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Original Article

Video Assisted Laryngoscope Facilitates Intubation Skill Learning in the Emergency Department

Su Ann Yong[1], Chung-Hsien Chaou[1,2,3], Shiuan-Ruey Yu[2], Jen-Tse Kuan[1], Chih-Chung Lin[3,4], Hung-Pin Liu[4], Te-Fa Chiu[5,*]

[1]Department of Emergency Medicine, Chang Gung Memorial Hospital, Linkou, Taoyuan, Taiwan
[2]Chang Gung Medical Education Research Centre, Chang Gung Memorial Hospital, Taoyuan, Taiwan
[3]College of Medicine, Chang Gung University, Taoyuan, Taiwan
[4]Department of Anesthesiology, Chang Gung Memorial Hospital, Linkou, Taoyuan, Taiwan
[5]Department of Emergency Medicine, China Medical University Hospital and School of Medicine, China Medical University, Taichung, Taiwan

Background: Up-to-date technology has been increasingly useful for learning resuscitation skills in the emergency and resuscitation settings. It improves the learning curve of the learners and helps them to avoid making mistakes on real patients. This study aimed to evaluate the educational efficiency for tracheal intubation by comparing Macintosh direct laryngoscope (DL) and video laryngoscope (VL) learning in novices.
Methods: This prospective randomized controlled study was conducted in an emergency department between 2013 and 2014. Fifth- and sixth-year medical students were enrolled and assigned to normal airway and difficult airway groups, respectively. They were then further randomized into using a VL or DL for tracheal intubation learning. Participants had three practices before proceeding to the post-course assessment. Our primary outcome was post-course assessment performance, which included intubation success rate, total intubation time and best glottic view. The secondary outcome was the sum of total intubation learning times during the three practices.
Results: We recruited 177 undergraduate students. Of these, 97 were assigned to the normal airway group (49 VL and 48 DL) and 80 were placed in the difficult airway group (40 each for VL and DL). VL significantly quickened the intubation learning time in both the normal airway and difficult airway groups (140 s vs. 158 s, 141 s vs. 221.5 s; both $p < 0.05$). The learning curve was much improved with VL when compared using time-to-event analysis ($p < 0.001$). VL also improved the glottic view performance during post-course assessments.
Conclusions: VL improves the learning curve in acquiring intubation skills compared with traditional DL. It shortens the time undergraduate students take to develop such skills and increased their first attempt success rates.

Key words: *video laryngoscope, intubation, Macintosh laryngoscope, skill learning, undergraduate medical education*

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[*]Corresponding author: Te-Fa Chiu, MD, Department of Emergency Medicine, China Medical University Hospital and School of Medicine, China Medical University, No. 2, Yude Rd., North Dist., Taichung City 404, Taiwan. E-mail: tefachiu@gmail.com

Introduction

An emergency department (ED) is a unique learning place for novice learners, full of all kinds of undifferentiated patients and requiring all sorts of procedural skills.[1] The learning experience within the emergency and resuscitation settings is now being recognized as a crucial stage for undergraduate medical students.[2-4] In those settings, medical students are expected to provide basic lifesaving techniques and deliver time-sensitive interventions upon graduation.[5,6] In recent years, the development of medical technology has made a large impact not only on the therapeutic field for disease treatment but also on the academic field for boosting the learning curve of medical competencies and clinical skills.[6-9] Advanced medical technology is playing a more and more important role in the educational system with the aim of assisting medical students to “learn faster and learn better.”

