Video and optic laryngoscopy assisted tracheal intubation – the new era

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SUMMARY
With advances in technology, videoscopy and optic intubation have been gaining popularity, particularly in patients with difficult airways or as rescue devices in failed intubation attempts. Their routine use is, however, an uncommon occurrence. This review paper will summarise some of those newly developed devices currently available to assist tracheal intubation, their advantages, disadvantages when compared with the conventional laryngoscope and finally, evidence to support their use in both elective and emergency airway management.

Key Words: tracheal intubation, optic intubation, laryngoscopy, videoscopy

METHODS
Video and optic laryngoscopes that have been tried by the authors are reviewed in this article. A review of citations from PubMed was conducted without time limit until April 2008. Full-text articles were retrieved of any citations that were considered potentially relevant and were included.

DRAWBACKS OF DIRECT LARYNGOSCOPY
Direct laryngoscopic tracheal intubation is taught to many healthcare professionals as it is an effective method to secure the airway. However, it is a not an easy skill to acquire and maintain without regular practice. Of concern, the consequences of poorly performed intubation attempts are potentially serious.

Direct laryngoscopy may fail in 1.5 to 8.5% of the population despite experienced operators, adequate positioning and mouth-opening. Difficult intubation occurs with a similar incidence. The clinical value of bedside screening tests for predicting difficult intubation remains limited. Screening tests such as the Mallampati oropharyngeal classification, thyromental distance, sternomental distance, mouth-opening and Wilson risk score yield passable sensitivity (20 to 62%) and moderate specificity (82 to 97%). In other words, one can encounter unanticipated difficult airway with direct laryngoscopy despite the availability of predictive tests.

Successful direct laryngoscopy requires alignment of the oral, pharyngeal and laryngeal axes so that the vocal cords can be seen. The requirement for ‘line of sight’ (Figure 1) necessitates manoeuvres which induce neck flexion, head extension, laryngeal manipulation and other stressful movements.

Direct laryngoscopy may cause significant haemodynamic disturbance, sore throat, airway injury and dental damage, the latter accounting for one-third of all confirmed or potential anaesthetic claims in the United Kingdom. Potentially, such injuries may be reduced by a technique not dependent upon achieving the ‘line of sight’. An ideal intubating device should have the following characteristics as shown in Table 1.

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VIDEO AND OPTIC LARYNGOSCOPY

A video laryngoscope collects electronically processed images with a camera attached at its tip. Images of the airway are observed on a monitor attached. Optical laryngoscopes are simpler devices based on optic techniques (fiberoptic cable and lens) and the glottis is observed through a viewfinder. Using an additional transmission camera, the obtained image may be displayed on a monitor screen.

These devices improve the view of the glottis, because the camera eye is only centimetres away from the glottis. Such indirect laryngoscopy results in improved glottic visualisation compared to direct laryngoscopy. This difference proves to be important for medical personnel who infrequently intubate and for students learning intubation skills in a clinical setting. Often, the success of these devices is unrelated to the traditional predictors of difficult airway, which have limited clinical value as mentioned earlier.

When it becomes unnecessary to align the oral, pharyngeal and laryngeal axes or to position the patient in the sniffing position, there is less cervical manipulation. Besides potentially less trauma to the airway, patients are also able to tolerate video laryngoscopy better, allowing awake assessment of the airway. Spontaneous ventilation preserved during intubation attempts also increases the safety margin in patients with limited respiratory reserve.

Video or optic laryngoscopy allows anaesthetists to view the upper airway anatomy on a separate monitor away from infectious secretions. This additional distance, in contrast to direct laryngoscopy, may potentially protect the healthcare worker from infection. Some optic or video laryngoscopic devices are supplied with disposable blades that reduce the risk of disease transmission between patients. This feature is particularly useful in managing multiple critically ill patients by reducing the turnaround time for equipment sterilisation.

The attached camera of a video laryngoscope can be used to facilitate teaching and learning by displaying the progress of intubation during practical teaching sessions. Experienced laryngoscopists can view the airway and the stages of intubation while supervising the inexperienced operator. Assistants applying optimum laryngeal external manipulation may also view the screen to modify their techniques and pressures accordingly. Tele-mentoring may even be possible during emergency or disaster situations when expertise is not at hand. Video laryngoscopy also allows the intubation process to be kept as an official record against claims of airway injuries.

The availability of a monitor screen also makes it possible to perform tracheal intubation on patients in non-standard positions if standing at the head of the patient is not an option. Take for instance, when resuscitating a patient out of hospital who cannot be moved into a supine position.

INTUBATING DEVICES

Video or optic laryngoscopes can be broadly classified as shown in Table 2.
Video and optic laryngoscopy assisted tracheal intubation

A) Flexible fibreoptic bronchoscopes

Considered the gold standard for the management of difficult airway, flexible fibreoptic endoscopy represented a dramatic advance when it was initially described in 1967. It is particularly useful in awake intubation, maintaining the margin of safety while minimising patient discomfort when the airway is adequately anaesthetised.

