Review Article

Videolaryngoscopes for placement of double lumen tubes: Is it time to say goodbye to direct view?

ABSTRACT

The advances in thoracic procedures require optimum lung separation to provide adequate room for surgical access. This can be achieved using either a double-lumen tube (DLT) or a bronchial blocker (BB). Most thoracic anesthesiologists prefer the use of DLT. However, lung separation in patients with potential difficult airway can be achieved using either BB through a single lumen tube or placement of a DLT over a tube exchanger or a fiberoptic bronchoscope. Numerous videolaryngoscopes (VL) have been introduced offering both optical and video options to visualize the glottis. Many studies reported improved glottis visualization and easier DLT intubation in patients with normal and potential difficult airway. However, these studies have a wide diversity of outcomes, which may be attributed to the differences in their designs and the prior experience of the operators in using the different devices. In the present review, we present the main outcomes of the available publications, which have addressed the use of VL-guided DLT intubation. Currently, there is enough evidence supporting using VL for DLT intubation in patients with predicted and unanticipated difficult airway. In conclusion, the use of VL could offer an effective method of DLT placement for lung separation in patients with the potential difficult airway.

Key words: Channeled videolaryngoscopes; double lumen tube; GlideScope®; McGrath®; videolaryngoscopes; video-stylets

Introduction

Several regional surveys among thoracic anesthesiologists showed that the double-lumen endobronchial tubes (DLT) is still the first choice for lung separation technique during thoracic procedures.[1-3]

Difficulty in tracheal intubation, mainly secondary to an insufficient laryngoscopic view is still a major problem that could be potentially associated with increased morbidity and mortality. The recent American Society of Anesthesiologists guidelines for the management of the difficult airway suggest the use of videolaryngoscopes (VL) as a choice for tracheal intubation in the nonemergent pathway where ventilation is adequate.[4] VL offer an effective tool for tracheal intubation in patients with predicted and unpredicted difficult airway.

Currently, several different classes of VL are available including traditional modifications of the angulated-blade conventional laryngoscopes, channeled VL, and video-stylets, but the efficacies are likely to be different between these devices.

Videolaryngoscope provides superior glottis view and easier tracheal intubation, despite that an improved view

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of the glottis does not always translate into easier tracheal intubation.

In addition, compared with direct laryngoscopy using the Macintosh laryngoscope, the use of VL took a longer time to tracheal intubation that can be explained by the variable learning curves of the practitioners.[5,6]

Videolaryngoscope provides new merits for lung separation enabling the use of DLT particularly, in patients with potential difficult airway instead of using a bronchial blocker through a single lumen tracheal tube (SLT).[7,8]

Methods of Search Strategy

In the present review, we screened published articles evaluating the use of various VL for placement of the DLT including the addressed outcomes, with the help of two independent expert librarians familiar with the literature search.

We searched the literature databases PubMed-MEDLINE (1950 to May 15, 2015). The search used the Medical Subject Heading keywords "VL," "DLT," "GlideScope®," "McGrath," "C-MAC," "STORZ C-MAC," "Channeled VL," "Airtraq®," "Pentax Airway Scope®," "King Vision™," "video-stylets," "OptiScope®," "Trachway®," and "outcomes." A citation search by manual review of references from primary articles also was performed.

Results

Several studies and case reports have addressed the use of different types of the available VL for placement of the DLT.

We recruited 33 publications demonstrating the use of different VL for placement of DLT.[5,7,9-41]

Tables 1-4 show the design, arms (when applicable), and prior operators experience in using the studied devices for placement of the DLT and end-points, as well as the main outcomes.

In this review, we presented the current practice in using each of the studied devices for placement of a DLT.

Angulated blades videolaryngoscope

GlideScope®

John A. Pacey, a Canadian surgeon, has introduced the use of the embedded a miniature video chip into a modified Macintosh laryngoscope in 2001 "the GlideScope®" (GVL, Verathon).[12]

The GlideScope® tended to be one of the most extensively studied VL for placement both of the SLT and DLT.

