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An initial learning experience of tracheal intubation with video laryngoscope

Experiences from a novice PGY

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Abstract

Tracheal intubation is an essential technique for many healthcare professionals and one of the mega code simulations in advanced cardiac life support. In recent years, video laryngoscopy (VL) has provided a rescue for difficult airways during intubation and has proven to have higher success rates. Moreover, VL facilitates a more rapid learning curve for inexperienced doctors.

In this article, we report 16 cases intubated with VL by a novice doctor of postgraduate year 1, who shared the learning experience and the difficulties encountered in this case series. We also conducted a statistical analysis to evaluate the learning outcomes of the trainee after 1 month.

Our results showed that the overall first-shot success rate was 81.3% for the 16 objectives. Over time, improvements in intubation performance measures, including shortened duration and lower Intubation Difficulty Scale score, have been observed. In this learning project, we found that limitation of mouth opening (<2.5 fingers wide) is an important risk factor for predicting the initial difficulty of tracheal intubation on the novice trainee.

For inexperienced doctors, VL produces high first-shot success rates for tracheal intubation and may be useful for training their performance in a short period of time. In addition, mouth opening <3 fingers wide may result in difficult intubation by novice doctors.

Abbreviations: BURP = Backward, Upward, Rightward Pressure; IDS = Intubation Difficulty Scale; K-score = Kheterpal 12 risk factors score; MO = mouth opening; VL = Video laryngoscopy.

Keywords: education, intubation difficulty scale, mouth opening, PGY, tracheal intubation, video laryngoscope

1. Introduction

Tracheal intubation is one of the most commonly used techniques for many healthcare professionals. Tracheal intubation is a mega code simulation for advanced cardiac life support. Video laryngoscopes (VL) are a group of devices that provide a direct view of the glottis. Their main advantage over the classic Macintosh blade is that it offers improved visualization when encountering difficult airway situations such as poor mouth opening (MO) and limited neck mobility. With VL, higher success rates of tracheal intubation in patients with difficult airways have been reported in the literature. It is the most common rescue technique when intubation fails with the classic Macintosh blade.[1] Moreover, personnel other than the intubation operator can also see the screen and help manage the airway.

Another crucial advantage of VL is that it facilitates a more rapid learning curve for inexperienced doctors.[2–4] For young doctors in internal medicine training, intubation is only occasionally performed. However, when intubation is required, it is always under emergency conditions. Thus, it is crucial to share first-hand learning experiences to facilitate the effectiveness of their learning. In this article, we report the first 16 cases that were intubated by a novice doctor of postgraduate year 1 using VL. The trainee shares the learning experiences and difficulties they encounter from a first-person perspective. Additionally, a statistical analysis was conducted to evaluate the learning outcome of the trainee after 1 month.

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All relevant data are available from correspondent author (Chia-Chih Alex Tseng) when requested appropriate.

The datasets generated during and/or analyzed during the present study are available from the corresponding author on reasonable request.

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2. Methods

This report is part of a prospective observational study conducted at the National Cheng Kung University Hospital. After approval from the Institutional Review Board (IRB B-ER-107-088), informed consent was obtained from all patients. The operator was in her first postgraduate training year, and she had a rotation course of anesthesiology in May 2020. Previously, she had experienced tracheal intubation only on the mannequins. We collected the cases in which the operator encountered under the same supervisor during this month. All patients underwent scheduled surgery in an operating room setting. In each case, the Kheterpal 12 risk factors were summed to create a *K*-score,[5] with each risk factor accounting for one point. MO was recorded before intubation. The Intubation Difficulty Scale (IDS)[6] and the duration of successful tracheal intubation were recorded immediately after intubation. The duration of the intubation attempt was recorded as the duration from the time when the blade passed the patient's teeth to the time of endotracheal tube cuff inflation. The placement of the endotracheal tube was confirmed using a 5-point auscultation and end-tidal carbon dioxide.

Before intubation, all patients were placed in the sniffing position after preoxygenated with 100% oxygen saturation with a face mask. Tracheal intubation was attempted after administering induction agents (propofol) and muscle relaxants (rocuronium). Intubation was performed with a VL with a size 3 blade (Trachway intubating blade, Biotronic Instrument Enterprise Ltd, Tai Chung, Taiwan) in 15 cases, and with a Glidescope Go VL with a LoPro S3 single-use blade (Verathon Inc, Bothell, WA) in one case. All intubation attempts were performed under close supervision by a certified anesthesiologist.

