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REVIEW ARTICLE/BRIEF REVIEW

Review article: Video-laryngoscopy: another tool for difficult intubation or a new paradigm in airway management?

Article de synthèse: La vidéo-laryngoscopie: un autre outil pour les intubations difficiles ou un nouveau paradigme pour la prise en charge des voies aériennes?

Jean-Baptiste Paolini, MD · François Donati, MD, PhD · Pierre Drolet, MD

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Abstract

Background *An adequate airway management plan is essential for patient safety. Recently, new tools have been developed as alternatives to direct laryngoscopy and intubation. Among these, video-laryngoscopy has enjoyed a rapid increase in popularity and is now considered by many as the first-line technique in airway management. This paradigm shift may have an impact on patient safety.*

Principal findings *Studies show that video-laryngoscopes are associated with better glottic visualization, a higher success rate for difficult airways, and a faster learning curve, resulting in a higher success rate for intubations by novice physicians. Thus, unanticipated difficult intubations may be less frequent if video-laryngoscopy is used as the first-line approach. In addition, on-screen viewing by the operator creates a new dynamic interaction during airway management. The entire operating room team can assess progress in real time, which enhances communication and improves teaching. However, if video-laryngoscopes become standard tools for tracheal intubation, these more costly devices will need to be widely available in all locations where airway management is conducted. Furthermore, algorithms for difficult intubation will require modification, and the question of selecting alternate devices will arise. If the incidence of difficult intubation decreases, the lack of motivation to teach and learn the use of alternative devices might adversely impact patient safety.*

Conclusion *The greater effectiveness of video-laryngoscopes associated with multi-person visualization could enhance overall patient safety during airway management. However, the routine use of video-laryngoscopy also introduces some issues that need to be addressed to avoid potentially dangerous pitfalls.*

Résumé

Contexte *Une prise en charge adaptée des voies aériennes est essentielle à la sécurité des patients. De nouvelles alternatives à la laryngoscopie directe et à l'intubation ont été récemment développées. Parmi elles, la vidéo-laryngoscopie est devenue rapidement populaire et beaucoup la considèrent maintenant comme la technique de première intention pour la prise en charge des voies aériennes. Ce changement de paradigme pourrait avoir un impact sur la sécurité des patients.*

Constatations principales *Les études montrent que les vidéo-laryngoscopes sont associés à une meilleure visualisation de la glotte, un taux de réussite supérieur en cas de voies aériennes difficiles et une courbe d'apprentissage plus rapide, aboutissant à des taux de réussite plus élevés pour les intubations réalisées par des médecins novices. En conséquence, les intubations difficiles inattendues pourraient être moins fréquentes si la vidéo-laryngoscopie était utilisée comme approche de première intention. De plus, le suivi sur écran par l'opérateur crée une nouvelle dynamique interactive au cours de la prise en charge des voies aériennes. Toute l'équipe de la salle d'opération peut évaluer l'évolution en temps réel, ce qui encourage la communication et améliore l'enseignement. Cependant, si les vidéo-laryngoscopes deviennent des outils standard pour l'intubation trachéale, ces dispositifs plus coûteux doivent devenir largement disponibles dans tous les endroits où*

J.-B. Paolini, MD (✉) · F. Donati, MD, PhD · P. Drolet, MD
Département d'anesthésiologie, Université de Montréal,
Montréal, QC, Canada
e-mail: jbpaolini@yahoo.fr

on prend en charge les voies aériennes. En outre, les algorithmes d'intubation difficile devront être modifiés et la question du choix de dispositifs de secours va être posée. Si l'incidence d'intubation difficile diminue, l'absence de motivation à enseigner et à apprendre l'utilisation de dispositifs de secours pourrait avoir un impact sur la sécurité des patients.