It has been designed for patients from preterm to morbidly obese through wide varieties of reusable and single-use blades such as the GlideScope® titanium, GlideScope® AVL, and GlideScope® ranger. Whereas, the oldest GlideScope® GVL has

Table 1: Studies included the use of GlideScope® for double lumen tube placement

Reference	Study	Arms	Operators experience	End points	Outcomes
Hsu *et al*. (2014)[9]	Randomized Prospective Blind? Powered	Tracheal orifice-covered ($n = 33$) Tracheal orifice-exposed ($n = 33$) Patients with normal airway	>300 times	Time to intubation Other outcomes Hemodynamic responses Sore throat Hoarseness of voice	Shorter time to intubation by 8 sec, $p < 0.0001$ and less frequent sore throat and hoarseness with concealing the tracheal lumen
Gamez and Slinger (2014)[10]	Randomized Prospective Blind? Powered	Placement over an airway exchange catheter using a GlideScope® Rusch Mallinckrodt Fuji-Phycon 17 participants Simulation study	5-15 times or greater	Time to intubation Other outcomes Difficult intubation score Failure rate	Shortest time to intubation by approximately 20 sec, $p < 0.01$ *and* easiest to use with using the Fuji-Phycon
Russell *et al*. (2013)[5]	Randomized Prospective Controlled Powered	Macintosh ($n = 35$) GlideScope® ($n = 35$) Patients with normal airway	3-6 times	Time to intubation Other outcomes Success rate Difficult intubation score Voice changes	Longer time to intubation by 38 sec, $p = 0.0013$, more difficult to use and associated with more frequent voice changes with using the GlideScope® Comparable rate of success at the first attempt
Hsu *et al*. (2012)[11]	Randomized Prospective Controlled Powered	Macintosh ($n = 30$) GlideScope® ($n = 30$) Patients with normal airway	>300 times	Time to intubation Other outcomes Success of the 1st attempt Sore throat	Shorter time to intubation by 17 sec, $p = 0.007$, and less frequent Sore throat with using the GlideScope® Comparable the success of the first attempt

Table 2: Studies included the use of the McGrath® for double lumen tube placement

Reference	Study	Arms	Operators experience	End points	Outcomes
Yao *et al*. (2015)[16]	Randomized Prospective Controlled Powered	Macintosh ($n = 48$) McGrath® ($n = 48$) Patients with normal airway	Experts	Time to intubation Other outcomes Cormack and Lehane grade DLT malposition Success rate at the first attempt Difficult intubation score Hoarseness Oropharyngeal trauma. Sore throat	The use of the McGrath® was associated with a longer time to intubation by 15 sec, $p < 0.05$ more Cormack and Lehane grade-1 views by 37%, and a higher incidence of DLT malposition by + 12.5% Comparable rate of success at the first attempt, difficult intubation score, and complications
Yao *et al*. (2014)[17]	Prospective Observational	McGrath® ($n = 43$) Patients with airway	N/A	Cormack and Lehane grade Other outcomes Time to intubation Overall success rate Difficult intubation score Complications	The McGrath® provided a high rate of grade-1 laryngeal views (88%), acceptable intubation time (54 sec), a high rate of successful intubation at the 1st attempt (95%), and was easy to intubate in 79%
Purugganan *et al*. (2012)[18]	Retrospective Controlled	Macintosh ($n = 40$) Miller ($n = 44$) McGrath® ($n = 15$) STRORZ C-MAC® ($n = 31$) Patients with normal and abnormal airway	> 25 times	Difficult intubation score Other outcomes Cormack and Lehane grade Number of intubation attempts. Airway trauma	The use of the McGrath® and C-MAC® was associated with lower Cormack and Lehane grades; $p < 0.006$ and easier intubation than the other two groups Comparable Number of intubation attempts

N/A; Not available

Table 3: Studies included the use of the Airtraq® for double lumen tube placement

