J Med Biosci Vol. 6 No. 1 January - June 2024;51-58 DOI: 10.14456/jmbs.2024.5

Original article

Comparison of intubation performance with different airway manikins by inexperienced hands, cross-over manikin study

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Abstract

Background: Endotracheal intubation (ETI) delay or failure may adversely affect patient outcomes. Therefore, airway simulation can solve this problem, but we must choose appropriate manikins for medical students.

Objectives: This study aimed to compare the application of various manikins for intubation performed by inexperienced hands and find the most effective manikins for simulation training.

Methods: This study was a prospective, randomized cross-over study. Subjects were randomly assigned to perform endotracheal intubation (ETI) using the direct laryngoscope and the video laryngoscope on three different manikins**.**

Results: The 32 subjects were divided into twelve internship physicians and twenty 6th year medical students. Their mean age is 24.8 ± 1.3 years, and the median number of successful intubations is 3.5 [interquartile range (IQR), 2.0 - 6.0]. The first intubation success rate in direct laryngoscope with mannikin 1 - 3 was 90.6%; Mannikin 1 illustrated the shortest time to successful ETI and showed all subjects can ETI on the first attempt. Manikin 3 with a direct laryngoscope, one internship, and two 6th year medical students failed first-time ETI. The internship group took less time than the 6th year medical student group.

Conclusion: Regarding the first intubation success rate, time to ETI, and ease of use, the manikin study demonstrated manikin 1 [Airway management trainer model (Laerdal, Norway)] is the most effective manikin for simulation training by inexperienced physicians.

Keywords: Intubation, intratracheal, instrumentation, manikins.

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Received: March 24, 2023
Revised: June 13, 2023
Accepted: August 29, 2023

Endotracheal intubation (ETI), a tube placed into the trachea with the cuff inflated below the vocal cord through the mouth, is essential in emergencies. The delay or failure of ETI may adversely affect patient outcome [1] Currently, direct and video laryngoscopy are the two most common devices for intubation procedures. Video-laryngoscopes have been linked to improved visualization of the glottis, increased success rates for difficult airways, and faster skill, leading to higher success rates in intubation procedures performed by inexperienced physicians. [2]

Clinical endotracheal intubation skill acquisition is required for novice practitioners, mainly the 6th year medical student (inexperienced hands) and interns' physicians. Simulators, namely manikins, provide an effective learning curve and improve the intubation experience in various situations. [2,3] Medical simulation using manikins has become an increasingly popular approach for educating and training healthcare professionals. From an academic perspective, the use of manikins in medical simulation has been shown to enhance learning outcomes, promote critical thinking and decision-making skills, facilitate integration of theoretical knowledge, provide feedback and evaluation, promote teamwork and communication, and improve patient safety. The success rate of trainers in effectively teaching and assessing trainees' performance during simulation-based training is a crucial factor in determining the overall effectiveness of these programs. However, the appropriate manikins for practicing the skill in specific scenarios are still questioned. [4]

Hence, this study aimed to compare the application of various manikins for intubation performed by inexperienced hands and find the most effective manikins for simulation training.

Materials and methods

Study design and subjects

This study has been approved, by Queen Savang Vadhana Memorial Hospital Institutional Review Board (IRB no. 033/2563) and registered in the Thai clinical trials registry (https://www.thaiclinicaltrials.org, identifier TCTR20211214003). This study was a prospective, randomized crossover study using a single pilot study of 32 subjects with little or no experience in ETI. The flow diagram of this study is shown in **Figure 1**.

The 32 subjects were divided into twelve internship physicians and twenty 6th year medical students, selected through convenience sampling from our airway training courses. After a brief explanation of the study, those who volunteered to participate included and obtained written consent from subjects, and they could withdraw from the study at any time.

To avoid a difference in ETI experience, the subjects were novice physicians with little or no experience in direct and video laryngoscope intubation. Each subject was considered inexperienced, having performed no more than ten instances of successful endotracheal intubation. [5] The subjects who had successfully performed ETI more than ten times before recruitment or had wrist or spinal injuries during the three months preceding the study were eliminated.