Components

There are many brands of flexible fibreoptic endoscopes on the market (e.g. Olympus America Inc, Center Valley, PA, USA), Pentax (Pentax Canada Inc, Ontario, Canada), Karl Storz (Karl Storz GmbH & Co. KG, Tuttingen, Germany). Most intubation fibrescopes have approximately 60 cm working length and distal manoeuvrable tips that deflect 140° up and down. They come in many sizes with different diameters suitable for adults and children. There is a light source at the distal end. Each fibrescope comes with a suction channel that can be used for administration of local anaesthetic under direct vision as well as oxygen insufflation if necessary. They may be battery operated or powered by an AC power source. Images can be projected on a monitor screen or viewed via the eyepiece.

Use

The success of flexible fibreoptic assisted intubation requires adequate planning and patient preparation. Judicious sedation produces a cooperative patient. As fibreoptic bronchoscopy requires a clear visual pathway, administration of antiallogogue prior to the start of the procedure is recommended.

If the patient is not at risk of aspiration, the airway should be anaesthetised. This can be achieved by various methods such as the superior laryngeal nerve block, transtracheal nerve block or topical lignocaine spray. The patient’s nasal passages should be treated with a topical vasoconstrictor to shrink the nasal mucosa before attempts at nasal intubation. Topical anaesthesia of the airway increases patient comfort, decreases the response to intubation and hence enhances the probability of success.

Patients can be positioned supine with the endoscopist standing at the head of the bed. The advantage of this position is that the airway anatomy is visualised as most anaesthesiologists are accustomed to seeing. Simple chin lift and jaw thrust may improve the view through the fibrescope and also help to prevent airway obstruction in the sedated patient. Alternatively, the patient may be seated facing the operator.

Manual dexterity with the bronchoscope improves the success rate with fibreoptic intubation. It must be appreciated that the tip of the scope can be flexed in only one plane using the control lever located at the handle. Movement of the tip of the scope in other planes requires rotation of the entire instrument. Generally, the proximal control section of the scope is held in the dominant hand with the index finger on the suction port and the thumb on the lever which regulates the distal tip angulations. The other hand holds the shaft of the scope distally and guides its advance. It is crucial to keep the bronchoscope taut between the left and right hands so that the orientation of the tip is the same as that of the control lever.

Silicone solution applied to the tip of the scope prevents fogging of the room temperature lens on exposure to warm humidified gas in the airway. The endotracheal tube lumen should be lubricated to facilitate its subsequent advancement into the trachea. The endotracheal tube is then threaded over the distal tip of the scope, fed proximally and fixed in position adjacent to the control handle using adhesive tape. A snug fit between the scope and the endotracheal tube minimises the concentric gap between the two and therefore the risk of the tube catching onto the laryngeal cartilages as it is advanced over the scope.

In addition to functioning as a biteblock, airway intubators such as the Bermann (Smiths Medical International, Watford, UK) or Patil-Syracuse airways (Anesthesia Associates, Inc., California, USA) can aid in directing the tip of the scope through the oropharynx. However, when incorrectly placed, they may push the tongue posteriorly to occlude the pharynx.
Fibreoptic intubation is particularly suited when done in a conscious patient as anaesthesia results in decreased tone of the pharyngeal muscles that support the soft tissues in the oropharynx. This may cause soft tissues in the oropharynx to collapse against the lens and occlude the view. Usually, an experienced assistant is needed to monitor the patient’s vital signs and oxygen saturation in addition to providing technical help to the main operator.

Advantages

It is the best device for inspecting the airway even in patients with small mouth openings. It is included in the American Society of Anesthesiologists Difficult Airway Algorithm for the anticipated difficult airway, as well as the ‘unanticipated can ventilate but cannot intubate’ scenario.

If the laryngeal mask airway (LMA) was used to rescue failed intubation attempts, subsequent intubation with a fibreoptic scope is possible through the LMA left in place. During intubation with the fibreoptic scope, it is possible to administer oxygen continuously via the side port to maintain oxygenation.

Endoscopy can be done orally or nasally with minimum haemodynamic disturbances as long as the patient is adequately anaesthetised. Unlike direct laryngoscopy, the sniffing position is not required; hence this method is useful in patients with cervical instability requiring cervical immobilisation.

After a successful intubation, the fibreoptic scope can be used to confirm endotracheal tube placement. It is particularly useful in confirming the placement of double-lumen endobronchial tubes due to the unreliability of the auscultation method. Besides inspecting the airway for trauma or other lesions, suctioning and pulmonary toilet can be performed with the fibreoptic endoscope.

Disadvantages

Awake flexible fibreoptic intubation is a skill that requires practice. An ‘acceptable level’ of technical expertise may be achievable after 10 fibreoptic intubations on anaesthetised patients and 15 to 20 intubations on awake patients with normal anatomy. The success rate of awake nasotracheal intubation performed by trainees after training varies from 66 to 90%. There are two main technical difficulties in performing flexible fibreoptic intubation. First, during insertion, collapsed pharyngeal mucosa may contact the lens, making visualisation and identification of anatomy difficult. Posterior movement of the tongue and epiglottis may obstruct the airway, making oxygenation and visualisation difficult. The degree of obstruction is dependent on the patient’s anatomy, body habitus and depth of sedation. Secretions and bleeding in the airway further compound the problem.

