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EDITORIAL

Features of new vision-incorporated third-generation video laryngeal mask airways

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Abstract

Numerous studies have shown that blindly inserted supraglottic airway devices (SADs) are sub-optimally placed in 50 to 80% of all cases. Placement under direct vision has been recommended. We describe the very first two new SADs of the third generation that incorporate a videoscope with flexible tip. Both devices are made up of two interlocking components—the SAD and a videoscope. The 3rd generation, direct vision SADs allow vision-guided insertion, corrective manoeuvres, if needed, and correct placement in the hypopharynx and possess additional features which permit insertion of a gastric tube and endotracheal intubation should the need arise. This article describes the two new devices' physical characteristics, features, rationale for use, advantages and limitations in comparison to existing devices. Each of the two new devices—the Video Laryngeal Mask (VLM^{TM}, UE Medical®) and the SafeLM® Video Laryngeal Mask System (SafeLM^{TM} VLMS, Magill Medical Technology®) consist of two parts: (a) a disposable 2nd generation SAD with a silicone cuff and an anatomically curved tube; and (b) a reusable patient-isolated videoscope and monitoring screen, with the flexible scope located into a specially-designed, blind-end channel terminating in the bowl of the SAD, preventing the videoscope from contacting patient body fluids in the SAD bowl. Third generation placement-under-direct-vision supraglottic airway devices possess several theoretical safety and ease of use advantages which now need to be validated in clinical use.

Keywords Anaesthesia · Airway management · Supraglottic airway device · Videolaryngoscope · Complications

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1 Introduction

Over two billion patients have undergone general anaesthesia with a supraglottic airway device (SAD) since Archie Brain first described the *Laryngeal Mask Airway* (LMA) [1, 2]. The SAD now commands a larger global market share than tracheal tubes (TTs) and is considered easier to insert with less complications. Indications for perioperative uses of SAD/LMA have significantly increased to include pre-hospital, emergency, obstetric and intensive care applications [3]. SAD has now an established role in the difficult airway algorithms and resuscitation guidelines as a rescue airway device to 'buy time' or as a device that acts as a conduit in guiding the TT into the trachea [4, 5].

Modifications and improvements to the original first generation SADs resulted in second generation dual-channel models incorporating separate ventilation and gastric access tubes as well as an anatomically curved feature, bite block and slant distal opening in the reinforced tip section of the distal cuff allowing a more compact fit into the oesophageal

introitus thereby producing a higher oropharyngeal leak pressure (OPLP) compared to 'ventilation tube-only' SADs [6, 7]. Larger diameter breathing and gastric drain tube channels allow insertion of wider-bore TTs and larger gastric tubes as well as facilitating upper gastrointestinal endoscopy.

Now, for the first time, we describe in this editorial, two early examples of a true 3rd-generation comprehensive, multifunction supraglottic airway device, incorporating most of features of 2nd-generation SADs with an additional lockable videoscope which can be unclipped after successful insertion (Fig. 1).

2 Supraglottic airways remain valuable first-line airway devices despite blind insertion resulting in sub-optimal positioning

All SADs currently have one thing in common: they are inserted blindly, based on an educated guess regarding their correct placement, appropriate size and insertion depth which rely on commonly-used, often-inaccurate indirect assessment and clinical tests [3]. SADs have proved to be forgiving devices despite common non-perfect placement but, occasionally, result in more serious misadventure and poor clinical outcome. Most clinicians hope and trust that in daily practice, cuff inflation with a standard volume or pressure and/or manual palpation of the cuff will, by default, achieve near-perfect placement of the SAD allowing adequate and safe gas exchange and affording protection against gastric aspiration in all patients irrespective of difficult airway. Once a 2nd generation SAD is in place, the golden standard is to check OPLP after the cuff is inflated to 40–60 cm H_2O [8]. The position of the SAD can be further evaluated using a fibreoptic scope.

It is increasingly recognised that observations of thorax excursions, manual palpation of the cuff, listening to the disappearance of an audible air leak after injection of a standard volume of air into the cuff, indirect subjective observational tests (suprasternal notch test, bubble test, audible noise detection at the mouth) or measurements of cuff pressure and OPLP are not enough to confirm adequate positioning of SAD [8]. The realisation that there are so many indirect tests to achieve best placement is itself evidence that none of these tests are, in isolation or in simple combinations, foolproof evidence of correct position. Fibreoptic evaluation, after placement of the SAD, helps to confirm malpositioning but, virtually invariably, this process does not allow corrective manoeuvres to bring the device into an optimal position.

