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Original Article

Comparison of Endotracheal Intubations Performed With Direct Laryngoscopy and Video Laryngoscopy Scenarios With and Without Compression: A Manikin-Simulated Study

Mustafa Kürşat Ayrancı*, Kadir Küçükceran, Zerrin Defne Dündar

Emergency Medicine Department, Necmettin Erbakan University Meram Faculty of Medicine, Konya, Turkey

Background: In the International Liaison Committee on Resuscitation 2019 update, it is recommended that endotracheal intubation (ETI) implementation trainings be held more frequently. There is limited data in the current literature on the comparison of cardiopulmonary resuscitation performance using direct laryngoscopy (DL) and video laryngoscopy (VL) by new ETI operators. The aim of this study was to compare the intubation period of intubations operated with DL and VL for the scenarios with and without compression and to assess the performance criteria of compression and ventilation in a manikin-simulated scenario with compression, for the experienced and new ETI operators.

Methods: This manikin trial was carried out through a total of four scenarios, two of which were elective intubation and the other two were intubations with compression. A total of 90 people in 45 groups (each group consists of 2 persons) performed four scenarios in the manikin. Ventilation and compression performance data of the scenarios were recorded.

Results: A significant difference was found between the scenarios in terms of intubation period and VL in both scenarios with and without compression (in scenarios with compression, DL: 23.21 ± 11.33, VL: 17.06 ± 4.71, $p < 0.001$; in scenarios without compression, DL: 19.40 ± 8.03, VL: 15.04 ± 3.31, $p < 0.001$). In intubation interventions with and without compression, the success rate of DL in the second intervention was more statistically significant compared to VL ($p = 0.008$ and $p = 0.011$). In the intubation scenarios with compression, the intubation success rates of the new operators were lower than the experienced participants, and it was statistically significant ($p = 0.009$).

Conclusions: During intubation interventions with and without compression, in terms of the success rate after the first attempt and ensuring adequate airway management, VL was found to be more effective. In all intubation attempts, especially in compression intubations, new operators should be encouraged especially for using VL (at least until they have sufficient experience).

Key words: *direct laryngoscopy, video laryngoscopy, intubation experience*

Introduction

During adult cardiopulmonary resuscitation (CPR), endotracheal intubation (ETI) is regarded as a more appropriate method than bag-mask ventilation (BMV) and supraglottic airways (SGA) for ensuring and maintaining an open and safe airway.[1-3] In the International Liaison Committee on Resuscitation 2019 update, it was stated that, when advanced airway

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*Corresponding author: Mustafa Kürşat Ayrancı, MD, Emergency Medicine Department, Necmettin Erbakan University Meram Faculty of Medicine, 42080, Konya, Turkey. E-mail: drmka157@gmail.com

management is used in out-of-hospital and in-hospital cardiac arrests, ETI or SGA can be used according to the fact that the skills of the rescuer and the quality of training opportunities and class of recommendation and level of evidence were raised.[4] In addition, more frequent practical courses are recommended for healthcare providers who perform ETI, and besides, follow-up and quality improvement programs should be provided for prehospital emergency healthcare systems performing ETI.[4] ETI should be performed when trained personnel is available to implement the procedure under high skill and confidence.[5]

Direct laryngoscopy (DL) is an intervention method where the operator inserts the laryngoscope blade and provides a view of the glottis patency. To perform ETI in emergency services, the primary method is DL.[6-9] Video laryngoscopy (VL) has a camera underside of the laryngoscope blade and provides the image of the airway from the patient on the LCD monitor, and this method eliminates the problems related to the line of sight for the airway.[10]

It reveals that ETI may be associated with a number of complications, and the procedure requires skill and experience.[11] ETI interventions during CPR are associated with improper placement of displacement of the tube and prolonged interruption in chest compression.[11] The interruption of chest compressions endangers coronary and cerebral perfusion.[5] The current guidelines and literature emphasize the importance of uninterrupted chest compressions and minimizing interruptions in chest compressions.[5,11]

Compared to DL, VL provides a better view of the larynx, offers less traumatic intubation, minimizes the interruptions, increases the success rate of intubation, and reduces the complication rate.[5,12]

In the current literature, there is no study in the form of a 4-scenario that compares non-compression and compression intubation times and at the same time other ventilation and compression performance criteria.