Among the important lifesaving procedural skills that are performed frequently in the ED, endotracheal intubation is one of the most important resuscitation techniques novice medical providers need to learn. Previously, as described by Tarasi et al., intubation skill acquisition was based on clinical experience accumulation. The above study reported that medical students made an average of 17 attempts using a traditional laryngoscope to achieve success in intubation.[10] According to Walls et al. 2011 prospective observational multi-center study, the failure rate for first intubation attempts was 5% in 8,937 ED intubations, whereas the failure rate after multiple attempts was 1%. It was also reported in the same study that 13% of intubations were assisted by other specialists, including anesthesiologists.[11] In brief, early case exposure with continual experience cumulation and familiarity with multiple intubation tools during medical training may increase the overall intubation success rate, and, further, may decrease the help needed from other specialists in handling a variety of emergency situations.[12]

Video laryngoscopy has been utilized to assist airway management since the 2000s.[13] The tool enables the intubator, as well as the observer, to visualize the relevant anatomical structure that was previously difficult to see from an ordinary angle. Several previous studies compared video laryngoscope (VL) and direct laryngoscope (DL) intubation in different levels of medical learners and under different airway management scenarios.[14-19] Most of them targeted novices such as medical students[15,16] and paramedics,[19,20] and examined the learning outcomes based on intubation success rates during and after training. On the other hand, Stroumpoulis et al. and Wetsch et al. assessed the role of the VL in expertise (experienced anesthesiologists) to find if it improved glottic exposure and facilitated difficult airway intubations.[14,17] However, detailed quantification regarding educational efficiency, especially on the improvement of learning curves and learning outcomes, is still scarce. The current prospective randomized educational study aims to compare the educational efficiency and intubation success rates between the traditional DL and the VL for tracheal intubation among novice learners.

Methods

Study Design

This study was a prospective randomized, controlled educational study to evaluate teaching quality and efficiency using the traditional DL and the VL for emergent endotracheal intubation in undergraduate learners. The study was conducted between September 2013 and March 2014. Our research was approved by the local institutional review board (IRB, No. 103-0776C). Informed consent was obtained from all participants.

Participants and Data Collection

Participants were fifth- and sixth-year undergraduate medical students who were in their clinical clerkship rotation, year one and two respectively. These medical students were recruited via e-mail and posters. All students who were willing to participate in the study were included. The only exclusion criteria was student refused to participate in the study. All enrolled participants first filled out basic information charts containing age, gender, numbers of intubation training courses taken in the past, numbers of intubations performed on manikins/patients in clinical practice and their success rate. The participants were randomized into two groups receiving different teaching methods using computer-generated random numbers. The two groups of participants were not allowed to communicate with each other during the training process.

Study Protocol

Our study aimed to compare teaching quality and efficacy by using a VL with traditional blade and a traditional DL on normal and difficult airway manikins. We developed five different sizes of laryngoscope blades that were mounted with a micro camera system and combined with a rechargeable handle and liquid-crystal displayer (LCD) screen to form one VL. This VL had the same handle and blades as a traditional DL (Fig. 1). We applied our self-invented VL for intubation in this one-year clinical research project. AirSim® TruMan Standard manikins (TruCorp., Lurgan, N. Ireland, United Kingdom) were used to simulate intubation scenarios in two airway settings, normal and difficult (filled with 20 cc of air in addition to a neck collar for C-spine immobilization). An endotracheal tube size of 7.5 mm and stylets with soft adjustable tips were used in our study.

The study protocol is illustrated in Fig. 2. The fifth-year medical students ("pure novices") were assigned to manage normal airway intubation while the sixth-year medical students (rather experienced compared with the fifth-year students) were given the difficult airway intubation scenario. Each group was further randomized into two subgroups using either the VL or DL. The participants were separated into smaller groups of six. They watched a 30-minute instructional video about traditional DL intubation and the modified Cormack–Lehane classification of glottic views. Participants then proceeded to intubation practice. For normal airways, the VL group was taught by a supervisor through an LCD screen, but the students performed intubation, during both practices and post-course test, on manikins in the traditional manner without watching the player. On the other hand, the difficult airway group was supervised and performed intubation using only the LCD screen. Students in the difficult airway group were allowed to watch the player while performing intubation during practices and post-course test. In the DL group, students were instructed and evaluated while only using the DL.

Fig. 1. Laryngoscope blades that were mounted with a micro camera system and combined with a rechargeable handle and liquid-crystal displayer screen to form one video laryngoscope.

