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Learning endotracheal intubation with the Video Endotracheal Tube Guide

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Abstract

Introduction
Video laryngoscopes facilitate the visualization of the glottis but do not guarantee endotracheal intubation due to difficulties in guiding the endotracheal tube to the airway. The video endotracheal tube guide (VETG), inserted into the lumen of the endotracheal tube, provides images of its progression and assists in guiding it to the airway.
Objectives
To analyze the learning of endotracheal intubation among medical students using the VETG.
Methodology
A cross-sectional, observational, analytical study of differences in learning endotracheal intubation in simulation mannequins with direct laryngoscopy, with or without the VETG, in two groups of medical students during and after a demonstration lecture. Data on the procedures and responses from the questionnaire were collected and analyzed using the Student's t-test and chi-square test.
Results
Fifty-one medical students participated in the demonstration lecture, of whom 37 practiced endotracheal intubation in simulation mannequins—18 using direct laryngoscopy alone and 19 with the assistance of the VETG. During the demonstration lecture, the percentage of students visualizing the epiglottis, vallecula, and vocal cords was higher with the VETG (P 0.000053). In the practical session, the time to visualize the epiglottis ($P < 0.0029$) and complete the intubation ($p=0.0006$) was shorter with the VETG on the second attempt. The success rate of intubation on the first attempt was higher with the VETG (P 0.002). The percentage of visualization of anatomical structures was greater with the VETG on both the first (P 0.067) and second attempts (P 0.038).
Conclusion
Learning endotracheal intubation with the VETG appears promising, as it facilitates the demonstration of anatomical structures by the instructor and increases the percentage of correct intubations and the visualization of anatomical structures by medical students in a shorter time.

Keywords: Endotracheal intubation, Video, VETG, Technique, Learning

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Introduction

A fundamental skill for all physicians, endotracheal intubation provides access to the airway to ensure gas exchange through mechanical ventilation in emergency situations associated with respiratory failure, as well as in elective situations during general anesthesia for surgical procedures. [1,2] However, its execution can be challenging in difficult airways and fraught with risks; the most common of these are pulmonary aspiration and esophageal intubation, [1] which are related to hypoxemia even death.

Hypoxemia worsens with an increasing number of attempts, [3] rising from 14% to 47% when a second attempt is necessary. [4] Pulmonary aspiration during endotracheal intubation increases the likelihood of hypoxemia by up to 4 times and the chance of cardiac arrest by 22 times. [5] These are significant concerns, as it has been observed in an intensive care unit that 13.6% of endotracheal intubations required more than 3 attempts, and 19% resulted in hypoxemia, 9.6% in hypotension, 7.4% in esophageal intubation, and 5.9% in bronchopulmonary aspiration. [1]

In endotracheal intubation with direct laryngoscopy, alignment of the oral, pharyngeal, and laryngeal axes is sought through proper positioning. The laryngoscope blade is inserted through the oral cavity to identify the epiglottis, and its elevation allows visualization of the arytenoid cartilages and vocal cords for inserting the endotracheal tube through the vocal folds into the trachea. [6,7] The video laryngoscope can improve visualization of the glottis, [8] allowing for a reduction in cervical spine extension, [2,3] making it especially useful in cases where positioning to align the oral, pharyngeal, and laryngeal axes is not possible. [3] Another potential benefit of this device could be in education, as it would facilitate the visualization of anatomical structures, [9] however, even with the glottis visualized, successful tube placement is not guaranteed. [10]

Endotracheal intubation of a difficult airway can be a challenge, even for experienced professionals using the correct technique. [1] It is essential to train practitioners, starting with a learning method that can provide confidence and excellence in medical practice. [2] This study aimed to analyze the learning of endotracheal intubation with the use of the VETG. It sought to determine if there are differences in the percentage of visualization of the anatomical structures of the airway between direct laryngoscopy, with or without the use of the VETG, as reported by medical students after a demonstration lecture on simulation mannequins. It also aimed to compare the time to visualize the epiglottis, the time to completion, the percentage of complete or partial visualization of the epiglottis, glottis, and trachea, and the percentage of correct endotracheal intubation execution by medical students on simulation mannequins, between direct laryngoscopy with or without the use of the VETG.