The primary aim of this study, for the experienced and new ETI operators, is to compare the intubation period of intubations operated with DL and VL for the scenarios with and without compression and to assess the performance criteria of compression and ventilation in a 4 scenario with compression. The secondary aim is to compare the DL and VL for each scenario in terms of ease of use.

Methods

This study was designed as a prospective, randomized, single-blind, and cross-over manikin-simulated trial. Ethics committee approval was obtained for this study. An informed consent form was received from all participants.

Study Population

The specialists who received basic life support and advanced cardiac life support training and who had the skill of CPR and ETI in their daily professional practice, research assistants, emergency medical technicians, and nurses were included in the study on a voluntary basis. A total of 90 volunteer participants aged over 18 years old, including 45 teams (2 rescuers per team), were randomly included in the study. While grouping the teams, the participants were selected ignoring the variables such as age, gender, weight, height, etc. Teams were determined by drawing lots method, and the scenario they will apply was reported just before the first scenario of the team by sealed orders.

Instruments Used

The instruments and tools used in the study are as follow: Laerdal Resusci Anne Advanced Skill Trainer with Sim Pad PLUS® manikin, Macintosh laryngoscopy and Mac#4 blade, Storz® branded C-MAC video laryngoscope and C-MAC monitor and C-MAC Mac#3 blade (Karl Storz GmbH and Co., Tuttlingen, Germany), 7.5 size cuffed endotracheal tube in accordance with the manufacturer’s recommendation, BMV for ventilation, 10 mL injector, lubricant gel for endotracheal tube, lockable and height-adjustable stretcher, standard CPR board, and 3-step stair.

Scenarios

The manikin was laid on the stretcher, a standard CPR board was placed between the manikin and stretcher, and a stair was placed next to the stretcher for the person to perform chest compressions. The manikin was adjusted to simulate an asystole cardiac arrest.

The study was performed over 4 scenarios:

(1) ETI via DL without compression;
(2) ETI via VL without compression;
(3) ETI via DL during uninterrupted chest compressions;

(4) ETI via VL during uninterrupted chest compressions.

Fig. 1 shows the intubation scenarios in detail.

Standardization Measures

(1) Before applying the scenarios, the manikin, video laryngoscope, direct laryngoscope, stretcher, and other materials to be used, these were introduced to all volunteer participants in the study by the researchers.

(2) All participants were given, on the manikin, 10 minutes of exercise time to intubate with both DL and VL, and 10 minutes to practice a proper compression and proper ventilation. During this time, the participants were provided to watch the manikin on SimPad to evaluate their own performances.

(3) During all scenario applications, on the other hand, SimPad was not shown to the participants. No feedback was given to the participants for intubation periods obtained as data and performance criteria of compression and ventilation. The easiness scorings of the participants were noted in a sealed envelope in such a way that only the researchers would know.

(4) The participants were asked to perform ETI via DL and VL without compression (scenario A and B).