Numerous studies have consistently shown that 50–80% of all blindly-inserted 1st and 2nd generation devices SADs (irrespective of type, brand, size and cuffed or non-cuffed design) are placed sub-optimally in the hypopharynx [3, 9, 10]. There is overwhelming evidence of suboptimal

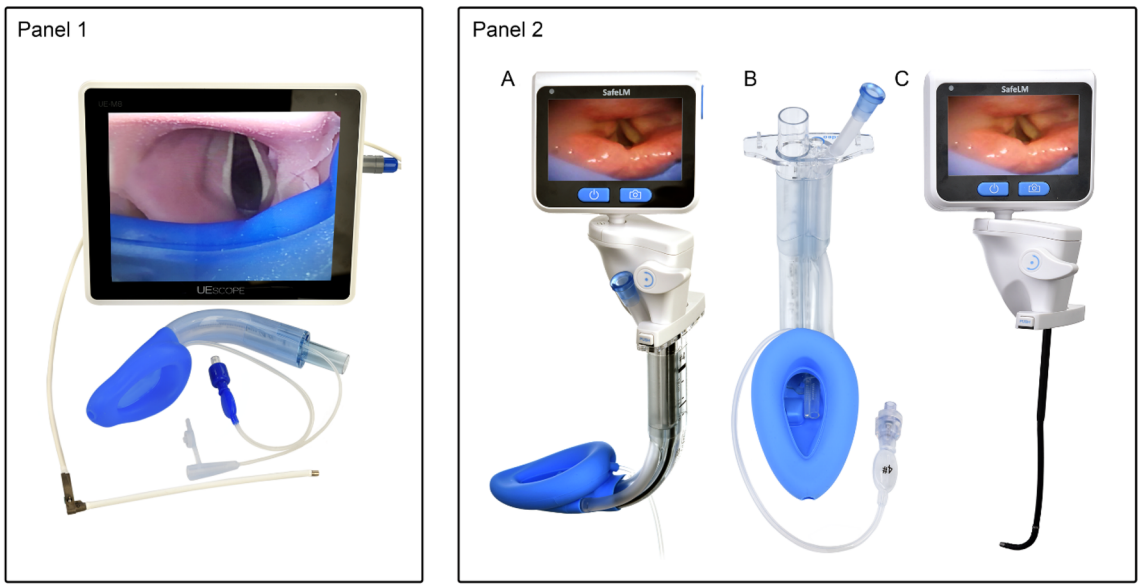

Fig. 1 Shows two video laryngeal masks combining a 2nd generation laryngeal mask and a videoscope that is inserted into the tube of the laryngeal mask. The UE Medical VLM® device (left) shows the monitor screen, the laryngeal mask and the videoscope. The SafeLM® Video Laryngeal Mask System (VLMS) on the right shows: **A** Assembled SafeLM® VLMS; **B** Disassembled SafeLM® VLMS with laryngeal mask, showing camera and light source arising at bowl, with at the top three orifices for channels (airway tube; videoscope tube and gastric drainage channel); and **C** Monitor screen attached to flexible videoscope via the control body. The camera angle adjusting handle enables the digital tip of the flexible videoscope to move the tip in a 140° range, featuring a complete view of the glottis. Monitor screen and LMA are connected with the locking latch on connecting base with release buttons on each side

positioning demonstrated by clinical observation [11–13], radiographic imaging (CT-scan, MRI, X-rays), fibreoptic studies and ultrasound [14–20]. Suboptimal positioning, potentially, may compromise safety which includes: (a) epiglottis downfolding within the bowl of the device (up to 80% of cases); (b) epiglottis folding double; (c) floppy distal cuff folding backwards, not positioned across the entrance of the oesophagus; (d) distal cuff touching the vocal cords; (e) cuff folding (especially in PVC material cuffs) potentially creating gaps and airway leaks; (f) incorrect insertion depth of SAD; and g) use of an incorrect size or incorrect cuff inflation [3, 9, 10]. Sub-optimally placed SADs may result in potentially poor airway seal, airway leak and obstruction, 'loss' of airway and potential for regurgitation, gastric aspiration or airway trauma. Although a fibreoptic scope may reveal a suboptimal positioning and is strongly recommended, adverse evaluation does not necessarily allow, per se, for correction. The value of OPLP and intracuff pressure is dubious if the SAD is not already in optimal position in the hypopharynx [8].