Methods

Approved by the Ethics Committee of the Faculdade Evangélica Mackenzie do Paraná, under CAAE 70628223.9.0000.0103, all study participants signed the Informed Consent Form (ICF). This is a cross-sectional, observational, analytical study of differences in learning endotracheal intubation in simulation mannequins using direct laryngoscopy, with or without the VETG. The study involved two groups, totaling 51 medical students from the 6th and 7th semesters, who participated in a demonstration lecture on how to perform the techniques. Immediately after, the students completed a questionnaire regarding their perceptions of the use of the VETG.

Initially, the students were shown endotracheal intubation using direct laryngoscopy, and subsequently, the technique with the assistance of the VETG was demonstrated. In both techniques, a Macintosh curved blade laryngoscope was used to locate and lift the epiglottis to visualize the glottis. The difference lay in the placement of the endotracheal tube, which was performed either by direct visualization of the glottis or by the introduction of the endotracheal tube with the assistance of the VETG.

The VETG was designed by Franck CL, one of the authors with internal property code BR 20 2022 016199 8, is a prototype comprising a waterproof microcamera with a diameter of 3.9 millimeters at the distal tip and a smartphone holder at the proximal tip, interconnected by a semi-rigid conduit with its anatomical curvature. The VETG is inserted through the lumen of the endotracheal tube until its distal tip is positioned very close to the distal tip of the endotracheal tube. Operated and directed by the right hand of the practitioner, the VETG can guide the endotracheal tube and produce images during its journey from the lips to the trachea with precision, stability, and safety.

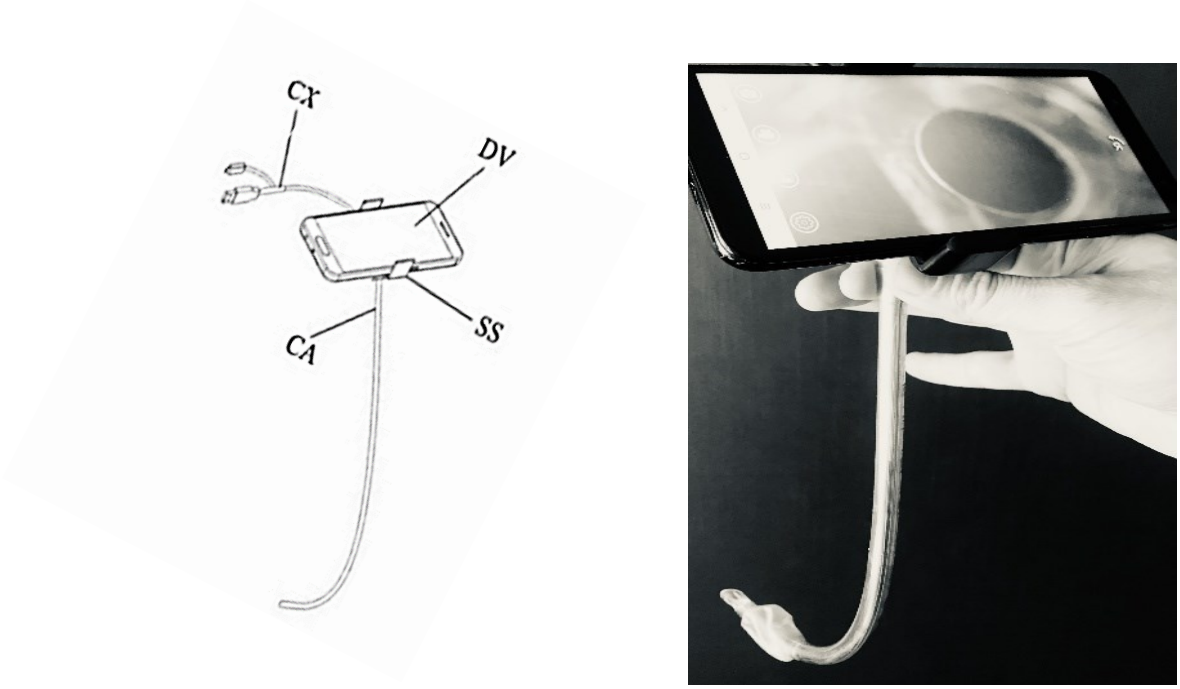

Figure 1: Drawing and photography of VETG.
Conections (CX), vídeo device (DV), suport system (SS), endotracheal tube conductor (CA).