Reference	Study	Arms	Operators experience	End points	Outcomes
Yi *et al*. (2015)[28]	Randomized Prospective Controlled Powered	Airtraq® ($n = 35$) GlideScope® ($n = 35$) Patients with normal airway	>30 times	Time to intubation Other outcomes Cormack-Lehane grades Success rate Difficult intubation score Hemodynamic variables Sore throat	Shorter time to intubation by 18 sec, $p = 0.002$, and less hemodynamic changes with using the Airtraq® Comparable rate of success at the first attempt, difficult intubation score, and Sore throat
Hamp *et al*. (2015)[27]	Randomized Prospective Controlled Powered	Macintosh ($n = 20$) Airtraq® ($n = 20$) Patients with normal airway	N/A	Hemodynamic variables Other outcomes Catecholamine levels Bispectral index Time to intubation	Higher epinephrine level and non-statistically shorter time to intubation by 18 sec, $p = 0.26$ with using the Airtraq® Comparable hemodynamic changes
Chastel *et al*. (2015)[26]	Prospective Observational	Airtraq® ($n = 37$) Patients with normal and abnormal airway	>20 times	Success rate for intubation Other outcomes Glottis exposure Complications	only 33 (89%) were successfully intubated within 120s (mean time: 44 ± 27s) using the Airtraq®
Wasem *et al*. (2013)[24]	Randomized Prospective Controlled Powered	Macintosh ($n = 30$) Airtraq® ($n = 30$) Patients with normal and abnormal airway	N/A	Time to intubation Other outcomes Difficult intubation score Cormack and Lehane grade Hemodynamic variables Hoarseness Oropharyngeal trauma Sore throat	Comparable time to intubation , difficult intubation score, and Cormack and Lehane grade The use of the Airtraq® was associated with higher incidence of hoarseness Comparable rate of success at the first attempt
Hirabayashi and Seo (2007)[25]	Prospective Observational	Airtraq® ($n = 10$) Patients with normal and abnormal airway	N/A	Time to intubation	Time to intubation was 49 ± 22 s Improved glottis view in 90% Correct placement of left DLT in 70%

Abbreviation: N/A; not available

only reusable blades [Figure 1a]. The GlideScope® has a color display monitor with the anti-reflective screen, high-resolution camera, anti-fog feature, and unique 60° blade angulation. In addition, the newly introduced the GlideScope® titanium has Mac-style blades size 3 and 4 for a traditional feel [Table 5].

The GlideScope® may be used to indirectly or directly elevate the epiglottis to expose the glottis exerting a lifting force of approximately 0.5-1.5 kg. Then tracheal intubation requires the use of either a GlideRite® rigid stylet (266 mm in length that is designed for use in SLT 6.0 mm and larger), a preshaped

Table 4: Studies included the use of the rigid video-stylets for double lumen tube placement

Reference	Study	Arms	Operators experience	End points	Outcomes
Yang *et al*. (2013)[36]	Randomized Prospective Controlled Single blind Powered	Macintosh ($n = 200$) OptiScope® ($n = 200$) Patients with normal and abnormal airway	>30 times	Time to intubation Other outcomes Success rate Cormack and Lehane grade number of attempts Need for external manipulation Oral mucosal or dental injury	The use of the OptiScope® was associated with a shorter time to intubation by 5.5 sec, $p < 0.01$, higher success rate (+9%), $P = 0.036$, better Cormack and Lehane grade views, less need for external laryngeal manipulation, and fewer number of oral mucosal, or dental injury
Hsu *et al*. (2013)[39]	Randomized Prospective Controlled Powered	Macintosh ($n = 30$) Trachway® ($n = 30$) Patients with normal and abnormal airway	>300 times	Time to intubation Other outcomes Need for external manipulation Hoarseness	The use of the Trachway® was associated with a shorter time to intubation by 20 sec, $p < 0.001$, and less incidence of hoarseness

malleable stylet with a 60-90° angle or an airway exchange catheter (AEC).

The manufacturer recommends inserting the GlideScope® down the midline of the tongue to the epiglottis, that could potentially narrowing the remaining room for the passage of the relatively large DLT, particularly in patients with restricted mouth opening. In addition, the GlideRite® rigid stylet is shorter than the commonly used DLT that precludes its use for placement of DLT.

The GlideScope® and double lumen tube

Shortly after introducing the GlideScope®, Hernandez and Wong[13] have described its successful use for placement of a DLT in a patient with potential difficult airway that was facilitated with bending the stylet of the DLT so that the distal 16-20 cm of the DLT curve follows the curve of the GlideScope®.[13]

Onrubia *et al*.[14] described a successful use of the GlideScope® for DLT insertion in an awake patient with difficult airway, despite this option could have potential risk of soft-tissue trauma for the patients when used in inexperienced hands.

