Chapter 3
Videolaryngoscopy and Indirect Intubating Aids in Airway Management

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Abstract The use of videolaryngoscopy has been incorporated into the latest revised 2013 American Society of Anesthesiologists Difficult Airway Algorithm, not only as a rescue device, but also as an initial approach to intubation. This chapter provides an overview of some popular videolaryngoscopes and indirect intubating aids which a body of evidence in the literature supports. We outline how videolaryngoscopy differs from direct laryngoscopy, the advantages and disadvantages, tips on how to improve the success of intubation, and how to document when using a videolaryngoscope. The individual characteristics of the Glidescope, CMAC, Pentax Airway Scope, McGrath MAC and McGrath series 5, Airtraq, King Vision, Venner AP Advance, intubating LMA Fastrach and C-Trach, Bonfils, Shikani, Levitan optical stylets are further expounded, with instruction and clinical tips for usage. Their clinical efficacy in the literature, problems and complications, and keypoints are summarized.

Keywords Videolaryngoscopy · Intubating aids · Difficult airway

Introduction

The aim of this chapter is to provide an introduction to some selected videolaryngoscopes (VLs) and indirect intubating aids which a body of evidence in the literature supports. Their clinical efficacy in the literature is summarized. A simple

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classification of videolaryngoscopes and indirect intubating aids is shown in Table 3.1.

The use of videolaryngoscopy and indirect intubating aids has increased tremendously not least due to the dire consequences of failed airway management [1, 2]. Instead of performing potentially traumatic maneuvers to directly visualize the larynx via direct laryngoscopy, videolaryngoscopy uses newer technology to 'look around the corner'. Indirect laryngoscopy refers to a technique where the view of the glottis is achieved through a series of cameras, video technology, fiberoptics or prisms transmitted to an eyepiece or monitor screen. It has been incorporated in the latest revised 2013 American Society of Anesthesiologists difficult airway algorithm not only as a rescue device, but also as an initial approach to intubation [3].

Systematic reviews have shown good evidence that the Airtraq®, Laryngeal Mask Airway (LMA) CTrach®, GlideScope®, Pentax AWS® and Storz V-MAC® achieve better success in subjects at a higher risk of difficult laryngoscopy [4]. Beyond achieving the primary aim of improved intubation success, videolaryngoscopy allows more gentle handing of the airway, thereby decreasing the chance of dental and airway trauma as well as reducing cardiovascular responses to airway stimulation in experienced hands. Ancillary advantages include facilitating airway training, video recording of airway management and potentially allowing telemedicine or tele-intubation. The benefits of videolaryngoscopy and indirect intubating aids are presented in Table 3.2.

Intubation Using the Conventional Macintosh Blade

In order to perform intubation successfully with direct laryngoscopy, one needs to create a line of sight for the operator to visualize the glottis directly. This necessitates placing the patient in an appropriate position before direct laryngoscopy to anteriorly displace the mandible, tongue and other soft tissue. This also clears the path for subsequent endotracheal tube (ETT) entry. This potentially stressful maneuver may result in oral and dental trauma or haemodynamic instability. In patients with limitations in cervical mobility or mouth opening, the line of sight may not be achievable, resulting in poor laryngeal views, difficult or impossible intubation [6].

Intubation Using Videolaryngoscopes

Videolaryngoscopes, on the other hand, have a camera located at the distal third of blade which allows the operator to 'see around the corner' without forcefully achieving the line of sight. Although this avoids the complications of direct laryngoscopy, introduction of the ETT into the trachea may be more difficult as soft tissue is not displaced in the fashion as when classic direct laryngoscopy was

Table 3.1 Classification of videolaryngoscope and indirect intubating aids

Classification	Characteristics	Examples
Macintosh-like videolaryngoscopes. May consists of	(i) The basic design resembles the Macintosh laryngoscope. They may be doubly used for direct laryngoscopy if the video technology was incorporated into the Macintosh-shaped blade	(i) Storz V-MAC®, Storz C-MAC®, McGrath MAC®, Venner AP Advance®
(i) Macintosh blade or		
(ii) Angulated blade	(ii) Angulated blade permits only indirect visualization of the glottis and requires a styletted pre-shaped tracheal tube	(ii) Glidescope®, McGrath series 5®, Storz D-Blade®
Optical or video devices with guiding channels	Not resembling the Macintosh laryngoscope, these devices have guiding channels that guide the tracheal tube into the trachea	Pentax Airway Scope (AWS)®, Airtraq®, KingVision®
Intubating supraglottic devices	These are laryngeal mask airways that serve the dual functions of ventilation as well as intubation, which may be blind (Fastrach®), visually guided (C-Trach®) or guided with a flexible videoscope, e.g. Ascope® (through an AMBU Aura-i®)	LMA Fastrach®, LMA C-Trach®, AMBU Aura-i®
Fiberoptic scopes and optical stylets	These are fiberoptic scopes, which may be flexible or rigid. The rigid scopes are further classified into the malleable or non-malleable types	Rigid Bonfils®, Shikani®, Levitan®
Invasive intubation devices	These devices would include devices for retrograde intubation, or cricothyroidotomy. They are generally used for second line rescue airway management as they are more invasive and potentially cause more morbidity. They are not discussed further in this chapter	

Table 3.2 Advantages and disadvantages of videolaryngoscopes and related intubating aids intubating aids

Advantages
–Greater angle of view and improved laryngeal grade
–Preliminary data suggests improved intubation success, particularly in predicted difficult and difficult intubations and those performed by novices
–Portable and suitable for rugged pre-hospital use
–Intubation possible in unconventional positions
–Video stream of intubation process to facilitate training
–Image recording capability allowing documentation or education
–Video-conferencing and 'tele-intubation'
–Single use which minimizes cross contamination
–Potentially less dental and airway trauma
Disadvantages
–In routine airways: Improved view may not translate to better intubation success. Direct laryngoscopy remains the fastest and most cost effective way to achieve intubation [5]. Intubation times are generally longer with videolaryngoscope due to operator's unfamiliarity, visual attention in 2 different places (monitor and patient's pharynx) and difficulty in introducing the tracheal tube
–Videolaryngoscopes that do not feature Macintosh blades generally requires the use of a stylet, which may potentially increase traumatic complications
–Secretions or fogging which obscures the view
–Cost associated with purchase and maintenance of the device
–Not all devices may be locally available for training purpose

performed. For successful intubation using VL, two things need to occur: (i) optimal blade insertion to view the glottis, and (ii) optimal introduction of the ETT to the vocal cords. Videolaryngoscopes are designed for insertion into the upper airway to provide a glottic image either by one of two methods: (i) in the midline over the tongue; (ii) or along the floor of mouth with displacement of tongue and flattening of the submandibular space [7]. These two methods of laryngoscopy are rarely interchangeable between laryngscopes. A device that functions in the floor of the mouth displacing the tongue and compressing the submandibular tissues (e.g. VLs with Macintosh-like blades C-MAC, McGrath MAC, Venner AP Advance) should not be used over the tongue nor should a device that is designed to pass over the tongue (e.g. anterior angulated blades like Glidescope, McGrath series 5) be used along the floor of the mouth. Correct positioning is critical for successful function of these devices during laryngoscopy and intubation. The steps to achieving successful intubation with a videolarygoscope are summarized in Table 3.3.

Successful intubation with videolaryngoscopy generally requires the use of a preformed styleted ETT [8]. Not uncommonly, the tip of the ETT may be caught on the arytenoid cartilages, inter-arytenoid soft tissues, cricoid cartilage or the anterior commisure of the glottis. Some of the techniques used to improve the passage of the ETT through the vocal cords are summarized in Table 3.4. These problems may be less frequent with laryngoscopes that incorporate a guiding channel to direct the ETT path, such as the Pentax AWS the Airtraq and the King Vision's channeled blade.