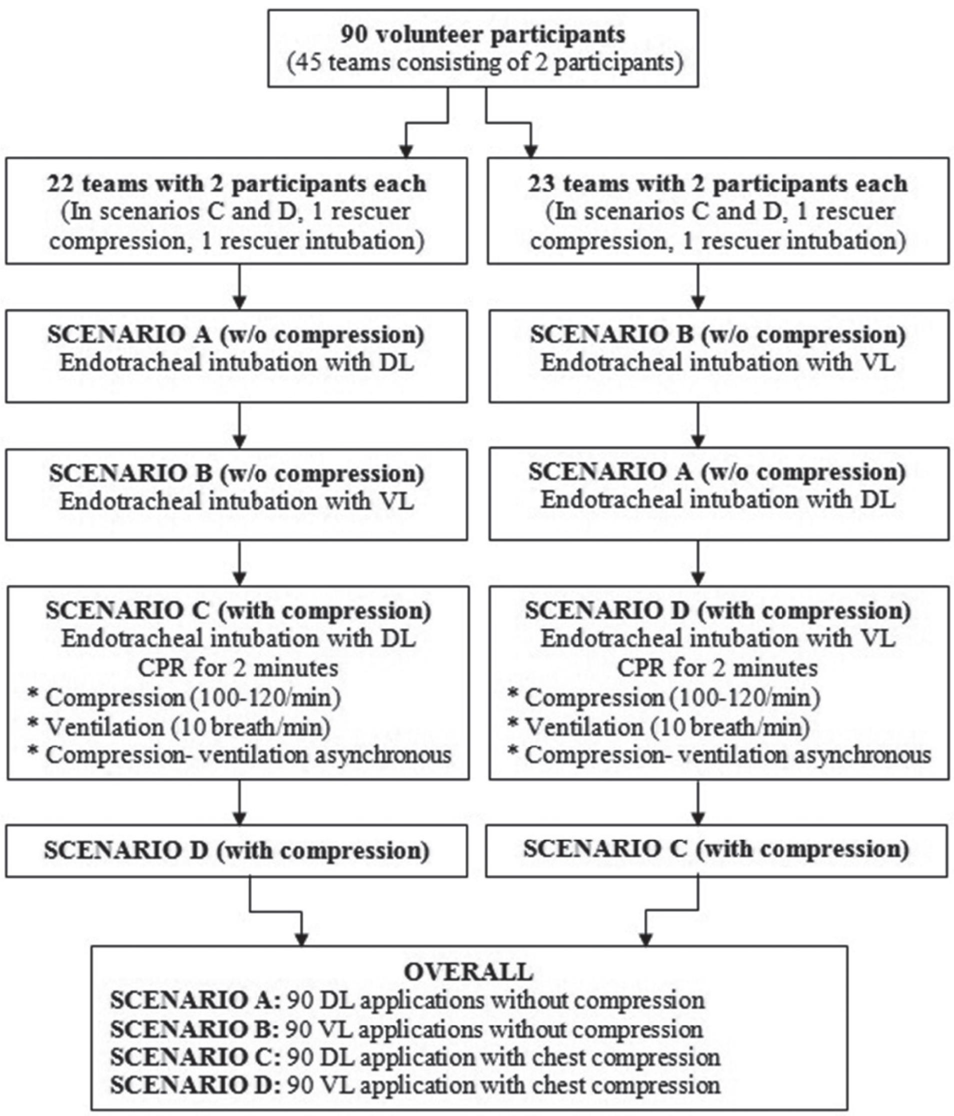

Fig. 1. The study flow card.

CPR: cardiopulmonary resuscitation; DL: direct laryngoscopy; VL: video laryngoscopy; w/o: without.

(5) In the scenarios performing intubation via uninterrupted chest compression (scenario C and D), intubation and chess compressions were started synchronically. While a team member made a chess compression for 2 minutes, the other team member performed intubation. Within this period, if intubation performing time exceeds 30 seconds or in the event of improper (stomach) intubation, the participant performing the intubation was asked to remove the tube and to try the intubation for the second time following ventilating the manikin 4–5 times by using BMV.
(6) Intubation times in all scenarios were recorded by researchers by means of a stopwatch. Intubation time was started with the contact of laryngoscopy to the manikin and the time until the cuff of the endotracheal tube was inflated was accepted. To confirm the accuracy of the intubation, participants made this verification according to the guideline recommendations, while the researchers made it over SimPad by visual check of ventilation of the manikin.
(7) Again in terms of standardization, the stretcher was raised to the xiphoid level of the intubation operator for the person to perform chest compression, and the step was used to keep the stretcher at the knee level.
(8) Tools to be used by the intubation operator were kept next to the manikin on a table according to the scenario type. A blind healthcare staff delivered the intubation tube to the operator upon his/her request, inflated the cuff, and provided the ventilation using a BVM while the operator corrected the place of the tube.
(9) In the intubation scenarios with compression, the intubation operator was granted the right to ask his/her team-mate who performs the compression to interrupt the compression for a short time (not to exceed 5 seconds).
(10) In all scenarios, the same brand and amount of lubricant were applied to the edge of the intubation tube by the same researcher.
(11) To adapt to compression speed (100–120/min) as recommended by the 2015 American Heart Association/ European Resuscitation Council (AHA/ERC) resuscitation guidelines, a metronome that produces 110 metrical ticks (beats) per minute was used in the scenarios with chest compression.
(12) Prior to starting the scenarios, the participants were informed that the ventilation rate target was 10 breaths/min, but an audible and visual warning device was not used.
(13) To prevent performances from being affected by physical fatigue, the participants were given at least 2 hours of rest time between the scenarios C and D.