Two powered randomized clinical trials compared the effects of using the Macintosh and GlideScope® laryngoscopes for the DLT insertions on the time to intubation in patients with the normal airway.[5,11] They reported contradictory results as shown in Table 1 that can be explained with the diversity of prior operator experience in using the GlideScope® for the DLT insertion.[5,11] The use of GlideScope®-guided DLT insertion was associated with a longer time to intubation by 38 s and more frequent voice changes when used by inexperienced users.[5] The noted prolonged intubation time may have clinical importance in patients with high-risk for hypoxemia who undergo thoracic procedures.

Tips to facilitate GlideScope® double-lumen tube intubation

Different tips can be used to facilitate the placement of the DLT using the GlideScope® which potentially may shorten the duration of intubation.

Bustamante *et al*.[15] described a successful use of sequential rotation of the DLT using the GlideScope® in 12 patients as follows:

(a) After engaging the tip of the bronchial lumen of the DLT into the glottis and removal of the stylet, an initial 180° counterclockwise rotation is performed to align the axis of the bronchial lumen with the patient's tracheal axis.
(b) Then, an additional 90° clockwise rotation is performed to align the DLT with the left main bronchus.

Chen *et al*.[7] have described the use of an AEC alongside the GlideScope® guidance for placement of a DLT in a patient with the unanticipated difficult airway. In this report, the GlideScope® did not permit passage of the DLT, despite improved glottis visualization.

In addition, the type of DLT design can play a role in facilitating the placement of DLT over an AEC using a GlideScope®.[10] The Fuji-Phycon DLT (Silbroncho®, Fuji Systems, Tokyo, Japan) was found to be easier to pass over an AEC compared with both the Rusch (Bronchopart®, Teleflex, Research Triangle Park, NC) and Mallinckrodt (Broncho-Cath®, Covidien, Mansfield, MA) DLT warrants consideration in patients with difficult airway [Table 1].[10] The flexibility and the 45° angulated distal bevel of the reinforced bronchial lumen of the Fuji-Phycon DLT can potentially facilitating passage of the DLT into the glottis. In contrast, the Rusch and Mallinckrodt DLTs have a bronchial end that is cut perpendicular to the axis of the tube (i.e., a square cut) or with a very short bevel, respectively.[10]

Another tip that can facilitate the placement of a DLT using the GlideScope® have been demonstrated by Hsu *et al*.[9] through the angulation of the tip of DLT to a hockey-stick shape with more acute angle concealing the tracheal orifice that resulted in 21% shorter time to intubation [Table 1].

Table 5: Comparisons of the specifications of the GlideScope®, McGrath®, Berg CEL-100™, Airtraq®, Pentax AWS®, King Vision™, OptiScope®, and Trachway®

	GlideScope®	McGrath®	Berg CEL-100™	Airtraq®	Pentax AWS®	King Vision™	OptiScope®	Trachway®
Class	Traditional	Traditional	Traditional	Channeled	Channeled	Channeled	Video-stylet	Video-stylet
Types	Titanium AVL Ranger	MAC EDL Slim 11.9 mm	Humanized shaft design	Yellow	PBlade INTLOCK	Standard "Non-channeled"	Malleable stylet, Modular design allowing the stylet to be attached	Malleable stylet, Modular design
Blade sizes	3, 4 available	3, 4 available	DLT'# 35 or 37 Fr	DLT # 28-41 Fr.	DLT # 28-32 Fr	DLT # 32-37 Fr	DLT #35 Fr or larger	DLT #35 Fr or larger
Display	6.5"color Digital, DVD-quality monitor with anti-reflective screen	2.5" LCD colour display	TFT HD display	Direct view AWDR video system A-360 Wi-Fi camera Universal smart phone adapters Endo cam	2.4" diagonal color LCD Direct-view type (0°) CCD color filter	2.4" OLED color Screen 2.4" TFT LCD screen technology allowing crisp imaging of the airway with excellent color reproduction.	4" LCD	–
Camera	Digital with high-resolution for real-time view	CMOS	CCD camera with high-resolution	–	CMOS	CMOS 640 x 480 VGA 30 frames/sec	–	–
Light	LED light	High intensity LED	LED light	–	White LED, dual type	White LED	White LED illuminates the airway Additional red LED light trans illuminates through the skin	–
Field of view angle	60° degree	–	40° degree	80° degree	90° degree	160° degree	–	–
Anti-fog feature	√	√	CMF proprietary processing technique	√	√	Coating on distal lens	Through white LED light	–
Height	GVL 4/GVL 3 14 mm/14 mm	202 mm	–	Yellow 18 mm	INTLOCK 131 mm	Standard 13 mm	OptiScope 405 mm Clarus Video System 317 mm	380 mm
Width	GVL 4/GVL 3 20 mm/16 mm	170 mm	–	28 mm	49 mm	26 mm	–	–
Thickness	GVL 4/GVL 3 53 mm/37 mm	38 mm	–	19 mm	96 mm	–	5 mm	5 mm
Use of stylet	GlideRite® Rigid Stylet	Stylet	Stylet	No	No	No	Video stylet	Video stylet
Use of AEC/Bougie	AEC mainly with a Fuji-Phycon DLT	Can be	?	Can be	AEC, Bougie	?	N/A	N/A
Cost $ US[a]	~US $27,000	~US $2,500 Disposable blade US $139.5	–	~US $90	~US $16,000 Disposable PBlade US $200	~US $1,500 Disposable $90	–	–

