Tzu Chi Medical Journal 24 (2012) 100–103

Contents lists available at SciVerse ScienceDirect

Tzu Chi Medical Journal

journal homepage: www.tzuchimedjnl.com

Review Article

Role of video laryngoscopy in the management of difficult intubations in the emergency department and during prehospital care

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ARTICLE INFO

Article history:
Received 18 June 2012
Received in revised form
22 June 2012
Accepted 26 June 2012

Keywords:
Airway algorithm
Comack-Lehane scale
Difficult tracheal intubation
Emergency department
Prehospital care

ABSTRACT

Although the advent of emergency medicine as a specialty has led to advances in emergency airway management, airway management is still challenging for emergency physicians. Moreover, patients in need of intubation frequently present in the emergency department (ED) with medical or traumatic conditions that greatly increase the difficulty of managing the airway. In most cases, a direct laryngoscope is used for intubation, and a series of maneuvers are required to directly visualize the vocal cords and place a flexible plastic tube into the trachea. Difficult intubations usually occur with an inadequate glottic view. Operating room studies have shown that video and optical laryngoscopy, in which a miniature video camera enables the operator to visualize the glottis indirectly, improves glottic exposure and the ease of intubation compared with direct laryngoscopy. Video laryngoscopy is becoming more accessible to emergency physicians, yet whether these performance characteristics translate to emergency patients remains unclear. The aim of our article is to provide an up-to-date literature review of video laryngoscopy. We especially focus on learning with mannequins, and clinical performance in normal and difficult airways in the ED and prehospital settings.

1. Introduction

A difficult tracheal intubation (DTI) is a tracheal intubation requiring multiple intubation attempts in the presence or absence of tracheal pathology [1]. Most tracheal intubations in the emergency department (ED) are performed on an emergency basis (i.e., intubation cannot be delayed or avoided), which increases the technical difficulty of the intubation and patient risk. The intubation failure rate in a previously reported ED series was about 1%–2% [2]. Furthermore, the advent of emergency medicine as a specialty has led to advances in emergency airway management.

The Macintosh laryngoscope has been the most widely used device for intubation since its invention by Foregger in the 1940s [3]. Performing tracheal intubation by direct laryngoscopy uses a series of maneuvers, such as extending the head, opening the mouth, displacing and compressing the tongue, and lifting the mandible forward, in order to directly visualize the vocal cords and place a flexible plastic tube into the trachea. DTI, hence, can be defined as one that requires multiple attempts, multiple operators, multiple devices, excessive lifting force, or external laryngeal manipulation, or is performed with an inadequate glottic view [4]. The precise incidence of DTI in the ED is unknown. A recent multicenter National Emergency Airway Registry project analyzed 8937 ED intubations and found that the incidence of DTI was approximately 5% [5]. However, the rate in the prehospital situations was higher, independent of cardiorespiratory status [6].

The development of video and optical laryngoscopy could be the most important change in this paradigm. Video laryngoscopes (VLs) are new intubation devices, which contain miniature video cameras, enabling the operator to visualize the glottis indirectly. In operating room studies, they have been shown to improve glottic exposure and the ease of intubation compared with direct laryngoscopes [7–9]. Their design is similar to conventional laryngoscopes, enabling clinicians familiar with direct laryngoscopy to use them successfully without the need for any extensive special training. Video laryngoscopy is becoming more accessible to emergency physicians (EPs), yet whether these performance characteristics translate to emergency patients remains unclear.

The aim of this article is to provide a topical review of the literature on VLs and discuss their clinical role in adult airway management in the ED and during prehospital care.

