipated difficulty Anatomical abnormalities Airways masses Failed DL	C-spine injury Airway swelling Novice VL users
Strengths	Short learning curve DL often possible May nor require an introducer	Excellent visualisation in many airways that would otherwise require flexible fibreoptic intubation	Easiest to co-ordinate aim of tube (aim with device) Minimal mouth opening required
Weaknesses	Least advantage from video system	Require greatest skill Always require introducer	Can be awkward to insert due to length of device Tendency to insert too deeply
Ideal introducer	Any bougie with coude tip Malleable stylet in "hockey stick" shape	GlideRite stylet Malleable stylet in "hockey stick" shape Steerable introducers	Gum elastic bougie through endotracheal in channel
Ideal forceps	Magill	Boedeker[17] or Suzy[18] forceps	Not applicable

It is important to realise that any intubation performed by indirect laryngoscopy should be expected to require a device to guide the tube around the increase curvature of the airway. This may be an introducer, bougie or forceps. The ideal introducers/bougies for the various types of VL are detailed above. When using a hyperangulated VL blade, it may be necessary to use specially curved forceps.[17, 18]

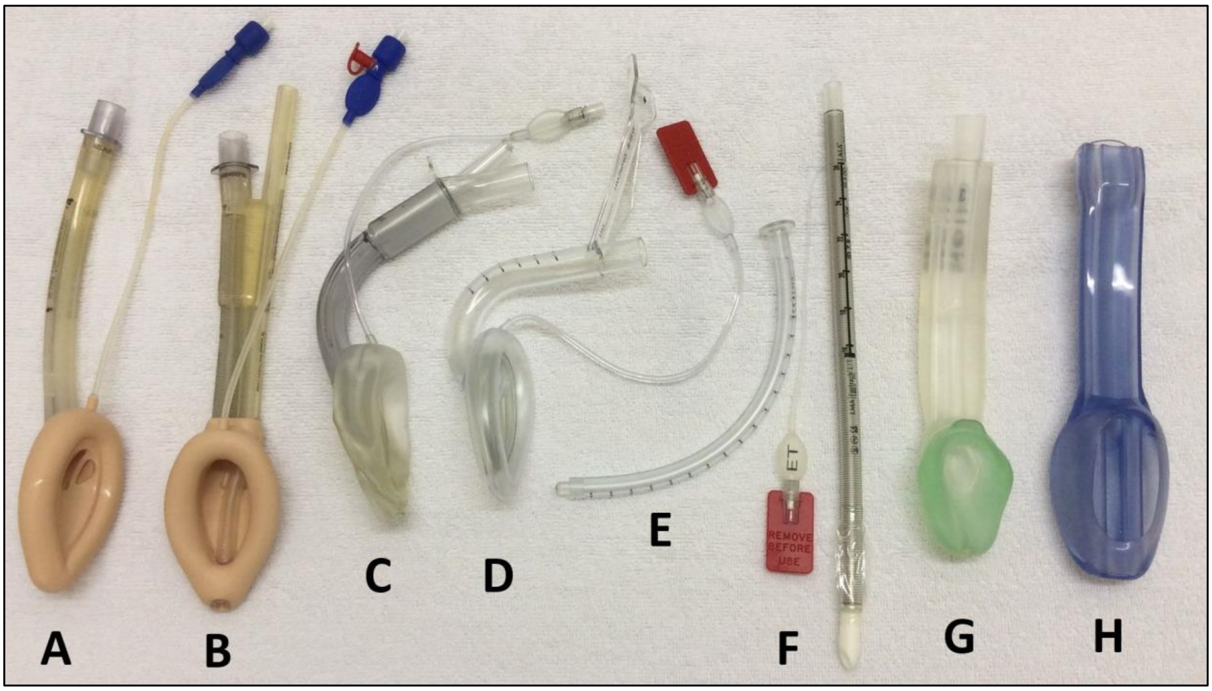
3. Shaped forceps (eg. Suzy or Boedeker) for use with video laryngoscopes, and standard Magill forceps.[18]

4. Proposed classification of characteristics of indirect laryngoscopes.[19]

Supraglottic airways

There has been a noticeable trend in the airway management algorithms to strengthen the role of supraglottic airways (SGAs) in the management of both anticipated and unanticipated difficult airways.[2, 20, 21] (For the purposes of these notes, the term SGA will be presumed to include the various forms of supraglottic and extraglottic airway devices).[22] Since Brain's original release of the LMA-Classic in the late 1980's, SGAs have become thoroughly entrenched in our practice. Recent audits demonstrate that, in many settings, their use exceeds that of endotracheal intubation.[23, 24] There are now more than 40 commercially available SGAs on the market. Understandably, the weight of evidence for efficacy rests with the older devices.[25]

