A Comparison of Paramedic First Pass Endotracheal Intubation Success Rate of the VividTrac VT-A 100, GlideScope Ranger, and Direct Laryngoscopy Under Simulated Prehospital Cervical Spinal Immobilization Conditions in a Cadaveric Model

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Keywords: airway management; Emergency Medical Services; intubation; paramedics prehospital; spinal immobilization; video laryngoscope

Abstract

Objective: The primary goal of this study was to compare paramedic first pass success rate between two different video laryngoscopes and direct laryngoscopy (DL) under simulated prehospital conditions in a cadaveric model.

Methods: This was a non-randomized, group-controlled trial in which five non-embalmed, non-frozen cadavers were intubated under prehospital spinal immobilization conditions using DL and with both the GlideScope Ranger (GL; Verathon Inc, Bothell, Washington USA) and the VividTrac VT-A100 (VT; Vivid Medical, Palo Alto, California USA). Participants had to intubate each cadaver with each of the three devices (DL, GL, or VT) in a randomly assigned order. Paramedics were given 31 seconds for an intubation attempt and a maximum of three attempts per device to successfully intubate each cadaver. Confirmation of successful endotracheal intubation (ETI) was confirmed by one of the six on-site physicians.

Results: Successful ETI within three attempts across all devices occurred 99.5% of the time overall and individually 98.5% of the time for VT, 100.0% of the time for GL, and 100.0% of the time for DL. First pass success overall was 64.4%. Individually, first pass success was 60.0% for VT, 68.8% for GL, and 64.5% for DL. A chi-square test revealed no statistically significant difference amongst the three devices for first pass success rates ($P = .583$). Average time to successful intubation was 42.2 seconds for VT, 38.0 seconds for GL, and 33.7 for seconds for DL. The average number of intubation attempts for each device were as follows: 1.48 for VT, 1.40 for GL, and 1.42 for DL.

Conclusion: The was no statistically significant difference in first pass or overall successful ETI rates between DL and video laryngoscopy (VL) with either the GL or VT (adult).

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Introduction

Endotracheal intubation (ETI) in the prehospital environment has a highly variable reported success rate.[1-4] Direct laryngoscopy (DL) has been the standard prehospital method of ETI. Since the invention of the GlideScope (GL; Verathon Inc, Bothell,

Abbreviations:
ANOVA: analysis of variance
DL: direct laryngoscopy
EMS: Emergency Medical Services
ETI: endotracheal intubation
GL: GlideScope
VAS: visual analog scale
VL: video laryngoscopy
VT: VividTrac

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Washington USA) in 2001, video laryngoscopy (VL) has become more common in both the operating room and emergency department settings, and it is becoming increasingly more common in the prehospital environment. Since 2001, there has been an increasing number of video laryngoscope devices available. Video laryngoscopy has shown to improve ETI success in both the operating room and emergency department, but it has not been as extensively studied in the prehospital enviroment.[4-8] In particular, the GL has been shown to improve ETI success rates in a ground-based Emergency Medical Services (EMS) system.[9]

However, not all data support the superiority of VL over DL. A recent study comparing the C-MAC Endoskope (Karl-Storz; Tuttligen, Germany) to DL failed to reduce the total number of airway attempts required in a helicopter-based EMS system.[10] Two recent studies have shown mixed results with regard to the prehospital use of VL. One study showed no difference in success rates between DL and both the King Vision (Ambu A/S; Ballerup, Denmark) and C-MAC, and another study showed improved success rate utilizing the King Vision when compared to prior DL rates.[11,12] A recent hospital-based study comparing GL to DL in a busy trauma center showed the GL to be associated with longer intubation times as well as a greater incidence of mortality and incidence of hypoxia of 80% or less in a subgroup of severely head injured patients.[13]

Another video device available is the VividTrac VT-A 100 (VT; Vivid Medical, Palo Alto, California USA). This device is a disposable channeled VL that utilizes the USB port for power and to project the image produced on a computer screen or SonoSite ultrasound machine screen FUJIFILMS (SonoSite, Inc; Bothell, Washington USA). Software that supports the device can be downloaded from the website free of charge, which also enables the device to record video as well as still images during intubation. This device has not been studied in the prehospital environment or under prehospital conditions. One recent study compares the technical aspects of the device to the C-MAC, McGRATH Mac (Medtronic; Minneapolis, Minnesota USA), and KingVision.[14] In this study, the VT was compared to the most studied video device, the GL, and to DL under simulated prehospital cervical immobilization conditions in a human cadaveric model.