Clinical signs of incorrect positioning of SADs include [9, 10]: (a) resistance to device insertion in the hypopharynx; (b) dislodgement during cuff insufflation; (c) malalignment of bite block with upper incisors; (d) poor oropharyngeal airway seal (1st seal) increasing the risk of ineffective gas exchange; (e) poor oesophageal seal (2nd seal) increasing the risk of gastric insufflation and subsequent aspiration; (f) inability to insert a gastric drain tube; (g) clinically inadequate ventilation (insufficient tidal volume, poor capnography trace, air leak, airway obstruction); and (h) gas leak and/or airway obstruction and low values for OPLP, intracuff pressure and oxygen saturation. Reported complications resulting from suboptimally positioned SADs are airway or tissue trauma, potential nerve injuries and difficulty advancing the tracheal tube when using the device as an intubation conduit. These issues are more frequent if the SAD is used inappropriately as first-line airway of choice in a patient with a known or predicted difficult airway. Such patients will have some anatomical deviation or variation from the norm making the airway difficult and anatomic fit more likely to be imperfect. This does not of course preclude use of SAD as a rescue device where planned intubation has failed.

3 Optimal anatomical fit for SADs leads to better function

From an anatomical point of view, an adequately-sized SAD sits optimally if: (a) the distal tip of the distal (2nd) cuff seals the entrance to the oesophagus, while the proximal (1st) cuff occupies the hypopharynx; and (b) the epiglottis sits exterior to the device and is flattened between the posterior surface of the tongue and the anterior surface of the proximal cuff of the SAD, while (c) the tip of the epiglottis is aligned with the rim of the proximal cuff, providing evidence of the use of a correct size and correct cuff inflation [9, 10]. A correctly-sized, optimally-positioned SAD results in two competent seals, protecting the respiratory (1st seal) and gastrointestinal (2nd seal) tracts.

Videolaryngoscopy (VLS) can reveal virtually all malpositions. A flow-chart published by the authors, demonstrates how the vision-guided 'insert-detect-correct-as-you-go' technique allows manoeuvres to immediately correct any malposition [10, 13, 21]. The use of a videolaryngoscope not only allows clinicians to document these malpositions but clearly demonstrates if there is a need to change either the size or type of SAD when optimal position cannot be obtained.

Our previous research demonstrated that an exact position of SADs is the primary goal, with correct values for intracuff pressure (I-CP) and OPLP as secondary target endpoints. I-CP and OPLP have no value if the device is sitting incorrectly. Van Zundert et al. demonstrated that the vision-guided insertion technique could achieve quasi-100% perfect position of an SAD [21]. Even non-cuffed SADs can be positioned adequately using VLS, although there is a small risk of an air leak if there is a gap around the glottis.

Our previous research hypothesised and mooted the idea of a third-generation of direct-vision SADs which would include a videolaryngoscope with an array of cameras and light sources, allowing insertion of the SAD under direct vision [3]. In this theoretical research, we provided evidence, for the first time, of such direct-vision SADs becoming worthy of the moniker 'third generation'.

4 New 3rd generation SADs with incorporated videoscope

Our theoretical research published earlier in this esteemed journal[3] has now resulted in the production of two videolaryngeal masks, i.e., the Video Laryngeal Mask (VLM™, UE Medical®, Zhejiang, China) and the SafeLM® Video Laryngeal Mask System (SafeLM™ VLMS, Magill Medical Technology Co Ltd®, Changsha, China). Both these video laryngeal masks are CE marked and are also available in China for use on patients. As far as we know, applications for their uses in Europe, UK, USA, and Australia are ongoing.