Table 3.3 How to perform indirect laryngoscopy using the "mouth-screen-mouth-screen" and optimal blade insertion technique

Step 1	Look in the mouth: Introduce the videolaryngoscope (VL) into the mouth and advance it towards the base of the tongue, taking care to avoid lips and teeth
Step 2	Look at the screen/monitor: Optimise the position of the laryngoscope to obtain the best view of the glottis. Use midline approach for anterior angulated blades (e.g. Glidescope®, McGrath series 5® C-MAC D-Blade). Sweep tongue aside anterolaterally to flatten submandibular tissues as done in direct laryngoscopy if using Macintosh-like VLs (e.g. C-MAC 3,4 blades; McGrath MAC 3,4 blades; A.P.Advance 3, 4 blades) [7]
Step 3	Look in the mouth: Introduce the ETT close to the VL blade edge with care to keep the styletted tip in view at all times
Step 4	Look at the screen/monitor: Direct the ETT between the vocal cords to achieve intubation under visual guidance. As the videolaryngoscope is being withdrawn, examine for any inadvertent trauma caused during intubation

Table 3.4 Tips to improve intubation success with videolaryngoscopes

1. To improve glottic view
   a. Increase lifting force on VL handle
   b. Withdraw and reintroduce the blade (may have deviated from the midline whilst concentrating on screen)
   c. Apply external laryngeal pressure
2. To prevent fogging
   a. Use of anti-fog solution (eg. C-Trach®, Glidescope® reusable GVL, and on tip of disposable plastic blades eg. McGrath®, Pentax AWS®,Venner AP Advance®. The newer Glidescope® stat blades have a patented anti-fogging coating that minimises this need)
   b. Turn on VL 1–2 min prior to use (eg. C-MAC®'s own heating mechanism acts as anti-fog). If view fogs upon entering the patient's mouth (which is warmer), remove blade (to ambient air) and re-insert again, to de-mist
   c. Warm the blade prior to use to prevent fogging
3. To increase the ease of ETT passage between the vocal cords
   a. Relax the upward lifting force eg. lift less
   b. Withdraw the videolaryngoscope blade by 1–2 cm. This allows the glottis to relax into a more posterior position, meeting the tip of the ETT
   c. Use stylet with pronounced curve: 90° angle superior to 60° [9]
   d. Use a flexible tip ETT, eg. the Endoflex™ that's capable of distal angulation of tip [10, 11] (Fig. 3.1) or Styletscope™ which adjusts the angle of the ETT tip between 30–90°
   e. Withdraw the stylet slightly, about an inch, and rotate the ETT
   f. "Reverse-loading" of stylet in the opposite direction of the natural curvature of the tracheal tube [9, 12]

Predictive Test for Difficult Intubation Using Videolaryngoscopes

The predictive value of clinical bedside tests for predicting difficult intubation with direct laryngoscopy remains limited. Sensitivity is generally poor in detecting the difficult airway [13]. Factors such as operator experience with the device, patient's poor mandibular advancement, short sternothyroid distance, severe retrognathia as well as various neck pathologies such as post-radiation changes, scarring and masses may indicate possible difficult videolaryngoscopy [7, 14, 15]. One airway assessment tool, the El-Ganzouri index, shows promise when it is used for patients undergoing GlideScope intubation. It comprises seven variables that assesses mouth opening, thyromental distance, neck movement, jaw prognation, body weight, Mallampati score and history of difficult intubation to predict a likely difficult airway [16].

Glidescope®

Overview and Characteristics

The GlideScope® videolaryngoscope (Verathon Inc., Washington, USA) became commercially available in 2001 and is a widely used video laryngoscope. It comes with a 60 degree curved blade with various sizes to facilitate intubations in neonates as small as 1.8 kg and morbidly obese adults. There is a wide angle of view via the metal-oxide semiconductor camera and a light emitting diode (LED) located at the distal tip of the blade. The unit consists of a video monitor which has a resolution of 320 $\times$ 240 pixels. The device switches on with a single button, and the image does not require further adjustment. The 12 V lithium rechargeable battery has an average battery life of 90 min and approximately 500 charge cycles.

Other GlideScope models include the GlideScope advanced video laryngoscope (AVL) suited for difficult airways and comes with optional disposable blades (See Fig. 3.2a, b). The GlideScope® Ranger, designed for portability, also has digital video recording ability. The GlideScope® product range is presented in Table 3.5. The Glidescope Titanium range introduced in 2014 comprises four reusable blades (Macintosh size T3 and T4, and angulated LoPro T3 and T4 blades) which are lightweight, slim and low- profile designs. It promises improved maneuverability and working space in patient's mouths.

Instruction for Use

The GlideScope is first introduced into the midline of the oral pharynx to identify the epiglottis. The GlideScope may be used like a Macintosh laryngoscope to indirectly lift the epiglottis or produce a Miller's lift. After obtaining the best glottic view, the endotracheal tube (ETT), preformed with a generic stylet, or the GlideRite® Rigid Stylet is then guided into position alongside the blade under direct vision. It is only when the distal tip of the ETT disappears from direct view that the monitor is viewed. The tube is gently rotated or angled to redirect as needed and the stylet is removed prior to advancement of the tracheal tube past the vocal cords.

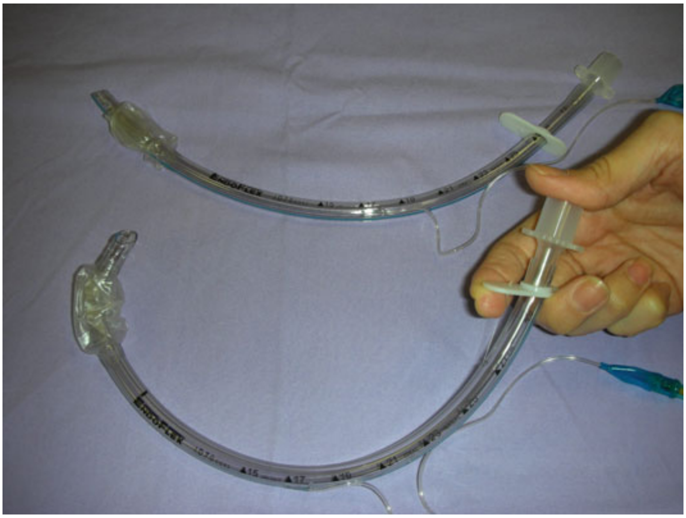

Fig. 3.1 Endoflex tracheal tube. The operator can flex its distal tip by engaging a monofilament built into the *side* of the tube as shown

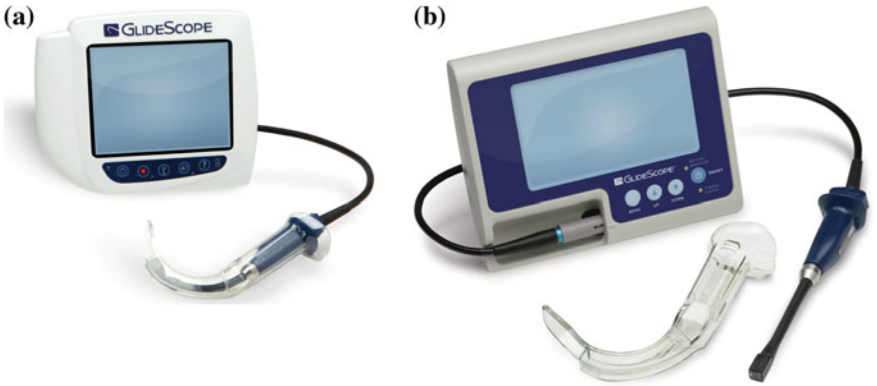

Fig. 3.2 **a** Glidescope Advanced Videolaryngoscopy (AVL) system with single use stat blades, **b** Glidescope GVL system with cobalt GVL stat blades

Clinical Performance

A meta-analysis of first time success intubation rates in 1,076 patients predicted to have a normal airway was 96.4 %, with an overall success rate of 99.8 %. In 213 patients with difficult airways, the first time success rate was 92.3 % with an overall success rate of 85.4 % [17]. Two meta-analyses of literature comparing the GlideScope with direct laryngoscopy found that there was definite improved

Table 3.5 Range of glidescope products

	Glidescope videolaryngoscope (GVL)	Glidescope advanced videolaryngoscope (AVL)			Glidescope ranger	
		Single use	Preterm/ small children	Reusable	Ranger	Single use
Suitable for patient weight	1.8 kg to morbidly obese	500 grams to morbidly obese	500 grams to 28 kg	4 kg to morbidly obese	10 kg to morbidly obese	500 grams to morbidly obese
Blade sizes (#)	GVL® 2, 3, 4, 5	GVL® Stat 0, 1, 2, 2.5, 3, 4	GVL® Stat 0, 1, 2, 2.5	GVL® 2, 3, 4, 5	Ranger® GVL 3, 4	GVL® Stat 0, 1, 2, 2.5, 3, 4
Monitor screen feature	Anti-reflective 7 inch colour monitor 320 × 240 pixel 167 × 207 × 83 mm Weight 1.4 kg	Anti-reflective 6.5 inch colour monitor 640 × 480 pixels 190 × 225 × 80 mm Weight 1 kg			Anti-reflective 3.5 inch colour monitor 320 × 240 pixel 168 × 173 × 49 mm Weight 0.56 kg	

glottic visualization, which was more pronounced in difficult intubations than routine intubations. Novice operators using the Glidescope experienced improved first intubation success rates and shorter intubation times compared to direct laryngoscopy [17, 18] but these findings were not found in experts [18].