The components of the *K*-score include age older than 46 years, male sex, body mass index (BMI) > 30 kg/m^2, thick neck, thyromental distance <6 cm, presence of facial hair, neck mass or radiation-induced changes, Mallampati classification III or higher, poor jaw protrusion (measured by the ability to bite the upper lips with the lower teeth), snoring, neck instability or limitation of neck extension, presence of incisors, and obstructive sleep apnea. IDS was assessed after successful intubation. The variables of this scale include more than one attempt at intubation, more than one operator required for intubation, use of more than one alternative technique (e.g., bougie, stylet), Cormack-Lehane Grade score-1 (range: 0–3), lifting force required (yes/no), BURP maneuver required (yes/no), and vocal cord mobility (yes/no). The details of each intubation attempt are listed in Table 1.

2.1. Statistical analysis

Data were collected, coded, and analyzed using SPSS software (version17.0; SPSS Inc, Chicago, IL). The *K*-score, MO, duration to successful tracheal intubation, and IDS were compared between the first half and the second half of the month using the Kruskal–Wallis rank sum test to assess the differences in learning outcomes over time. The correlations between variables (duration, IDS) and the order of intubation were analyzed using the Pearson partial correlation coefficient. Statistical significance was set at $P < .05$.

3. Results

3.1. Case series

The following case series were described from the first-person perspective of the operator: Demographic and clinical data are listed in Table 1.

3.1.1. Case 1. A 23-year-old male (weight 105 kg, height 175 cm, BMI, 34.3 kg/m^2) was scheduled to receive eye surgery. The patient had a *K*-score of five. The MO was three fingers wide. Jaw protrusion was poor. Airway management is expected to be difficult due to obesity. Mask ventilation was performed smoothly. The patient's Cormack-Lehane grade was 1, and his IDS score was 2. The intubation duration was 95 s. I was not familiar with the feeling of handling VL, and the blade was initially inserted laterally. The image on the screen showed the lateral wall of the oral mucosa instead of the expected glottis structure, which confused me. After adjusting the direction of the blade, the proper structure was visualized. However, as I proceeded to intubate the patient with my right hand, my left hand was not stable enough to maintain a clear view of the glottis.

Table 1

Clinical characteristics of the cases.

Order	Gender	Age	Risk K-score	IDS	Duration(s)	First attempt	Perception difficulty	Future difficulty	Comment
Case 1	M	23	5	2	95	S	40	35	Deviated direction in the beginning caused failure to see the epiglottis, not to mention glottis.
Case 2	F	43	2	7	70[a]	F	40	35	Still problems with entrance direction and unsteady strength of hands.
Case 3	M	41	4	3	101	S	40	35	Improved entrance direction. It was easier to see epiglottis.
Case 4	F	51	2	0	45	S	20	20	Seeing epiglottis was smooth. Incoordination of bilateral hands became significant.
Case 5	M	78	5	6	60[b]	F	25	25	Tube insertion itself resulted in poor view.
Case 6	M	66	3	4	66	S	40	35	Improvement of finding landmarks, but still had problems with tube insertion.
Case 7	F	42	1	0	60	S	20	20	By adjusting the angle, insertion of tube improved.
Case 8	F	67	4	4	60[c]	F	45	30	Adjusting the insertion angle improved in such patients who had poor mouth opening.
Case 9	M	79	3	0	78	S	25	15	Slow placement of tube help see the landmarks clearly.
Case 10	M	61	6	0	28	S	35	30	Absence of incisors may lead to air leak when mask ventilation, but intubation was easier.
Case 11	M	51	3	1	61	S	50	50	Cooperating with BURP to facilitate inlet view.
Case 12	F	7.	4	0	46	S	25	25	Complete the intubation smoothly with stable hands coordination.
Case 13	M	73	1	0	50	S	25	25	Laryngospasm happened and insertion became difficult under this condition.
Case 14	M	72	5	0	44	S	20	15	More mature skills with no obstacles.
Case 15	F	56	2	0	17	S	15	15	More mature skills with no obstacles.
Case 16	M	70	4	1	34	S	25	25	Could intubate independently with less duration.

F = Failure; F = female; IDS = the intubation difficulty scale; M = male; S = Success.
[a,b,c]were the durations of second attempt; [a,b,c] included the durations of second attempt; *K*-score, Kheterpal difficult mask and intubation scale[1]; perception difficulty, VAS 0-100 reported by intubation doctor; future difficulty, VAS 0-100 predicted by intubation doctor when the patient needs another intubation.