Data Collection

Age, gender, height, weight, task, and the number of previous successful intubation experiences of all participants were recorded. CPR performance data for the C and D scenarios were recorded by looking at the SimPad QCPR of the manikin. In accordance with the 2015 AHA/ERC resuscitation guidelines recommendations, settings of the simulator were adjusted as follows: compression depth 5–6 cm, compression speed 100–120/min, and ventilation rate 10 breaths/min. In the scenarios A and B, the information regarding that the participants were successful in intubation attempts, and their intubation times were recorded. Similarly, in the scenarios C and D, the information regarding that the participants were successful in intubation attempts, and their intubation times were recorded. In the article published by Reed[13] in 2007, the first 100 intubation attempts made by an emergency medicine intern were recorded, and as a result, while complications were common in the first 20 attempts, it was observed that complications improved after 30 attempts. In another study conducted by Komatsu et al.[14] in 2010, the intubations of 15 interns from different specialties on 679 patients were evaluated. It was concluded that 29 attempts were required for an 80% tracheal intubation success rate. In our study, we considered the participants with 30 or more attempts as experienced. Additionally, the following information was recorded: compression performance criteria and ventilation performance criteria.

After all the scenarios, the participants were asked to rate the easiness assessment scores (between 1 and 10) of the intubations they made for each scenario, between 1 and 10, in a sealed envelope, and this information was recorded.

It was investigated whether there was any difference in scenarios in terms of times of intubation with DL and VL, performance criteria of compression-ventilation, and easiness.

Statistical Analysis

Statistical analyses of the data were made by using SPSS 20.0 (SPSS Inc., Chicago, IL, USA) packaged software. Analyses of normality of the data were made by using histograms and Kolmogorov–Smirnov test. Quantitative data were stated as mean ± standard deviation, while categorical variables were stated as frequency (percentage). The differences between the groups were investigated using the Mann–Whitney *U* test in non-normally distributed quantitative variables, while the Student *t*-test was used for normally distributed quantitative variables. Categorical variables were compared between groups using the chi-square test. The $p < 0.05$ value was accepted as statistically significant.

Results

In our study, 90 volunteer participants were included. In the A and B scenarios, 180 intubations without compression (DL + VL) were performed. In the C and D scenarios, a total of 180 intubations with uninterrupted chest compression (DL + VL) were performed. 61.1% (n = 55) of the participants were male, their mean age was 28.57 ± 3.84 (minimum: 23, maximum: 46), and 76.7% of them (n = 69) were research assistants. Table 1 shows the characteristics of the participants.

Comparing the participants' times of intubation without compression, there was a statistically significant difference between the groups (DL: 19.40 ± 8.03, VL: 15.04 ± 3.31, $p < 0.001$).

Evaluating the scenarios where intubation with compression was performed, there was a statistically significant difference between the participants in terms of intubation times for ventilation performance criteria (DL: 23.21 ± 11.33, VL: 17.06 ± 4.71, $p < 0.001$). Other ventilation performance criteria were very close to each other in both groups, and no statistically significant difference was found (Table 2).