Upon identifying the trachea, up to 53% of the operators experience failure in threading in the endotracheal tube on the first attempt. The various reasons postulated include impingement on the epiglottis, arytenoid cartilage or pyriform fossae. Rotating the endotracheal tube 90° counterclockwise directs the tip into the trachea. Other devices or procedural factors that hamper the insertion of the endotracheal tube over a fibroscope include the airway intubator, cricoid pressure or jaw thrusting. A good view of the glottis is not always followed by successful intubation, a problem contributed to by the narrow angle of view from the tip of the fibreoptic scope.

Summary

Flexible fibreoptic intubation is recommended by the American Society of Anesthesiologists for the difficult airway and is widely used. However, the time needed for the preparation and sterilisation of the scope delays the management of the emergency unanticipated difficult airway. It is not as robust as a direct laryngoscope and is expensive to buy, maintain and service. Even in experienced hands, flexible fibreoptic endoscopy takes longer to achieve intubation as compared to direct laryngoscopy and hence the role of fibreoptic intubation in patients with normal airway remains undefined.

B. i) GlideScope®

Figure 2: GlideScope® Video Laryngoscope.
Components

The GlideScope® Video Laryngoscope (Verathon Inc, WA, USA) has a high resolution complementary metal-oxide-semiconductor camera embedded within the blade, and a light-emitting diode (LED) mounted alongside for illumination. The camera is sufficiently remote from the glottis to provide a wide visual field. The image is displayed on a 7 inch (18 cm) colour liquid crystal display (LCD), which can be mounted on a stand-alone mobile stand or intravenous pole. The images can also be displayed on other devices or recorded using a standard video output port (National Television System Committee). The laryngoscope flexes 60° at the midline to view the anterior glottis without the need for direct line of sight. It has a slim blade profile and comes in three different sizes, so it can be used in children. Its patented anti-fogging mechanism prevents fogging of the camera lens when it is inserted into the oral cavity.

GlideScope Cobalt® is a variation of the original GlideScope that incorporates a disposable plastic blade into a video baton. GlideScope Ranger® is the more portable and robust version, which is useful for intubation at a remote site.

Use

The manufacturer recommends inserting the GlideScope down the midline of the tongue to avoid distortion of the pharyngeal or laryngeal anatomy. In patients with smaller mouths, the blade may be inserted nearer to the left corner of the mouth, attaining a larger space for endotracheal tube insertion. The GlideScope may be used to produce a Macintosh type indirect lift of the epiglottis or a Miller direct lift. After visualisation of the glottis, a stylet sloped at 90° (such as the GlideScope Rigid Stylet®), facilitates the introduction of the endotracheal tube.

Advantages

The main advantage of GlideScope is to allow comparable or superior laryngeal visualisation in both routine and difficult airways without the need for direct line of sight. This translates to less need for cervical manipulation and improved laryngeal view. In a study of 728 patients, a grade 1 or 2 Cormack and Lehane view of the glottis was obtained in 99% of patients despite limited prior experience with the device. Cervical spine motion was reduced 50% at the C2-5 segment in a crossover study as compared with direct laryngoscopy in healthy patients with in-line stabilisation.

The GlideScope might have a faster learning curve compared with the Macintosh laryngoscope in the normal and difficult airway, regardless of the experience of the operator. In simulated difficult airway, anaesthetists found it easier to intubate with the GlideScope and took less time in doing so.

Intubation using GlideScope requires approximately 0.5 to 1.5 kg of lifting force. By using less force, it theoretically should result in less traction being applied to the soft tissue, thereby lessening oropharyngeal injury and haemodynamic disturbance. However, this has yet to be tested in clinical studies. There have been few case series of awake laryngoscopy using the GlideScope. Awake use would allow assessment of potentially difficult airways prior to induction and paralysis.
The advantages of using GlideScope during the emergency setting relate to the excellent view, which is less affected by secretions or blood compared with fibreoptic endoscopy. There is no restriction on the type or size of endotracheal tube that can be placed, whereas for the fibreoptic bronchoscope, the size of the endotracheal tube used is limited by the diameter of the bronchoscope. The GlideScope is easier to maintain, more robust and less likely to be damaged during use.

Disadvantages

While visualisation of the glottis with the GlideScope is easy, most anaesthetists encounter problems manipulating the endotracheal tube through the vocal cords. Successful placement of the endotracheal tube usually requires a stylet. In patients with limited mouth-opening, introduction of the GlideScope can present a problem, as with the use of a Macintosh laryngoscope.