Problems and Complications

Although the GlideScope provides an improved view when compared with direct laryngoscopy, this does not necessarily lead to better intubation success [19]. This paradox arises because the camera sited near the distal tip of the GlideScope blade acts as the 'eye' of the operator to obtain a wide angle of view. Superior, indirect view of the glottic can be achieved without the alignment of oral-pharyngeal-laryngeal axes and displacement of pharyngeal tissues to enlarge the retropharyngeal space. However, when tissues are not displaced to create the line of sight, as it is done during direct laryngoscopy (leading some users to perceive that the blade is "bulky" due to the limited oropharyngeal space) no direct path is made for the ETT advancement, In contrast, during direct laryngoscopy, intubation may be possible with adjuncts such as the bougie even in poor glottic view. Reported GlideScope-related injuries include palatopharyngeal, anterior tonsillar pillar or soft palate perforations caused by the tracheal tube, even without apparent force or difficulty during intubation [20]. The operator may be fixated on the monitor screen and fail to observe initial blade or ETT insertion, thus causing trauma.

Keypoints

The GlideScope comes with a wide rage of different models to suit different patient's sizes and needs. It is one of the most popular and researched videolaryngoscope currently on the market. Advancement of the ETT should only be done under direct vision or via the videocamera image to avoid inadvertently traumatizing the pharynx or larynx. The airway should also be examined as the blade is being removed.

McGrath®

Overview and Characteristics

McGrath® Series 5 (Aircraft Medical Limited, Edinburgh, United Kingdom) is a portable videolaryngoscope, weighing just 325 g. The CameraStick™ assembly consists of a light source and a miniature camera and the image is displayed on a

Fig. 3.3 **a** McGrath series 5 videolaryngoscope, **b** McGrath MAC videolaryngoscope

1.7-inch liquid crystal display (LCD) screen mounted on top of the laryngoscope handle. The LCD screen tilts and swivels through a 90° arc to allow the user to operate in a comfortable position whilst maintaining visual contact with the patient, the laryngoscope and during advancement of the ETT. The length of blade can be adjusted to suit patients as young as 5 years old to large adults, thus reducing the hassle of stocking different sized blades in the crash intubation cart. It is powered by a single AA battery and switches on quickly. Infection control can be maintained easily with the sterile single use disposable blades and fully immersible handle (See Fig. 3.3a).

The newer **McGrath MAC** (see Fig. 3.3b) uses a flatter 11.9 mm slim blade, which is similar to the Macintosh. It has a less pronounced curve as compared to the McGrath Series 5. The user can use it like a regular Macintosh for direct laryngoscopy or switch to using it like a McGrath Series 5 to further improve the grade of view by videolaryngoscopy, this combines the advantages of both types of devices to reduce the blind spot during intubation. It features different-sized disposable blades, equivalent to Macintosh sizes 2, 3 and 4. The other advancement from the older McGrath Series 5 is the reinforced steel core alloy chassis capable of withstanding a drop of 2 m. Compatible with the McGrath MAC, the X blade™ is a new blade launched in 2013, with an anterior angulation that is designed for the difficult airway. It is slimmer, less bulky and helps to reduce blind spot by its portrait display.

Instruction for Use

The McGrath series 5 and McGrath X blade is inserted in the midline of the oral cavity, following the base of the tongue to locate the epiglottis. Unlike direct laryngoscopy, sweeping the tongue or aligning the airway axes is not required. The epiglottis is lifted to expose the vocal cords using a gentle pivoting motion. A styleted ETT preformed to a 45–90° curvature or a bougie with a 30° distal curve is recommended by the manufacturer to guide ETT insertion. The entry of the ETT into the pharynx is directly visualized until it is visible on the screen to further advance the ETT under indirect view. Withdrawing the stylet slightly before ETT passage between the vocal cords minimizes the risk of injury. The McGrath MAC blades are used like a normal conventional Macintosh laryngoscope and the patient's tongue needs to be swept aside and displaced anterolaterally to view the vocal cords.

Clinical Performance

Overall success with McGrath in 360 unselected patients was 98–100 % in several series, [8, 21, 22] 100 % in 50 morbidly obese patients, [23] and 91 % in 91 adults in whom direct laryngoscopy failed [24, 25]. In a randomized controlled trial (RCT) comparing McGrath series 5 to Macintosh intubation in 120 uncomplicated tracheal intubations, the authors found that the use of the McGrath took a significantly longer time to intubation 47.0 versus 29.5 s, without an improvement in grade of laryngoscopy view by novice anaesthesologists [22]. In 88 patients with simulated difficult airway, the McGrath series 5 improved the glottic view by 1–3 grades compared with the Macintosh. Tracheal intubation was also successful in all patients using McGrath as compared to a 59 % success rate in the Macintosh group. Stylets were used in all patients, but laryngeal manipulation was not allowed during intubation [26].

In 80 patients with Mallampati grade $\geq$3, McGrath was able to achieve 90 % grade 1 Cormack and Lehane view as compared to 72 % when a Henderson straight blade was used. However, apart from improving laryngeal view, secondary outcomes such as intubation duration, number of attempts or complications was similar [27]. When compared to the C-MAC in 130 Mallampati grade of $\geq$3 intubations, time to successful intubation with the McGrath was longer at 67 s versus 50 s in the C-MAC, despite the McGrath videolaryngoscope providing significantly more grade 1 laryngoscopic views. Intubation success, complication rate, and haemodynamic responses between the two videolaryngoscopes were similar [28]. A benefit of the McGrath's slim blade profile is in allowing awake airway evaluation [29]. A recent RCT comparing awake intubation in patients with anticipated difficult airway by experienced anaesthesiologists using a flexible fiberoptic scope or the McGrath found no difference in time to tracheal intubation [30].

Problems and Complications

Users worldwide describe occassional flickering of the screen with the McGrath series 5 that impedes the view. In overcoming this, the manufacturers advocate the sole use of a lithium ion battery, a battery change if flickering is encountered, and cleaning/good maintenance of the battery contact points in the handle (Teoh WH. Personal communication with Aircraft Medical and distributors). Due to its anterior blade angulation, intubation with a pre-styletted ETT is recommended, and as with the Glidescope, palatal perforations have also been reported with the McGrath [31].

Keypoints

The McGrath is a portable and useful device. It improves the laryngeal view in normal and difficult intubations and has a high intubation success rate. More comparative studies with other devices are required for a conclusive evaluation. With the expanding range of blades available, including the McGrath MAC and the X blade, it is versatile in managing difficult airways.

Storz V-MAC®, C-MAC®

Overview and Characteristics

The V-MAC® (Karl Storz, Tuttlingen, Germany) is a videolaryngoscope with a Macintosh blade, launched in 2003. The prototype features the laryngoscope, which houses the camera, as well as a separate LCD screen. It requires a fiber light cord and a camera cable, which connect to the light source and camera control unit, respectively. The monitor may be placed on the patient's chest to allow the operator to attempt intubation and view the patient and the monitor in one axis.