This incoordination resulted in the disappearance of the glottis from the screen, leading to a risk of esophageal intubation.

3.1.2. Case 2. A 43-year-old female (weight 60 kg, height 166 cm, BMI, 25.7 kg/m^2) was scheduled to receive eye surgery. She had normal stature, with a *K*-score of 2. MO was 2.5 fingers wide. Mask ventilation was smooth. However, I encountered difficulties during intubation. First, the mouth was not easy to open, and I spent some time trying to slide smoothly on the laryngoscope. Second, the same obstacles as in Case 1 were encountered when searching for the glottis (lateral insertion of the VL and incoordination of the left and right hands). After visualization of the epiglottis, her Cormack-Lehane grade was 3, and a BURP maneuver was needed to expose the glottis. I made two attempts to intubate, but still failed because of the obscured view of the anatomical structures. Intubation was eventually completed by a senior resident (25 s). The durations of my two attempts were 40 and 70 s, respectively. The IDS was 7. This was a difficult intubation for me. So far, I realized that my problems were an incorrect entrance direction and the unsteady strength of my left hand to keep the glottis exposed.

3.1.3. Case 3. A 41-year-old man (weight, 124 kg; height, 173 cm; BMI, 41 kg/m^2) was scheduled to undergo eye surgery. He had a *K*-score of 4. MO was 4 fingers wide. The patient was obese, as in case 1. Thus, I expected to encounter difficulties either for ventilation or intubation. Mask ventilation was performed smoothly. Although the patient's Cormack-Lehane Grade was 3, I completed the intubation by myself under BURP help. The experience of Case 2 helped me make adjustments to find a better view and accelerate my intubation procedure. The IDS score was 3. The intubation duration was 101 s.

3.1.4. Case 4. A 51-year-old female (weight 56.2 kg, height 161 cm, BMI, 21.6 kg/m^2) was scheduled to receive laparoscopic myomectomy. She had normal stature, and her *K*-score was 2. MO was 3 fingers wide. Intubation was performed smoothly. My skill in inserting the laryngoscope improved, sliding the blade first onto the central tongue base and then into the epiglottic vallecula. The IDS score was 0. This is a relatively simple case, with no difficulties. The intubation duration was 45 s, faster than in the previous cases.

At this stage, I had improved my technique for inserting the laryngoscope, and I could expose the epiglottis independently without multiple attempts. The next step was to address the lack of coordination between the movement and strength of the left and right hands.

3.1.5. Case 5. A 78-year-old man (weight 71 kg, height 165 cm, BMI, 26 kg/m^2) was scheduled for eye surgery. The patient was relatively old and had a *K*-score of 5. The MO was 2.5 fingers wide, and he had poor neck extension. I expected that it would be difficult to intubate for me because of the potentially poor view. Although the glottis was initially clearly seen on the VL, my view was blocked by the endotracheal tube after it was inserted. Therefore, the tube could not be precisely placed in the trachea. I tried for 60 s but eventually failed to intubate the patient. Intubation was performed by a supervisor with duration of 35 s. The patient's IDS score was 6. Through this case, I realized that the angle of insertion of the endotracheal tube was a previously ignored but important skill. If the endotracheal tube is inserted at an incorrect angle, it can obstruct the view of the VL. It is important to practice right hand manipulation to adjust and rotate the angle of the endotracheal tube tip at will, or esophageal intubation may occur due to the curvature of the endotracheal tube.

3.1.6. Case 6. A 66-year-old man (weight, 70 kg; height, 173 cm; BMI, 25 kg/m^2) was scheduled to undergo eye surgery. He had a *K*-score of 3. MO was 3 fingers wide. When intubating, he had a Cormack-Lehane grade of 3. After the BURP maneuver was performed, intubation was performed smoothly. The IDS score was 4, and the duration was 66 s. In this case, I felt more confident when encountering a patient with a higher Cormack-Lehane grade. The coordination and strength of my hands improved, allowing me to have a more stable view of the screen. At this point, the time required from opening the mouth to lift the epiglottis using a laryngoscope decreased with my experience from previous cases. However, the time to insertion of the endotracheal tube (66 s) still needs improvement, as was the case in Case 5.

3.1.7. Case 7. A 42-year-old woman (weight, 64 kg; height, 168 cm; BMI, 22.6 kg/m^2) scheduled to undergo laparoscopic myomectomy. She had a *K*-score of 1. MO was 3 fingers wide. The patient was expected to be a simple case for intubation. Mask ventilation and intubation both went smoothly, and no difficulty was encountered. The IDS score was 0, and the duration was 60 s. In such a patient with a normal anatomic structure, I am confident in completing the intubation independently.

