The Video Laryngoscopy Market: Past, Present, and Future

Kenneth Rothfield, MD

Chairman
Department of Anesthesiology
Saint Agnes Hospital
Baltimore, Maryland
Adjunct Associate Professor
Department of Organizational Systems and Adult Health
University of Maryland School of Nursing
Baltimore, Maryland

Dr. Rothfield has received research support in the form of equipment loans from AI Medical Devices, Ambu, Hanu Surgical Devices, Karl Storz, Truphatek, and Verathon Medical.

Over the past decade, video laryngoscopy has profoundly transformed airway management. Its recent inclusion in the American Society of Anesthesiologists Difficult Airway Algorithm validates its adoption. Not surprisingly, the commercial success of the GlideScope (Verathon Medical), the first mass-produced video laryngoscope (VL), has inspired many other companies to enter the airway management market.
Some companies developed capital equipment to compete directly with Verathon; others have focused on low-cost devices, with an eye toward prehospital providers who currently have much less access to these devices.

In recent years, the VL market has become crowded with devices that possess more similarities than differences. Although most VLs represent a substantial improvement over conventional laryngoscopy, the technology has not fully matured. The ultimate goal of making intubation foolproof has yet to be achieved. Device cost alone will not ensure market dominance. This review will discuss the current state of this evolving technology as well as provide predictions about the future.

A Highly Competitive Industry

To successfully design, patent, manufacture, and market a medical device is no easy feat, requiring equal measures of ingenuity and capital. Even the most cleverly designed device will fail if it cannot be sold for a reasonable price, and with adequate sales volume and profit margin to create value for the company. Buyers of medical devices have substantial influence over the industry, particularly now that most hospitals are coping with the reorganization of US health care and shrinking revenue.

Because the core technology used in VLs overlaps significantly with the mass-produced consumer electronics market, suppliers of key parts such as LCD screens and camera chips have little control over the industry. In addition, because devices do not require the same rigorous testing and clinical trials as pharmaceuticals, 510(k) FDA registration and entry into the market is easier. These factors help explain why competition in the VL market has become increasingly intense among many established companies as well as newcomers.

New Technologies Present

New Human Factors Challenges

Human factors refers to the interface of people and things. Engineers specializing in this field commit to improving the ease of use and efficacy of devices and systems. Human factors, therefore, is a helpful framework for considering the past, present, and future of video laryngoscopy.

Historical approaches to laryngoscopy concentrated on displacing soft tissue between the oral opening and the glottis to create a narrow sight line. Not surprisingly, the main challenge of direct laryngoscopy is to obtain an adequate view of the glottic opening. Multiple factors, including patient anatomy and operator skill, may thwart successful direct laryngoscopy. Delivering the endotracheal tube (ETT) to its final destination, however, generally has been less vexing.

VLs have reversed this situation: Visualization has become easy, but tube placement sometimes becomes difficult. Devices such as the GlideScope generally provide a high-quality view of the airway, even in patients with predictors of difficult laryngoscopy. This was confirmed by Aziz and colleagues, who demonstrated a 98% rate of success in more than 2,000 patients with anticipated difficult intubation.1

Challenges with placement of the ETT, however, frequently arise. Many of these problems are overcome with training and improved technique. For example, overzealous advancement of the VL blade lifts the trachea anteriorly from its normal anatomic position and may create a slight but critical misalignment between the tube and the glottis, making intubation impossible. This problem may be remedied simply by withdrawing the VL blade until the epiglottis comes into view.

In other instances, the right arytenoid cartilage becomes an obstacle, snaring the ETT tip during insertion. Interestingly, there are reported situations in which direct laryngoscopy has rescued unsuccessful video laryngoscopy in which the vocal cords were visualized but tube placement was not possible. Therefore, despite the relatively easy airway visualization afforded by VLs, tube placement still requires adequate fine-motor skills and judgment, and successful tube delivery heavily relies on operator hand, wrist, and finger dexterity. It should be mentioned that visualization is not guaranteed because VL blades are rigid; the patient sometimes must be manipulated to “fit the device,” not the other way around.