All participants had three practice attempts under direct supervision before proceeding to the post-course tests (secondary outcomes). Each successful intubation during the learning process was recorded as intubation learning time (ILT). After the training period, the participants were tested without instruction. The primary study endpoint was the participants' performance during the post-course test, including intubation success rate, total intubation time (TIT) and best glottic view achieved. TIT was subdivided into three parts: the sum of the time to visualize the best glottic view, the time to deliver the endotracheal tube and the time to inflation of the lung. Intubation failure was defined as misplacement of the endotracheal tube into the esophagus or TIT exceeding 120 seconds. The secondary study endpoint was the total ILT (TILT) for the three practice attempts (TILT = ILT1 + ILT2 + ILT3). In addition, the success rate of first attempt intubations and grading of the best Cormack and Lehane glottic view were also documented. We used the adapted Cormack and Lehane glottic classification system by grouping grades 1 and 2a as grade A and grades 2b, 3 and 4 as grade B for the best glottic view score.

Statistical Analysis

The sample size of this study was predetermined based on the intubation times in previous research,[16,21] under the significance level of 5% and a power greater than 80%. Continuous variables were presented as mean (SD) and categorical variables as count (%). The comparisons of continuous outcomes between the two groups were done using Student's t-test or Wilcoxon rank-sum test, where appropriate. The compar-