Both systems offer a 2nd-generation SAD fitted with an integral videoscope, which combines the advantages of an integrated videolaryngoscope incorporated into a 2nd-generation SAD (Fig. 1). Table 1 lists the physical characteristics of the two devices, which show many similarities. Both the SAD and the videoscope are inserted 'in-one-go'. Both devices come with a silicone-cuffed SAD, similar to an LMA-Protector™ (Teleflex®, Wayne, PA, USA), and an

Table 1 List of physical characteristics and specifications two vision-incorporated 3rd generation video laryngeal mask airway

Specification	Video laryngeal mask (VLM)	SafeLM® Video Laryngeal Mask System
Manufacturer		
• Name	• UE Medical	• Magill Medical Technology Co Ltd
• Address	• Zhejiang UE Medical Corp, China	• Changsha, China
• Website	• www.ueworld.com	• www.magillmed.com
Indication for use as airway device (vision-guided)		
• Routine anaesthetic procedures	• Yes	• Yes
• Rescue of airway device for CPR	• Yes	• Yes
• Rescue device in case of difficult airways	• Yes	• Yes
Laryngeal mask		
• Available sizes, based on weight (kg)	• Single use	• Single use
• Material cuff	• 3 (30–50); 4 (50–70); 5 (70–100 kg)	• 3 (30–50); 4 (50–70); 5 (70–100 kg)
• Material tube	• Medical-grade silicone	• Medical-grade silicone
• Material pilot cuff	• Medical-grade silicone	• Polyvinyl chloride
	• Medical-grade silicone	• Medical-grade silicone
Laryngeal mask channels		
• Functional separation	• Yes	• Yes
• Visual tube channel for videoscope, n	• 1 (closed-tip channel dead end)	• 1 (closed-tip channel dead end)
• Ventilation airway channel, n	• 1, anatomically curved	• 1, anatomically curved
• Distal end slope to facilitate TT insertion	• Yes (in bowl of device)	• Yes (in bowl of device)
• Gastric tube channel, n	• 1	• 1
• Tracheal tube channel, n	• 1 (same as ventilation channel)	• 1 (same as ventilation channel)
• Position of orifices	- Middle	- Middle
- Airway tube	- On the left side of device	- On the left side of device
- Gastric tube	- Via airway channel	- Via airway channel
- Tracheal tube		
Laryngeal mask distal drainage orifice		
• Position	• In the middle of the distal cuff	• In the middle of the distal cuff
• Design	• Elongated cuff 10°slant	• Elongated cuff 10°slant
• Drainage chamber behind cuff bowl	• No	• No
Laryngeal mask design		
• Cuff (enlarged air-inflatable high airway seal)	• Yes	• Yes
• Distal tip	• Reinforced	• Reinforced
• Airway tube—flexible-curved	• Yes, flexible	• No, rigid
• Airway tube—anatomically shaped oval tube	• Yes	• Yes
• Cross-section airway	• Elliptical	• Elliptical
• Mask aperture bars	• None	• None
Supraglottic airway devices extra features		
• Colour of cuff/tube	• Blue/transparent	• Blue/transparent
• Guiding handle/fixation tab	• None	• None
• Built-in bite block	• Yes	• Yes
• Minimal interdental gap for insertion (mm)	• Yes, relative to upper teeth (cm)	• Yes, relative to upper teeth (cm)
• Indicator on tube of insertion depth	• Yes	• Yes
• 15 mm connector, fixed or detachable	• Detachable	• Fixed
• Phthalates (DHEP) free	• Yes	• Yes
• Inflation valve, Lüer cone, ISO 594-1	• Yes	• Yes
• Cuff pilot inflation line	• Yes, separate cuff pilot balloon	• Yes, separate cuff pilot balloon
• Cleaning line	• For suction, extra oxygen???	• No
• Maximum cuff pressure (cm H_2O)	• 60	• 60
• MRI imaging	• MR compatible	• MR conditional (metal spring)
Laryngeal Mask as intubation conduit		
• Maximum size of tracheal tube (mm)	• Size 3 (7.0); size 4 (7.5); size 5 (8.0)	• Size 3 (6.5); size 4 (7.0); size 5 (7.0)
• Maximum size for gastric tube (Fr)	• 16 Fr (all sizes)	• 14 Fr (all sizes)
Videoscope		

Table 1 (continued)