When performing video laryngoscopy, the operator's visual attention may be diverted from the mouth to the screen while introducing the laryngoscope and endotracheal tube. This could potentially result in damage to the lips, teeth, tongue, pharynx or endotracheal tube cuff. In addition, the operator may be unaware of the location of the endotracheal tube until it appears on the monitor. There have been case reports of palatopharyngeal arch injuries requiring surgical interventions during the use of GlideScope\(^3\). Tube advancement, whenever possible, should be visually controlled.

Summary

Its ease of use and advantages over traditional laryngoscopes enables the GlideScope to be used in both routine and difficult intubations.

B. ii) McGrath® Series 5

Components

The McGrath® (Aircraft Medical, Edinburgh, UK), available since January 2006, incorporates a light source and miniature camera within the CameraStick™ assembly to view the larynx during intubation. The image is displayed on the 33×22.5 mm LCD screen which is mounted on top of the laryngoscope handle. The LCD screen tilts and swivels through a 90° arc to allow optimal viewing. A single AA 1.5 V battery housed within the handle powers the device; each battery provides more than 60 minutes of non-continuous use. The disposable sterile blade covers the camera/light assembly.

Use

The McGrath video laryngoscope unit is used in the same manner as an ordinary laryngoscope, with the exception that the blade is introduced in the midline or slightly to the left, using a gentle curving action until the glottis is identified. There is usually no need for any lifting force. Endotracheal intubation can be performed with a stylet to facilitate its manipulation through the vocal cords.

Advantages

In an initial clinical evaluation in unselected patients, tracheal intubation was successfully completed in 147 (98%) patients using the McGrath video laryngoscope. Cormack and Lehane grade I views were obtained in the majority (95%)\(^3\). The median time taken to complete tracheal intubation was 25 seconds, with 96% completed in less than one minute. In a case series involving patients with known difficult airway (Grade 3 or 4 laryngeal view when conventional laryngoscopes were used), the use of the McGrath video laryngoscope improved the laryngeal view of all the patients to Grade 1 view\(^3\).

Disadvantages

Despite the good laryngeal view, the main problem reported was difficulty in passing and advancing the tracheal tube past the larynx. Two reasons account for these difficulties. First, during
Video and optic laryngoscopy assisted tracheal intubation

direct laryngoscopy, a straight line of sight is created by aligning oral, pharyngeal and laryngeal axes, facilitating the passage of the endotracheal tube. When using the McGrath video laryngoscope, these axes are not aligned and the tip of the endotracheal tube must therefore pass around a relatively acute angle to enter the larynx. Less space is available for tube insertion when using the McGrath laryngoscope, as the pharyngeal tissues are not displaced as far anteriorly as during direct laryngoscopy. Mounting the tube onto a stylet and angling the distal tip upwards by 60 to 70° at the proximal end of the cuff may overcome these problems, allowing easier insertion of the tube into the larynx.

The second problem frequently encountered was difficulty in advancing the tube into the trachea once the tip of the tube had passed the vocal cords. For the reasons described above, the tip of the tracheal tube can abut the anterior tracheal wall at a relatively acute angle, preventing its advancement into the trachea. Shippey et al recommended withdrawing the stylet and laryngoscope blade slightly, and rotating the top of the blade handle caudally to enable the tube be advanced more easily. Rotating the tracheal tube clockwise or anti-clockwise can be helpful.

As the McGrath video laryngoscope has no video output jack, video recording is not possible.

Summary

McGrath video laryngoscope is portable and easy to use when compared to the direct laryngoscope. It offers a valuable addition to the armamentarium currently available to rescue the difficult or failed tracheal intubation and may also be suitable for patients with normal airways.

B. iii) Pentax Airway Scope, AWS-S100

Components

The Pentax Airway Scope, AWS-S100 (Pentax Medical Company, NJ, USA) is a new battery-operated video laryngoscope first described in 2006 that has shown promising results in patients with difficult airways.

It consists of a handle with a 2.4 inch (6 cm) LCD screen, a disposable, polycarbonate rigid blade called PBLADE®, a light source and camera system mounted 3 cm from the tip of the blade. The monitor screen can be tilted (0 to 120 degrees) to facilitate viewing of the images from the cranial, lateral and caudal end of the patient. The AWS is operated by two AA batteries which allow almost one hour of operating time.

The PBLADE tip is positioned posterior to the epiglottis and lifts it during laryngoscopy. It has a channel for suction and a separate groove that holds and guides the insertion of the endotracheal tube. It can accommodate an endotracheal tube up to 11 mm in external diameter or even a double-lumen tube.

Use

The AWS is introduced into the patient's mouth and advanced into the posterior pharynx along the midline until the glottic opening is observed on the LCD monitor. One of the most important features of the Pentax AWS that facilitates intubation is the target mark on the monitor, which indicates the direction of travel of the endotracheal tube as it advances from the tube channel. The operator utilises this target mark during intubation and starts advancing the endotracheal tube once the target mark has aligned with the glottic opening.

Advantages

The characteristic shape of PBLADE fits the oropharyngeal anatomy and enables even the less experienced operators to obtain an optimal view during tracheal intubation. Tracheal intubation is faster and more successful on first attempt for novices with AWS as compared to the Macintosh. The view obtained with the airway scope is not affected by the Comack and Lehane grade of Macintosh laryngoscopy view in normal airways, due to the direct elevation of the epiglottis. In a study involving 405 unselected patients, visualisation of the glottis and the success rate of intubation was 100%.