The newer generation C-MAC videolaryngoscope is a portable model, which consists of only the laryngoscope connected to the monitor via one cable (See Fig. 3.4a). The C-MAC differs in the slimmer, closed blade design with no gaps for hygienic traps, as well as better image quality. In contrast to the V-MAC which uses fiberoptic technique with external light source, C-MAC uses a 800 × 480 pixels Complementary Metal Oxide Semiconductor digital camera and a LED, located laterally in the distal third of the blade. There is no need for focusing or white balance. The embedded optical lens provides a wider angle of view of 80° (see Fig. 3.4b).

Karl Storz is now offering the 4th generation of the C-MAC system that is battery operated and allows video or image storage. The D-BLADE (DCI®) is a

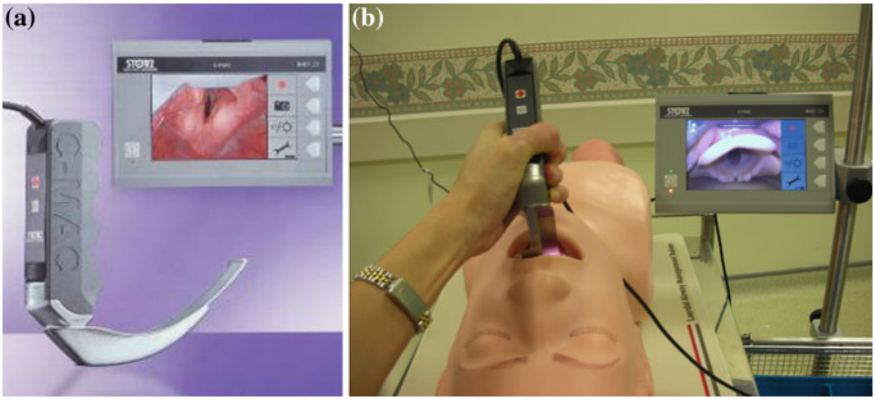

Fig. 3.4 **a** C-MAC videolaryngoscope, **b** C-MAC provides a widened viewing angle to 80° improving glottic views

further extension of the existing system and differs in its pronouncedly curved blade. It is recommended for the subset of patients with difficult airway who cannot be managed with the C-MAC. Experienced anesthesiologists were able to achieve 100 % success intubation in 20 patients with unexpected difficult intubation whilst using the C-Mac D Blade [32].

The C-MAC PM (Pocket Monitor) is a further improvement in portability as its monitor is attached to the top of the laryngoscope handle. The C-MAC S is a single use system, which features a disposable one-piece blade-handle unit to optimize protection against cross contamination of infectious material. See Table 3.6 for a summary of product features.

Instruction for Use

A videolaryngoscope that comes with Macintosh blades combines the dual advantages of direct laryngoscopy and enhanced video view (wider angle) in the one device, thereby improving glottic visualization [33]. There is practically no learning curve and its use is intuitive to all anaesthetists who have grown-up learning to intubate with a standard Macintosh direct laryngoscope by sweeping the tongue anterolaterally. Hence, they need not master new skills to achieve a good view on laryngoscopy. However, delivering the ETT through the vocal cords is a dynamic process that requires some hand-eye coordination, and the authors recommend 20 clinical intubations to gain device-specific proficiency. This is true for all videolaryngoscopes on the market. However, the C-MAC's ease of blade insertion (and laryngoscopy technique) has been ranked easiest and best amongst other videolaryngoscope devices e.g. Glidescope and Pentax AirwayScope [34]. Tracheal tube advancement is also generally simpler than when angulated blades are used, and a bougie or stylet not always necessary.

Table 3.6 List of V-MAC and C-MAC products

V-MAC	Reusable standard Macintosh blade Comes in paediatric and adult sizes Fiberoptic technique with an external light source Separate 8 inch LCD monitor Not portable
C-MAC	Portable Slimmer blade profile (14 mm) with slanted edges to minimize dental trauma Closed blade design with no gaps for hygienic traps Reusable standard Macintosh blades sizes ranging 2–4, and D-Blade. Separate 7 inch LCD monitor with 800 × 480 pixel resolution Lithium rechargeable battery lasting up to 2 h Embedded optical lens has an increased aperture angle of 80° Anti-fog mechanism present
C-MAC® PM	Highest portability and recommended for preclinical use High-resolution 2.4" LED display with 240 × 320 pixels Rechargeable Li-ion battery with one hour operating time Pocket monitor unit can be fully immersed in disinfection solution
C-MAC® S	Single disposable piece consisting of the blade and handle providing protection against infections D-BLADE with short handle MACINTOSH blades which are easily exchanged

Clinical Performance

Systemic review of the V-MAC showed a first time intubation success rate of 87–93 % in unselected airways, overall success rate of 98–100 % in predicted difficult airway and overall success rate of 99–100 % in unselected airways [4]. In 150 morbidly obese patients [23] and 450 patients with normal airways [8], the V-MAC required half the number of attempts for tracheal intubation with the least amount of time or extra adjuncts required as compared to the GlideScope or McGrath. In a preliminary study of 60 unselected patients, a good view and intubation were achieved in all, with a median intubation time of 16 s. Three patients with unexpected difficult laryngoscopy were intubated easily using the straight blade technique [35]. In 100 patients with normal airways, the C-MAC has a high first time success rate of 93 % [34]. In 300 patients with predictors of difficult airway, the C-MAC achieved a better view and first time success (93 vs. 84 %) as compared with the Macintosh amongst a diverse range of operators [36].

Problems and Complications

It is of note that despite a plethora of publications on the use of the VMAC and C-MAC since their introduction into clinical use since 2003 and 2008 respectively, there is no report in the literature regarding any injuries or perforations of pharyngeal structures, compared to the Glidescope (introduced in 2001) and McGrath in 2006. Compared to oher videolaryngoscopes, subtle differences pertaining to the geometry of the C-MAC blade and position of the camera on the blade may account for its safety track record.

Keypoints

There is good evidence in the literature that the V-MAC has a high overall success in subjects at a higher risk of difficulty during direct laryngoscopy. The range of V-MAC and C-MAC products from Storz provide a wide scope of options and versatility. For the majority of anaesthesiologists trained in the use of the Macintosh blade, the ease of switching to the C-MAC system is a benefit. In contrast to other videolaryngoscopes, the C-MAC can obtain both a direct laryngoscopic view and a camera view, which is displayed on the video screen. It is particularly useful during direct laryngoscopy training when the instructor can follow the student's intubation attempts directly to provide real time guidance and to monitor for complications.

PENTAX Airway Scope (AWS)®

Overview and Characteristics

The PENTAX Airway Scope (AWS) videolaryngoscope (Pentax Medical, Tokyo, Japan) is a channeled indirect videolaryngoscope available since 2006. It has a tube guidance system, which assists in directing the ETT into the trachea, eliminating the need for a stylet. It consists of a 2.4 inch LCD screen mounted onto a characteristic orange-coloured handle, which is connected to an anatomically shaped, disposable rigid Pblade (See Fig. 3.5). The light source and camera system is located 3 cm from the tip of the blade. The monitor screen may be adjusted from 0 to 120 degree to facilitate viewing of images from positions relative to the patient's head. The ETT channel, which guides its insertion, fits ETT sizes up to 11 mm in external diameter or even a double-lumen tube [37]. Suctioning of secretions may be performed under direct vision via the PBlade's dedicated built-in channel. The lightweight (430 g), simple design, water resistant and durable construction allows prehospital, inclement weather use. Two AA batteries operate it, which allows an hour of usage. Video documentation of intubation is possible with compatible external monitors or recording devices. An improved version was introduced in 2014 called the Pentax AWS-S200, which is lighter (235 g) and accomodates a wider repertoire of PBlades. In addition to the standard adult PBlade (55 g that houses ETT 8.5–11.0 mm outer diameter), there is now a thinner adult blade (25 g, ETT 7.5–10.0 mm), a neonatal blade (ETT below 5.0 mm) and a pediatric blade (ETT 5.5–7.6 mm).