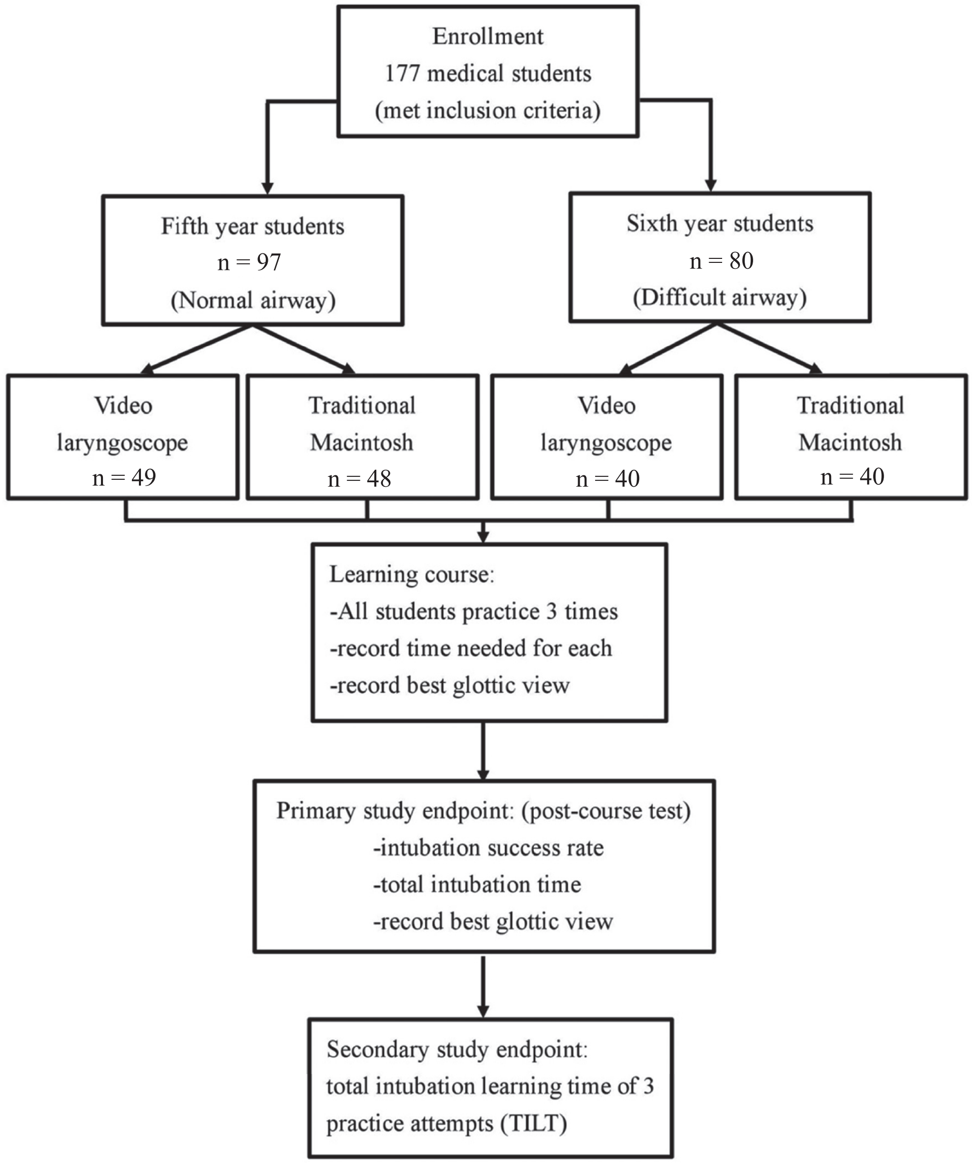

Fig. 2. Flow chart of the study protocol.

isons of categorical outcomes between the two groups were done using the chi-square test. A Kaplan–Meier time-to-event plot (cumulative failure plot) was constructed to illustrate the total learning time of the two groups, and a log-rank test was used to compare different time-to-event curves. The analyses were performed using SAS statistical software version 9.3 (SAS Institute Inc., Cary, NC, USA). A *p*-value of less than 0.05 was considered statistically significant.

Results

A total of 204 students were invited and 177 students (87.2%) agreed to participate the study. They were divided into different groups after randomization. The students' demographics and baseline intubation skills are summarized in Table 1. All students had attended intubation lectures and had experience in intubating manikins before this study. For the normal airway group, only 1 (2.04%) had intubated a real patient using a VL, whereas for the difficult airway group (sixth-year students), 9 (2.25%) had used VLs and 7 (1.75%) had used DLs for intubation.

A comparison of the learning process for different intubation learning tools is presented in Table 2. It can be seen that the video-assisted group had a higher

Table 1. Demographic characteristics and baseline intubation skill[a]

Variable	Video n = 89 (%)	Macintosh n = 88 (%)	*p*-value
Age	23.3 (3.09)	23.4 (1.63)	0.324
Gender			
Male	51 (57.3)	47 (53.4)	0.602
Female	38 (42.7)	41 (46.6)	
Previous intubation lecture	89 (100)	88 (100)	
Clerkship training in anesthesiology	12 (13.5)	10 (11.4)	0.669
Manikin intubation experience	89 (100)	88 (100)	
Real patient intubation experience	10 (11.2)	7 (7.95)	0.459
Previous intubation in manikin			
Normal airway group	49 (55.1)	48 (545)	0.946
Difficult airway group	40 (44.9)	40 (45.5)	

[a] Continues variables were presented as median (interquartile range) and categorical variables were presented as count (%). Comparisons between two intubation tools were using the chi-square test as categorical variables while Wilcoxon rank-sum test as continues variables.

first time success rate in all three learning attempts (100% for regular intubation and > 97% for difficult airway intubation). Using a VL resulted in significantly shorter intubation learning times in 4 out of 6 learning practices, and the TITs in all four subgroups became progressively shorter on each attempt. Nearly all of the video-assisted subgroup succeeded on their first attempt during each practice (only 1 sixth-year student failed on the first practice attempt). Most of the students in both the normal and difficult airway groups achieved a grade A for the adapted Cormack and Lehane glottic view using a VL. For the DL group, only half were able to obtain a grade A glottic view. A few of the fifth-year students had difficulty in determining the glottic view while all of the sixth-year students were able to achieve a best glottic view during practices.

A comparison of the endpoints, including total intubation learning time and results of the post-course test, is shown in Table 3. The video-assisted learning method required significantly shorter total intubation learning time compared to the traditional learning method in both the normal airway intubation group (140 s vs. 158 s, $p = 0.01$) and the difficult airway intubation group (141 s vs. 221.5 s, $p = 0.00$). The success rate for the post-course test did not show a significant difference in the normal airway group (VL: 100% vs. DL: 97.9%, $p = 0.31$), but for difficult airway manipulation, video-assisted intubation had a significantly increased success rate (VL: 97.5% vs. DL: 87.5%, $p = 0.009$). In general, the sixth-year students achieved better glottic views compared with the fifth-year students. A Kaplan–Meier plot was drawn using successful intubation as an end point to evaluate the time-to-learned between groups (Fig. 3). Again, participants using a VL showed a sharper incline in their learning curves, which indicates less total learning time compared with traditional teaching methods ($p < 0.001$).