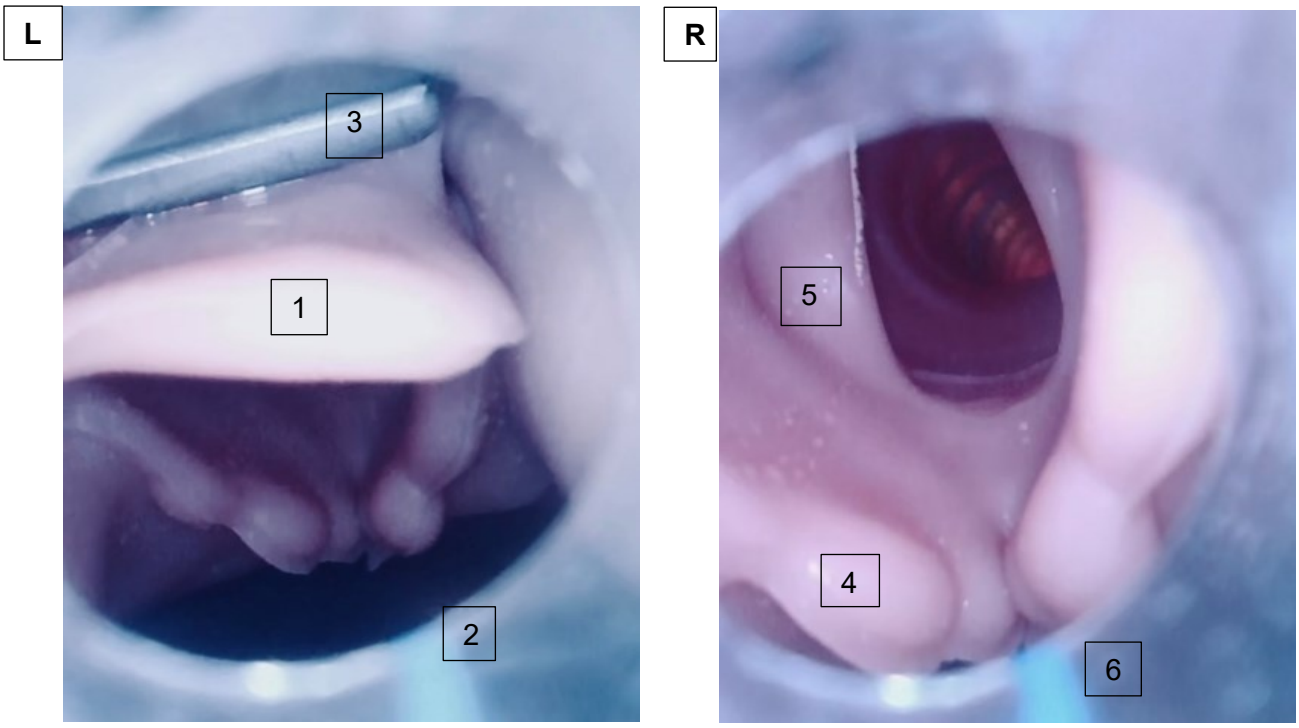

Figure 2: Direct Laryngoscopy with the VETG.
Left figure (L) with the VETG approaching the epiglottis (1) and the internal lumen of the distal tip of the endotracheal tube (2), showing the laryngoscope blade in the vallecula (3).
Right figure (R), positioned below the epiglottis, showing the arytenoids (4), vocal cords (5), and the internal lumen of the distal tip of the endotracheal tube (6).