Times of intubations with compression via both DL and VL were statistically longer than times of intubations without compression ($p = 0.010$ for DL, and $p = 0.001$ for VL).

When performance criteria in the scenarios with compression are examined, time without compression was almost half of DL in VL, but it was not statistically significant (0.67 ± 1.38, 0.34 ± 0.77, $p = 0.055$). In both scenarios, the participants reached a speed of around 109 compressions/min, but compression rates at sufficient speed were around 90% and there was no statistically significant difference. The rates of com-

Table 1. Characteristics of the participants

Variable	N = 90
Age, year, mean ± SD	28.57 ± 3.84
Gender, n (%)	
Male	55 (61.1)
Female	35 (38.9)
Height, cm, mean ± SD	172.0 ± 7.5
Weight, kg, mean ± SD	74.79 ± 14.22
Body mass index, kg/m^2, mean ± SD	24.92 ± 3.60

SD: standard deviation.

Table 2. Ventilation and compression performance criteria in scenarios of intubation with compression

Ventilation performance criterion	DL (n = 90) mean ± SD	VL (n = 90) mean ± SD	*p*
Time of intubation (sec)	23.21 ± 11.33	17.06 ± 4.71	< 0.001
Mean ventilation rate (breath/min)	12.28 ± 7.50	12.58 ± 7.22	0.785
Ventilation ratio in sufficient volume (%)	49.11 ± 22.95	48.91 ± 20.45	0.951
Ventilation ratio exceeding the maximum volume limit (%)	2.50 ± 8.84	2.46 ± 6.10	0.969
Ventilation ratio below the minimum volume limit (%)	48.39 ± 22.76	48.57 ± 21.30	0.957
Compression performance criterion	**DL (n = 90) mean ± SD**	**VL (n = 90) mean ± SD**	***p***
Time without compression (sec)	0.67 ± 1.38	0.34 ± 0.77	0.055
Mean compression rate (compression/min)	109.33 ± 5.74	108.54 ± 6.39	0.385
Compression ratio with complete chest recoil (%)	76.57 ± 22.37	77.86 ± 20.82	0.690
Comprassion ratio in sufficient depth (%)	76.31 ± 31.30	81.50 ± 26.98	0.235
Compression ratio at sufficient rate (%)	91.89 ± 18.88	88.70 ± 23.79	0.321

DL: direct laryngoscopy; SD: standard deviation; VL: video laryngoscopy.

pressions with complete return of rib cage were also close to each other, and it was about 77% (Table 2).

In intubation interventions with and without compression, the success rate of intubations with DL in the second intervention was more statistically significant compared to VL ($p = 0.008$ and $p = 0.011$) (Table 3). The success rate after the first attempt with VL was 100% (n = 90) in the scenarios without compression, while it was 98.90% (n = 89) in the scenarios with compression.

When the intubation experiences of the participants are questioned, those with 30 or more previous intubation successes were considered experienced, and the number of experienced participants was 31.1% (n = 28). All the experienced participants succeeded in their intubations on their first attempt in all scenarios. Compared to experienced participants, the successful intubation rate at the first attempt of the new participants was lower in the intubations with compression, and this was statistically significant ($p = 0.009$) (Table 4).

Considering the easiness assessments of all the participants regarding the scenarios, in intubations performed without and with compression, there was a statistically significant difference in favor of VL. Easiness scoring in scenarios without compression was 7.22 ± 1.02 for DL and 8.77 ± 1.08 for VL ($p < 0.001$). In the scenarios with compression, on the other hand, these values were 7.01 ± 1.16 for DL and 9.04 ± 1.07 for VL ($p < 0.001$).

Evaluating the easiness assessment under intubation experience (Table 5), in scenarios with DL, experienced participants had higher easiness assessment scores than those with less experience and this was statistically significant ($p < 0.001$). In scenarios with VL, there was no significant difference in the experience. The highest easiness assessment scores were in VL scenarios with compression.