Specification	Video laryngeal mask (VLM)	SafeLM® Video Laryngeal Mask System
• Flexible tip	• Reusable	• Reusable
• Camera	• Yes	• Yes
• Specific videoscope dead end channel	• Separate (together with light source)	• Separate (together with light source)
• Connection to LMA	• Yes	• Yes
	• Yes, clipped to airway tube	• Yes, locking orifice on control body
Videoscope monitor		
• Dimensions monitor screen	• 20 × 16 cm – 8" touch colour LCD	• 8.5 × 7.42 cm – 3" IPS LCD colour
• Resolution (pixels)	• 1024 × 768	• 800 × 480
• Rotation of display screen	• N/A (separate from laryngeal mask)	• Yes, 90° (lateral)–270° (vertical axis)
• Powered and/or battery use	• Both, power button, charging indicator	• Both, power button, charging indicator
• Image capture	- Yes	- Yes
- Still images/video clips	- > 3 h	- 8 h recording time
- Working hours videoscope	- 32 GB	- 16 GB
- Storage (SD card)	- Yes	- Yes
- USB port		
Control body		
• Locking latch on connecting base	• N/A	• Yes
• Camera angle adjusting handle	• N/A	• Yes, >140° (vertical axis)
• Illumination orifice	• N/A	• Yes
• Release buttons	• N/A	• Yes (2 buttons)

anatomically-curved airway tube for patient comfort, reducing sore throat and increasing manoeuvrability of the device to allow accurate placement.

Miniaturisation has facilitated the new devices' ability to put into practice, in real-time and on a routine basis using our vision-guided 'insert-detect-correct-as-you-go' insertion technique, to visualise whether the SAD results in a correct position, whether the device used is the correct size, and whether any correcting manoeuvres or adjustments of size are needed to provide an optimally placed device. The vision-guided technique allows clinicians to observe the cuff's seal when apposed to supraglottic structures, to prevent downfolding of the epiglottis and to avoid air leakage and airway obstruction. It further allows, again, under direct vision, the insertion of a TT via the ventilation tube using the LMA directly as the intubation conduit.

Both video-laryngeal mask devices—VLM™ and SafeLM™ VLMS—consist of a reusable videoscope which can be inserted into a dedicated videoscope channel of the SAD with a channel dead-end (blind, closed tip) that appears in the bowl of the SAD, completely sealing away the videoscope channel from the bowl, separating the videoscope from the oral content.

Thus far, direct vision-guided placement of SADs could be achieved using a videolaryngoscope, but insertion of both SAD and videolaryngoscope significantly curtails the space in the oral cavity; manoeuvring of device correctly into the oropharynx could become limited. While placement is far more accurate, it makes insertion of the SAD more complex, time-consuming and introduces competition for space in the oral cavity. With these new devices, there is no competition for space, as the videoscope is located within the SAD itself.

Both devices consist of a reusable videoscope attached to a disposable SAD with a clicking lock mechanism (Fig. 1). The videoscope of the VLM® is clipped to the airway tube and connected to a separate monitor via a cable. In the SafeLM® VLMS, both the SAD and the videoscope are clipped together with a unique secure matching connection, confirmed by an audible 'click sound' which indicates that the two components are secured into position, producing one single robust device consisting of a monitor screen, the control body of the videoscope, the connecting base and the SAD. The locking orifice on the videoscope will automatically snap and be secured to the locking latch on the SAD. After use, the videoscope can be unlocked from the SAD by pressing the release buttons on both sides of the connecting base.

Whereas the videoscope of the VLM® is connected by wire to a large videoscope monitor (20 × 16 cm, resolution 1024 × 768 pixels), the videoscope of the SafeLM® version boasts a C-connector to an adjustable hi-res LCD monitor colour screen (7.42 cm diagonal display screen, resolution 800 × 480 pixels). The rotation angle of the SafeLM® display screen is 90° along its lateral axis and 270° along its vertical axis. This feature is not available in the VLM® device. Both devices have a sloping distal end in the bowl of the SAD to guide the tracheal tube to the glottis. However, whereas the VLM® does not allow the tip to be adjusted, the SafeLM® system comes with a camera angle adjusting handle that allows to see under direct

vision up to 140° angle of view of the oropharynx and larynx and helps to navigate the SAD and, if needed, the tracheal tube into position. On the upper left corner of the SafeLM® display panel is an indicator of battery charging (red indicates battery is charging, green indicates charging is complete). A 2000mAh internal rechargeable lithium battery can be fully charged in ± 2 h using an external power source. With the aim of battery conservation, it is wise to power off the videoscope after its removal from the LM. The left button underneath the monitor screen is the power 'on/off' button of the videoscope.