Discussion

To the authors' knowledge, this is the first article to focus on the learning process and to quantify the facilitation of a VL on intubation skills learning. Our study results confirmed the role of the VL in novice medical students' mastery of intubation skills; video-assisted intubation learning not only shortened the time-to-learned but also improved success rates, especially in difficult airway intubation, which is consistent with previous findings.[19,21-23] The advancement of technology is easing many procedural skills, especially intubation in the ED. Nowadays, there are multiple methods that can be used for intubation; they are mainly categorized into two major groups, DL and VL, each having pros and cons. Most studies, though, have supported the VL as very good teaching tool[24] that is also very helpful in difficult airway intubation.[25,26]

Our study results are similar with previous findings in showing that the VL is associated with a better

Table 2. Learning process of different intubation tools[a]

Variable	Fifth-year		p-value	Sixth-year		p-value
	Video n = 49 (%)	Macintosh n = 48 (%)		Video n = 40 (%)	Macintosh n = 40 (%)	
First practice						
Intubation learning time 1 (ILT1)	57 (29)	65 (36)	0.47	52.5 (14)	84 (84)	0.000*
Best glottic view						
Grade A new	41 (83.7)	24 (50.0)	0.002*	40 (100.0)	21 (52.5)	0.000*
Grade B	7 (14.3)	22 (45.8)		0 (0.0)	19 (47.5)	
Unable to be determined	1 (2.04)	2 (4.17)		0 (0.00)	0 (0.00)	
Success rate on the first attempt	49 (100)	47 (97.9)	0.310	39 (97.5)	29 (72.5)	0.002*
Second practice						
Intubation learning time 2 (ILT2)	41 (19)	43 (24)	0.421	41.5 (15)	51.5 (58)	0.002*
Best glottic view						
Grade A	45 (91.8)	22 (45.8)	0.000*	39 (97.5)	20 (50.0)	0.000*
Grade B	4 (8.16)	24 (50.0)		1 (2.50)	20 (50.0)	
Unable to be determined	0 (0.00)	2 (4.17)		0 (0.00)	0 (0.00)	
Success rate on the first attempt	49 (100)	46 (95.8)	0.149	40 (100)	31 (77.5)	0.001*
Third practice						
Intubation learning time 3 (ILT3)	39 (14)	41 (20)	0.017*	40 (12)	52.5 (50)	0.001*
Best glottic view						
Grade A	45 (91.8)	26 (54.2)	0.000*	37 (92.5)	37 (92.5)	0.000*
Grade B	4 (8.16)	20 (41.7)		3 (7.50)	3 (7.50)	
Unable to be determined	0 (0.00)	2 (4.17)		0 (0.00)	0 (0.00)	
Success rate on first attempt	49 (100)	47 (97.9)	0.310	40 (100)	31 (77.5)	0.001*

[a]Continues variables were presented as median (interquartile range), and categorical variables were presented as count (%). Comparisons between two intubation tools were using the chi-square test as categorical variables while Wilcoxon rank-sum test as continues variables.
*Statistically significant.

glottic view[23,27] and higher success rate of intubation on the first attempt.[21,28] In addition, we further demonstrated that the VL facilitated the learning process, especially in novice learners. Some previous studies indicated that the VL was not superior for experienced care providers. For instance, Burnette et al. reported that in an easy airway intubation scenario, the traditional DL outperformed the VL in the hands of experienced anesthesiologists, while in a difficult airway scenario for the same population, the VL was better.[29] In a study by Wetsch et al., however, the VL did not facilitate endotracheal intubation in difficult airway scenarios among experienced providers.[17] In the current research, the major advantage of the VL was observed during the learning process, possibly due to the video camera system that allows the instructor to see what the learners see during intubation. Once the learners have been educated, the difference between the VL and DL in the post course assessments was not as significant.