In a cross-over, randomised comparative study with 203 patients with restricted neck movements, the glottis was always clearly seen in the AWS group even though the view was obscured in 11% of patients in the Macintosh group. There was a 100% success rate of intubation with the AWS compared to Macintosh used with elastic bougie group (success rate 89%). Intubating time was similar (51 vs. 54 seconds).

With the AWS, the ability to continuously and easily guide the endotracheal tube under vision is advantageous compared to other video laryngoscopic devices. One limitation associated with other video laryngoscopes, such as the GlideScope, is that even when a clear view of the glottis is obtained, it may often be difficult to intubate the trachea. With the AWS, the attachment of the endotracheal tube is designed such that the tube advances towards the target mark on the screen and thus intubation should be easy, by manoeuvring the position of the
glottis within the target mark. The operator also need not look away from the patient to view the monitor, thereby reducing the risk of trauma during insertion.

Compared with the Macintosh laryngoscope, the AWS produces less movement of the upper cervical spines for intubations in patients with normal cervical spines. Liu et al described their successful intubation with the AWS in three patients with cervical spine problems (with limited neck movement) and prominent teeth. Despite a Comack and Lehane grade of 3 or 4 with direct laryngoscopy, complete view of the larynx was seen with the AWS and intubation was achieved easily.

Awake intubation has also been described with the AWS. It was facilitated by a suction catheter inserted through the PBLADE suction channel to spray lignocaine under vision.

Disadvantages
PBLADE, which is bigger than the McCoy blade, requires the mouth-opening to be greater than 2.5 cm. A smaller mouth-opening may limit the placement of the PBLADE beneath the epiglottis. Another limitation is the AWS’s length of 32.5 cm. PBLADE comes in only one size and the AWS may not achieve ideal placement in larger sized patients when the PBLADE may fail to reach the larynx.

However, problems of a fixed PBLADE size and curvature may be solved by the use of a bougie. The bougie (inserted through the tracheal tube that is mounted on the PBLADE) is centered on the target symbol of the AWS’s LCD monitor, which is directed at the glottis. When the bougie is inserted through the glottis, the tracheal tube from the PBLADE can be detached and railroaded through the glottis.

Summary
The AWS is a promising device for patients with normal and difficult airways alike. Its ability to improve laryngeal view in patients with known difficult Macintosh laryngoscopy makes it useful for both routine and difficult intubation.

C. i) Airtraq
Components
The Airtraq (Prodol Meditec SA, Spain) laryngoscope is designed to facilitate tracheal intubation in patients with normal and difficult airways. It is an anatomically shaped, single-use optical laryngoscope with two separate channels: the optical channel, which contains a high definition optical system and the guiding channel, which holds the endotracheal tube and guides it through the vocal cords. A battery-operated low temperature LED at the tip of the blade provides illumination for up to 90 minutes.

The image is transmitted to a proximal viewfinder through a combination of lenses and a prism which allows the visualisation of the glottis, surrounding structures and tip of the tracheal tube. An optional colour videocamera clips onto the proximal viewfinder and transmits the image to a display via a lightweight cable. An anti-fogging system for the lenses is activated by turning on the LED. For the anti-fogging system to be effective, the LED must be switched on at least 30 seconds before use.
Airtraq works with any style of endotracheal tube including double-lumen tubes and comes in two sizes – regular and small. Endotracheal tubes of inner diameters 7.0 mm through 8.5 mm, and 6.0 to 7.5 mm can be used with the regular size and the small size Airtraq respectively.

Use

The Airtraq blade is inserted into the mouth in the midline and passed over the centre of the tongue with the left hand. The Airtraq/endotracheal tube assembly is advanced over the tongue with minimal distortion to the anatomy. The aim is to introduce the tip into the vallecula and then elevate the epiglottis by suspending it. The tip can also be placed under the epiglottis (Miller style) as an alternative method of introduction. The tracheal tube is then advanced down the channel while maintaining the vertical lifting force and the endotracheal tube cuff can be observed passing through the vocal cords.

After the cuff has passed the vocal cords, the endotracheal tube is separated from the guiding channel by using the peeling method. It is easily done by placing a finger between the channel and endotracheal tube and pushing the tube down the length of the channel until it fully separates from the channel. The Airtraq is then removed while holding the endotracheal tube in place. The ‘reverse manoeuvre’ may facilitate the insertion of Airtraq in morbidly obese patients. For this manoeuvre, the Airtraq is inserted 180° opposite to that recommended and once in place, rotated into the conventional pharyngeal position.

Advantages

Good intubating conditions are achieved with Airtraq and the intubation time is significantly shorter in difficult airways (e.g. cervical immobilisation or obesity) compared with Macintosh laryngoscopy. In a study comparing Airtraq with a standard Macintosh laryngoscope for tracheal intubation in morbidly obese patients, there was a reduction in the incidence of failure to intubate within 120 seconds, thereby preventing the reduction in arterial oxygen saturation. All patients in the Airtraq group were of Cormack and Lehane grade 1 and intubations were successful at first attempts.