Discussion

In our study, times of intubations without compression (via DL and VL) and with compression (via DL and VL) were compared over 4 scenarios. In the current literature, there was no similar study comparing times of intubations with and without compression and other ventilation and compression performance criteria over a 4-scenario study, as in our study. In the DL and VL groups with compression, other performance criteria were similar, except for the intubation time. In terms of the success rate of the experienced and new participants at the first attempt, there was no statistically significant difference in the scenarios of intubation without compression, but it was higher in experienced participants; besides, it was statistically significantly higher in favor of VL group in the scenarios of intubation with compression. In our study, scenario-intubation easiness assessments of experienced and new participants were also compared.

Table 3. Comparison by number of intubation attempts

Scenario	1. Attempt n (%)	2. Attempt n (%)	*p*
Intubation w/o compression			
DL	85 (94.40%)	5 (5.60%)	0.008
VL	90 (100%)	0 (0.00%)	
Intubation with compression			
DL	82 (91.10%)	8 (8.90%)	0.011
VL	89 (98.90%)	1 (1.10%)	

DL: direct laryngoscopy; VL: video laryngoscopy; w/o: without.

Table 4. Intubation attempts by the intubation experience

Scenario	Intubation experience (n)	1. Attempt n (%)	2. Attempt n (%)	*p*
Intubations w/o compression (DL+VL)	< 30 (n = 124)	119 (95.97%)	5 (4.03%)	0.052
	≥ 30 (n = 56)	56 (100%)	0 (0.00%)	
Intubations with compression (DL+VL)	< 30 (n = 124)	115 (92.70%)	9 (7.30%)	0.009
	≥ 30 (n = 56)	56 (100%)	0 (0.00%)	

DL: direct laryngoscopy; VL: video laryngoscopy; w/o: without.

Table 5. Easiness assessment scores by the experiences of the participants

Scenario	Number of experience	Mean ± SD	*p*
DL w/o compression (n = 90)	< 30 (n = 62)	6.97 ± 0.96	< 0.001
	≥ 30 (n = 28)	7.79 ± 0.96	
VL w/o compression (n = 90)	< 30 (n = 62)	8.68 ± 1.14	0.246
	≥ 30 (n = 28)	8.96 ± 0.92	
Compression + DL (n = 90)	< 30 (n = 62)	6.74 ± 1.12	< 0.001
	≥ 30 (n = 28)	7.61 ± 1.07	
Compression + VL (n = 90)	< 30 (n = 62)	9.06 ± 1.14	0.793
	≥ 30 (n = 28)	9.00 ± 0.90	

DL: direct laryngoscopy; SD: standard deviation; VL: video laryngoscopy; w/o: without.

During intubation intervention, chest compressions may need to be interrupted somewhat; however, it does not require any interruption in chest compressions for ventilation after an advanced airway has been placed.[5,15] In a study conducted by Wang et al.[16] on the paramedic operators, total interruption time in CPR associated with tracheal intubation interventions has been indicated to be up to 110 seconds, and interruptions were more than 3 minutes in 25% of them. For such reasons, in recent years, particularly in airway management during CPR in emergency services, to prevent intubation-induced prolonged interruptions (such as improper intubation) in chest compression, preferring tools like VL is considered as a new plan. In this process, the fact that VL may be more useful in the emergency and intensive care units has been supported by many manikin-simulated studies and clinical studies. In their meta-analysis study, Hoshijima et al.[17] stated that the time of intubation without compression did not differ significantly between DL and VL, VL was more successful during difficult airway management, intubation viewing success was always in favor of VL, and external laryngeal pressure was less used for VL. In our study results, on the other hand, in the scenarios with and without compression, compared with DL, intubations with VL were more successful in terms of time. Times of intubations without compression were also shorter than intubations with compression. Also, in terms of the difference between the mean time of VL intubation and the mean time of DL intubation, this difference was higher in the scenarios with compression (scenario C and D) (approximately 6 sec); in scenarios of intubations without compression (scenario A and B), this difference was closer to each other (approximately 4 sec). In other words, VL was more successful in intubations performed during chest compressions.