In the second phase, participants practiced endotracheal intubation on simulation mannequins following the steps demonstrated in the teaching session. A total of 37 students participated, with 18 performing endotracheal intubation using direct laryngoscopy alone and 19 using the VETG after visualizing the epiglottis via direct laryngoscopy. During this phase, the following metrics were analyzed: success rates between the student groups, the number of attempts needed to achieve correct endotracheal intubation, time taken to visualize the epiglottis (classified as absent, partial, or complete), time required to complete the endotracheal intubation, improvement in technique on the second attempt, rate of incorrect intubations, and various causes of failure, such as esophageal intubation, incomplete, and selective intubation.

Data were collected using Google Forms and subsequently compiled into an Excel spreadsheet, where appropriate statistical analysis was performed based on the parameters collected in the study. Quantitative variables were compared using the Student's t-test, and qualitative variables were analyzed using the chi-squared test.

Results

In the demonstration session, 51 students participated and completed the questionnaire, with the following results: 100% believed that the VETG helped to better understand the explanation of the technique and that its use also facilitated the visualization of the anatomical structures indicated during the session; 96.1% believed that using the VETG from the initial contact with the intubation technique provided benefits to their learning; and 98% stated that the explanation provided with the video facilitated the implementation of the technique on the simulation mannequins, even for conventional endotracheal intubation.

A significant difference was found between the groups regarding the percentage of anatomical structure visualization during the demonstration session (P 0.000053). Students reported a higher percentage of visualization of the vallecula, epiglottis, and vocal cords when the instructor used the VETG for endotracheal intubation on the simulation mannequin.

In the second phase, which involved practicing endotracheal intubation on simulation mannequins following the steps demonstrated in the session, 37 students participated. Of these, 18 performed endotracheal intubation using direct laryngoscopy only, and 19 used the VETG after visualizing the epiglottis with direct laryngoscopy. The rate of correct intubation executions in both attempts was 62.5% for students who used direct laryngoscopy, whereas for students who used the VETG, the correct execution rate in both attempts was 100%.

Individual times in seconds were compared for each participant to identify the epiglottis and complete the endotracheal intubation across the two attempts. As shown in Table 2, significant differences were observed in both the first and second attempts for visualizing the epiglottis and completing the endotracheal intubation.

The rate of successful intubation was compared between the groups. Among those who used direct laryngoscopy, 11 students (61.1%) successfully intubated on the first attempt, and 16 students (88.9%) on the second attempt. Among those who used direct laryngoscopy with the assistance of the VETG, all 19 students (100%) successfully intubated on both attempts. Table 3 presents the differences between the groups for the first attempt (P0.0025) and the second attempt (P 0.1352).

Table 1: shows the comparison of the visualization of anatomical structures between endotracheal intubation on simulation mannequins using direct laryngoscopy, with or without the aid of the VETG.
DL: Direct Laryngoscopy, DL- VETG: video endotracheal tube guide

	DL		DL- VETG		
	Total views	%	Total views	%	P value
Epiglottic vallecula	32	63	48	94	0.000053
Epiglottis	51	100	50	98	
Vocal fold	9	18	50	98	

Table 2: Viewing time (seconds) of anatomical structures in two attempts.
DL: Direct Laryngoscopy, DL- VETG: video endotracheal tube guide, Sd: standard deviation

Attempts	Anatomical structure	DL	DL- VETG	Sd DL	Sd DL- VETG	P value
First	Epiglottis	7.42	4.14	4.13	1.17	0.0005
	Intubation	23.08	13.52	17.3	07.23	0.0142
Second	Epiglottis	6.33	4.03	3.12	1.70	0.0029
	Intubation	16.83	9.3	8.20	4.32	0.0006

Table 3: Correct endotracheal intubation in two attempts.
DL: Direct Laryngoscopy, DL- VETG: video endotracheal tube guide

Attempts	Correct	DL	DL%	DL- VETG	DL- VETG %	P value
First	Yes	11	61	19	100	0.002
	No	7	39	0	0	
Second	Yes	16	89	19	100	0.135
	No	2	11	0	0	

Table 4: shows the percentage of anatomical structure visualization during endotracheal intubation on simulation mannequins and whether the visualization was partial or total for the epiglottis and the glottis during the second attempt. During endotracheal intubation, only the VETG allowed visualization of the trachea. However, the statistical difference in the visualization of anatomical structures occurred during the second attempt (P0.038).
DL: Direct Laryngoscopy, DL- VETG: video endotracheal tube guide