3.1.8. Case 8. A 67-year-old woman (weight, 51 kg; height, 152 cm; BMI, 24 kg/m^2) was scheduled to undergo a uterine suspension. She had a *K*-score of 4. The MO was 2.5 fingers wide, and she could not perform an upper-lip bite. Considering the previous experience of patients with such characteristics, I thought that this would be a relatively difficult case. During intubation, Cormack-Lehane grade 3 was noted, and a BURP maneuver was performed. I made two attempts at this patient, due to a poor view for the first time. In the second attempt, I adjusted my blade insertion angle and was successful. The duration of the first and second attempts was 45 and 60 s, respectively. The IDS score was 4. The increasing experience of using VL allowed me to adjust the viewing angle and obtain better exposure of the glottis.

3.1.9. Case 9. A 79-year-old man (weight, 77 kg; height, 162 cm; BMI, 29 kg/m^2) was scheduled to undergo radical prostatectomy. The MO was 3.5 fingers wide. No remarkable risk was noted. He had a *K*-score of 3. The intubation was smooth despite the relatively old age. The IDS score was 0, and the duration was 78 s. The lesson I learned from this case was to insert the laryngoscope slowly. If the laryngoscope is inserted too deep too quickly, it could disorient the inexperienced intubator, since the usual landmarks are absent on the screen.

3.1.10. Case 10. A 61-year-old man (weight, 76 kg; height, 169 cm; BMI, 27 kg/m^2) was scheduled to undergo ureteroscopy. He had a *K*-score of 6. He had poor neck extension and an upper lip bite. MO was 4 fingers wide. Despite the high risk score, I thought this patient would not be a difficult case because of good MO. During mask ventilation, there was a small air leak due to the poor seal between the mask and face due to missing teeth. Nevertheless, intubation was easily completed. The absence of teeth provided a wide operative space for the laryngoscope. The IDS score was 0, and the duration was 28 s.

3.1.11. Case 11. A 51-year-old man (weight, 93 kg; height, 177 cm; BMI, 30 kg/m^2) was scheduled to undergo eye surgery. He had a *K*-score of 3. MO was 3 fingers wide. No remarkable risk factors were identified. Cormack grade was 2. BURP was performed, and intubation was completed. No other difficulties were observed. The IDS score was 2, and the duration was 61 s. In patients with a long epiglottis, the vocal cord can be difficult to expose, even with much lifting effort. For novices like me, it is important to cooperate with the assistant to perform BURP.

3.1.12. Case 12. A 70-year-old woman (weight, 53 kg; height, 155 cm; BMI, 22 kg/m^2) was scheduled to undergo eye surgery. She had a *K*-score of 4. MO was 3 fingers wide. A history of snoring and Mallampati class III was noted. The intubation was performed smoothly. The IDS score was 0, and the duration was 46 s. At this stage, I thought the most important factor that influenced intubation was a wide MO. If the MO was adequate, intubation would be easier for me.

3.1.13. Case 13. A 73-year-old man (weight, 63 kg; height, 161 cm; BMI, 24 kg/m^2) was scheduled to undergo arteriovenous fistula repair. The patient had a risk score of 1 (old age). The MO was 3.5 fingers wide. I predicted that I would intubate the patient smoothly. However, despite the use of a muscle relaxant, the vocal cord was not paralyzed, and the glottic orifice was narrowed. An obvious resistance was felt when passing the tube through the glottis. I spent time rotating the tube to pass through the closed orifice. The IDS score was 1, and the duration was 50 s. This was my first encounter with a non-paralyzed vocal cord, and more skills were needed to insert the tube against the significant resistance. The endotracheal tube was inserted successfully by rotating the tube.

3.1.14. Case 14. A 72-year-old man (weight, 52 kg; height, 157 cm; BMI, 21 kg/m^2) was scheduled to undergo radical prostatectomy. He had a *K*-score 5. The MO was 4 fingers wide, and he had good neck extension. The intubation was performed smoothly. The IDS score was 0, and the duration was 44 s.

3.1.15. Case 15. A 56-year-old woman (weight, 59 kg; height, 164 cm; BMI, 21 kg/m^2) was scheduled to undergo eye surgery. She had a *K*-score 2. The MO was 3.5 fingers wide. The intubation was performed smoothly. The IDS score was 0, and the duration was 17 s.