Its use has been described as a rescue airway device following failed direct laryngoscopy. Airtraq produced less haemodynamic stimulation resulting from airway management compared with direct laryngoscopy. This may be related to the fact that less traction force is needed to lift the mandible when using the Airtraq compared to the direct laryngoscope. In addition, the passage of the endotracheal tube through the vocal cords may be less traumatic due to constant glottic visualisation and alignment of the tube to the axis of trachea.

The use of Airtraq has been shown to be easy to master for both novice and experienced anaesthetists. In the mannikin models simulating normal and difficult airways, there was an increase in first time intubation rate as well as lower incidence of oesophageal intubations with the Airtraq compared with a standard laryngoscope, demonstrating rapid acquisition of skills. Subjectively, Airtraq was considered by the operator to be easier to use.

The Airtraq requires a minimal mouth-opening of 18 mm for the regular size and 16 mm for the small size.

Disadvantages

The view through Airtraq is less panoramic than that obtained during regular intubation, thus it is harder to correct malposition during laryngoscopy if one is not entering the mouth in the midline. One approach to this problem is to elevate the jaw with jaw thrust, then attempt to visualise the vocal cords. The decreased amount of pressure on the blade will improve the ease of manoeuvre.

Summary

Airtraq can facilitate the management of both normal and difficult airway. Its portability and short set-up time makes it useful in the emergency situation when airway needs to be secured quickly.
D) CTrach

Components

The Intubating Laryngeal Mask Airway (ILMA) was introduced in 1997 as a further development of the classic LMA. It is designed as a ventilatory device, which also acts as a conduit for blind tracheal intubation. CTrach (The Laryngeal Mask Company, Singapore) is a variant of the ILMA containing an integrated fibreoptic system that allows visualisation of the larynx to increase the success of intubation.

The CTrach has an epiglottis elevating bar, which elevates the epiglottis during the passage of the endotracheal tube through the CTrach into the larynx. A lens lies behind the epiglottis elevator and captures the image from the front of the mask aperture, which is located over the glottis when the CTrach is in place. The CTrach is shaped to enable a close fit with the oropharyngeal curve and optimum alignment with the laryngeal inlet. CTrach can be autoclaved, allowing 20 applications.

The captured image is transmitted to a detachable digital ‘viewer’ with a light source and a digital camera. The CTrach has two built-in fibreoptic channels, one to convey light and the other to convey the image to the viewer. The viewer has a high resolution 3.4 inch (8.7 cm) LCD colour display. The image sharpness can be adjusted with a focusing wheel located at the side of the viewer. Image adjustment such as the light intensity can be changed by push buttons. An attached rechargeable battery lasts up to 30 minutes for continuous use and a charger cradle for recharging the viewer is included in the system.

Use

With the patient’s head in the neutral position, the CTrach is inserted without the viewer attached. After inflating the mask and optimising ventilation, the CTrach viewer is attached to the magnetic latch connector. When the glottis is seen on the viewer, the endotracheal tube is passed through the vocal cords under vision. After the endotracheal tube placement is confirmed, both the viewer and the CTrach mask are removed, leaving the endotracheal tube in place.

Advantages

Insertion and ventilation are almost always possible in all patients with minimum cervical manipulation. Tracheal intubation success rate exceeds 93% at first attempts, which exceeds Fastrach’s success rate of 68 to 80%. The ability to view the glottis and optimise placement of the LMA CTrach under vision enabled a higher first-attempt success rate of tracheal intubation. Near continuous ventilation and oxygenation during the intubation process were added advantages in patients with poor reserves when intubating LMAs were used. In a study comparing tracheal intubation of morbidly obese patients, oxygenation was better in patients managed with CTrach than with direct laryngoscopy. Even in instances of optics failure, the CTrach can be used as a regular intubating LMA.

Disadvantages

The most common problems are poor view and airway trauma. Poor initial view (unable to view the glottis) is very common (i.e. in about half the cases). It usually results from anatomical and technical problems, which include obstruction by laryngeal and pharyngeal structures such as down-folding of the epiglottis, obstruction by the arytenoids and saliva, as well as secretions obscuring the surface of the lens. However, by performing some adjustment manoeuvres, it is possible to improve poor views, leading to high rates of successful intubation.

With about half the patients needing laryngeal mask manipulation for ventilation and view optimisation, the duration of tracheal intubation is increased by about 57 seconds compared with direct laryngoscopy. This may increase the risk of regurgitation in patients with risk factors or in emergency situations.