	First attempt				Second attempt			
Anatomical structure	DL	DL%	DL- VETG	DL- VETG %	DL	DL%	DL- VETG	DL- VETG %
Total epiglottis	11	68.8	18	94.7	11	68.8	18	94.7
Partial epiglottis	5	31.3	1	5.3	4	25.0	1	5.3
Total glottis	9	56.3	15	78.9	10	62.5	16	84.2
Partial glottis	4	25.0	1	5.3	4	25.0	0	0.0
Trachea	0	0.0	16	84.2	0	0.0	17	89.5
P value	0.067				0.038			

Discussion

The videolaryngoscope provides better visualization of the glottis [8] with less cervical extension, [2,3] thereby potentially enhancing the chances of success on the first attempt and improving laryngoscopic view in simulation laboratories, operating rooms, emergency departments, and intensive care units (ICUs). It can be especially useful in situations where optimal alignment of the three axes cannot be achieved. [4] On the other hand, a disadvantage may occur with difficult advancement of the tube towards the glottis, even when it is visible on the monitor, which prolongs the time required for tracheal intubation. This difficulty may arise due to inexperience or the videolaryngoscope being positioned too close to the glottis, leaving insufficient space for the endotracheal tube. [10] Generally, videolaryngoscopes have the camera located at the distal tip of their blade. In contrast, the VETG has the camera located at the distal tip of the guide, producing images as it advances towards the airway.

The use of videolaryngoscopy can reduce the average time of laryngoscopy and intubation performed by novice students, with a 15% higher success rate compared to direct laryngoscopy. [2,8] Similarly, this study demonstrated that the VETG resulted in a shorter time to complete endotracheal intubation and a 39% higher success rate on the first attempt, though it was 11% higher on the second attempt. A learning curve and effectiveness of training were observed, with a reduction in intubation time from the first to the third attempt, [11] as also shown in this research, which evidenced a reduction in average times from the first to the second attempt in both groups.

It was noticed that the time to achieve endotracheal intubation was more than twice the time required for adequate visualization of the glottis. The average time for adequate visualization of the glottis was 16.4 seconds, while the median time for obtaining endotracheal intubation was 36.4 seconds. This indicates that the ease of visualizing the glottis does not necessarily eliminate the technical difficulty of introducing the endotracheal tube through the glottis. [12] In this study conducted with simulation mannequins, the time for locating the epiglottis with direct laryngoscopy and the time to complete endotracheal intubation with both techniques was more than double after locating the epiglottis, even though the concept of VETG is to deliver the endotracheal tube while visualizing the path facilitated by the semi-rigid anatomical curvature.

A study involving medical students showed a success rate of 76.8% for endotracheal intubations, with most failures related to the inability to visualize the glottis. [13] Another study compared direct laryngoscopy and videolaryngoscopy in the learning process for 5th-year students and concluded that videolaryngoscopy allowed for better visualization of the vocal cords on mannequins. [14] Similar to this study, which showed a 21.7% improvement in total glottis visualization with the use of VETG, in which allowed visualization of the trachea in 89.5% of cases due to visualization occurring during the introduction of the endotracheal tube.

Correct endotracheal intubation on the first attempt is significant for patient prognosis. Repeated attempts are associated with increased adverse events such as oxygen desaturation, aspiration, hypotension, and cardiac arrest. [15] The correct endotracheal intubation rate with direct laryngoscopy using VETG reached 100% on both the first and second attempts with novice students using simulation mannequins.

Among the limitations of this study, the relatively small sample size of medical students and the lack of comparison with other imaging devices, which are still considered the most frequent teaching method in medical education, should be noted to assess their impact on student evaluations. Advantages of the device include its low cost and the ability to reproduce real-time images via Wi-Fi to a smartphone or smart television, both for demonstration lectures and for corrections during practical training of medical students.

Conclusion

Learning endotracheal intubation with the VETG appears promising, as it facilitates the demonstration of anatomical structures by the instructor and increases the percentage of correct intubations and the visualization of anatomical structures by medical students in a shorter time.

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