Conclusion *La plus grande efficacité des vidéo-laryngoscopes associée à la visualisation par plusieurs personnes pourrait améliorer la sécurité globale des patients au cours de la prise en charge des voies aériennes. Toutefois, l'utilisation en routine de la vidéo-laryngoscopie soulève également quelques questions auxquelles on doit répondre afin d'éviter des écueils potentiellement dangereux.*

The concern for patient safety in the operating room and critical care areas has led to the development of new technologies, training in the simulation environment, evidence-based algorithms, and perioperative checklists. More than 20 years ago, a closed claims analysis conducted under the auspices of the American Society of Anesthesiologists (ASA) concluded that a leading cause of anesthesia-related injury was the inability to intubate the trachea and secure the airway.[1] In spite of the development of numerous airway devices in the past two decades, many of which make intubation easier or unnecessary, a recent British survey concluded that difficulty with tracheal intubation is the most common factor related to serious airway complications during anesthesia, suggesting that the problem is still present.[2] Thirty years ago, anesthesiologists had to rely solely on bag-and-mask ventilation and/or direct laryngoscopy (DL) with tracheal intubation to oxygenate the patient. Several alternative tools are now available, including a variety of supraglottic devices, intubating laryngeal mask airways, gum elastic bougies or stylets, fibreoptic bronchoscopes, modifications of blades, and video-laryngoscopes (VLs). Among all of these, VLs have rapidly gained in popularity as rescue or even primary devices because they offer a better glottic visualization than DL and the learning curve is fast for both novices and experienced laryngoscopists. Some authors have predicted that video-laryngoscopy will dominate the field of emergency airway management in the future.[3] The increased use of VLs is probably related to the many perceived advantages that they provide, including improved and shared visualization of the airway to facilitate teaching or coordination between operator and assistant, a rapid learning curve and ease of use by novices, and minimal head or neck manipulation. Consequently, as VLs are regarded by many as better all-around devices than traditional direct laryngoscopes, they are increasingly used as part of the first-line strategy, not only for anticipated difficult tracheal intubation but also as a substitute for DL even in routine cases. This suggests that VLs may then be part of a new paradigm characterized by their use as standard intubation tools. Should this tendency keep growing, will it imply a higher level of safety for patients both in the operating room (OR) and in other locations, such as the intensive care unit (ICU) or the emergency department (ED), or will it raise the threshold of suspicion for a difficult airway while depriving practitioners of a reliable rescue device?

The purpose of this article is to review the safety implications of using VLs as a primary tool for airway management and to discuss the effects of such a paradigm shift on the approach to tracheal intubation for anesthesiologists, who are airway experts, and also for other physicians who need to perform tracheal intubation on an occasional basis.

Video-laryngoscopy

Characteristics of video-laryngoscopes

Both direct laryngoscopes and video-laryngoscopes consist of a handle and a blade, but in the latter case, the end of the blade is equipped with a video camera, enabling the operator to visualize the glottis indirectly on a video screen. The designs of both types of laryngoscopes share many features, enabling physicians skilled with DL to use VLs with minimal added training. Video-laryngoscopes allow a wide viewing angle and make alignment of the oral, pharyngeal, and tracheal axes unnecessary. Currently, several different types of VLs are available, each with a different blade shape, user interface and geometry, and tube insertion strategy. Most currently available devices belong to one of the following categories (Fig. 1).

Macintosh type

Certain VLs have a Macintosh-type blade similar to that of standard laryngoscopes; the difference is the inclusion of a camera. The blade is inserted into the oral cavity using the standard direct laryngoscopic technique, and the glottis can then be seen either under direct vision or on a video screen.[4,5] The endotracheal tube (ETT) is inserted in much the same way as with DL, with or without a stylet. The V-MAC® (Karl Storz, Tuttlingen, Germany), its newer version, the C-MAC® (Karl Storz, Tuttlingen, Germany), and the McGRATH® MAC (Aircraft Medical, Edinburgh, UK) belong to this category.