3.1.16. Case 16. A 70-year-old man (weight, 75 kg; height, 169 cm; BMI, 26 kg/m^2) was scheduled to undergo eye surgery. He had a *K*-score 4. MO was 3 fingers wide. The intubation was performed smoothly. Cormack-Lehane Grade 2 was noted during intubation, but there was no need for a BURP maneuver. The IDS was 1 point. The intubation duration was 34 s.

At this time, the difficulties I encountered in the first week had mostly been overcome. I was able to control the initial direction when inserting the VL and to find the landmarks smoothly. The coordination of the left and right hands improved after training, as did the insertion of the endotracheal tube.

Comparing intubation durations from the first and second halves of the month, there was a significant improvement (chi-square 4.27, df = 1, $P < .05$). The IDS score of the second half of the month was also significantly lower than that in the first half. (Chi-square 4.15, df = 1, $P < .05$). No significant differences were found on *K*-score and MO. In our records, the longest duration was 101 s at the beginning of the study, and the shortest duration was 17 s (Table 1). There was a negative correlation between the duration of intubation (mean = 54.38 s, SD = 22.67) and the order of cases ($R = -0.744$, $P < .001$) (Fig. 1). There was also a negative correlation ($r = -0.595$, $P = .015$) between IDS (mean = 1.75, SD = 2.35) and the order of cases (Fig. 2).

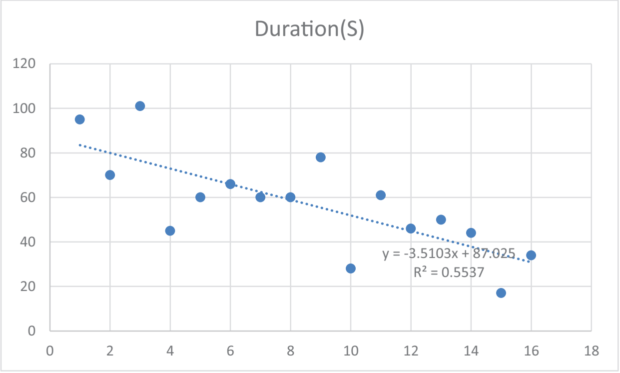

Figure 1. The correlation between duration and order of intubation. $R = -0.744$, $P < .001$.

4. Discussion

In our series, 16 patients who underwent tracheal intubation with VL were observed to assess the learning outcome of a novice postgraduate year 1 over the course of one month. A rapid learning curve was noted, as shown in Figures 1 and 2.

Thirteen patients were successfully intubated at the first attempt, resulting in a success rate of 81.3%. The success rate was 71.4% during the first half month and 100% during the second half month. This was similar to the success rates reported in the literature.[7,8] This rate was not far from that of previous reports analyzing the rate of tracheal intubation with VL,[9] and it was also higher than previously reported success rates of tracheal intubation training with the classic Macintosh blade during novice practice.[3,7] Studies analyzing differences between VL and direct laryngoscope in the literature showed that, for novices, video-assisted techniques significantly increased the success rate of intubation, and did not require more time than direct laryngoscopy.[3,7–12] In addition, studies showed a shorter learning curve for residents in the hospital using VL.[8,9,13,14] In these studies, the first-shot success rates of VL by novices were comparable to those in our study.

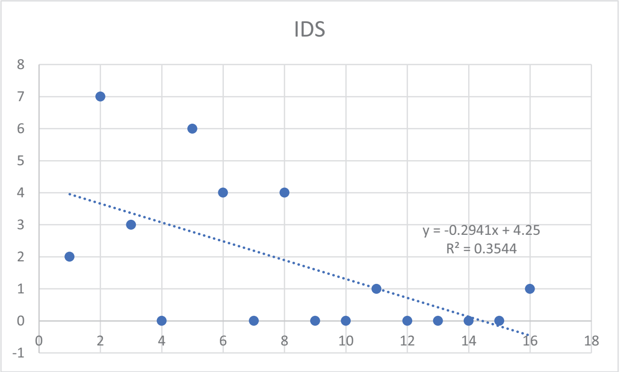

Figure 2. The correlation between IDS and order of intubation. IDS= the intubation difficulty scale. $R = -0.595$, $P < .05$.

A faster learning curve was reported for intubation using VL. Nouruzi-Sedeh et al showed a significant improvement in intubation duration after five attempts by novices.[7] Aghamohammadi et al revealed similar improvements after six attempts by medical students on mannequins.[10] Our results demonstrated rapid improvement, which is consistent with the results of previous studies. The intubation duration decreased, and the success rate was 100% in the second half of the month. For direct laryngoscopy, more than 50 attempts are needed to achieve a stable success rate of > 90%.[15] Our data suggest that remarkably fewer attempts may be required to achieve a stable success rate. In summary, there was an efficient improvement in intubation performance in one month by the same operator. This result implies that VL may be an efficient tool for intubation training if the time and number of subjects are limited.