The efficacy of SGAs as rescue airways is undisputed. With over 2500 studies, the LMA-Classic is undoubtedly the most well documented device,[25, 26] and has been shown to provide effective ventilation in CICO events in 94% of cases.[27] Although there is not the same level of evidence, this performance may be extrapolated to many of the newer devices.[28-35] Increasingly, the use of 2nd generation SGAs (which provide a mechanism for gastric drainage) is being recommended for airway rescue.[29, 36-39] The LMA-ProSeal remains the gold standard in this regard, but several newer devices such as the i-Gel, 3gLM and Air-Q Intubating Laryngeal Airway (ILA) may offer additional benefits.[30, 34, 40-63]

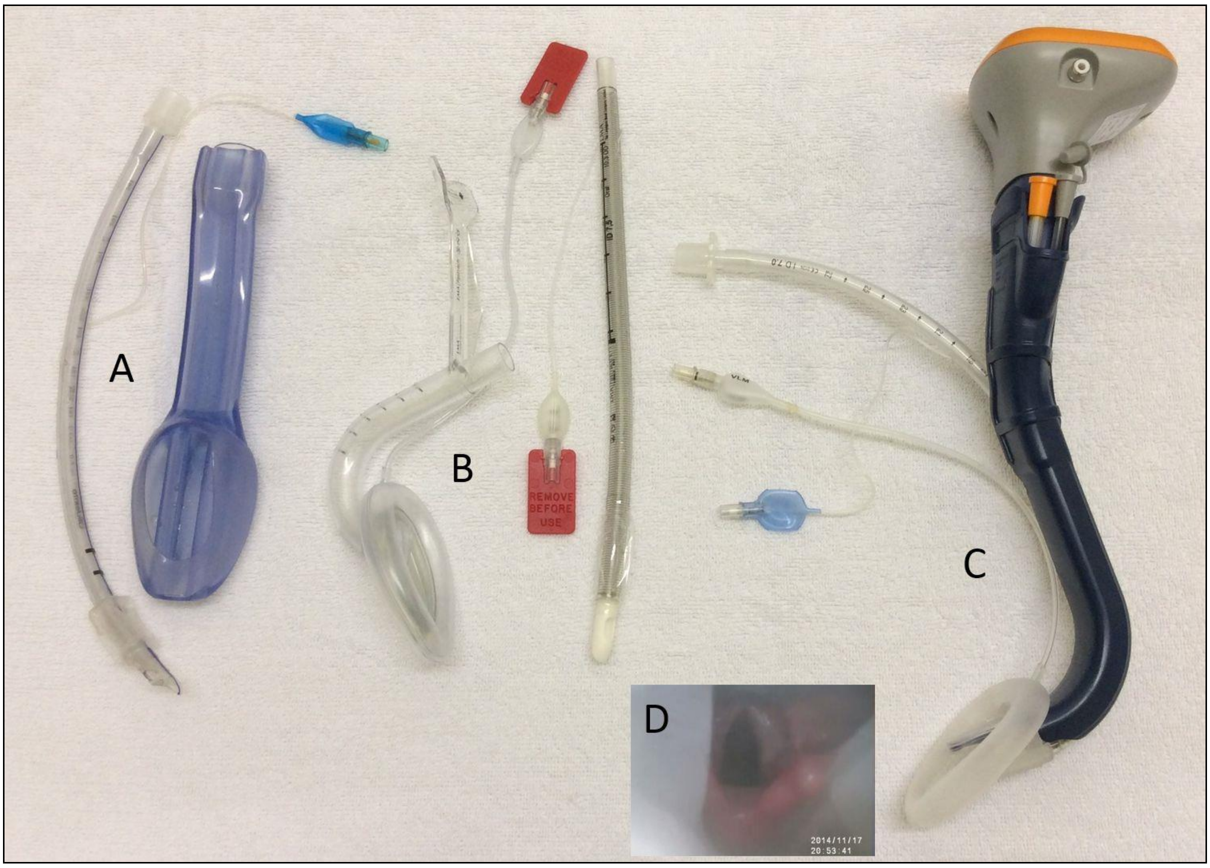


5. A variety of SGAs. A: LMA-Classic B: LMA-Proseal C: LMA-Supreme D: LMA-Fastrach (disposable version) E: LMA-Fastrach push-rod F: LMA-Fastrach ETT G: i-Gel H: 3gLM