Protocol

1. To standardize subjects' knowledge and skills, all subjects arose a 15-minute training.[6]
2. A direct laryngoscope (Macintosh #4 blade) and video laryngoscope (McGRATH®) blade were used in all the subjects with three manikins in this study. Each subject can intubate at least six times (one for a direct laryngoscope and another one for a video laryngoscope in 3 manikins)
3. Each subject can practice one attempt, each blade with three manikins.
4. Instructors adjust the manikin head in a sniffing position, and the bed height is the same level as the wrist.
5. The time is counted from picking up the blade to removing the stylet from the endotracheal tube.
6. The order of the manikin arrangement was randomized using a card selection method prior to the study. Three permutations were used, as follows:
    1) Group A: Manikin 1, 2, 3, respectively
    2) Group B: Manikin 2, 3, 1, respectively
    3) Group C : Manikin 3, 1, 2, respectively
7. Intubation finished over 120 seconds or placed into the esophagus is ineffective. Three attempts of ETI are allowed, and three or more failures are considered ETI failures.
8. After intubation, subjects assess the difficulty of manikin intubation.[7]

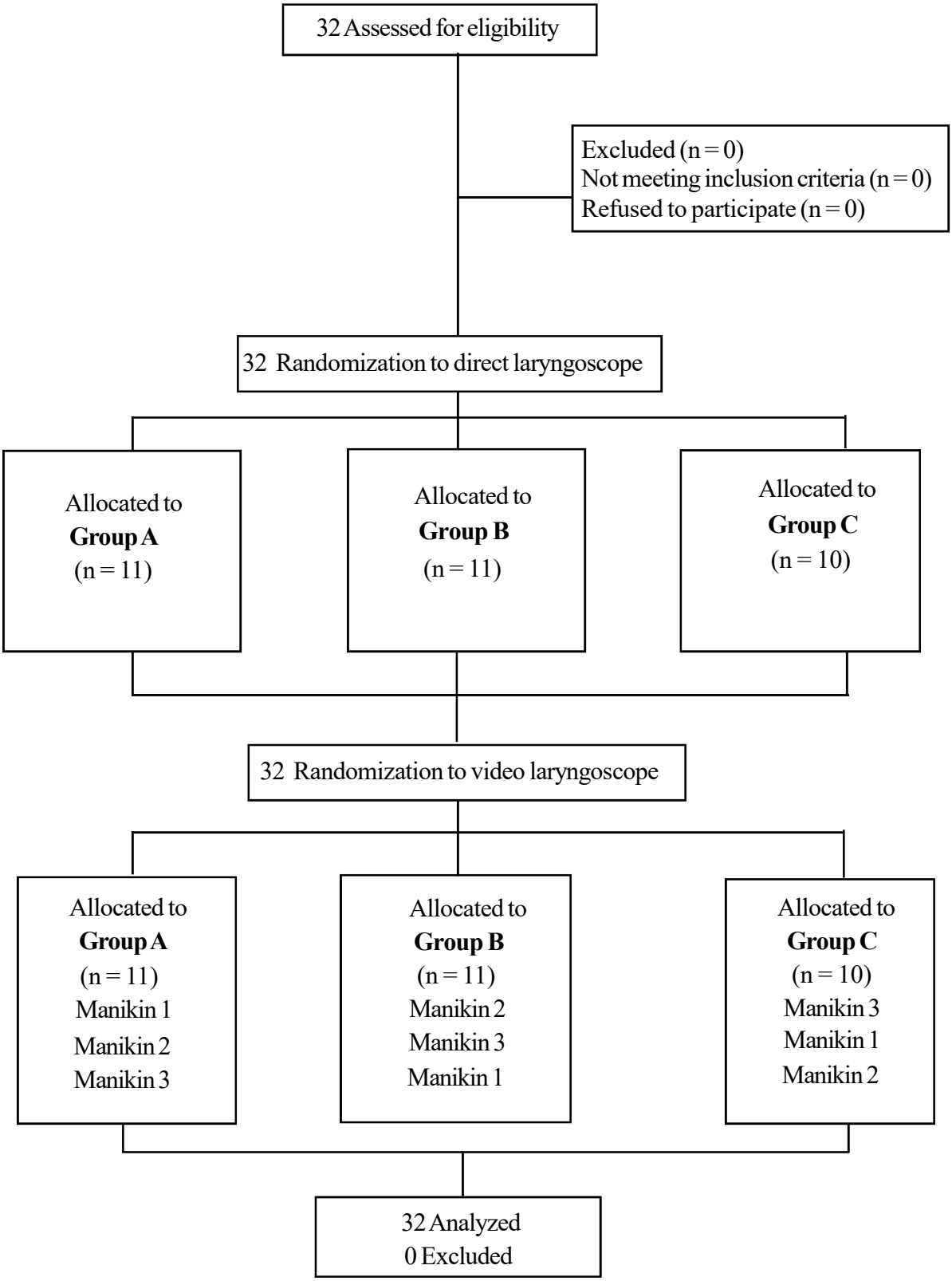

Figure 1. Flow diagram of randomization and simulation process.