Angulated blade type

Other VLs are equipped with an angulated blade, which is characterized by a sharper curve than the Macintosh blade. The curvature of the blade allows a clear view of the glottis

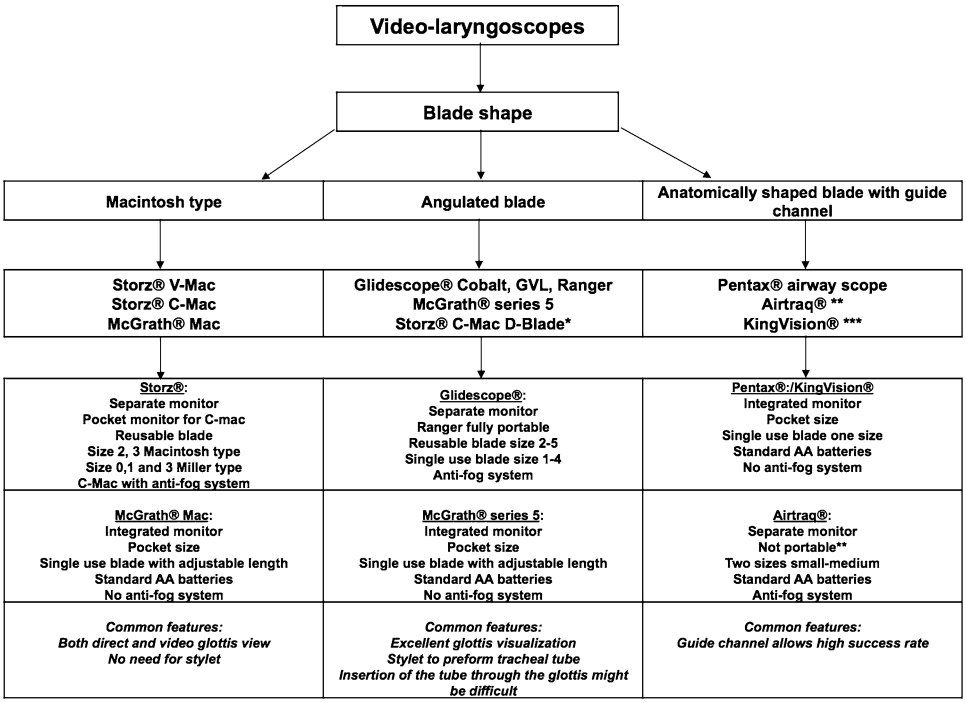

Fig. 1 Taxonomy of video-laryngoscopes. * D-BLADE = C-MAC's specific characteristics but has the same common features as other angulated blades; ** Although not a video-laryngoscope *per se*, the Airtraq can be used with a clip-on camera and a wireless recorder; *** KingVision = same features as Pentax-AWS but equipped with an anti-fog system

on the video screen with minimal flexion or extension of the patient's head and neck, but direct visualization is usually not possible.[4,5] These VLs are normally introduced in the middle of the oral cavity without tongue displacement. They glide along the palate and the posterior pharynx until the tip of the blade reaches the vallecula or the posterior aspect to the epiglottis if the epiglottis obscures the glottis.[4,5] Contrary to devices with a Macintosh-type blade, the ETT has to be introduced "around the corner" and should be mounted on a pre-shaped 60° angle stylet to match the blade's curvature. A limitation of this type of VL is the potential difficulty to direct a tube toward the glottis despite obtaining a clear view. The GlideScope® video-laryngoscope (GVL) (Verathon Medical, Bothell, WA, USA), the C-MAC® D-BLADE (Karl Storz, Tuttlingen, Germany), and the McGRATH® Series 5 (Aircraft Medical, Edinburgh, UK) are all examples of VLs with angulated blades.

Tube channel type

Other VLs have an anatomically-shaped blade with an angle resembling those found on the older Bullard™ or WuScope fibreoptic laryngoscopes and with a guide channel that directs the ETT towards the glottis. These VLs have a screen mounted on their handle. The Pentax-AWS® (Airway Scope; Hoya Corporation, Tokyo, Japan) and the King Vision® (King Systems; Noblesville, USA) belong to this category. The Airtraq® (Teleflex Medical S.r.l., Varedo, MB, Italy) does not rely on a camera *per se* but uses an optical system to provide glottic viewing and also features this particular shape. Since the Airtraq can be used with a specially designed clip-on wireless camera that relays the image on a separate monitor screen, it is also considered by some to be a VL.[4] With most of these instruments, the ETT is preloaded into the guide channel; the VL is then inserted along the midline of the patient's mouth without displacing the tongue laterally and advanced slowly until the epiglottis is viewed.[4] The tip of the blade is positioned posterior to the epiglottis, directly elevating it in order to visualize the vocal cords. It is important to place the glottic opening in the centre of the monitor. The ETT is then inserted into the trachea via the guide channel. Multi-person visualization is possible via the screen located at the top of the handle or, in the case of the Airtraq, on a separate monitor.