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1016-3190/$ – see front matter
http://dx.doi.org/10.1016/j.tcmj.2012.07.002

2. Types of VL

A variety of new intubation devices have been designed to improve visualization, avoid complications, and provide fast and simple solutions for patients with difficult airways. Several VLs with differing specifications, user interfaces and geometries have been developed. This review does not focus on the specific features and characteristics of the VL. These can be found in the operating manuals of manufactories. Each particular device's unique characteristics make it either advantageous or disadvantageous in different situations. The following four types of VL are the most widely used, [7]: (1) a VL with standard Macintosh blades, of which the Karl Storz V-Mac and C-Mac (Karl Storz, Tuttlingen, Germany) are two examples; (2) a VL with angulated blades, of which the GlideScope (Verathon Inc., Bothell, WA, USA), and McGrath Series 5 (Aircraft Medical Ltd, Edinburgh, UK) VLs are available; (3) a VL with a tube channel, of which the Ambu-Pentax Airway Scope (AWS; Louisville, KY, USA) and Airtraq (Prodol Ltd, Vizcaya, Spain) are typical examples; and (4) a VL with a video stylet, of which the Clarus Video System (Clarus Medical LLC, Minneapolis, MN, USA) is a typical example [9].

3. Learning and practicing with mannequins

A VL has a short learning curve for experienced EPs (residents and attending physicians) [10–13], less experienced interns [14,15], and even paramedics and paramedic students [16,17], when using mannequins with a normal or simulated difficult airway. Interestingly, there were few differences between operators in visualization using the percentage of glottis opening, success rate of intubation, and time to intubation with any type of VL [10–17]. Intubation using a VL resulted in an improved glottic view, and was easier, faster, and equally or more successful than conventional direct laryngoscopy. Further studies, including meta-analyses, are required to clarify these observations.

Simulated difficult airway scenarios in those studies were created by immobilization of the cervical spine to produce trismus [10,12,13], inflation of the tongue to simulate edema [13], chest compression mimicking cardiac resuscitation [11,14–16], or combinations of these scenarios [12]. The geometry of the Storz video Macintosh blade is identical to that of the traditional Macintosh blade. However, the Storz blade incorporates a fiberoptic viewing port near the distal tip of the blade, which is conveyed to video with an 80-degree visualization field (45 degrees beyond what is routinely obtained with direct laryngoscopy). In experienced hands, in difficult airways, a Cormack-Lehane grade 1 or 2 view was obtained in 51% of direct laryngoscopies versus 97% using the Storz VL. The median time to intubation was 25 seconds for direct versus 20 seconds for the Storz VL [10]. The GlideScope produced better visualization of the cords than a direct laryngoscope. However, experienced EPs had better performance and inexperienced EPs showed no difference in the success rates and time required for successful tracheal intubation using the GlideScope [12,13]. This suggests that the GlideScope could be an option for airway management even by EPs with little experience and no training in its use, although training makes sense. Emergency airway management in suboptimal conditions can result in difficulties in tracheal intubation. The 2005 and 2010 guidelines for cardiopulmonary resuscitation (CPR) recommend that all rescuers minimize interruption of chest compressions [18]. Tracheal intubations using the Pentax AWS, GlideScope, and direct laryngoscope are all possible without interruption of chest compressions [11,14–16] in experienced hands. For less experienced intubators, the time to tracheal intubation was shorter with the Pentax AWS than with the GlideScope and direct laryngoscope [14–16].

More recently, in a typical out-of-hospital setting, intubations were performed in a simulated trapped car accident victim [19], with access possible only through the opened driver's door. Twenty-five anesthetists who also worked also as EPs in their countries participated. They found that the devices with a tube guide (Airtraq and Pentax AWS) enabled tracheal intubation to be achieved significantly faster and with a lower failure rate than devices without a tube guide. However, no VL outperformed direct laryngoscopy with a Macintosh laryngoscope in this simulation study.

The absence of secretions and blood limits the generalizability of study findings on mannequins. In a learning study [20] using lightly embalmed cadavers, 14 residents, one-half of whom had done fewer than 30 intubations, had a 93% success rate with intubation using a direct laryngoscope. There was a 100% success rate when intubating with three types of VLs. They suggest that the VL is a powerful tool that may help improve the overall learning curve for tracheal intubation.

4. Clinical performance in normal airways

Airway management in the ED is still challenging for the EP. Patients in need of intubation frequently present with medical or traumatic conditions that greatly increase the difficulty in managing the airway. Unlike in operating room anesthesia, ED intubation occurs after precipitous developments in patients' conditions and their unplanned presentation usually restricts the time to perform a proper evaluation to determine the existence of a difficult airway. In one study, rapid sequence intubation with a direct laryngoscope was the initial method chosen by EPs to minimize aspiration, airway trauma, and other complications of airway management with a 99% success rate [5]. Most often, however, experience is gained in the ED while using a device. In teaching hospitals, intubations are typically performed by emergency medicine residents or by attending EPs if a resident is not successful.