Devices

This study included three mannikins: Airway Management Trainer model (Laerdal, Norway), Airsim Advance X model (TruCorp, Airsim Advance X model) and RespiTrainer Advance™ model (Ingmar Medical, Ltd, USA)

Statistical analysis

The sample size was calculated with G*Power 3.1 with a two-tailed *t* - test (Cohen's d = 0.55, alpha error = 0.05, power = 0.95). With the minimum of 32 subjects necessary. Descriptive statistics, including frequency and percentage, were used for categorical variables. Continuous variables were reported as mean ± standard deviation (SD) for normally distributed variables and median (with interquartile range (IQR)) for non-normally distributed variables. The Kolmogorov-Smirnov test examined the normality of the distribution of variables.

Comparisons of categorical variables between internship and 6th year medical students were performed using the Chi-square or Fisher's exact test. Continuous variables were compared using the student's *t* - test or Mann-Whiney U test. McNemar's matched pairs test was used to compare success rate, and Wilcoxon signed Rank test was used to compare Time to ETI and Ease of use between the two tools. A two-tailed $P < 0.05$ was considered statistically significant for all tests performed. Predictive Analytics SoftWare (PASW) Statistics / 18.0 Statistics Package for the Social Sciences (SPSS, Inc., Chicago, IL, USA) software was used to perform all statistical analyses.

Results

Table 1 shows the distribution of status, gender, age, height, the number of successful intubation, and dominant hand of the 32 subjects divided into twelve internship physicians and twenty 6th year medical students. As shown in Table 1, there were no significant differences in baseline characteristics of the two groups except for the number of successful intubations. The internship group has many successful intubations with significantly related to more working experien.

Table 2 shows the first intubation success rate in direct laryngoscope with mannikin 1 - 3 was 90.6%; however, video laryngoscope with mannikin 1 - 3 was 96.9%.

Table 1. Subject characteristics (n = 32).

Characteristics	All subjects (n = 32) n (%)	Internship (n = 12) n (%)	6th year medical student (n = 20) n (%)	*P* - value
Status				
Internship	12 (37.5)			
6 th year medical student	20 (62.5)			
Gender				
Male	9 (28.1)	2 (16.7)	7 (35.0)	0.422
Female	23 (71.9)	10 (83.3)	13 (65.0)	
Age (years), mean ± SD	24.8 ± 1.3	25.3 ± 1.2	24.4 ± 1.3	0.051
Height (cms), mean ± SD	162.9 ± 8.3	163.7 ± 6.8	162.4 ± 9.3	0.684
Number of successful				
Intubations, median (IQR)	3.5 (2.0 - 6.0)	6 (4.0 - 9.0)	3 (1.0 - 4.0)	0.001*
0	2 (6.2)	0 (0.0)	2 (10.0)	0.516
≥ 1	30 (93.8)	12 (100.0)	18 (90.0)	
< 5	22 (68.8)	5 (41.7)	17 (85.0)	0.027
5 - 10	8 (25.0)	5 (41.7)	3 (15.0)	
> 10	2 (6.3)	2 (16.7)	0 (0.0)	
Dominant hand				
Right	31 (96.9)	12 (100.0)	19 (95.0)	1.00
Left	1 (3.1)	0 (0.0)	1 (5.0)	

Table 2. Success rate of ETI (n = 32).