Even if Macintosh-type and angulated blade-type VLs seem more likely to provide clinicians with an experience resembling traditional DL, studies suggest that the skills needed to use devices equipped with a tube channel are easily mastered by experienced and novice laryngoscopists alike.[6,7]

Despite their different shapes and characteristics, there is little information regarding which VL design could be more advantageous in various clinical situations. Examples of different types of video-laryngoscope are provided in Fig. 2.

Video-laryngoscopy in the OR in the hands of anesthesiologists and their trainees

Patient safety during airway management in the OR

Major complications during airway management arise as a result of the inability to establish or maintain the airway,

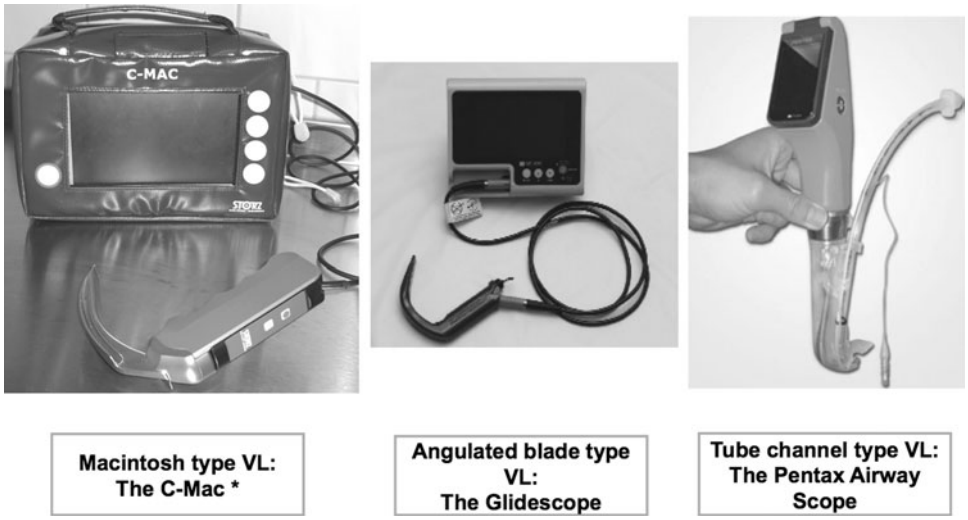

Fig. 2 Examples of different types of video-laryngoscopes. * The C-MAC is shown in a portable bag for pre-hospital use

difficult or failed intubation (including unrecognized esophageal intubation), pulmonary aspiration, and iatrogenic airway trauma. Most airway events during the perioperative period occur in healthy patients having elective surgery under the care of an experienced anesthesiologist.[2,8] Aspiration is a leading cause of anesthesia mortality and is usually the result of either an inappropriate use of first generation supraglottic devices or a lack of proper rapid sequence induction (RSI) for patients with obvious risk factors for a full stomach.[2] Obesity and obstructing airway lesions are major risk factors of airway complications,[2,8] with each being involved in approximately 40% of major airway complications. When a "cannot ventilate and cannot intubate" (CVCI) situation develops, persistent intubation attempts before switching to alternative rescue techniques are associated with severe outcomes (death or brain damage [BD]).[2,8] Either nonsurgical (laryngeal mask airway device, Combitube®, transtracheal jet ventilation, needle cricothyrotomy, retrograde intubation) or surgical (cricothyrotomy or tracheotomy) rescue techniques are associated with poor outcomes in CVCI situations when they are used too late (death/BD = 80-90%).[2] One-quarter of incidents occur at the end of anesthesia or in the early recovery room, showing poor extubation planning.[2,8] Major audit-type reports emphasize that elements of poor management, communication, and planning were observed in the majority of airway complications and deaths.[2,8]

Why are video-laryngoscopes so popular, and do they have a potential to improve patient safety?