MAC; Macintosh, DLT; double lumen tube, DVD; digital versatile disc, LCD; liquid-crystal-display, TFT; thin-film transistor, HD; high-definition, OLED; organic light-emitting diode, CCD; charge-coupled device, COMS; complementary metal–oxide–semiconductor, LED; light-emitting diodes, CMF; chloromethyl furfural, AEC; airway exchange catheter.
[a]These are the available online average cost, that may differ from one country to another.

McGrath®

The McGrath® (Covidien, Mansfield, MA) has a lightweight, durable 2.5" LCD color video screen with a complementary metal oxide semiconductor (CMOS) camera and high intensity LED light source. It has optical polymer 11.9 mm slim McGrath® MAC disposable blades (2, 3, and 4) [Figure 1b]. A recently added thinner McGrath® MAC EDL X blade™ combines the benefits of both direct laryngoscopy and VL. The use of a stylet with a bended tip with 60° is recommended to facilitate the tracheal intubation [Table 5].

The McGrath® and double-lumen tube

Three clinical trials have described the successful use of the McGrath® VL for tracheal intubation with DLT [Table 2].[16-18]

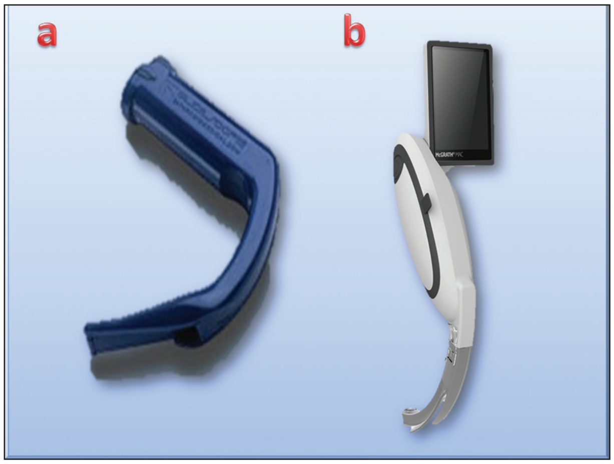

Figure 1: Angulated blade video laryngoscopes: (a) GlideScope® and (b) McGrath®

The use of the McGrath® VL for insertion of DLT improves the glottis visualization and allows easier intubation [Table 2].[16-18] However, one of these studies was observational and the other had the bias of retrospective analysis.[17,18]

In a recent study, the placement of a DLT using a McGrath® VL in patients who had a good glottic view took a longer time to intubation by 15 s and had 12.5% higher incidence of DLT malposition than with the Macintosh laryngoscope, despite improved glottis view.[16]

Tips to facilitate McGrath® double-lumen tube intubation

Similar to the GlideScope®, the McGrath® VL has a hyper-angulated blade, which requires the operator to steer with a stylet during intubation.[16]

Several techniques have been described to improve the efficacy of the McGrath® VL for placement of DLT.

The Parker Flex-It™ articulating stylet is designed to facilitate quick intubation through allowing changing the SLT curvature to follow the curvature of the airway, particularly for intubating difficult airways due to exaggerated airway curvatures and very anterior larynges. The combination of a Parker FlexIT™ stylet and the McGrath® VL can be a potential effective method for DLT intubation.[19]

Imajo *et al*.[20] described the successful use of a fiberoptic bronchoscope alongside a McGrath® VL for placement of a DLT in an elderly woman who had a predicted anatomically difficult airway after failed trials of combined use of the McGrath® and a gum elastic bougie.