Fig. 3.5 Pentax airway scope with tracheal tube in its guiding channel

Instruction for Use

Successful laryngoscopy and intubation with the AWS requires an "insertion–rotation–elevation–intubation" technique [38]. Firstly, the AWS is introduced into the patient's mouth in the midline (insertion), its blade advanced into the posterior pharynx with the screen rotated towards the user (rotation) till the glottis is observed on the LCD monitor. The epiglottis is identified and elevated directly with the PBlade tip (elevation).The vocal cords need to be sited within the green target symbol on the monitor, to facilitate intubation by indicating the direction of ETT travel. Once the target mark is aligned with the vocal cords, the preloaded ETT is advanced via the tube channel, and then removed from the groove. Neck extension to align the airway axes is not required to achieve a good glottic view due to its anatomically shaped blade. The use of a bougie prior to the introduction of ETT may further reduce cervical spine movement in patients with spinal pathology [39].

Clinical Performance

Systematic review of AWS shows 97–100 and 99–100 % overall success in patients with predicted difficult airway and unselected airway, respectively [4]. In an initial study of AWS in 320 unselected patients, it was found to have a 96 % first time intubation success and a 100 % overall success rate with a mean intubation time of 20 s. It converted 14 % of the grade 3 and 4 Cormack and Lehane views using the Macintosh to grade 1 or 2 views [40]. Intubation with the AWS by 74 operators on 405 patients found a 100 % glottis visualization and intubation rate [41].

In addition to improving views, its tube guide-facilitated intubation eliminated the problems commonly faced by other videolaryngoscope during ETT insertion. When compared with Macintosh, GlideScope and C-Mac, AWS had the shortest intubation times, best grade 1 laryngeal view (97 %) and best first time intubation success rate of 95 % in a group of 400 patients with normal airways [34]. There was also less postoperative sorethroat with the AWS compared to the Glidescope [42].

In 46 patients with sleep apnea undergoing uvuloplasty, the AWS has been shown to have better first attempt success rate (100 vs. 82.6 %) and faster intubation time (12.9 vs. 29.9 s) than the Macintosh [43]. In 203 patients with restricted neck movements, a grade 1 view and intubation was achieved 100 % with the AWS as compared to the Macintosh, where grade 1–2 views were seen only in 89 % and successful intubation only in 89 % [44]. This study corroborated with a comparative study of 4 airway devices in 120 patients with restricted neck movements, which also found AWS had improved views, ease of intubation and the least haemodynamic disturbance amongst the Macintosh, Truview and Glidescope [45]. In 270 patients with difficult direct laryngoscopy, intubation was achieved in 99.3 % using the AWS [46].

In contrast, one study found the AWS not to be useful. In 105 obese patients randomized to a size 4 Macintosh or AWS found that the time to intubation was longer in the Pentax group with a poorer first time (86 vs. 92 %) and overall success rate (90 vs. 100 %) [47]. It is unclear how the patients in this study were positioned. There is controversy regarding the optimum head and neck placement of patients for AWS intubation, with some advocating the "sniffing morning air position" and others a neutral neck position without a pillow [47].

Numerous reports of awake intubation for difficult airways via oral or nasal routes have been described in literature with the AWS [48]. In patients with airway pathology, it may not be possible to avoid injury with the ETT as it is being advanced over the flexible fiberscope. The AWS is beneficial in this aspect as it allows the course of tracheal intubation to be monitored. Successful intubation with the AWS has also been described in the prone position [49], in mannequins undergoing simulated chest compression (hence its benefit over conventional Macintosh laryngoscopy in resuscitation scenarios) [50], and in the first robotic tracheal intubation in humans [51].

Problems and Complications

The PBlade, which appears somewhat bulky, requires a mouth opening of at least 2.5 cm. Another limitation is the standard adult PBlade's length of 32.5 cm. Placement of the blade may not be ideal in larger sized patients. In instances where an optimum laryngeal view cannot be obtained due to the inability to lift the epiglottis with the AWS, a jaw thrust maneuver has been described to lift the epiglottis and expose the glottis [52] or using a bougie [53].

Intubation with the AWS appears to have a higher failure rate when the reinforced ETT is used. It is postulated that the ETT channel and target symbol is designed for preformed, curved PVC tubes and when reinforced tubes are used, the reinforced ETT moves posterior to the target symbol. This problem can be resolved by first inserting a bougie into the trachea under direct vision prior to railroading in the reinforced ETT [54].

Keypoints

The AWS improves the laryngeal view, and its strength lies in its unique tube guiding channel which facilitates tracheal intubation under vision, eliminating the use of a bougie or need for stylet. There is good evidence for its role in the management of predicted difficult airway, and increasingly in not only routine airways, but also difficult intubations, prehospital resuscitation and intubation in non-supine positions.

Airtraq®

Overview and Characteristics

The Airtraq® Avant (Prodol Meditec SA, Spain) laryngoscope is an anatomically shaped, optical laryngoscope with a guiding channel which holds and directs the ETT to the glottic opening. It has two viewing systems and either allows the user to look into the airway through the eyecup or through a wireless camera and display recorder.

It consists of 4 components:

(1) The reusable Optics, which contains the optic, electronic and anti-fog system. Each full battery charge allows illumination for up to 90 min and the service life of the optics approximates 50 uses. Battery charge and service life light indicators are included.
(2) The disposable Blades and Eyecup protects the Optics system from patient contact and can be easily assembled with the Optics. The blade comes in a regular size 3 for use with ETT sizes 7.0–8.5 and a small size for use with ETT sizes 6.0–7.5. Both can work with any types of ETTs including double lumen tubes. They require a minimum mouth opening of 18 mm.
(3) The Docking Station, which recharges the battery and displays service life.
(4) The optional Camera that can be attached to any Airtraq model to transmit images wirelessly when used with the Airtraq Wireless Display Recorder monitor.

Fig. 3.6 Airtraqs (single use) in a range of adult, pediatric and neonatal sizes

The Airtraq SP is fully disposable and comes in 2 more models for the adult intubation—the double lumen model that can hold double lumen tubes sizes 28–41 Fr and the adult nasal model. There are 3 models for paediatric use—the paediatric (compatible with size 4.0–5.5 ETTs), the infant (compatible with size 2.5–3.5 ETTs) and the infant nasal model (See Fig. 3.6). Newly launched in 2014 is the Airtraq A360 WiFi camera that sits atop the Airtraq. With a 2-axis flip screen and video recording capability, the image can be transmitted by wifi to PCs, tablets, laptops. Soon, there will be a snap-on connector and App for all smartphones, and integrated adapter to FOB cameras.

Instruction for Use

The Airtraq/ETT assembly is inserted into the oral cavity in the midline and advanced over the tongue with minimal anatomical distortion. The tip of the Airtraq blade is introduced into the vallecula to lift the epiglottis or it may be placed under the epiglottis to expose the glottic opening. The tracheal tube can then be advanced down the channel while the vertical lifting force is maintained. After successful insertion of the ETT into the trachea, the tube is peeled off the guiding channel. A finger placed between the channel and the ETT facilitates the separation of the ETT. The Airtraq is then removed while holding the ETT in place.

Successful tracheal intubation using the Airtraq laryngoscope requires the glottic opening to be centred in the view, and positioning the inter-arytenoid cleft medially below the horizontal line in the centre of the view [55]. In obese patients, the Airtraq may be inserted 180° opposite to that recommended and once in place, rotated into the conventional pharyngeal position [56]. Contrary to manufacturer's instructions, Stott et al. [57] recommends the use of the dominant hand to manipulate the Airtraq. The non-dominant hand may perform a jaw lift maneuver to open the mouth. When an optimal image of the glottis has been obtained, the non-dominant hand can then maintain the Airtraq position whilst the dominant hand advances the ETT.

Clinical Performance

A meta-analysis of 12 RCT including 1061 patients showed a reduced intubation time when the Airtraq was used by experienced anaesthesiologists and novices. The risk of esophageal intubation was significantly reduced, first attempt successful intubation was increased in novices but not experienced operators [58]. It appears that the Airtraq is an effective device for intubation, especially in novice hands [58, 59]. Another systematic review of Airtraq intubation found 89–100 % success in unselected patients, 96–100 % success in patients with a higher risk of difficult direct laryngoscopy and 80–100 % overall success rate of intubation in patients with failed or difficult laryngoscopy [4].