Anesthesiologists like VLs because they make their life somewhat more serene. Video-laryngoscopes are easy to use, and the skills involved are easy to master by either novices or experienced anesthesiologists. Novices achieved a 69% intubation success rate when trained with a V-MAC compared with a 55% success rate when trained with a Macintosh laryngoscope.[9] During their first 235 uses of the V-MAC, anesthesiologists achieved a 99.6% intubation success rate.[10] The V-MAC shortened the learning curve of both DL and video-laryngoscopy.[9]

Video-laryngoscopy usually implies a very good to excellent visualization of the glottis. In 256 patients with Cormack-Lehane (C/L) views of 3 or 4 with a Macintosh laryngoscope, the use of the Pentax-AWS, a tube channel-type VL, was associated with a C/L view of 1 or 2 in all but one patient.[11] Jungbauer *et al*. compared the rate of C/L 3 or 4 views using DL vs using the V-MAC; their results were 36% *vs* 10%, respectively.[12] More optimizing maneuvers (external manipulation of the larynx, gum elastic bougie, and change in head positioning) were also needed for DL compared with use of the V-MAC.[12] Video-laryngoscopy frequently makes intubation easier. Using different airway tools, Malik *et al*. compared the number of patients with an intubation difficulty scale (IDS) score in three groups of 25 patients each. In the DL group, 14 patients had an IDS score of ≥ 4, indicating at least a moderate degree of intubation difficulty, compared with no patient in the Pentax-AWS group and one patient in the GVL group.[13] Video-laryngoscopes are associated with a high rate of intubation success both as first-line tools and as rescue devices. In patients with at least one predictor of difficult intubation, Aziz *et al.* showed that the C-MAC improved the success rate of the first intubation attempt compared with DL using a Macintosh blade (93% *vs* 84%, respectively).[14] The overall rate of successful intubations for experienced anesthesiologists using different VLs as a first airway device ranges from 96 - 100%.[4] After two failed DL attempts, a 99.3% success rate of intubation was realized using the Pentax-AWS as a rescue device,[11] and in a retrospective study of 2004 cases, Aziz *et al.* found a 97% success rate of tracheal intubation

using the GVL.[15] Even awake fibreoptic intubation, considered as the gold standard technique in the case of anticipated difficult airways, has recently been challenged by video-laryngoscopy. Rosenstock *et al.* compared use of flexible fibreoptic intubation with use of the McGRATH video-laryngoscope for oral tracheal intubation of awake adult patients with an anticipated difficult intubation.[16] The authors found no difference between the two techniques in time to intubation or success rate. These data suggest that VLs should improve patient safety by allowing a higher success rate in airway management.

By facilitating learning of both traditional laryngoscopy and video-laryngoscopy, VLs may improve safety by avoiding many unnecessary intubation attempts. Projecting what the operator sees on a screen creates a new dynamic interaction during airway management. The entire anesthesia team can assess progress in real time, which enhances communication and cohesion of the group and improves coordination between the assistant(s) and the operator. When an unanticipated difficulty occurs, the anesthesia team's rapid response is immediately seen (literally) and understood by the surgical team members, who can then ready themselves to face a crisis situation (wait silently for the anesthesia leader's orders). Once everyone views the ETT in the correct position with the cuff just beyond the vocal cords, all members of the OR team can breathe a sigh of relief and the procedure can start with serenity. For procedures with a high risk of airway edema, video-laryngoscopy could provide an easy and fast assessment of mucosal swelling before extubation. A video screen surrounded by a team whom each member is aware of the procedure fits better with the modern concept of teamwork, information sharing, and crisis resource management than a scenario with a single operator using DL with a Macintosh blade who sees a potential difficulty, conceals his/her doubts and fears, and thus delays the onset of an appropriate response from assistants and other participants.

Is there a potential downside to the routine use of video-laryngoscopy in the OR?