Success	Direct laryngoscope			Video laryngoscope			P1	P2	P3
	Manikin 1	Manikin 2	Manikin 3	Manikin 1	Manikin 2	Manikin 3			
Attempt 1									
Attempt 1 Success	32 (100.0)	32 (100.0)	29 (90.6)	32 (100.0)	32 (100.0)	31 (96.9)	-	-	0.625
Time to ETI 1 (sec)	8.5 (7.9 - 11.2)	12.5 (9.7 – 16.0)	19.9 (13.8 - 30.2)	10.1 (8.3 - 12.4)	12.5 (9.1 - 16.0)	15.0 (12.5 - 19.9)	0.006*	0.808	0.026*
Ease of use (1 - 5) (median)	1 (1 - 1.8)	2 (2 - 2.8)	4 (3 - 4)	1 (1 - 1)	1 (1 - 2)	3 (2 - 3.8)	0.366	< 0.001*	0.001*
Very easy	24 (75.0)	4 (12.5)	1 (3.1)	26 (81.3)	18 (56.3)	2 (6.3)	-	-	-
Easy	7 (21.9)	20 (62.5)	2 (6.3)	6 (18.8)	10 (31.3)	10 (31.3)	-	-	-
Neutral	1 (3.1)	7 (21.9)	8 (25.0)	0 (0.0)	4 (12.5)	12 (37.5)	-	-	-
Difficult	0 (0.0)	1 (3.1)	14 (43.8)	0 (0.0)	0 (0.0)	1 (3.1)	-	-	-
Very difficult	0 (0.0)	0 (0.0)	7 (21.9)	0 (0.0)	0 (0.0)	0 (0.0)	-	-	-
Attempt 2									
Attempt 2 success	-	-	3 (100)	-	-	No 1 (100)	-	-	-
Time to ETI 2 (sec)	-	-	28.0 (16.5 - 60.5)	-	-	20.0 (20.0 - 20.0)	-	-	0.317
Ease of use (1 - 5)	-	-	4 (3 - 5)	-	-	4 (4 - 4)	-	-	1.00
Very easy	-	-	0 (0.0)	-	-	0 (0.0)	-	-	-
Easy	-	-	0 (0.0)	-	-	0 (0.0)	-	-	-
Neutral	-	-	1 (33.3)	-	-	0 (0.0)	-	-	-
Difficult	-	-	0 (0.0)	-	-	1 (100.0)	-	-	-
Very difficult	-	-	0 (0.0)	-	-	0 (0.0)	-	-	-
Attempt 3									
Attempt 3 Success	-	-	-	-	-	1 (100.0)	-	-	-
Time to ETI 3 (sec)	-	-	-	-	-	30.0 (30.0 - 30.0)	-	-	-
Ease of use (1 - 5)	-	-	-	-	-	5 (5 - 5)	-	-	-
Very easy	-	-	-	-	-	0 (0.0)	-	-	-
Easy	-	-	-	-	-	0 (0.0)	-	-	-
Neutral	-	-	-	-	-	0 (0.0)	-	-	-
Difficult	-	-	-	-	-	0 (0.0)	-	-	-
Very difficult	-	-	-	-	-	1 (100.0)	-	-	-

P1, Comparison of direct versus video laryngoscope in mannikin 1, shows the duration of ETI in which direct laryngoscope was 8.5 sec and video laryngoscope was 10.1 sec, statistically significant. The median ease of use of direct laryngoscope was one, and video laryngoscope was 1, without statistical significance.

P2, Comparison of direct versus video laryngoscope in Manikin 2, shows time to ETI with direct laryngoscope was 12.5 sec, and ETI with video laryngoscope was 12.5 sec without statistically significant. The median ease of use of direct laryngoscope was 2, and video laryngoscope was 1, with statistical significance.

P3, Comparison of direct versus video laryngoscope in Manikin 3, shows time to ETI with direct laryngoscope was 19.9 sec, and ETI with video laryngoscope was 15.0 sec with statistically significant. The median ease of use of direct laryngoscope was four, and video laryngoscope was 3, with statistical significance. n (%) and median (IQR)

P1: *P* - value of direct laryngoscope versus video laryngoscope in Manikin 1,

P2: *P* - value of direct laryngoscope versus video laryngoscope in Manikin 2,

P3: *P* - value of direct laryngoscope versus video laryngoscope in Manikin 3

Table 3. Success rate between internship and 6th year medical student (n = 32).