Berg CEL-100 videolaryngoscope™

The CEL-100 VL™ (Connell Energy Technology Co. Ltd., Shanghai, China) has a blade that retains the same shape and curvature of the Macintosh blade with an additional slightly anterior curve (approximate 40° angle) at the distal tip [Table 5]. This blade design has the potential to provide the necessary space for inserting the DLT through displacing excess airway soft-tissue.

The distal 10 cm of the stylet of the DLT has to be reshaped to follow the curve of the CEL-100 blade. In similar to the GlideScope®, the CEL-100 VL™ blade has to be inserted along the midline of the tongue.

Lin *et al*.,[21] have reported the efficacy of the CEL-100™ for placement of DLT in 48 patients who had unanticipated high Cormack and Lehane grades when used by experienced anesthesiologists (>30 times) after prior two failed attempts for DLT intubation using the Macintosh laryngoscope.

Compared with the Macintosh laryngoscope, the use of the CEL-100 VL™ improved the glottis views and the success rate of DLT intubation at the first attempt (by 29% and 14%, respectively), and allowed easier intubation.[22] In that study, all DLT intubations were performed by expert anesthesiologists.[22]

Channeled blades videolaryngoscope

The use of channeled VL may offer additional benefits for DLT intubation in patients with limited mouth opening or restricted neck movement[23] in whom the use of traditional VL such as the GlideScope® or McGrath® can be difficult because of the larger outer diameter, the distal curvature, and the increased rigidity of the DLT.[24]

Airtraq®

A low-cost yellow Airtraq® (Prodol Meditec S.A.,Vizcaya, Spain), a VL with guiding channel to deliver the DLT, offers both an optical and multiple options to visualize the glottis including a direct view, AWDR video system, A-360 Wi-Fi camera, universal smart phone adapters, or Endo cam connection. The yellow Airtraq® has a unique, effective anti-fog system through warming up lens. The anatomically shaped yellow Airtraq® can be useful for placement of DLT sizes from 28 to 41 Fr in patients with a minimum mouth opening of 19 mm [Table 5] [Figure 2a].[25]

The operator has to load the left-DLT, after removal of the stylet, keeping the bronchial tip pointed toward the light of the Airtraq®, insert the Airtraq® into the midline of patient's mouth to slide it over the tongue until identifying the glottis structures, place the tip of the blade in the vallecular or underneath the epiglottis, and advance the DLT slowly using rotatory, twisting, or corkscrewing movements of the blade as required. Then, remove the Airtraq® after detaching the DLT from its guiding channel. The right-DLT style, a less frequently used, has to be rotated 180° toward the light of the Airtraq®.

The Airtraq® and double-lumen tube

Hirabayashi and Seo have described the successful use of the yellow Airtraq® for DLT intubation in 10 patients.[25]

The use of Airtraq® had a success rate of 89% for placement of DLT during routine and difficult airway management situations [Table 3].[26]

Compared with the Macintosh laryngoscope, the Airtraq®-guided DLT was associated with either a comparable or a shorter time to intubation, higher release of epinephrine, and comparable difficult intubation score, Cormack and Lehane grade and hemodynamic responses [Table 3].[24,27]

Recently, Yi *et al*.[28] have reported a shorter time to DLT intubation with the use of the Airtraq® than with the GlideScope®, despite the associated comparable success rate at the first attempt and difficult intubation score [Table 3].

In addition, Salazar Herbozo *et al*.[29] described the successful use of the Airtraq® for awake DLT intubation in two patients with predicted difficult airway.

However, the channeled Airtraq® laryngoscopes has not gained widespread popularity because it requires a minimum mouth opening of 19 mm, provides only subtle enhancement of visualization, and has a higher incidence of hoarseness over the Macintosh laryngoscopes.[24]

Pentax-Airway Scope®

The Pentax-Airway Scope® (Pentax-AWS, Hoya Corp., Tokyo, Japan) incorporates advanced imaging technology utilizing high-resolution color images, and identification of anatomical structures can be easily obtained thanks to a wide viewing 90° angle. The Pentax-AWS has a single use P-Blade allowing the use of SLT with an inner diameter of 6.5-8.0 mm, which is compatible with a range of DLT sizes from 26 to 32 Fr [Figure 2b]. This limits the usefulness of Pentax-AWS for placement of DLT with larger external diameter [Table 5].[30,31]

Yamazaki and Ohsumi[32]described the efficacy of the Pentax-AWS in improving the glottis view during rapid-sequence induction for placement of a 35 Fr DLT in a patient presented for emergency surgery because of a hemothorax.