The SafeLM® monitor has facility for entering a time setting and to allow for video or image capture for entry into the anaesthesia record or for teaching and research purposes. Once the videoscope is turned on, the video system allows snap shots (still images) by pressing the right button on the monitor screen and automatically start circular videorecording up to 8 h long, using the in-built 16 GB SD card. By connecting the SafeLM® to a laptop computer using a USB cable, the recordings (video and still images) can be stored to memory card, disk or folder and reproduction for a permanent record of secure LMA positioning. Also, the VLM® comes with an image capture feature. Still images and video recordings are possible using either a button on the visual system app of the 8″ monitor or a short/long press on the adapt cable.

Once the SAD is correctly positioned and evaluated for correct size, the videoscope-release button(s) separate the videoscope from the SAD and the videoscope can be removed. Subsequently, the SAD can be used as any other airway device. During retrieval of the videoscope, the camera angulation handle of the SafeLM® should not be manipulated as this may damage the flexible tip or the soft casing of the video channel of the videoscope. The videoscope of both systems is cleaned and disinfected according to the manufacturer's instructions and local regulations. Autoclaving, flushing or soaking in liquid is contraindicated as steam or liquid may leak into the device and may cause damage. Processing technology is used to treat the window material protecting the videoscope in situ as an anti-fog design feature. Only the VLM® comes with a cleaning line for suction of saliva or blood.

The new integrated device (SAD with videoscope) is easy to set up, assemble, operate, move in and out the pharynx and to separate components from each other. The vision-guided 'insert-detect-correct-as-you-go' technique allows correct placement of the SAD in the hypopharynx, checking its correct position as well as ascertaining that the correct size has been used. The videoscope not only assists with SAD placement, but it also allows for visual inspection of the supraglottic area beneath the LM cuff during insertion and for position adjustment and correction where needed. It also functions as an intubation guide to insert a TT under direct vision and checks for and documents, during extubation, any trauma to the oropharynx and larynx.

Both devices, the Video Laryngeal Mask and the SafeLM® Video Laryngeal Mask System, come in three 'standard' sizes (3, 4, 5) which allows insertion of TT sizes 6.5, 7.0, 7.5 mm and gastric tube size 16 Fr for VLM® and 14 Fr for SafeLM® for all sizes.

These devices eliminate the need for a separate (standalone), expensive (capital cost) and more cumbersome fibreoptic scope. Once the video component is removed, the SAD functions like a 2nd-generation SAD, ready for connection to the ventilator with oxygen supply or allowing spontaneous breathing. The device can be used in normal and difficult airways and in emergency situations.

5 Other SADs with integrated videoscope

Thus far, two vision-guided intubation systems have been manufactured that use SAD as an intubation guide, i.e., LMA-C Trach/ LMA-Fastrach™ (Teleflex®) and TotalTrack VLM™ (Medcom Flow®, Viladecans, Barcelona, Spain). Both systems offer an integrated videoscope using a fixed tube and a fixed view angle (creating a black spot analogous to technology of a motor car mirror). These devices were developed to allow visual insertion of the TT but were not designed to guide the SAD in situ. The monitor screen is attached after the insertion of the SAD (LMA-C Trach) or is an integral part of the system (TotalTrack VLM). Both systems allow simultaneous ventilation and intubation under direct vision but lack the adaptability to the pharyngeal dimensions of the patient's anatomy. A recent study using the TotalTrack VLM on 300 patients showed glottic visualisation in 83% and first attempt successful intubation in 85% of the studied patient [22]. However no studies are available that compare this device with other SADs. Since the introduction of the videolaryngoscope, the LMA-C Trach has been discontinued.

6 Advantages and limitations of the novel integrated SAD-videoscope systems

Potentially, the main advantages of the new airway devices we describe are: (a) simple and routine insertion like any other SAD but with visualised insertion across the airway; (b) fine control manoeuvres if malpositioning is detected; (c) secure optimal gas exchange instead of acceptance of 'good enough' or 'best achievable'; (d) reduction in the extra space needed and increased complexity to the operator when the videolaryngoscope is inserted into the oropharynx external to an SAD; (e) avoidance of damage to crowded airways); (f) intubation through the SAD of a TT

under direct vision; (g) recording facility into the patient anaesthesia record of correct placement of the SAD and anatomical airway and vocal cord aberrations, lesions or disease; (h) ensuring that oro-pharyngeal leak pressure (OPLP) pressure recordings are unaffected by spurious inaccuracy because of minor or gross SAD misalignment or malposition; and (i) reuse of the videoscope of the device.