The steeply curved blades of several video devices follow a more natural path to the posterior pharynx, as opposed to flatter blades that compress and straighten the airway. However, acutely curved blades may solve one problem but create another. For example, Verathon recommends the use of a special rigid, steeply curved stylet for use with the GlideScope. Although

Figure 1. The King Vision video laryngoscope eliminates the need for a stylet by incorporating a guiding channel for the endotracheal tube.
Turkstra et al reported that a standard stylet works just as well, this has not been the experience of the author, who has struggled with malleable stylet bending at the patient's teeth during manipulation, particularly when attempting to steer the tube tip anteriorly. A clever but labor-intensive solution is to approach intubation as a team, with one operator using a VL and a second using a bronchoscope as an articulating stylet.

Several newer VL devices have abandoned stylets altogether and incorporate a guiding channel within the blade of the instrument (Figure 1).

In theory, this feature should simplify placement of the ETT. However, precise alignment of the channel and the glottis remains a prerequisite to successful intubation. The use of an angled bougie as a guide has been reported anecdotally to increase success with such devices. At the present time, however, there is no clear evidence of the superiority of channeled blades.

Compared with the conventional laryngoscopy, merely inserting a VL into a patient's mouth may be a struggle. Ease of blade insertion may be compromised with acutely curved VL blades. Furthermore, long handles and attached cables may contact the patient's chest. Workarounds for these challenges include meticulous positioning (HELP [Head Elevated Laryngoscopy Positioning]) as well as introducing the blade at an angle. Finally, video laryngoscopy has been associated with proximal injuries to pharyngeal soft tissue, likely because nearly two-thirds of the course of the tracheal tube through the upper airway is not observed.

The size of the video screen has not received much attention, but it merits consideration when deconstructed for human factors. Self-contained VLs incorporate a miniature LCD or organic light-emitting diode screen. Such devices are attractive for their portability compared with stand-mounted units and a separate monitor. However, small screens require the use of the operator's near-field vision, which declines—sometimes substantially—after age 40 years. Use of near-field vision requires that the operator maintain a fixed orientation to the screen, with associated head movements to maintain focus. This position increases the physical complexity of the task for the provider. Furthermore, miniaturized images may impair dexterity—fine manipulation of the ETT during attempted intubation may be hard to discern on a tiny screen. Conversely, larger screens rely on the operator's far-field vision, require much less deliberate focusing, and permit the operators to shift their gaze to other areas and back to the screen with ease. Because large screens present a magnified image of structures, dexterity may be improved as small motions and structures are seen clearly.

Finally, like many other medical devices, some VLs may pose a risk for cross contamination and infection if meticulous reprocessing does not occur. For most of the emergency medical services market, the need for resterilization is a deal breaker, as paramedic vehicles lack this capacity.
The Ideal VL

As successful as video laryngoscopy has become, the current state of the art has room for improvement. Characteristics of the ideal VL include:

- Lightweight and portable
- Easy to insert with minimal patient manipulation
- Conformable to individual patient anatomy
- Reliable airway visualization despite fogging or interference from secretions
- Permits accurate passage of the ETT with minimal fine-motor skills
- Multiple display options (self-contained vs detached)
- Image storage capability with integration into the electronic health record
- No cleaning, reprocessing, or risk for cross contamination

Although no single device currently possesses all of these characteristics, several new models have addressed some of the shortcomings of the current crop of VLs with the goal of simplifying intubation and making the products easier to use. To be commercially successful, devices must be both priced competitively and highly differentiated from each other.

Articulation: The Next Frontier

Some devices that conform to individual patient anatomy are available, with more on the horizon. Articulating stylets show promise in decreasing the need for right-hand dexterity during tube delivery. During failed intubation, adequate alignment of the ETT and glottis is usually off by only a few millimeters. Ability to remotely control the ETT tip should remedy many of these situations.