Repeated conventional tracheal intubation attempts may contribute to patient morbidity [21], and even result in medical–legal problems. VLs offer great visualization of the larynx, which is superior to that obtained with direct laryngoscopes, and have a similarly high rate of successful intubation and a shorter time for tracheal intubation. A recent meta-analysis revealed that VLs are a good alternative to direct laryngoscopy during tracheal intubation in randomized trial studies. However, the advantages seem to be more prominent when difficult intubations are encountered, and in all studies, all intubations were performed by anesthesiologists and conducted in the operating theatre [22].

The GlideScope VL was first introduced in 2001. Its first reported use was in 2003. Since that time, most of reports have come from anesthesia settings with operating room patients and simulation laboratories. There are few reports evaluating the GlideScope's effectiveness in ED patients [23,24]. In a prospectively study, Platts-Mills *et al.* [23] reported their first experience with a GlideScope in a series of 280 ED patients enrolled from August 2006 to February 2008. A total of 22% were intubated with a GlideScope and 78% by a direct laryngoscope. With an overall success rate of 83% for all intubations, the first attempt success rate was 81% for the GlideScope and 84% for the direct laryngoscope. The GlideScope took longer to complete a tracheal intubation (42 seconds and 30 seconds, respectively). Sakles *et al* [23] conducted a larger scale retrospective observational study and concluded that the GlideScope had a higher first-attempt success rate than a direct laryngoscope for all airways. In their study, a GlideScope was used in 360 of 943 (38%) patients intubated between July 2007 and June 2009. They further demonstrated that, in the ED, the first-attempt success rate of intubations with a GlideScope using a GlideRite rigid stylet (Verathon Inc., Bothell, WA, USA) increased from 67.5% to 82.9% compared with intubation with a malleable stylet [25]. Concomitantly, they observed that the number of complications and, in particular, the incidence of oxygen desaturation, were lower in the former patients across a 4-year study period.

Although the learning curve for using a VL on mannequins is similar on successful rate and intubation time, clinical experience has varied center-to-center. Lim and Goh [26] reported their initial 6-month experience utilizing a Glidescope for orotracheal intubations. They were successful in 15 out of 21 (71.4%) cases. Their primary difficulty was angulating and maneuvering the endotracheal tube for insertion through the glottis. Choi *et al* [27] reported a multicenter analysis on using the GlideScope in the ED. The GlideScope was used in 345 (10.7%) of 3233 intubation attempts by EPs. Although the overall success rate of the GlideScope was not higher than that with a direct laryngoscope (79.1% vs. 77.6%, respectively), the success rate for patients with a difficult airway was higher (80.0% vs. 50.4%, respectively).

Only a few clinical studies have been published on the use of VLs other than the GlideScope in the ED. In a prospective study, Brown *et al* [28] compared the use of a Storz VL with a direct laryngoscope and rated glottic visualization with the Cormack-Lehane Scale. VL improved the view in 31 of 40 patients (78%) with Cormack-Lehane Scale grade 3 or 4 on direct laryngoscopy.

Sadamori *et al* [29] reported successful intubation in all 38 enrolled patients with the use of a Pentax AWS. They found the time to successful tracheal intubation was similar (32 $\pm$ 23 seconds versus 36 $\pm$ 20 seconds) for novice residents and experienced staff physicians. They suggested that the Pentax AWS may be a suitable device particularly for less experienced personnel, such as novice advanced life Support providers [29].