	Internship (n = 12)	6th year medical student (n = 20)	*P* - value
Direct laryngoscope (Macintosh #4 blade)			
Manikin 1			
Attempt 1 success	12 (100.0)	20 (100.0)	-
Time to ETI 1 (sec)	9.2 (7.9 - 10.0)	8.5 (8.0 - 11.7)	0.572
Ease of use (1 - 5)	1.0 (1.0 - 1.5)	1.0 (1.0 - 1.5)	0.897
Manikin 2			
Attempt 1 success	12 (100.0)	20 (100.0)	-
Time to ETI 1 (sec)	12.6 (9.3 - 16.7)	12.0 (10.6 - 15.2)	0.697
Ease of use (1 - 5)	2.5 (2.0 - 3.0)	2.0 (2.00 - 2.00)	0.095
Manikin 3			
Attempt 1 success	11 (91.7)	18 (90.0)	1.00
Time to ETI 1 (sec)	23.2 (19.0 - 49.8)	16.8 (12.7 - 24.7)	0.05
Ease of use (1 - 5)	4.5 (4.0 - 5.0)	3.0 (3.0 - 4.0)	< 0.001*
Manikin 3			
Attempt 2 success	1/1 (100.0)	2/2 (100.0)	-
Time to ETI 2 (sec)	60.5 (60.5 - 60.5)	22.3 (16.5 - 28.0)	0.221
Ease of use (1 - 5)	3.0 (3.0 - 3.0)	4.5 (4.0 - 5.0)	0.667
Video laryngoscope (McGRATH®) blade			
Manikin 1			
Attempt 1 success	12 (100.0)	20 (100.0)	-
Time to ETI 1 (sec)	11.4 (8.3 - 14.2)	9.7 (8.3 - 12.2)	0.533
Ease of use (1 - 5)	1.0 (1.0 - 2.0)	1.0 (1.0 - 1.0)	0.107
Manikin 2			
Attempt 1 success	12 (100.0)	20 (100.0)	-
Time to ETI 1 (sec)	14.1 (8.7 - 17.6)	12.0 (10.2 - 15.1)	0.907
Ease of use (1 - 5)	1.5 (1.0 - 2.5)	1.0 (1.0 - 2.0)	0.358
Manikin 3			
Attempt 1 success	12 (100.0)	19 (95.0)	1.00
Time to ETI 1 (sec)	15.5 (12.4 - 23.8)	15.0 (12.7 - 19.7)	0.861
Ease of use (1 - 5)	3.0 (2.0 - 4.0)	3.0 (2.0 - 3.0)	0.425
Manikin 3			
Attempt 2 success	-	No 1/1 (100.0)	-
Time to ETI 2 (sec)	-	20.0 (20.0 - 20.0)	-
Ease of use (1-5)	-	4.0 (4.0 - 4.0)	-
Manikin 3			
Attempt 3 success	-	1/1 (100.0)	-
Time to ETI 3 (sec)	-	30.0 (30.0 - 30.0)	-
Ease of use (1 - 5)	-	5.0 (5.0 - 5.0)	-

Table 3, Mannikin 1 illustrated the shortest time to successful ETI and showed all subjects can ETI on the first attempt. All subjects can ETI in the first attempt of Manikin 2. Still, they took much longer to intubate in direct and video laryngoscope intubation than Mannikin 1. Video laryngoscope was still more straightforward to use than direct laryngoscope.

Manikin 3 with a direct laryngoscope, one internship, and two 6th year medical students failed first-time ETI. The internship group took less time than the 6th year medical student group.

Manikin 3 with video laryngoscope, one of the 6th year medical students failed to first time ETI. It was concluded that mannikin 3 is challenging to use in airway simulation workshops.

Figure 2 reveals that video laryngoscope takes a shorter time to ETT in manikin 1, 3 with a statistical significance ($P < 0.05$).