Although video laryngoscopy has been shown to decrease the time novice learners need to learn intubation skills, it is still only one of the tools in airway management acting as a stepping stone to the mastery of intubation. Apprenticeships between mentors and students, self-training to fine-tune skills, and experience intubating real patients are other essential elements for making one skillful at intubation.[30,31] As Baciarello et al. and Shulman et al. stated regarding the learning curve of VL intubation, instant feedback from instructors to learners is a very important factor during the early part of their learning process.[23,32] In the current study, the use of a VL enabled direct instruction and immediate correction of technique that,

Table 3. Study endpoints of different intubation tools

Variable	Fifth-year Video n = 49 (%)	Fifth-year Macintosh n = 48 (%)	*p* value	Sixth-year Video n = 40 (%)	Sixth-year Macintosh n = 40 (%)	*p* value
Primary endpoints						
Post-course test						
Success rate	49 (100)	47 (97.92)	0.310	39 (97.50)	35 (87.50)	0.009*
Total intubation time						
Time to best glottic view	12 (9)	10 (7)	0.186	15 (9)	16 (21)	0.199
Time to tube insertion	20 (14)	19 (13)	0.590	22 (10)	27 (24)	0.283
Time to lung inflation	35 (14)	34 (13)	0.901	37 (14)	41 (26)	0.106
Best glottic view						
Grade A	26 (54.2)	1 (2.08)	0.001*	32 (82.1)	19 (52.8)	0.007*
Grade B	20 (41.7)	23 (47.9)		7 (17.9)	17 (47.2)	
Unable to be determined	0 (0.00)	0 (0.00)		0 (0.00)	0 (0.00)	
Secondary endpoint						
Total intubation learning time (TILT)	140 (60)	158 (76)	0.010*	141 (32)	221.5 (166)	0.000*

Continues variables were presented as median (interquartile range), and categorical variables were presented as count (%). Comparisons between two intubation tools were using the chi-square test as categorical variables while Wilcoxon rank-sum test as continues variables.
*Statistically significant.