The 'Holy Grail' of airway management is a device which can be inserted with minimal training, provides good protection against aspiration, serves as an effective conduit for the placement of an endotracheal tube, is cheap and disposable, and is effective in all patients. This device does not yet exist (or has not yet been proven in the literature). SGAs meet the first criterion (easy insertion), and provide effective ventilation and oxygenation in the majority of patients. The LMA-Fastrach (Intubating Laryngeal Mask Airway, ILMA) has been demonstrated in many studies to provide reliable intubation in patients with difficult airways and is the current gold standard for blind intubation through an SGA, but does not provide any strategies to prevent aspiration.[61, 64-71] However, its performance as a rescue airway remains unsurpassed, and all practitioners should be intimately familiar with its use and the manoeuvres to optimise success.[43, 62, 67, 70, 72-74] Whilst the proprietary silicone wire-reinforced Fastrach ETT is the most effective for intubation through the ILMA, other options do exist.[75-77]

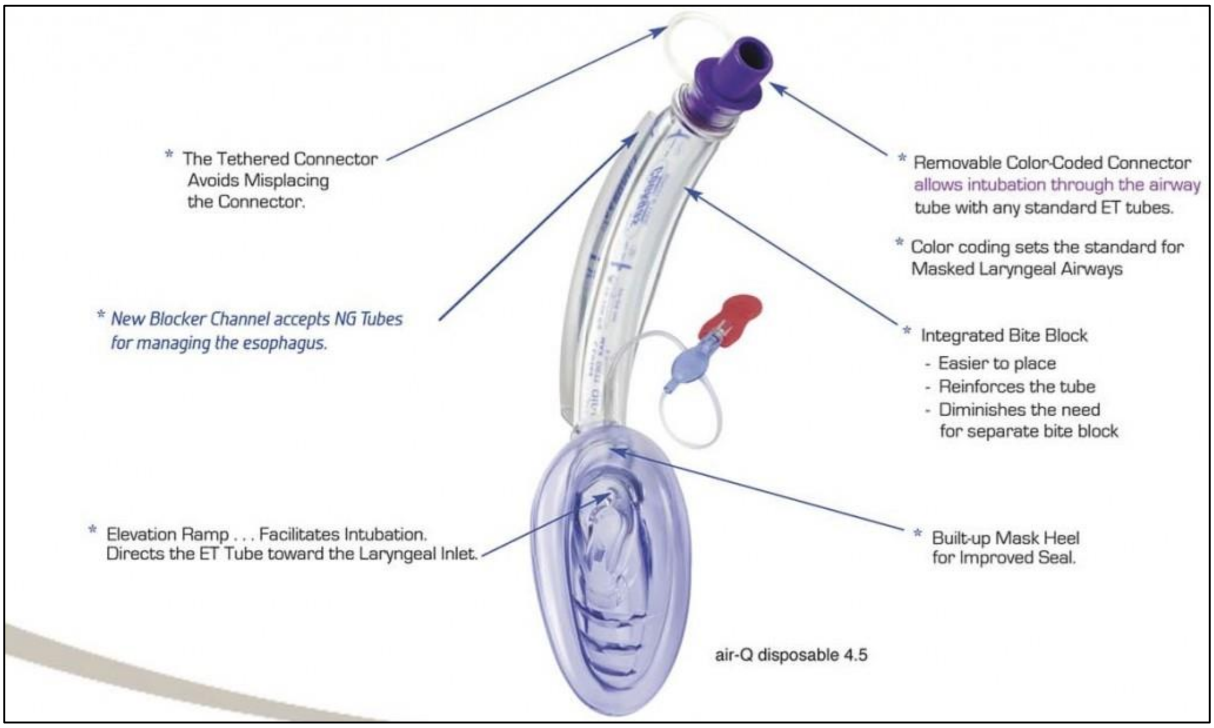
Although fibreoptic-guided intubation through many SGAs proposed for airway rescue can be achieved, it is advisable to use the more modern and cheaper devices such as the i-gel, Air-Q and 3gLM which allow adequate diameter ETTs to be inserted through the device.[30, 34, 35, 40-44, 46-55, 57-59, 63, 72, 73, 78-84] More studies are required to elucidate whether these devices are on par with the ILMA. Use of other SGAs (including the i-gel, ProSeal, etc.) may require an intermediate step, such as the use of an Aintree catheter.[28-32, 34, 35, 39, 50, 54, 85-92]