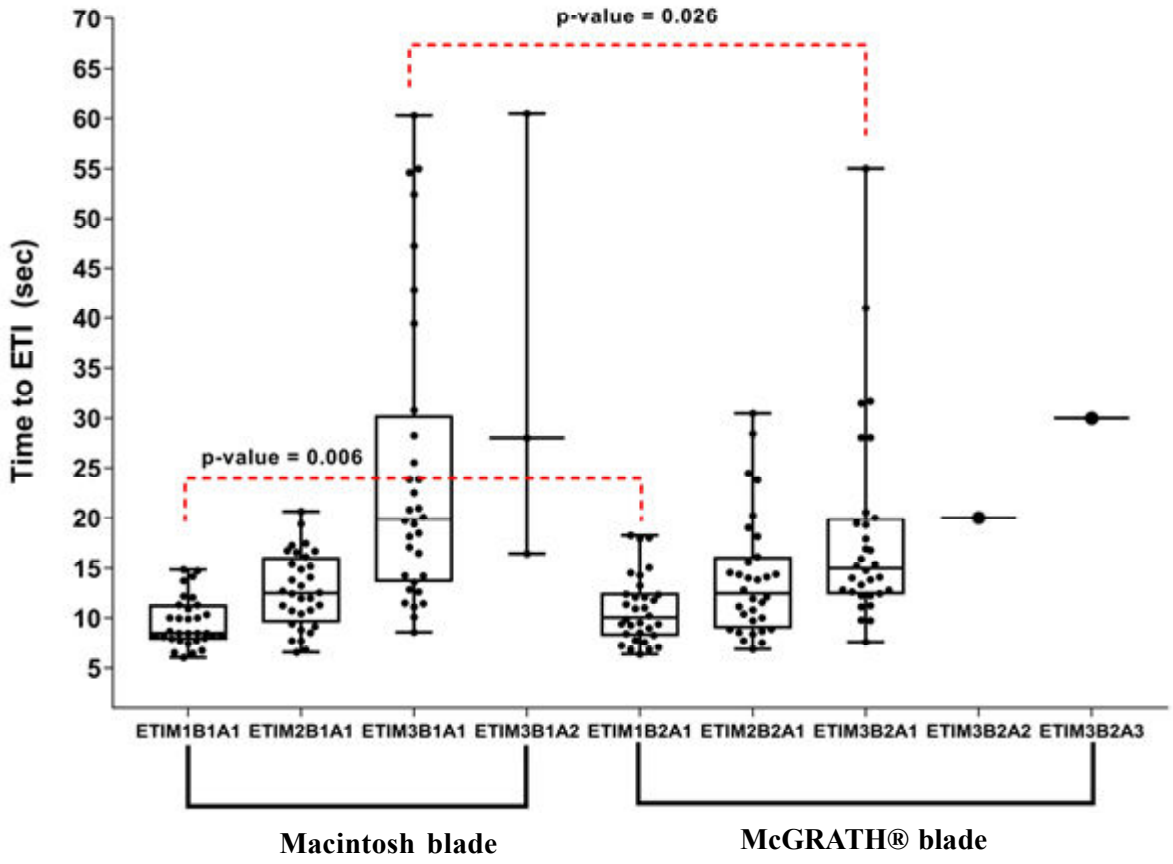

Figure 2. Comparison between direct laryngoscope and video laryngoscope.

Discussion

This work shows Manikin 1 was found to be particularly suitable for intubation simulation compared to other manikins due to its favorable anatomical structure, ease of handling, and the soft synthetic rubber material used. This observation is consistent with a previous study [8-10], supporting the notion that these simulators are routinely employed in our clinic for advanced life support training.

Although manikin 2 has similar ease of handling, The material is more rigid and does not support while putting the intubation tube.

Mannikin 3 is the least suitable for airway simulation training compared with the two models because it has the most rigid rubber material. Thus, it is more challenging to do ETI. This Mannikin 3 may suit experienced physicians such as a residency or may consider applying in training for the complex airway simulation.

There are several limitations inherent in this study that should be acknowledged. Firstly, the sample size may not be sufficiently large to generalize the findings to a broader population, particularly when determining the most effective manikins for simulation training.

Secondly, it is important to note that this study was conducted at a single center, which introduces the possibility of self-selection or volunteer bias. The subjects involved in the study may have distinct characteristics or motivations that differ from those in other settings or populations.

Acknowledging these limitations is crucial in order to interpret the results of this study accurately and to recognize the potential constraints that may affect the generalizability and external validity of the findings.

Future research endeavors should aim to address these limitations by employing larger and more diverse samples from multiple centers to enhance the reliability and generalizability of the results.

Conclusion

Regarding the first intubation success rate, time to ETI, and ease of use, the mannikin study demonstrated mannikin 1 [Airway Management Trainer model (Laerdal, Norway)] is the most effective mannikin for simulation training by inexperienced physicians. In addition, it is worth the financial investment and proper handling required time, which suits the application to medical practitioner school.

Acknowledgements

Queen Savang Vadhana Memorial Hospital supported this project. Author's contributions: NJ contributed to the study's planning and design. PT recruited subjects and collected data. NJ was the principal investigator of this study. NJ did all manuscript preparation and performed the statistical analysis. NJ and PT contributed to manuscript editing and expertise

Conflicts of interest statement

The authors have each completed an ICMJE disclosure form. None of the authors declare any potential or actual relationship, activity, or interest related to the content of this article.

Data sharing statement

The present review is based on the references cited. Further details, opinions, and interpretation are available from the corresponding authors on reasonable request.

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