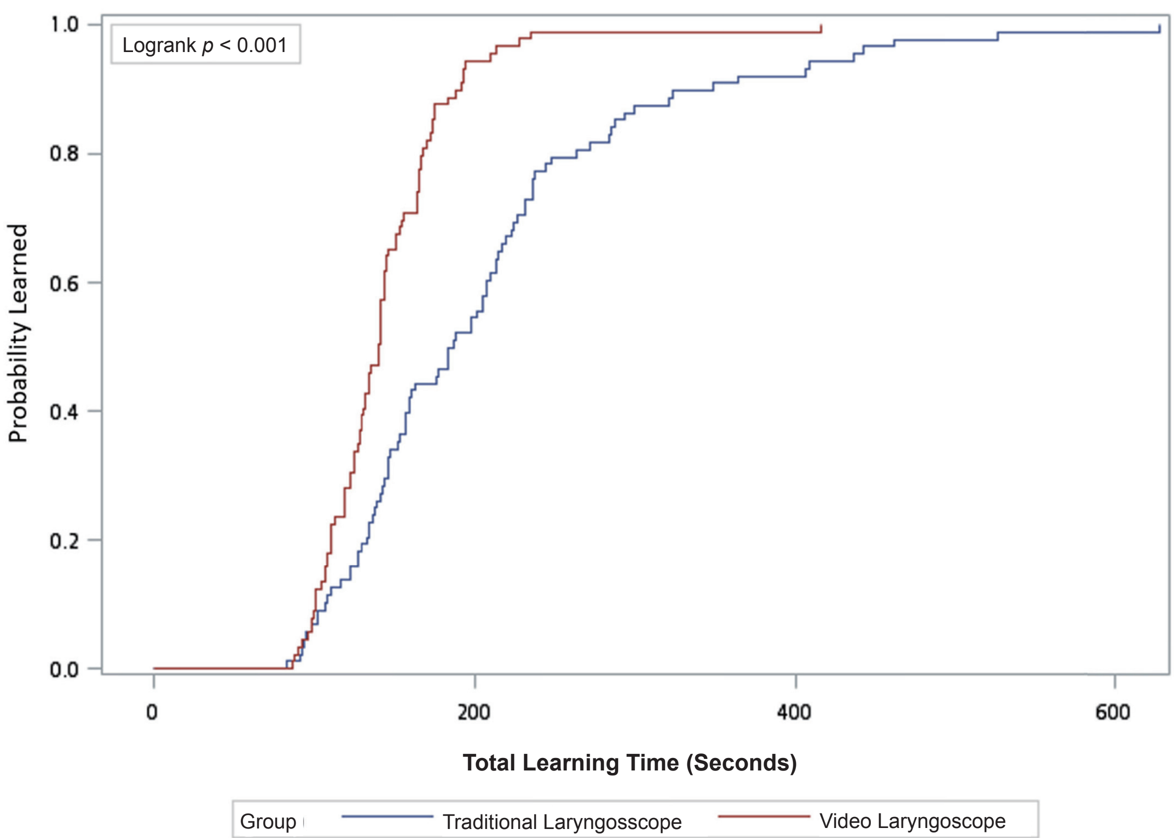

Fig. 3. Kaplan–Meier (cumulative failure) plot for the comparison of probability learned against total learning time between two groups of the participants.

coupled with sufficient verbal guidance from a mentor, led to quicker learning times. A similar phenomenon was found in a previous study.[32]

Nonetheless, a higher first attempt success rate and better glottic view do not mean shorter intubation learning time. Intubation time was not significantly shorter between the VL and DL groups in our study. The normal airway group (fifth-year medical students) using a VL took a slightly longer time for intubation during assessments, which may be attributed to their unfamiliarity with airway management without guidance as well as to equipment manipulation, such as holding a bulkier blade combined with an extra video camera or a styleted tube passage.[19] Even though our VL mounted with a traditional blade can be used as a regular laryngoscope and even with the help of its video system as a direct feedback route that could quicken the learning process, it did not significantly shorten intubation time in normal airway manikins during the assessments.

Endotracheal intubation is a complex but delicate skill that requires psychomotor coordination, as well as the practitioner being familiar with the multiple tools available.[33] In an ED setting, there are many unpredictable incidents that will further complicate the intubation success rate, such as difficult airways, lack of experienced healthcare personnel or anesthesiology specialists. Several previous studies recommended the VL for intubation as it improved glottic view[22,23,28,34] and enabled clearer instruction from mentors.[21] When dealing with difficult airway management (i.e., obese patients, trauma cases, neck anatomy variations due to underlying disease), the VL has been shown to be a better equipment choice.[14,35] Moreover, the VL proved to be beneficial in intubation teaching and learning in some previous studies. However, it is not the only factor that contributes to equipment selection in EDs around the world. Availability is another issue; the traditional laryngoscope is cheaper, more easily accessible in ordinary medical settings, easier to assemble and more familiar for most physicians.

Limitations

First, this is a single center study. Generalization of the study results must take into account differences in teaching and learning settings. Second, this study had a relatively small sample size. It is possible that the next batch of medical students may be exposed to other available video-assisted airway devices and different training programs. Third, our study was conducted on manikins instead of real patients and thus could not totally reflect real-world ED scenarios. Study on humans is difficult due to ethics issues and the chaotic environment in EDs. So far, there have been very few studies performed on patients except in the operation room. Intubation performed on an airway model is very different from intubation performed on a live patient, but standardizing the airway conditions contributed less bias to the study.

Conclusions

Intubation using a VL was highlighted for its indispensable role in medical student education as it generally quickened intubation time, increased the first attempt success rate and improved glottic views compared to a DL. The VL also had a better success rate when dealing with difficult airways, which is an essential skill in ED settings. Nevertheless, the DL retained its role as the main tool for regular intubation and is not inferior to the VL.

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Conflicts of Interest Statement

The authors declare no conflict of interest.

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