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<td><strong>Manoeuvres to improve CTrach view</strong></td>
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**Adjust the CTrach**

- Slightly shift the tip of the CTrach
- Advance the CTrach further (when epiglottis is the cause of a poor view)
- Partially withdraw the CTrach 1 cm and apply a forward lift to centre the view on the glottis (when the arytenoids obstruct the view of the glottis)
- Partially withdraw the CTrach 4-6 cm (guided by the markings on the tube) and reinserted it without deflating the cuff
- Position the tip of CTrach below the epiglottis under direct vision
- Remove CTrach and clean off secretions

**Perform suction through the channel for intubation using a suction catheter** if appropriate

- Advance the suction catheter, if the glottis aperture or the vocal cords become visible when lifting the epiglottis elevating bar, advance the CTrach further and/or perform intubation

**Adjust light intensity on viewer**

- If above manoeuvres fail, perform intubation even with limited or no view; verify intubation by capnography
Light intensity and sharpness of the image decline with usage. The warranty covers 20 applications. Compared with flexible fiberoptic intubation, CTrach offers a poorer image quality. The size of endotracheal tube that can be inserted is restricted by the size of CTrach and only the CTrach endotracheal tubes are compatible.

Time is also needed for prior preparation. The anti-fog solution needs to be applied as for fiberoptic bronchoscopes; parts of the assembly need to be lubricated; the light intensity and focus also require adjustment with a card provided in order to ensure a clear image during use.

Summary

Despite certain limitations with obtaining adequate laryngeal view and possible deterioration of the image after multiple uses, CTrach remains the only device that allows ventilation while image fine tuning is carried out. In the worst case scenario, one can attempt blind intubation since several studies have shown that ILMA can be used successfully, irrespective of the laryngoscopic finding. With the difficulties in viewing the larynx, expectations need to be moderated.

E) Bonfils Retromolar Intubating Endoscope

Katz and Berci described a straight rigid endoscope used as an endotracheal tube stylet during intubation in the 1970s. Bonfils modified this by adding a fixed curvature at the distal end. The Bonfils is a 40 cm long, rigid optical stylet with a fixed anterior tip curvature of 40° and an external diameter of 5 mm. Its fiberoptic bundle is encased in a stainless steel tube that provides 35,000 pixel resolutions and is manufactured with a 1.2 mm working channel. It comes in two adult sizes, which can accommodate endotracheal tubes of internal diameters 4 to 5.5 mm or 5.5 to 8 mm. A paediatric stylet (Brambrink Intubation Endoscope, Karl Storz GmbH & Co. KG, Tuttinglen, Germany), which can accommodate 2.5 to 3.5 mm endotracheal tubes is also available. It comes with a direct coupled interface that displays the image on a video monitor. There is an adaptor ‘side cone’ for fixation of the endotracheal tube. This adaptor has a side port that allows oxygen insufflation or instillation of local anaesthetic.

Use

Bonfils Retromolar Intubation Endoscope (Karl Storz GmbH & Co. KG, Tuttinglen, Germany) is introduced via the retromolar approach. Guided by the operator’s right hand, the Bonfils is advanced underneath the epiglottis and guided through the glottic aperture until the tracheal rings can be identified. The endotracheal tube can then be inserted into the trachea under direct vision. The retropharyngeal space can be improved by performing chin lift with the left hand or inserting a Macintosh blade simultaneously.

Advantages

The Bonfils fibroscope has been demonstrated to be a reliable and atraumatic device for difficult airway management. There is significantly less movement of the upper cervical spine during intubation with the Bonfils fibroscope as compared with the Macintosh laryngoscope. Its rigid structure allows easy navigation through the oral cavities of patients with a large tongue or long epiglottis, which need to be directly lifted.

It is a more effective intubating device for patients with simulated difficult airway, by immobilising the cervical spine and limiting the inter-incisor distance, compared with direct laryngoscopy. Its success in intubation has been described to be between 96 to 100% in patients with difficult airways. It allows faster intubation than other difficult airway devices such as the Intubating Laryngeal Mask Airway in patients with predicted difficult airway (76 vs. 40 seconds). In patients with a normal airway, time to intubation was found to be short (24 to 50 seconds).

Flexible fiberoptic laryngoscopy has been traditionally used for awake fiberoptic intubation. However, the initial learning curve is steep. Bonfils may be easier and takes less time to navigate through the larynx than the flexible fiberoptic endoscope. During the procedure, the patient can maintain spontaneous ventilation and it is possible to administer oxygen through the special adaptor attached to the shaft of the scope. In a case series described by Abramson, awake intubation with Bonfils took less than three minutes and supplementary oxygen during the procedure was not necessary.