In 90 patients with cervical spine immobilization, the Airtraq demonstrated best performance in terms of ease of intubation, glottic view, need for maneouvers to optimize visualization, as compared to the Macintosh and the C-MAC [60]. In 106 morbidly obese patients, the Airtraq achieves faster intubation (24 vs. 56 s) and was better at preventing arterial oxygen desaturation as compared to the Macintosh [61]. This was supported by another study in which 132 bariatric patients had a faster intubation time (14 vs. 37 s) and better glottic view in the Airtraq group when compared to the Macintosh group. One patient who failed Macintosh intubation was successfully intubated with the Airtraq [62].

In a large prospective study of a difficult airway algorithm involving 12,225 patients, 27 of the 28 who failed Macintosh intubation were intubated successfully with the Airtraq. Of the 27 patients, 3 required a bougie as an adjunct. The single patient who failed Airtraq intubation was a tall and obese man (1.9 m, 40 kg/m^2 BMI) with a floppy epiglottis which could not be lifted to give a good view. He was eventually intubated with an LMA CTrach [63].

In a study of 200 nasal intubations in normal and expected difficult airway, all normal intubations ($n = 100$) were successful in both the Airtraq and Macintosh groups. In the expected difficult intubation group, the Airtraq proved to be superior to the Macintosh with a better success rate (94 vs. 66 %), superior glottic view, shorter intubation time (45 vs. 77 s), and reduced number of optimizing manoeuvres [64]. The efficacy of nasal intubation with the Airtraq was found to be comparable to that of the C-Mac and GlideScope when a modified Magill forceps was used [65]. For insertion of a double lumen ETT, the Airtraq was comparable to the Macintosh in terms of intubation duration (20.1 vs. 17.5 s), although visualization was improved in the Airtraq group [66].

The Airtraq was shown to be disappointing when used as a first line airway device in the prehospital setting. Out of 212 patients in a RCT, the success rate of the Airtraq was 47 % versus 99 % when compared with the Macintosh. Problems identified with the use of the Airtraq were poor views due to blood or vomitus and handling problems such as poor visualization of the glottis, ETT displacement or cuff damage. Direct laryngoscopy was successful on the first attempt in 54 of the 56 patients who failed Airtraq intubation [67].

Problems and Complications

The attractiveness of the single use Airtraqs is its extreme portability and individual packaging, making it ideal to be stored as the portable videolaryngoscope with negligible maintenance for "grab bags" e.g. resuscitation bags, when an airway code, trauma or need for emergency medical management is called. Its success with novices in decreasing oesophageal intubation is encouraging but needs to be interpreted with caution, due to the Airtraq failures from poor view due to blood and vomitus as described above. Moreover, the tip of the ETT tends to exit lower from the Aitrtraq blade aperture compared to a similarly shaped device e.g. Pentax-AWS, and prior clinical experience is needed to learn subtle manipulations and device handling, so the ETT does not get caught on the inter-arytenoids or enter the oesphagus [7]. The view from the single use Airtraq is also limited (looking down an eyepiece) and less panoramic during regular intubation, making it harder to correct any malposition during laryngoscopy if the device is not maintained in the midline of the mouth. Fogging of the lens can obscure the laryngeal view, particularly when intubation is prolonged. Incidence of fogging in a study of 604 adult and paediatric patients was 12 %. Connecting the circuit to the ETT and activating the oxygen flush valve two to three times rapidly successfully defogged the lens [68]. However, the risk of barotrauma or gastric distension is cautioned.

Keypoints

There is evidence in the literature to show that the Airtraq is comparable to direct laryngoscopy in routine airway management. During difficult intubations in patients who are obese or with immobilized cervical spines, it has been shown to be superior. It is also useful in nasal and double lumen intubation. However, its efficacy in the prehospital setting and paediatric intubations remains to be seen.

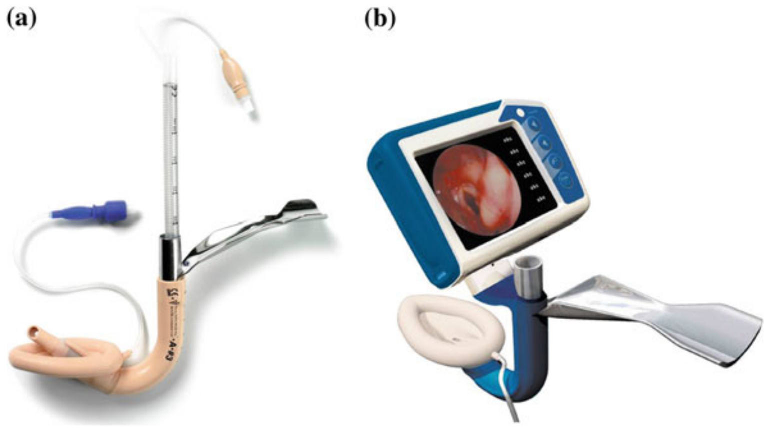

Fig. 3.7 **a** Intubating LMA Fastrach, **b** Intubating LMA C-Trach

Lma Fastrach® and Lma C-Trach®

Overview and Characteristics

The **LMA™ Fastrach** (LMA North America, Inc, San Diego, USA) is an evolution from the classic LMA which is designed to facilitate blind intubation via the LMA while allowing continuous ventilation. The Fastrach includes a rigid, anatomically shaped airway tube that allows the insertion of a size 8.0 ETT which is short enough to facilitate the ETT's passage past the vocal cords. The rigid handle allows single hand insertion, adjustment and removal of the device while freeing the other hand for manual bag ventilation. The mask aperture holds the epiglottic elevating bar, which elevates the epiglottis during ETT insertion. The ETT is also directed centrally and anteriorly to minimize arytenoid trauma or esophageal intubation. It is available in 2 sizes in adults (LMA sizes 4 and 5, both suitable for ETTs up to size 7.5) and 1 size in children (LMA size 3, suitable for ETTs up to size 7.0) (See Fig. 3.7a). The LMA Fastrach™ is available with a LMA Fastrach ETT (sizes 6.0–8.0 mm) and comes in reusable or disposable models [69].

The **LMA™ CTrach** (Teleflex, Buckinghamshire, United Kingdom) is a further modification containing an integrated fibreoptic system, which optimizes the light source and allows uninterrupted image transmission to the operator. A lens sits behind the epiglottis elevator and captures the image from the front of the mask aperture, located over the glottis when the CTrach is positioned. A detachable high resolution (10000 pixel, 3.4 inch) LCD digital viewer displays the captured image. The image is adjusted with a focusing wheel located at the side of the viewer. Light intensity is changed by push buttons. It comes with a charger cradle and rechargeable battery, when charged, allows 30 min of continuous usage. The CTrach is reusable and autoclavable, allowing 20 uses (see Fig. 3.7b).

Instruction for Use

The CTrach is first inserted without the viewer attached. The mask is inflated to optimize ventilation. The viewer is then attached to the magnetic latch connector. When the glottis comes into view, the ETT is passed into the trachea under vision before its placement is confirmed clinically. Both the viewer and the CTrach mask may then be removed.

Clinical Performance

The Intubating LMA Fastrach used to be the difficult airway device advocated in failed intubation algorithms, prior to the prevalent use of videolaryngoscopes. It allows ventilation, that videolaryngoscopes don't [70]. There is a high success rate of LMA insertion in 294 patients with normal airway when the CTrach is used for intubation. First attempt success rate exceeded 93.3 %, overall success rate averaged 98.3 % and average time to intubation ranged from 116 to 166 s. Ventilation was possible in all patients. Failures occurred due to poor views obtained through the LMA where intubation had failed or was not attempted [71–73]. In 104 morbidly obese patients, oxygenation was improved in those managed with the CTrach as compared to direct laryngoscopy. Blind tracheal intubation was mandatory in 17 % of those in the direct laryngoscopy group, while tracheal intubation was observed in all from the CTrach group. However, the duration of tracheal intubation was increased by 57 s in the CTrach group due to LMA placement, without increased incidence of adverse events [74]. Awake intubation in patients with difficult airways has been described using CTrach [75]. Twenty out of 21 intubations were well tolerated and successful: 19 under vision and 1 blindly. In one instance, intubation failed due to undiagnosed lingual tonsil hyperplasia.