All airway situations and complications cannot be dealt with using video-laryngoscopy. Aziz *et al.* found that the strongest predictor of GVL failure was altered neck anatomy with the presence of a surgical scar, radiation changes, or a mass.[15] The authors recommended that even the most enthusiastic providers of video-laryngoscopy "should maintain their competency with alternate methods of tracheal intubation, especially for patients with neck pathology, as intubation with VLs is not always successful, and certain predictors of failure can be identified."[15] With close to an overall success rate of 100% using VLs, would the overconfident anesthesiologist be motivated to maintain his/her skills with alternative tools? Moreover, would alternate devices be taught at all to trainees, seeing as they would be more interested in VLs and realize more success with their use? The recent study by Rosenstock *et al.* might further discourage those anesthesiologists unfamiliar with awake fibreoptic intubation from trying to master this challenging technique.[16] Nevertheless, this procedure will still be required (e.g., patients with limited mouth opening). If intubation is easier, a potential danger could be a casual attitude toward airway management. Video-laryngoscopes have the potential to provide a false sense of security, leading the anesthesiologist to omit basic safety rules, such as examining the patient carefully for predictors of difficult airway management or planning for extubation, a moment when nearly one-third of severe airway complications occur. Most algorithms were developed as rescue guides in case of difficult DL,[17-19] and strict adherence can resolve most problems. However, what should be done in case of a difficult intubation with a VL? Some of these algorithms rely on VLs as rescue tools, so what should be done if they are used as routine first-line devices? Would it be possible to develop an algorithm that can apply to the three different types of VLs, and how would each of them be used optimally for routine and difficult intubation? Amathieu *et al.* assessed an algorithm that included two devices with a viewing system, the Airtraq and the LMA CTrach™ (The Laryngeal Mask Company, Singapore), as rescue devices in case of failure of DL.[20] Overall, 12,225 patients undergoing abdominal, gynecologic, and thyroid surgeries were included over a two-year-period, and 40% of these patients were obese. Airway management was successful in all cases.[20] This interesting work did not include all types of surgical patients. If VLs are part of a new paradigm in which they are routinely used as primary intubation devices, there might be a need for rethinking airway management algorithms and adopting a strategy to manage failures.

Video-laryngoscopy as a first-line tool outside of the OR

Etiologies of airway complications outside the OR

Airway management is often required in the ICU or the ED and less frequently on general wards. Those situations usually require emergent airway control and involve patients whose hemodynamic status is altered. The situations might be carried out by non-airway specialists and, consequently, are considered extremely challenging procedures. Several articles have shown that emergency airway management involves ASA physical status III or IV more often outside the OR than inside the OR.[8,21,22] Direct laryngoscopy is frequently difficult (up to 10% of cases)

even when operators have adequate airway skills.[21] Aspiration occurs in 4-8% of cases and is the most frequent cause of death or BD.[22] Several reports focused specifically on airway incidents in the ICU,[23] and the most common complications were found to be due to inadvertent displacement of either tracheal tubes or tracheostomy tubes.[22,23] To improve patient safety, many authors recommend proper airway training, availability of adequate equipment (including capnography), and the presence of skilled staff in the ICU at all times.[22-24] Based on these recommendations, Jaber *et al*. suggested a management protocol aimed to enhance patients' safety during airway management procedures in the ICU.[25] A recent article estimated the rate of RSI as one in 800 patients attending the ED, which amounts to approximately 20,000 RSIs performed in EDs every year in the UK.[26] Despite the fact that tracheal intubation outside the OR is acknowledged as being more difficult,[21,27] nearly half of these high-risk procedures are performed by unsupervised trainees.[26] Airway experts emphasized that some operators lacked airway skills and/or experience/seniority to manage difficult airway situations such as those encountered in the emergency room (ER).[22]

Will video-laryngoscopy address these problems?