One potential solution is the TruFlex stylet (Truphatek). This reusable, stainless steel, articulating stylet is curved at the distal end and permits anterior tube tip displacement by actuating a lever. It is similar in appearance to the GlideRite stylet (Verathon Medical), but with a user-controlled angle of deflection. In theory, this feature may help in so-called “anterior” airways, or make up for imperfect placement of the laryngoscope blade (Figure 2). An initial pilot evaluation by one of the authors yielded favorable results.4

The simultaneous use of the GlideScope and a fiber-optic bronchoscope for tube guidance in the difficult airway has been previously reported (Figure 3).5 However, the routine use of a bronchoscope along with a VL requires 2 operators and is cost prohibitive. The Rapid Positioning Intubation Stylet (RPis, Airway Management Enterprises) is a hybrid of a traditional stylet and a flexible bronchoscope (Figure 4). According to the manufacturer, the “RPis is an airway rescue device for video and direct laryngoscopy which allows the hands of one provider to perform a similar method of intubating as the two provider method with a video laryngoscope and a fiber-optic bronchoscope. The RPiS is a dynamic stylet that can flex and retroflex at the tip, similar to a bronchoscope; however, it can be controlled with one hand while performing video or direct laryngoscopy with the other hand.”6

Articulation is not simply for stylets and tube guides. AI Medical Devices, Inc. has developed a fully articulating, guiding channel VL. Currently in prototype form, the FlexView VL features a portable inline LCD in addition to a lever that controls flexion of the distal section of the blade from a baseline of 40 degrees to a maximum of 110 degrees (Figure 5). Because the blade is gently curved in its baseline conformation, it may be more easily inserted into the oropharynx than other rigid VLs. The ETT is placed in a guiding channel without use of a separate stylet. Once in position,
the handle is squeezed to provide vertical compensation until the vocal cords are centered on the display and the ETT is advanced. Because the ETT is always in view, tissue trauma due to blind tube advancement is prevented. Although not currently available, the concept is intriguing and will merit thorough evaluation.

**Simplifying Preoperative Airway Evaluation**

Visualizing the airway preoperatively may have tremendous value in planning anesthesia for patients with anatomical deformities, tumors, and other coexisting conditions that may complicate their clinical management. Preoperative endoscopic airway evaluation has been recommended to accomplish this. Similarly, emergency room physicians and otolaryngologists frequently are called on to evaluate patients with complex airway issues. Unfortunately, conventional endoscopic approaches require airway topicalization as well as a bronchoscope, the use of which demands expertise and technical support. Otolaryngologist Brad NaPier has developed a video-enabled, single-use oral airway that provides a high-quality view of the glottis and is so well tolerated that no topical anesthesia is necessary. Currently in the working prototype stage, the LarynGoView (Hanu Surgical Devices) has great potential for use in a variety of settings, including preoperative clinics, emergency departments, and otorhinolaryngology offices (Figure 6).

**Robotic Intubation**

The use of robotics with intubation has been gaining some research attention. In the United States, the military-backed Telemedicine and Advanced Technology Research Center has sponsored research into an autonomous airway management system.

The system, developed by Energid Technologies, would integrate force feedback and maintain full video tracking of the procedure for assisting an operator. A small pilot study with 12 patients involving the Kepler Intubation System, a hybrid of a robotic arm and VL, yielded a 91% success rate for intubation. Although this technology is in its infancy, it holds promise for further developments to assist clinicians lacking experience but who must perform advanced airway management.

Although the current state of the art in video laryngoscopy has effectively solved the problem of obtaining an adequate laryngeal view, there is room for device improvement to make placement of the ETT more precise. Whether it is through user-enabled articulation, robotics, or other approaches, patients deserve to reap the benefits of these advanced approaches to airway management.

As the marketplace advances and matures, we will ultimately come closer to the ideal VL.
References


6. Personal communication with company.


---

Figure 6. The LarynGoView (prototype) is a modified bite block with a built-in solid-state image which provides an image of the glottis in unanesthetized patients.