In our study, in the scenarios of intubation with compression (scenarios C and D), the effects of DL and VL on compression and ventilation performance criteria were evaluated, and it was seen that there was no statistical difference except for intubation time. Again in the same scenarios, time without compression was under 1 second in intubations with both DL and VL. The personnel experienced in advanced airway management should be able to perform larynges copy without interrupting chest compressions, a short interruption shall be required in chest compressions due to the presence of vocal cords.[5] The intubation attempt should interrupt chest compressions in less than 5 seconds.[5]

Considering the intervention time of ETI and time for interruption to chest compressions during compression in real cases, these times will vary depending on the field of work (pre-hospital, resuscitation room, operating theater, intensive care unit, etc.) and will be longer for several reasons such as difficulties in airway management, secretion, hemorrhage, aspiration, stress factor of arrest case, etc. In addition, delay in intubation and interruption in chest compressions will directly affect both ventilation and compression during CPR. For these reasons, to gain experience, more attention should be paid to theoretical training and intubation training on the manikins and real cases.

Another importance of intubation during CPR is that intubation success rates are related to operators' intubation experience.[18] In a study conducted during the years when manikin and practical training were not very common, the intubation success rate of inexperienced people was shown to be 35–65% with DL, and it was said that intubation with at least 50 DLs was required to increase this rate to 90%.[19] Sayre et al.[20] and Bradley et al.[21] stated that the failure rates reached up to 50% in the operators who worked pre-hospital services and did not perform intubation frequently. Similarly, in our study, experienced operators succeeded at their first attempts at a ratio of 100% in all scenarios, and additionally, in the scenarios with compression, in terms of intubation success at the first attempt, there was a statistically significant difference between experienced and new operators in favor of experienced participants. In our study results, the intubation failure rate at the first attempt of new operators was 7.30% in the scenarios with compression, and 4.03% in the scenarios without compression. Our finding shows that new operators can use intubation via DL without compression more successfully in low stress environments than stressful environments such as prompt resuscitation.

In the manikin-simulated CPR trials, VL has been shown to improve ETI performance by relatively less experienced physicians and to minimize interruption of chest compressions during CPR.[22,23] In our study, in all scenarios, ETI success rate with VL was statistically significantly higher than DL.

In their manikin-simulated study comparing DL and VL, Yousif et al.[24] found that the level of satisfaction assessed by participants by visual criteria was lower for DL. In our study, in the scenarios with and without compression, easiness scores for intubation of all participants were statistically higher for VL use. Whereas, intubations with VL have a 100% success rate at the first attempt (VL without compression, 100%; VL with compression, 98.90%). In our study, DL easiness assessment score of experienced operators was statistically significantly higher in all scenarios than new operators. As a result, although VL is easier to use, as experience increases, the DL preference of operators increases.

The limitations of our study are as follows: Intubation time in manikin-simulated studies lasts a shorter time than in real cases. Additionally, several factors such as chest compression and intubation difficulty on the manikin and stress during real CPR cannot be clearly reflected in the study.

Conclusions

Comparing all the scenarios with and without compression, VL is more effective in succeeding intubation at the first attempt and securing the airway in a shorter time. In intubation with DL, if possible, more intubation operators should always be preferred. In all intubation's practitioners with little experience, especially that compression intubations should be encouraged especially for using VL (at least until they have sufficient experience). All experienced and new operators prefer VL for easiness. As more intubations are performed, VL and DL success rates will converge. In the process of gaining experience, operators should practice the manikin more often for difficult airway management and difficult CPR conditions. Our findings should be supported by further studies comparing real cases with VL and DL in airway management, especially in the emergency resuscitation room.

Conflicts of Interest Statement

The authors declare no conflict of interest.

Ethics Committee Approve

Pharmaceutical and Non-Medical Device Studies Ethical Committee by the decision number of 2019/1673.

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This study did not need financial funding.

Human Rights

During the research, the World Medical Association Declaration of HELSINKI and/or the World Psychiatric Association HAWAII Declaration of Good Clinical Practice rules were complied with.

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