Compared to the current blind technique of insertion of SADs, the vision-guided insertion using video laryngeal masks allows fine control manoeuvres using the flexible tip of the videoscope, to navigate the airway device in the correct position securing optimal gas exchange.

While we envisage that, in the medium-term future, potentially all SAD insertions will be under direct vision, many improvements can still be made: e.g., (a) manufacture entirely out of medical silicone to reduce airway trauma and postoperative sore throat; and (b) adoption of a universal, uniform VLS connecting base or VLS-SAD adaptor so that the other SAD brands can be connected in a universal way to the videoscope which would increase safety especially in an emergency.

Potential disadvantages of the VLM® include: (a) continuous intraoperative monitoring of the SAD in situ is not possible; (b) the tip of the flexible videoscope is not adjustable; (c) the VLM® device needs further investigation into whether the device allows oxygenation/ventilation during SAD insertion; and (d) whether a universal system exists that allows the insertion of a videoscope in all brands of SADs. Potential disadvantages of the SafeLM® VLMS include: (a) continuous intraoperative monitoring of the SAD in situ is not possible; (b) the LCD screen monitor could be improved further using a HD camera version; (c) the angle of TT guidance slide (angulation handle) needs to be carefully checked before final insertion of the TT into the trachea; (d) a waterproof sealed device would be preferable; (e) SafeLM® needs further investigation into whether the device allows oxygenation/ventilation during SAD insertion; and (f) matching the videoscope to the LM on the locking latch of the connecting base is specific for the SafeLM® VLMS. Current videolaryngoscopes do not specifically fit other brands of SADs. We envisage the production of a universal connector between videolaryngoscope and SAD which would further promote the use of the vision-guided insertion technique. Cost analysis will enable users to make a balanced financial decision as to when to use the video-laryngeal mask. Inclusion of 'black spot' technology is to be recommended and encouraged on future devices. The authors expect that only full clinical studies will fully elucidate these advantages and shortcomings. Clearly, the next step is acquisition of clinical data to verify these devices' efficacy.

7 Conclusions

Anaesthetists aspire to improve the quality of SAD insertion conditions, aim for an optimally positioned SAD and to avoid misplaced and failed SADs. These goals can be achieved by inserting SAD devices under direct vision. The development of these new airway devices meets the theoretical criteria we have described and are good examples of how innovation can usefully follow theory. While it is perhaps premature to conclude that the VLM® and the SafeLM® video-laryngeal masks will be clinically more effective, we firmly believe that other manufacturers will follow suit to make further improvements regarding reliability and safety and that the innovations will be driven by our earlier description of 3rd generation SADs. Ultimate assimilation or uptake of a device is a balance between efficacy, safety, user preference and cost. The next step is to gather evidence by rigorous testing of the devices in simulators and airway manikins. Favourable outcomes from simulator study would prompt to use this device in real patients for its clinical effectiveness, usability and safety. We believe that the anaesthetic community will embrace these emerging technologies and further demonstrate whether these devices truly circumvent unwanted malpositioning. The authors hope that blind insertion of SADs will eventually become the exception rather than the rule and that vision-guided placement will, one day, become the gold standard. SADs placed blindly are already considered forgiving devices when it comes to suboptimal placement albeit with increased risk of airway complications. Our patients rely heavily on us, the experts in airway management, to avoid complication and reduce risk. The ideal solution to avoiding malpositioning is continuous improvement towards a family of 3rd generation, all-in-one, vision-guided SAD-videoscope devices used as the norm within the scope of anaesthesia practice.

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Declarations

Conflict of interest AVZ is a Council Member of the Australian and New Zealand College of Anaesthetists Research Committee; JJP is the Chair of the Safe Anaesthesia Liaison Group, Royal College of Anaesthetists. The views expressed in this article are personal and not of that organisation; The authors have no conflict of interests in relation to the device being discussed.

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