Problems and Complications

Associated problems with the CTrach include poor view and airway trauma. Reasons for poor view include poor light intensity and obstruction by the down folding epiglottis, arytenoids or secretions [71, 76]. Adjustment manoeuvres to improve poor views can lead to high rates of successful intubation. Compared with fibreoptic scopes, image quality of the CTrach is poorer. Even though the warranty covers 20 applications, image quality deteriorates with use. Nonetheless, even in poor view or optics failure, the Ctrach can be used as a regular intubating LMA. The size of the ETT used is limited by the size of the CTrach. Only the CTrach ETTs are compatible. Preparation is required before use, which may cause delay

Fig. 3.8 Bonfils rigid fiberscope

due to application of anti-fog solution, lubrication of the assembly, as well as the adjustment of image focus and light intensity.

Keypoints

The CTrach is a unique device that allows continuous ventilation to minimize the likelihood of hypoxia during intubation. It is particularly useful in patients with low functional respiratory reserve, such as those encountered during "cannot intubate-cannot ventilate" scenarios or during cardiopulmonary resuscitation. As an LMA, it may be ideal for prehospital use. It is unknown if the increased duration required to achieve intubation translates to an increased risk of aspiration.

Bonfils®

Overview and Characteristics

The Bonfils Retromolar Intubation Fiberscope (Karl Storz GmbH, Tuttlingen, Germany) is a 40 cm long, straight, rigid intubating stylet with a 40 degree curved tip to facilitate targeted intubation under vision. It has a 110 degree wide angle of view. The eyepiece is mounted on the handle proximally, and is used for direct viewing or may be attached to a camera and video monitor system. A light source or battery pack is attached to the handle (see Fig. 3.8).

Table 3.7 Characteristics, indications and advantages of Bonfils fiberscope

Characteristics	Advantages	Indications
Rigid, straight fiberoptic device with a 40-degree curved tip and 110-degree angle of view	* Facilitates targeted intubation which can be achieved without cervical spine manipulation * Wide angle view allows visual assessment of aberrant anatomy to determine feasibility of intubation * Can maneuver around and displace mobile structures	* Intubation in patients with unstable or fixed cervical spine * Allows intubation in patient with difficult airways, particularly in those with anterior larynx, long floppy epiglottis or mobile airway tumors
Slim profile of 5 mm external diameter allowing intubation via the retromolar approach	Minimal airway trauma, hemodynamic instability	* Intubation in patients with small mouth opening and/or delicate dental work, loose or inconveniently placed teeth which impede intubation * Possible awake oral airway assessment or intubation
No leading edge that must displace tissues prior to viewing the larynx	Minimizes tissue injury	Intubation in patients with a history of traumatic intubation or friable tissues
Lightweight, durable, portable and fast set up	Allows intubation in remote locations	Intubation in pre-hospital settings or "code blue" situations
Available in paediatric sizes with 2 mm or 3.5 mm external diameter	One of the few difficult airway devices available for use in children	Children with congenital airway anomalies

The Bonfils comes in one size for adults, which has a 5 mm outer diameter (fits ETT size 6.0 mm and above), and 2 sizes for children, which have outer diameters of 2 mm (2.5–3.5 mm ETT) or 3.5 mm (4.5–5.5 mm ETT). The adult version has a 1.2 mm working channel within the shaft, which allows local anaesthetic administration into the airway via the distal tip. The Bonfils is designed to be durable, lightweight and portable. The characteristics and advantages are summarized in Table 3.7 [77].

Instruction for Use

The ETT is loaded onto the scope body, and is locked at the proximal end by a detachable ETT holder. The distal end of the Bonfils fiberscope is aligned with the beveled tip of the ETT. Via the tube adaptor, it is possible to insufflate oxygen or suction the airway. Low flow oxygen (less than 3 liters per minute) insufflation minimizes fogging of the lens, and disperses oral secretions from the lens tip. It is imperative to ensure that the attached camera and video monitor system are focused and orientated, as the attachment is not fixed.

In the recommended retromolar intubation technique, the operator's left hand grasps the mandible to expose the laryngeal inlet. The scope is advanced down the right side of patient's mouth, alongside the molars and underneath the epiglottis. The scope is then rotated to view the epiglottis and guided through the vocal cords to identify the tracheal rings. The ETT may then be railroaded using a gentle corkscrew motion after releasing it from the ETT holder. Alternatively, the scope can be advanced midline to the epiglottis. This is easier for novices to locate the laryngeal inlet. Instead of a chin lift maneouvre, direct laryngoscopy may enlarge the retropharyngeal space.

Clinical Performance

Overall successful intubation in "predicted normal airway" patients and "predicted difficult or difficult airway" patients were 96.4 and 95.6 % in a meta-analysis [17]. There are several case series describing the use of the Bonfils in normal airways with contradicting results. Intubation success was 98.3 % with a median intubation time of 33 s in 60 patients by anaesthesiologists unfamiliar with the Bonfils. Based on their experience, the authors recommended a learning curve of 20 intubations [78]. However, in another study of 36 unselected patients, the overall successful intubation rate was only 86 % with a long median intubation time of 80 s. There were 5 failed intubation, due to inability to locate the laryngeal inlet and esophageal intubation [79].

Comparison with Flexible Fiberoptic Bronchoscope

The FOB is the gold standard in difficult airway management and awake intubation, and is a component of the ASA difficult airway algorithm [3]. In a RCT, 116 patients with difficult airways were included to undergo Bonfils—or FOB-aided tracheal intubation. Endoscopic view was better, and the time to intubation shorter in the Bonfils group (160 vs. 229 s). Of the 3 failed intubations with the FOB, intubation was achieved with the Bonfils in 2 patients [80]. Bonfils preparation requires a shorter time, and the ability to observe ETT advancement between the vocal cords lowers the risk of injury. The Bonfils' rigid structure can displace soft tissue or a floppy epiglottis and allows advancement past the obstruction. There is improved endoscopic orientation with the Bonfils. The operator only requires one hand for maneuvering with a better translation of hand-to-scope movements.

Comparison with the Macintosh Laryngoscope

In patients with normal cervical spines, intubation is more successful (100 vs. 91.7 %) and faster with the Macintosh (18.9 vs. 52.1 s) [81]. The Bonfils, however, is more effective for intubation in patients with immobilized cervical spines and limited inter-incisor distance when compared with the Macintosh (success rate of 81.6 vs. 39.5 %) [82]. Cervical spine movement is also less when Bonfils is used (5.5 vs. 22.5°), thus potentially benefitting patients with unstable cervical spine, or those needing a cervical collar [81]. The Bonfils was an effective rescue device after failed direct laryngoscopy and intubation in 25 patients undergoing elective cardiac surgery, achieving intubation in 24 patients. The last patient was eventually intubated nasally with the FOB. Mean intubation time using the Bonfils was 47.5 s without occurrence of adverse event [83].

Other Settings

The successful use of the Bonfils in the prehospital emergency setting [84], awake intubation [85] and in patients with obstructing airway tumors has been described [86]. This success is related to its small shaft diameter and wide angle of view. Unlike laryngoscopes or even videolaryngoscopes, there is no leading edge that must first displace the tissue before viewing the glottis. By shortening the tracheal and the bronchial connectors of double lumen tubes, intubation with DLT using the Bonfils has been described in patients who failed direct laryngoscopy [87].

Problems and Complications

The rigidity of the scope may increase the risk of airway trauma in inexperienced hands and the non-malleable shaft may limit the ability to angle the scope in cases where the larynx is extremely anterior. Other problems encountered are poor views, failure to locate the laryngeal inlet and problems with railroading the ETT. To avoid problems of ETT disengagement from the scope and into the trachea, when loading the ETT onto the Bonfils, beveled end should face left for scope insertion from the right side or the centre of the mouth. Impingement of the ETT tip on the vocal cords should be excluded before rotating the ETT using a twisting motion to slide it off the scope. Readjustment of the scope to prevent leverage on the teeth should be considered. Hand movements to manipulate the scope need to be subtle as slight movements at the handle translate to large movements at the distal end. Counterclockwise wrist movements are performed to direct the Bonfils to the left and vice versa. The handle of the scope is pulled down like a jackpot stick to direct Bonfils tip anteriorly and the opposite is done to direct Bonfils tip posteriorly. A good initial view needs to be established by maintaining a shallow scope insertion to avoid getting lost or seeing “red-out”. If indiscernible pink tissue is seen, the scope should be withdrawn slightly. Perform chin lift to enlarge the retropharyngeal space. One needs to master the subtle hand movements which direct the scope and recognize signposts such as the uvula and the epiglottis.