Methods

Study Design

This was a non-randomized, group-controlled trial utilizing five non-embalmed, non-frozen cadavers that were intubated under prehospital spinal immobilization conditions using both DL and VL, utilizing the GL and the VT. The Institutional Review Board of the University of New Mexico (Albuquerque, New Mexico USA) approved the study. Funding for the study was provided by the Valente Fund, University of New Mexico. The study was performed at MedCure Surgical Training Center (Henderson, Nevada USA). A cohort of 14 paramedics from the following agencies participated: Las Vegas Fire Rescue (Las Vegas, Nevada USA); Medic West Ambulance (Las Vegas, Nevada USA); American Medical Response (Las Vegas, Nevada USA); Boulder City Fire and Rescue (Boulder City, Nevada USA); and Community Ambulance (Henderson, Nevada USA); all agencies were located within the state of Nevada. All participants were volunteers and received no compensation. The experience of the paramedics ranged from zero months (graduating paramedic student) to over 16 years, with an average experience of 62 months. The average self-reported number of intubations per year was 4.3 in this group.

Experimental Protocol

Each paramedic participant was given a two-hour standardized training session, as per the manufactures directions for use of both the GL with Glide Rite stylet as well as the VT (adult) with VividVision Tablet. This training session included both a didactic portion as well as a practical session with Laerdal Airway Management Trainers (Laerdal; Stavanger, Norway). All participants had to demonstrate competency with each device before moving to the cadaver portion of the trial, as determined by an on-site emergency medicine physician. All paramedics were already familiar and trained previously in DL techniques and were given the opportunity to examine and practice with the DL equipment utilized in this study during the training session.

After demonstrating competency, each participant was asked to intubate all five cadavers with each of the three intubation devices: DL, GL, and VT. The order in which each participant used each of the devices on each cadaver was randomly assigned. Care was taken to ensure participants did not intubate the same cadaver with two different devices consecutively.

Direct laryngoscopy participants were given a standard laryngoscope handle, with brand new batteries, a back-up set of batteries (of which none were needed), and each of the following blades: Miller sizes 2, 3, and 4 as well as Macintosh sizes 3 and 4. Blade choice and size was left to the paramedic's discretion for each intubation attempt. Cadaver stations provided the paramedic with their choice of either a size 7.0, 7.5, 8.0, or 8.5 endotracheal tube and 10cc syringe, as well as a new (straight out of the box) SunMed Introducer (Bougie; SunMed LLC, Grand Rapids, Michigan USA) and malleable stylet.

Cadavers at three of the stations were placed directly on the linoleum floor and two cadavers were placed on a cot (Stryker Corporation; Kalamazoo, Michigan USA) with a seat placed at the head simulating conditions in the back of an ambulance. All stations utilized two research assistants previously trained on the study protocol; one assistant was available to hold in-line spinal immobilization if a paramedic chose to have the cervical collar (Laerdal; Stavanger, Norway) that was placed on all cadavers undone during an attempt. Research assistants were trained to have the participant observe strict cervical spine immobilization during all intubation attempts. The second research assistant was responsible for timing and filling out all standardized data forms. Each paramedic was given 31 seconds from the time the tip of the respective device entered the mouth to pass an endotracheal tube and initiate a ventilation with a Bag Valve Mask (Ambu A/S; Ballerup, Denmark). Each attempt was record in seconds as 00:00, without rounding, using standardized stop watches. All participants were given a maximum of three attempts per device per cadaver to successfully intubate each respective cadaver. Participants were allowed to use bimanual laryngeal manipulation as well as a jaw thrust at their discretion with assistance provided by a trained research assistant. Participants were not permitted to place the cadaver in ear to sternal notch or sniffing position as strict spinal immobilization had to be observed. Confirmation of successful ETI was confirmed by one of the six on-site emergency medicine physicians. An Ambu aScope (Ambu A/S; Ballerup, Denmark) was available for any questions regarding successful ETI.

After intubating the cadavers, participants were asked to rate their view of the glottis using utilizing a visual analog scale (VAS)

score after the completion of each intubation attempt. Upon completion of all trials, participants were also asked to rate the following features of each device: ease of tongue control, ease of endotracheal tube passage, and overall satisfaction of tool used; all data were recorded utilizing a VAS score.

Outcome Measures

The primary outcome measure for this study was a comparison of first pass success ETI using the GL, VT, and DL. In addition, time to successful intubation and the number of attempts to successful intubation were recorded. After intubating, paramedics filled out surveys asking questions about view of glottis obtained, ease of tongue control, ease of endotracheal tube passage, and overall satisfaction for each device.

Data Collection and Analysis

All data were captured by trained research assistants using standardized data collection forms and entered into Microsoft Excel (Microsoft Corporation; Redmond, Washington USA). With regards to the primary outcome, a Chi-square test was done to determine if there was a statistically significant difference amongst the different devices for first pass success rates. Secondary outcomes, including time to successful intubation, number of attempts, and satisfaction scores, were compared using one-way analysis of variance (ANOVA). In select cases, two of the devices were compared using unpaired t-tests.

Results

A total of 281 intubation attempts were performed with only a total of seven instances where a paramedic could not intubate the cadaver in under 31 seconds within three allowed attempts. There were four instances in which the number of attempts was not documented, but amongst the available data, successful ETI within three attempts across all devices occurred 99.5% of the time overall and individually 98.5% for VT, 100.0% for GL, and 100.0% for DL. First pass success was overall 64.4%. Individually, first pass success was 60.0% for VT, 68.8% for GL, and 64.5% for DL. A Chi-square test revealed no statistically significant difference amongst the three devices for first pass success rates (P = .583).