5. Clinical performance in difficult airways

It is not surprising that the VL has been adopted and has played a role in the adult “difficult airway algorithm” in the ED. A VL is recommended as a rescue device when oxygenation is not possible by bag-mask ventilation or an extra-glottic device, or when oxygenation is possible but intubation is required and predicted to be unsuccessful with a direct laryngoscope [4]. There are only a few case reports on the use of a VL in clinically difficult airways, e.g., in cardiac resuscitation [30,31], trauma [32], immobilization of the cervical neck [33], and a predicted difficult airway [34]. Bara *et al* [30] reported their use of the Pentax AWS to establish airways in two patients with in-hospital cardiopulmonary arrest. In one patient, initial intubation attempts with a direct laryngoscope failed because of a poor laryngoscopic view (Cormack-Lehane Scale grade 4). In the other case, a laryngeal mask airway, and even surgical cricothyroidotomy failed to ventilate the patient [30]. Sadamori *et al* [31] also reported their experience using the Pentax AWS in a patient after CPR from an out-of-hospital cardiopulmonary arrest caused by hanging. Restoration of spontaneous circulation occurred after 15 minutes of advanced life support (including tracheal intubation with the Pentax AWS). Chest compressions were not interrupted for tracheal intubation. Kovacs *et al* [34] reported their successful use of a Clarus Shikani Optic Stylet for awake intubation in a patient with several predictors of difficult mask ventilation (i.e., obesity, edentulous status, obstructive sleep apnea, bronchospasm).

6. Clinical performance in prehospital care

In the prehospital setting, the emergency care provider must anticipate that some patients manifest with difficult airways. The use of a VL to secure an airway in the prehospital setting has not been explored widely, but has the potential to be a useful tool. In a mini-review, Bjoernsen and Lindsay [35] noted that some studies and case reports have indicated that the VL is a promising device for emergency intubation in the future, and that VL will dominate the field of emergency airway management.

Although all types of VL have been used in mannequin studies, the GlideScope [36,37] and Storz C-Mac [38,39] have dominated studies in emergency medicine services. Sakles *et al* [36] demonstrated the possibility of using a GlideScope, and a telemedicine network to assist a healthcare worker in performing tracheal intubation in a remote hospital. In a retrospective study, Struck *et al* [37] analyzed the prehospital use of a GlideScope in anticipated and unexpected difficult airways in a helicopter emergency medical service setting over a 3-year period (July 2007–August 2010). The GlideScope was used in 23 cases. A total of 17 patients presented with multiple traumas, including nine with cervical spine immobilization, three with burns, and three with nontraumatic diagnoses. Eight patients experienced failed intubations with direct laryngoscopy. They noted that, since the introduction of the GlideScope, no other backup airway device was necessary.

Carlson *et al* [38] retrospectively reviewed intubations performed from March 2010 to October 2010 by a single helicopter emergency medical service using a Storz C-Mac VL. They recorded and reviewed videos in 87 different patients with a total of 102 attempts at laryngoscopy. Thirty-six providers performed 64 cases, with the majority of providers ($n = 21$) performing only one intubation. The first-attempt success rate was 76%, with a 98% success rate within three attempts. In their preliminary prospective, multicenter, observational study, Cavus *et al* [39] enrolled 80 consecutive patients requiring prehospital emergency intubation treated by a physician trained in the use of the Storz C-Mac. Indications for prehospital intubation were trauma in 45 cases (including maxillofacial trauma in 10 cases), CPR in 14 cases, and unconsciousness of a neurologic etiology and cardiogenic dyspnea in 21 cases. The median time to successful intubation was 20 seconds; 63 (80%) patients were intubated on the first attempt. Of note, six patients could not be intubated with the videolaryngoscopic view, but they were successfully intubated in the same attempt using a Storz C-Mac with a direct laryngoscopic view [39]. They concluded the importance of options when using a Storz C-Mac in the prehospital setting.

7. Conclusions

Emergency airway management often involves a combination of factors that increase the technical difficulty of intubation and increase patient risk. Safe practice requires a rapid assessment of the patient’s clinical status and potential life threats, coupled with an understanding of the risks and benefits of rapid sequence intubation and other airway techniques. The clinician must have the equipment and skills needed to ventilate and intubate the patient quickly. Direct laryngoscopy should "always" be retained as a primary skill; however, the video laryngoscope has the potential to be a good primary choice for the patient with potential cervical spine injuries or limited jaw or spine mobility, and in the difficult-to-access patient. Whether VL represents a new era or a paradigm shift from direct laryngoscopy in adult airway management in the ED remains to be determined.

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