Three were 3 patients could not be intubated on the first attempt. All of them had limited mouth opening (MO ≤ 2.5 fingers wide). It seems that the limitation of MO is an important risk factor for predicting difficult intubation in novice trainees. In the near future, we expect to conduct more studies on novice operators with VL.

In the following text, the trainee shares a summary of their learning experiences and the difficulties they encounter when training using a first-person over the course of one month.

The following are my subjective explanations about my initial thoughts about tracheal intubation. These findings may be helpful for novice doctors to learn tracheal intubation in the future. Before intubating a real patient, I had intubated mannequins numerous times and watched professional tutorials to ensure that I familiarized myself with the entire tracheal intubation process. Although I had practiced mannequins many times before, several obstacles remained when I intubated a real patient:

First, I was not familiar with the direction in which the force should be applied, and I did not realize that failing to insert the blade tip into the central epiglottic vallecula would lead to an incorrect view on the screen. This often disoriented me due to the presentation of a deviated view filled with soft tissue from the lateral oral or pharyngeal wall without obvious landmarks. To correct this error, I learned to insert the scope into the larynx slowly and cautiously put the blade tip at the midline. Important landmarks, such as the epiglottis, will then appear in order as expected, and the doctor would be more space-oriented. Gentle and slow placement may also cause less damage to patients.

Second, in the beginning, I exerted too much force to lift the epiglottis. This leads to arm fatigue, and thus should be avoided. As I gained more experience over time, I realized that the accurate placement of the blade and gently adjusting the blade into a better position in the epiglottic vallecula is a key technique. After reaching the proper position, the epiglottis can be lifted without much effort. We identified that female operators with less muscle power may not be the cause of difficult intubation.[16] Although it takes time to position the blade into the most effortless position, this maneuver does not cause a noticeable increase in the total duration of intubation. For a novice operator, this delay in the initiation of tube insertion often causes psychological stress, which leads to poor placement of the blade and subsequent compensational brute force. The extra exertion then causes easy fatigue and produces unsteadiness of the view from the scope.

Third, it is important for both hands to work in coordination. In the beginning, I had significant difficulty holding the laryngoscope with my left hand while simultaneously intubating with my right hand. When completing exposure of the larynx with the VL, I shifted my attention from my left hand to the work on my right hand and focused on adjusting the angle of the tube. However, even a tiny movement caused significant deviation of the image on the screen and prolonged the intubation time. This phenomenon was apparent during the first week of training. Over time, improved coordination of the two hands helped me precisely insert the tube into the vocal cord to an adequate depth.

Aside from the VL training, I also performed 10 cases of intubation using a conventional laryngoscope during this project. The most striking difference between the two techniques was that the VL provided a broader view if I reached the correct anatomical space. To obtain a clear view of the glottis using a conventional laryngoscope, the operator needs to line the three axes (oral, pharyngeal, and tracheal) to a straight line. This skill required practice and was a bottleneck during my practice. In contrast, VL allowed me to get a proper view of the glottis, and I could complete the intubation in a straightforward manner by looking at the video screen. Although VL provides a clearer view and requires less force and skills, I think there are still some disadvantages for beginners. VL lacks a sense of reality compared to conventional direct laryngoscopy. I was poor at assessing the true depth of the laryngoscope by watching the video monitor at the beginning. The view lacked perception of distance and was different from what I saw in the direct laryngoscope. This made me struggle for a short period of time.

This study showed the progress of intubation performance in a short period by a novice doctor of postgraduate year 1 training with VL. MO width > 3 fingers wide was found to be an important predictor of success on the first attempt of tracheal intubation training by a novice doctor. Placing the blade tip at the midline of the tongue base and gently positioning the tip into the epiglottic vallecula with two-hand coordination was also important. Successful intubation requires a refined technique at every step, and the details and insights behind these steps cannot be learned only from tutorials, but require hands-on experience. In conclusion, for inexperienced doctors, VL may be useful in training their performance in a short period of time.

Author contributions

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Visualization: Yu-Hwa Wu.
Writing – original draft: Chai-Bae Shih.
Writing – review & editing: Yu-Hwa Wu, Chung-Ren Lin, Chia-Chih Alex Tseng.

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