Intubating laryngeal masks have also been equipped with video capabilities to allow intubation though the SGA under indirect video laryngoscopy. The first device with this ability was the LMA-CTrach, a modification of the LMA-Fastrach which included a fibreoptic bundle and video display. Despite promising results, this device was withdrawn from the market.[59, 74, 93-105] Recently, the TotalTrack VLM has been introduced. This device feature a disposable intubating laryngeal mask coupled with a reusable video camera and display. Three clinical trials have been completed and are in press. The results of the first clinical trial by a South African group show success rates and efficacy rivalling that of the ILMA and CTrach, but further study is required.[106]

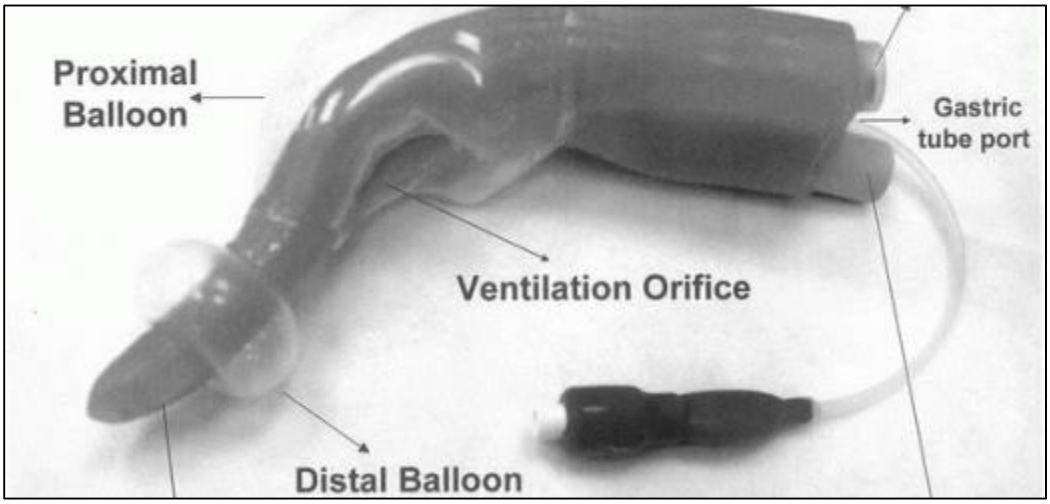


6. Intubating supraglottic airways. A: 3gLM and Parker Flex-Tip ETT B: LMA-Fastrach and proprietary silicne wire-reinforced ETT C: TotalTrack VLM D: Video image through TotalTrack VLM

Three SGAs falling into the proposed 3rd generation have been announced but are not yet in regular clinical use: the Elisha, Baska, and 3gLM.[22, 107, 108] All are designed to facilitate blind intubation through the device, allow gastric drainage, and have ‘self-energising’ seal, where the act of delivery of positive pressure ventilation causes a dynamic increase in sealing pressure. The 3gLM is also designed with multiple mechanisms to prevent aspiration.[83] The Elisha are described in one preliminary trial each,[108, 109] and while two publications on the 3gLM are in press (*author’s data*), results released in conference presentations elucidate SGA function approaching that of the LMA-Proseal, with a good success rates for blind intubation as described.



7. Air-Q Intubating Laryngeal Mask. Image from http://cookgas.com/index.php/products-newer-older-air-q-blocker/



8. Elisha Airway Device. Source: http://anestesiar.org/WP/uploads/2014/02/Elisha-520x245.gif

9. Baska Airway. Source: http://www.device.com.au/wp-content/themes/custom/js/timthumb.php?src=http://www.device.com.au/wp-content/uploads/2013/03/baska_mask.jpg&w=460&h=345

Surgical airways

The NAP4 audit yielded thought-provoking data regarding surgical airways. The majority of surgical access to the airway performed by anaesthetists was by cricothyroidotomy, but this failed in 65% of attempts.[24] Interestingly, the majority of failed attempts were needle cricothyroidotomy. Where surgical cricothyroidotomy was perfomed, the success rate was much higher. Admittedly, a large portion of the surgical cricothyroidotomies were performed by surgeons already in the operating theatre, but the data lends to the hypothesis that an open surgical technique is more successful in any hands than a needle technique.

Certainly, the current paradigm is that surgical airway access should be performed with a bimanual, tactile, “scalpel, finger, bougie” technique, whereby access to the trachea is confirmed by palpation with the little finger before a bougie and thereafter an endotracheal tube is inserted.

Resources

Links to most of the above content, a large collection of open-access airway material and the latest version of these notes can be found at www.openairway.org

The references (listed below) are available on request from ross@wildmedix.com

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