Average time to successful intubation was 42.2 seconds for VT, 38.0 seconds for GL, and 33.7 seconds for DL. A one-way ANOVA demonstrated there to be no statistically significant difference amongst the three devices (P = .257). The increased average time to intubation of 8.5 seconds (95% CI, -1.60 to 18.6 seconds) for VT compared to DL was further evaluated with an unpaired t-test, and again, there was no statistically significant difference (P = .0983).

The average number of intubation attempts for each device were as follows: 1.48 for VT, 1.40 for GL, and 1.42 for DL. A one-way ANOVA demonstrated there to be no statistically significant difference amongst the three devices (P = .806).

Using a 100-point VAS, mean satisfaction scores were as follows: 74.9 for VT, 49.4 for GL, and 69.9 for DL. The difference between the mean satisfaction scores of VT and GL of 25.5 (95% CI, 2.94 to 48.1) was statistically significant (P = .0284). Using a 100-point VAS, the paramedics rated tongue control with the different devices. The averages for each device were 82.3 for VT, 65.2 for GL, and 74.4 for DL. A one-way ANOVA found no statistically significant difference amongst the three devices (P = .268). Again using a 100-point VAS, the paramedics rated the ease of endotracheal tube passage for the different devices. The average scores for each device were 63.0 for VT, 45.6 for GL, and 82.5 for DL. The mean score for DL was 36.9 points higher (95% CI, 18.9 to 54.9) than for GL, and this was statistically significant (P = .0003). The mean score for VT was 17.4 points higher (95% CI, -0.913 to 35.7) than GL, but this was not found to be statistically significant (P = .0616). Finally, using a 100-point VAS, the paramedics ranked their view of the glottis. The average scores for each device were 88.6 for VT, 78.8 for GL, and 58.6 for DL. The paramedics ranked their view of the glottis 30.0 points higher (95% CI, 12.8 to 47.2) using VT than for DL, which was statistically significant (P = .0014), and they also ranked their view using GL 20.2 points higher (95% CI, 0.854 to 39.5) than DL. This was also found to be statistically significant (P = .0414).

Discussion

The results failed to produce any statistically significant difference in the primary outcome of first pass intubation success rates when comparing DL, GL, or VT. Also, there was no statistically significant difference in the average time to successful intubation or in the average number of attempts for successful intubation amongst the three devices. Therefore, despite some data that suggest the superiority of VL over DL,[4-9] this study adds to the growing body of literature that argues against this.[10-13]

Although studies about ETI (including this one) often use first pass success rates as the primary outcome, another important outcome to consider is the time to successful intubation. This study demonstrated a trend towards increased time to intubation with VL, especially with the VT. This result was not statistically significant, but this finding has been seen in previous studies and is worth further exploration.[13] The trend toward increased time to intubation with VL in this study was accompanied by survey responses suggesting that the paramedics found endotracheal tube passage easier with DL than with VL. The difficulty in tube passage with VL could explain longer times to successful intubation, despite the better scores for views of the glottis with VL than DL in the surveys.

Regardless of how the debate about VL versus DL resolves, it is highly likely that VL will be an important tool for intubation in the prehospital setting in the future. For this reason, it is important that the various types of VL devices are studied and compared. As mentioned above, this is the only study the authors are aware of evaluating the use of VT for prehospital providers. With similar first pass success rates, times to intubation, and number of attempts to successful intubation, this study does not provide strong evidence to favor VT over GL, or vice versa. Although, the statistically significant preference for VT over GL seen on the satisfaction survey is notable, the participants may have been more willing to give VT a higher score because of the novelty of the device and excitement at getting to try it.

Limitations

The study was performed in a cadaveric model under simulated prehospital conditions and not on actual patients in the field. It is not certain that these results can be applied to live patients. The study sample was small, and it is possible that there are differences among the intubation devices that were not detected in this study. Paramedics were limited in an attempt to 31 seconds. This number was chosen arbitrarily and it may or may not be an actual reflection of times before desaturation in an actual given individual patient.

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A small number of paramedics from multiple agencies were utilized. These paramedics may not have been representative of the overall paramedic population. Also, these paramedics did not have prior formal training in the use of VL. This could lead to better results with DL compared to VL than might be seen in other studies with different intubators, and this should be considered in evaluating the results.

Finally, the results from the surveys in this study should be interpreted cautiously as they represent the opinions of a small group of paramedics who may have been biased by their knowledge that they were involved in a research study about different intubation devices. However, significant findings from these surveys at least require further evaluation.

Conclusion

There was no statistically significant difference in the primary outcome of first pass ETI success rate in a group of paramedics using DL and VL with either the GL or VT (adult). There was also no statistically significant difference in the time to successful intubation or in the average number of attempts before successful intubation amongst the three devices. Even though the paramedics intubated as well with GL as they did with VT with regards to the above parameters, they gave VT significantly higher overall satisfaction scores. Further assessment of the differences between these devices needs to be done in actual field trials.

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