Many clinicians practicing in the ICU or ED believe that VLs might help address some of the multiple issues regarding the etiology of airway complications outside the OR. The risk of complications associated with a "poor view" on DL (C/L grade 3 or 4) during airway management is twice as high outside the OR than it is in the OR.[28] This inconsistency indicates that a device allowing a better visualization of the glottis could play a major role in improving patient safety, especially outside the OR. Brown *et al.* studied glottic exposure in 198 patients who underwent tracheal intubation in two academic EDs. The intubations were performed by emergency medicine doctors or residents using the V-MAC, a Macintosh-type VL.[29] The authors found that the glottic view was better when the V-MAC was used as a VL, leading to an overall intubation success rate of 97%.[29] Sakles *et al.* found a similar success rate of tracheal intubation in an ED using the GVL.[30] Use of the GVL showed a higher success rate when compared with DL in an ED (78% *vs* 68%, respectively).[31] After adjusting for difficult airway predictors, the odds ratio of a successful tracheal intubation using the GVL was three times greater than that for DL.[31] In addition to providing a better view, VLs can assist experienced airway physicians in teaching airway management and tracheal intubation to emergency medicine residents or attendings. Video-laryngoscopy can favour communication among the different specialists involved in the management of critically ill patients by allowing multi-person visualization. The success and convenience of these devices has led emergency medicine airway experts to call for a widespread use of VLs in EDs.[3] Others see a bright future for VLs in difficult airway management in the pre-hospital setting,[32] suggesting that they can be at the heart of a new standard approach.[33] Although most of the studies have been conducted with angulated blade-type VLs, video-laryngoscopy seems to have won the battle outside the OR and forced the definition of a new paradigm in which VLs play a pivotal role.

Are there any drawbacks to this new paradigm?

If physicians involved in emergent airway management are trained to use VLs as first-line tools, then these devices should be available at all times in every environment where they could be needed (ED, ICU, hospital wards, pre-hospital). This implies regular checking and maintenance of several costly devices. These tools provide an excellent view of the glottis, but they do not achieve a 100% success rate. In what situations should their use as a first-line tool be considered suboptimal, and how should professionals be trained to identify such circumstances? What should be the best rescue devices for the various scenarios in which VLs might unexpectedly fail? Also, if the failure rate is low and alternative techniques are more difficult to master than video-laryngoscopy, what would be the motivation to be trained to use alternative techniques? Following a six-month observational period of ED airway management, Lim *et al*. reported, an overall 71.4% success rate using the GVL.[34] There were nine doctors involved, eight ER doctors with limited experience with GVL and one experienced anesthesiologist. A C/L grade 1 or 2 was always achieved, but failures were caused by difficulty in angulating and maneuvering the ETT through the glottis for insertion.[34] In a larger prospective observational cohort, Platts-Mills *et al*. reported a similar problem, a good glottis view was obtained with the GVL despite the operators' lack of experience, but failures resulted from difficulty passing the ETT through the "sharp angle created by the blade".[35] When Ural *et al.* compared endotracheal intubation before and after GVL implementation in an ICU, they did not observe a difference in the success or complication rates of emergent airway management.[36] More recently, in a retrospective study of 822 emergent intubations, even the enthusiastic team of Sakles *et al.* reported equivalent overall success rates with use of the GVL *vs* DL (84% *vs* 86%, respectively).[37] Moreover, other authors have found a very high success rate of airway management by skilled operators outside the OR without[38] or with very infrequent use of VLs.[28,38,39] Despite the rapidly growing use of VLs in the ED and ICU, there is still no evidence-based paradigm where primary airway management

outside the OR, particularly endotracheal intubation, relies mainly on video-laryngoscopy.

Conclusion

Patient safety during airway management does not rely on a single specific point, and whether or not VLs are a part of airway management or a new airway management paradigm, patient safety will be enhanced only if they are integrated in well thought-out strategies. As the perceived advantages of VLs prompt a growing number of providers to use them as first-line tools, inside and outside the OR, these devices will come to be even more widely available. Still, to ensure that the use of VLs makes a positive contribution to patient safety, their limitations need to be better defined, and appropriate alternate techniques to overcome their shortcomings and failures need to be identified and learned.

Key points

- Video-laryngoscopes are becoming increasingly popular both in the operating room and in other locations, e.g., the emergency department and the intensive care unit.
- Safety in airway management relies on multiple elements, including clinical skills, efficient tools, planning, and experience.
- Video-laryngoscopes have the potential to increase patient safety by facilitating learning, teaching, and success of tracheal intubation.
- Video-laryngoscopy has the potential to become a first-line option for intubation in the near future. This shift implies the development of new algorithms to define the proper role of each type of video-laryngoscope and to identify appropriate alternatives in case of failure.

The authors have no conflicts of interest to declare.

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