Tips to facilitate Pentax-AWS double-lumen tube intubation

Several techniques have been reported to address the limitation of using the Pentax AWS for placement of DLT larger than a size 32 Fr.

Some investigators[33] have suggested the use of either an AEC or a bougie to facilitate DLT intubation using the Pentax-AWS.

Suzuki *et al*.[34]described the successful use of an AWS with removed back plate of the tube channel to place a 39 Fr DLT in a patient with unpredicted difficult airway.

Furthermore, the INTLOCK, a specialized laryngoscope blade that encases the tip of the AWS to fit the oropharyngeal anatomy, allows placement of DLT. Unfortunately, it was associated with some minor complications such a mild hemorrhage, sore throat, and hoarseness of voice in 50% of the studied patients that case series, however, included only 10 patients.[31] These complications can be potentially minimized by using the Pentax AWS with an infant-size INTLOCK and a smaller 32-Fr DLT.[30]

King Vision™

The King Vision™ (King Systems, Indianapolis, IN, USA) has been designed with a durable, reusable video display with a disposable standard "nonchanneled" and channeled blade at an affordable price [Table 5 and Figure 2c].

Recently, El-Tahan *et al*.[35] demonstrated the successful use of the standard nonchanneled blade of the King Vision™ VL for placement of a 35 Fr DLT, as illustrated in the management of a morbidly obese patient with predicted difficult airway and severely restrictive pulmonary dysfunction. They described four necessary steps to insert a DLT using a nonchanneled blade of King Vision™ VL: First, bend the DLT stylet so that the distal 21 cm of the DLT curve follows the curve of the nonchanneled blade and the proximal curve of the DLT remains directed to the right side [Figure 3a and b]. Next, insert the DLT, exercising caution to avoid damage to the tracheal cuff by the upper teeth during its passage through

Figure 2: Channeled video laryngoscopes: (a) Airtraq®, (b) Pentax Airway Scope®, and (c) King Vision™

the mouth opening. Then, after the bronchial cuff passes through the vocal cords, withdraw the stylet of the DLT. Finally, rotate the DLT 180° counterclockwise while advancing the DLT to the desired depth.[35]

Compared with the Airtraq® and the AWS, the nonchanneled blade King Vision™ VL has the thinnest and shortest stature (26 mm vs. 28 mm and 49 mm and 13 mm vs. 18 mm and 131 mm, respectively) and the widest field of view (160° vs. 80° and 90°, respectively) [Figure 2a-c], the dimensions of which may make it superior for those with limited mouth opening.[35]

Video-stylets

Video-stylets offers both an optical and video option to visualize the glottis, as well as to guide the DLT, particularly in patients with limited mouth opening and restricted neck movement.

OptiScope®

A video-stylet specifically designed for a DLT (OptiScope®, Pacific Medical, Seoul, Republic of Korea) has a malleable tip, a length of 40.5 cm and an outer diameter of 5 mm, accommodating a 35 Fr or larger DLT. This OptiScope® rigid video-stylet is derived from the Clarus Video System (Clarus Medical, Minneapolis, MN, USA) [Table 5].

Yang *et al*.[36] demonstrated a shorter time to intubation, a higher success rate for the first attempt at DLT intubation, a less frequent mucosal trauma, and a better vocal cord view with the use of the OptiScope® than with the Macintosh laryngoscope. That study was not blind, and the operators had diverse experience with both intubating devices.[36] Similarly, other investigators have reported successful OptiScope®-assisted DLT intubation in patients with a difficult airway.[37,38]