Table 4

Strategy for optimising videoscopic view

<table>
<thead>
<tr>
<th>Use of anti-sialagogue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequate patient sedation/local anaesthesia (if intubation attempted awake)</td>
</tr>
<tr>
<td>Prior suctioning</td>
</tr>
<tr>
<td>Anti-fogging agent</td>
</tr>
<tr>
<td>Placing tip/lens in warm water to minimise fogging</td>
</tr>
<tr>
<td>Oxygen insufflation</td>
</tr>
</tbody>
</table>
Table 5

Summary of the types of optic and video laryngoscopes

<table>
<thead>
<tr>
<th>Flexible fibreoptic bronchoscope</th>
<th>GlideScope</th>
<th>McGrath Series 5</th>
<th>Pentax AWS-S100</th>
<th>Airltrq</th>
<th>CTrach</th>
<th>Bonfils</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost (Singapore dollars)</strong></td>
<td>$13,000-$16,000</td>
<td>Information not available</td>
<td>$13,000-$15,000</td>
<td>Disposable blade $35-$45/piece</td>
<td>$11,000-$13,000</td>
<td>$13,000-$16,000</td>
</tr>
<tr>
<td><strong>Image display/external output</strong></td>
<td>View via eye piece or direct coupled interface</td>
<td>1.7 inch colour LCD</td>
<td>2.4 inch colour LCD</td>
<td>Optical system with optional colour video camera</td>
<td>3.4 inch LCD display</td>
<td>View via eye piece or direct coupled interface</td>
</tr>
<tr>
<td>PAL/NTSC compatible</td>
<td>No video output jack</td>
<td>No video output jack</td>
<td>NTSC compatible video signal</td>
<td>NTSC or PAL compatible video signal</td>
<td>USB 2.0 port can download recordings of the intubation</td>
<td></td>
</tr>
<tr>
<td><strong>Power supply</strong></td>
<td>AC or battery powered LED light source, available as battery or rechargeable version</td>
<td>AC powered videolaryngoscope.</td>
<td>1 AA battery lasts up to 2 hours</td>
<td>Batteries last approximately 1 hour</td>
<td>Rechargeable battery lasts up to 30 minutes</td>
<td>2 rechargeable batteries which can last 2 hours or connect to AC supply</td>
</tr>
<tr>
<td><strong>Sizes available</strong></td>
<td>Adult and paediatric</td>
<td>Adult and paediatric</td>
<td>Adult</td>
<td>Adult</td>
<td>Adult</td>
<td>Adult and paediatric</td>
</tr>
<tr>
<td><strong>Accepted ETT size</strong></td>
<td>Corresponds to the diameter of the scope. ETT should fit snugly to the fibreoptic scope to prevent the assembly from catching on to the soft tissues.</td>
<td>No restriction</td>
<td>No restriction</td>
<td>External diameter 8.5-11.0 mm</td>
<td>Internal diameter sizes 7.0-8.5 mm with the regular size and 6.0-7.5 mm for the small size</td>
<td>Limited by the size of LMA. Recommended LMA FastMach™ ETT which is straight, wire reinforced and cuffed between 6-8 mm internal diameters. Regular ETT not recommended</td>
</tr>
<tr>
<td><strong>Portability</strong></td>
<td>+ Portable eye piece version. Fragile</td>
<td>+++ Glidescope Ranger is the portable version</td>
<td>+++ Can withstand impact of 2 m drop</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td><strong>Disposable</strong></td>
<td>No</td>
<td>Only GlideScope Cobalt uses disposable blade</td>
<td>Disposable blade</td>
<td>Disposable PBLADE</td>
<td>Single use device</td>
<td>Allows 20 applications</td>
</tr>
<tr>
<td><strong>Set up time</strong></td>
<td>Long</td>
<td>Short</td>
<td>Short</td>
<td>Short</td>
<td>Short</td>
<td>Moderate (multiple steps to achieve intubation)</td>
</tr>
</tbody>
</table>

LCD=liquid crystal display, PAL=phase alternating line, NTSC=National Television System Committee, LED=light emitting diode, LMA=laryngeal mask airway ETT=endotracheal tube.
Compared to flexible fibreoptic bronchoscopy, it takes less time to prepare in the event of unanticipated difficult intubation (160 vs. 229 seconds)\(^6\). It is also cheaper and more robust.

Disadvantages

As with other devices with a fibreoptic lens, Bonfils shares similar disadvantages such as fogging or obscured view by blood or secretions. Its rigid nature does not allow for nasotracheal intubation. Although easier to manoeuvre than the flexible fibreoptic endoscope, it still requires prior training for successful intubation, particularly to negotiate the fixed anterior curvature through the orotracheal angle in patients with limited mouth opening.

Summary

Bonfils offers certain advantages over fibreoptic endoscope and should be considered in suspected or known difficult airway.

THE FUTURE OF TRACHEAL INTUBATION

During emergencies or resuscitation, prompt and successful management of difficult airways can improve outcomes and decrease mortality and morbidity. The advantages offered by these new devices allow pre-hospital staff or inexperienced doctors to secure a definitive airway with less difficulty. This is perhaps a leap from the conventional Macintosh laryngoscope. A unique advantage of video laryngoscopy is to allow ‘tele-intubation’ in situations when specialist staff are not available.

The wide array of devices currently available also expands the armamentarium of the anaesthetist to facilitate tracheal intubation in different circumstances. Indirect video and optic laryngoscopy are superior in some ways to direct techniques and greatly improve the finesse of endotracheal intubation. They are a possible replacement of traditional Macintosh assisted direct laryngoscopy for routine intubation as they may decrease the incidence of difficult airway encountered.

REFERENCES


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