Keypoints

Bonfils' rigid structure makes it more maneuverable and its slim profile makes it useful in patients with small mouth opening, limited cervical spine movement or narrowed airways. Compared with the flexible fiberoptic scope, endoscopic orientation is improved. It is more robust, portable and easy to set up. Although intubation success rate is high, the use of Bonfils is not intuitive and requires dexterity. Nonetheless it remains an effective tool for difficult airway management after initial training.

Shikani® and Levitan® Optical Stylet

Overview and Characteristics

The Clarus Shikani Optical Stylet (Clarus Medical, Minneapolis, USA) was first described in 1999 [88]. It is a reusable, malleable stylet with a lens at its distal end and a fiberoptic cable within its stainless steel shaft. An eyepiece is located on the handle to allow viewing. Alternatively, images can be captured by a connected camera and displayed on a video monitor. It allows real time airway visualization during intubation. The adult model accommodates ETT sizes from 5.5 to 9.0, while the pediatric version fits ETT sizes 3.5–5.0. The ETT is loaded on the Shikani and kept in place by an 'adjustable tube stop' with an oxygen port which allows oxygen delivery [89]. The stylet and light source are immersible for efficient sterilization. Unlike the fiberscope, the Shikani cannot be orientated in a precise direction. However, it is malleable, portable and cheaper. It may act as a light wand by providing illumination in the neck.

The Clarus Levitan (Clarus Medical, Minneapolis, USA) is similar to the Shikani, except that its shorter length of 30 cm allows an ETT to be fitted without the tube stop. It is can be used to facilitate ETT, LMA or tracheostomy tube placement. Since most videolaryngoscopes work with a stylet, having one which provides fiberoptic visualization capability optimizes the vocal cords view. It comes in one size and fits ETT sizes 5.5–9.0 (See Fig. 3.9).

Fig. 3.9 Clarus shikani and levitan optical stylet

Instruction for Use

The use of the Shikani is similar to that of the Bonfils; laryngoscopy may or may not be used with it for intubation. Neck extension may be more effective than a neutral neck position [90].

Clinical Performance

Initial evaluation of the Shikani is favourable with a 100 % intubation success rate in 2 studies involving 140 surgical patients which included 5 awake intubations [88, 89]. In 12 difficult pediatric airways due to congenital syndromes, airway trauma or tumors, intubation was achieved in 11 patients [91, 92]. The Shikani has also been described to facilitate intubation via the intubating LMA. The operator introduces an ETT loaded onto the Shikani stylet through the airway channel of the LMA to achieve intubation under vision [93].

In 301 intubations with the Levitan, success rate was 99.7 % with a mean intubation time of 23 s [94]. In a crossover trial comparing the Levitan with the Bonfils, both devices showed a good overall success rate of 94 % and similar intubation times (Bonfils 36 s vs. Levitan 44 s) and ease of intubation. However, first time success rate was higher with the Bonfils (73 vs. 57 %) and there were fewer complications such as sore throat and dysphonia [95]. Both devices were equally effective in patients with normal airways when used by trained anaesthesiologists.

Problems and Complications

The Shikani has a limited depth of view, with a focal distance of one centimeter. Other problems are similar to fiberoptic devices such as obscured view by secretions. During advancement its angulated shape may also impinge onto the laryngeal structures or tracheal wall [91].

Keypoints

The Shikani or the Levitan dual functions as the main intubating device or as an intubation adjunct, owing to its feature as an optical malleable stylet. This unique device provides a different approach to securing the airway and is invaluable in that aspect. Due to the limited literature on the Shikani and Levitan, further comparative studies are required to establish its role and efficacy.

Newer Videolaryngoscopes

Newer generations of devices continue to show promise in managing routine and difficult airways, with better, lighter technology, improved optics, and greater affordability. An example of this is the **King Vision®** videolaryngoscope (AMBU Ballerup, Denmark), with its durable reusable video display and size 3 disposable blades for difficult and routine intubations (see Fig. 3.10). In particular, its channeled blade (allows 6.0–8.0 mm ETT) has been shown to facilitate intubation by novice personnel without incidence of esophageal intubation, compared to the Macintosh laryngoscope [96]. Results of more clinical studies are underway, and the launch of the King Vision aBlades in 2014 will herald even greater affordability coupled with high performance visualisation.

The **Venner A.P Advance®** videolaryngoscope (Venner Medical, Switzerland) (see Fig. 3.11) has 3 levels of functionality. It can be used as a traditional stand alone laryngoscope. Connection to the 9 cm viewing screen at the tip of the reusable handle provides the enhanced views of videolaryngoscopy, used in

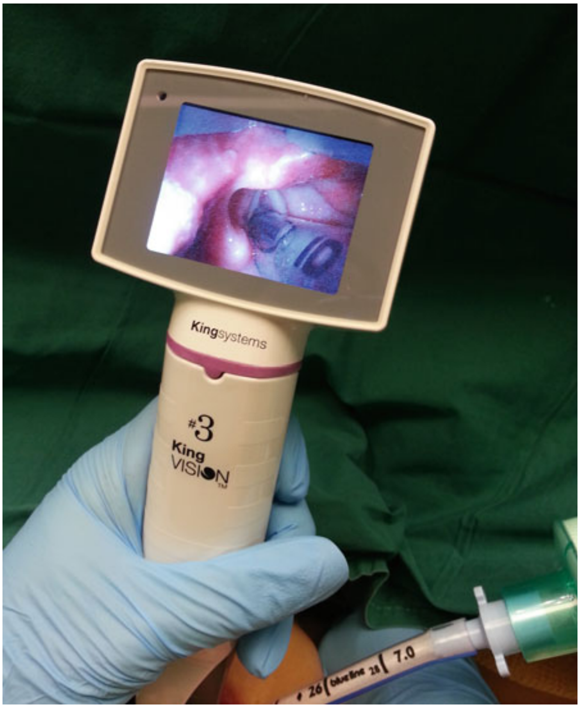

Fig. 3.10 King vision videolaryngoscope

conjunction with the MAC 3 and MAC 4 Macintosh style disposable blades or its Difficult Airway Blade (DAB) which has an upward elevation on the blade tip that allows visualization of anterior larynxes, and intubation without stylet due to a guiding conduit. There are emerging publications of its efficacy in cervical spine cases [97], simulated difficult airways [98] and for base of tongue biopies [99].

Documentation

When documenting laryngoscopy grade, there has been much debate about whether the grades achieved on videolaryngoscopy are comparable to direct laryngoscopy [100]. A simple way is to replace Cormack and Lehane Grade 1 or 2 view with a prefix v1 or v2 for views achieved on videolaryngoscopy [101]. Documenting the type of videolaryngoscope used, the size or type of blade, and need for adjuncts like a bougie, stylet or external laryngeal pressure to successfully intubate provides further comprehensive information for future intubators.

Fig. 3.11 Venner A.P. Advance videolaryngoscope

Conclusion

Videolaryngoscopes and indirect intubating aids provide improved visualization of the larynx with high success rates of intubation. Its incorporation into the revised 2013 ASA Difficult Airway Algorithm lends further weight to the fact that these devices should be embraced as the initial first-line approach to intubate anyone suspected of a difficult airway. This translates to a paradigm shift in how we practice, where routine clinical intubations should be performed with videolaryngoscopy, so that device-specific proficiency is attained. Subtle skills in delivering the ETT through the vocal cords needs to be learnt and practiced, so that when the real difficult airway presents itself, the operator is not performing a videolaryngoscopic intubation for the very first time and getting an improved view of the larynx but then not being able to successfully intubate rapidly.

There are considerable differences between the different products available, resulting in distinct advantages and disadvantages, depending on the airway situation. Clinical research is beginning to provide evidence to prove this premise, although no one device is shown superior, and its true clinical effectiveness also depends on the intubator's skills. Continuing training and familiarity with new devices remain an essential component in maximizing the utility of these devices and minimizing the complications.

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