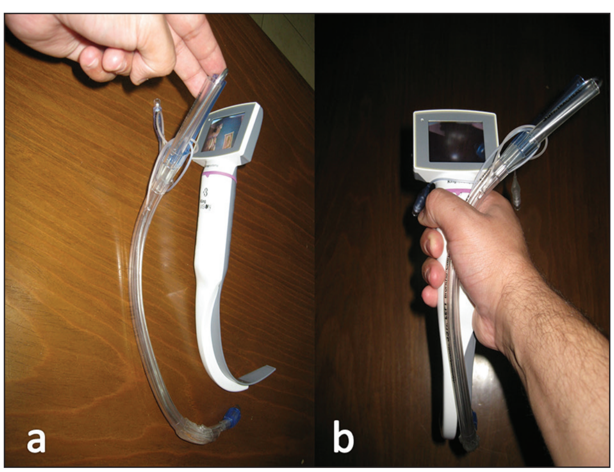

Figure 3: Bending the double-lumen tube stylet so that the distal 21 cm of its curve follows the curve of the nonchanneled King Vision™ blade and the proximal curve remains directed to the right side

The OptiScope® has the potential to replace the use of awake DLT intubation over a fiberoptic flexible bronchoscope in patients with predicted difficult airway. Furthermore, the Clarus Video System has been successfully used for awake DLT intubation in a patient with a large epiglottis cyst.[38]

Trachway®

The Trachway® malleable video-stylet (Biotronic Instrument Enterprise Ltd., Tai-Chung, Taiwan) has an atraumatic tip and a rotatable monitor, potentially facilitating the insertion of DLT. Hsu *et al*.[39] have reported a shorter intubation duration by 20 s and less frequent hoarseness of voice with using the Trachway® video-stylet for placement of DLT than with the Macintosh laryngoscope.

Lighted stylet

The use of a lighted stylet-guided DLT intubation has been described in 34 patients as the only method to determine the depth of DLT insertion, thereby enhancing the chances of successful positioning on the first attempt without further manipulation of the DLT.[40]

Bonfils retromolar intubating endoscope

Bonfils retromolar intubating endoscope (10331B model) (Karl Storz GmbH, Tuttlingen, Germany) has an outer diameters of 5.0 mm, usable shaft length of 40 cm, distal deflection of 40°, movable eyepiece, 35 megapixel light bundle, and an adaptor for tube fixation and oxygen application.

Bonfils rigid fiberscope, one of the widely used airway assist devices for tracheal intubation in patients with limited neck movements, is increasingly used for DLT intubation to improve the laryngeal view, particularly in patients with unpredicted difficult airway. However, to accommodate the Bonfils rigid stylet into the DLT, the DLT has to be shortened by 1.5 cm, this can be possible in some types of DLT like bronchocath.[41]

Video Laryngoscopes-Guided Double-Lumen Tube Intubation and Experience of the Operators

Of note, the longer intubation durations with the use of different VL-assisted DLT insertion can be shortened with building up the operator's experience [Tables 1-4]. Furthermore, familiarity and regular use of any VL device is a key to the effective clinical practice.

Sakles *et al*.[42] have reported significant improvement in the first pass success of tracheal intubation using the GlideScope® over a 7-year period. Thus, we expect that increasing the exposure of the operators to the use of VL for intubation with DLT would improve their performance and hence increasing the first pass success in a comparable time to the use of direct laryngoscopy.

This can be achieved through conducting structured training courses to teach the practitioners of thoracic anesthesia how to use different VL for placement of DLT using the high-fidelity simulation of lung isolation. The latter becomes an important tool for teaching specific skills and evaluating performance during anesthesiology training.[43]

Further multicenter studies are needed to compare the performance of those 10 studied devices for placement of DLT by inexperienced anesthesiologists who are regularly insert DLT during the daily practice in the thoracic surgery particularly in a population at increased risk of a difficult airway.

Currently, there are two recruiting randomized, prospective, controlled studies comparing the efficacy of the GlideScope®, Airtraq®, and King Vision™ for DLT insertion by inexperienced anesthesiologists on manikins and in humans (www.clinicaltrials.gov identifier number NCT02305667).

Conclusion

Until that time, the author thinks that it is too early to say goodbye to the use of direct laryngoscopy or to recommend the routine use of any of the described VL devices for DLT intubation.

However, currently there is enough evidence supporting the use of VL for placement of DLT in patients with predicted and unanticipated difficult airway.

The use of VL could offer an effective method of DLT placement for lung separation in patients with the potential difficult airway.

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Conflict of interest
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