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Comparison of Airway Simulators for the AirwayScope® Video-Laryngoscope

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Abstract

Introduction: Although the importance of training using simulators is widely recognized, there are no reported comparative studies of training with simulators for laryngoscopes. We compared three airway simulators with the video-laryngoscope AirwayScope® to determine their effectiveness and usefulness.

Methods: Three simulators-DAM (simulator A), SaveMan® (simulator B), and Heartsim® (simulator C)-were compared with Simman® (simulator D). Altogether, 70 paramedics were divided into three groups. Following practice using simulators A, B, and C, each group underwent evaluation using simulator D (test 1). We then evaluated the ease of intubating each of the simulators (test 2). We measured the intubation time (T) from blade insertion to visual confirmation of the glottis (T1), to tracheal tube insertion through the glottis (T2), and to chest rise confirmation (T3). Finally, we evaluated the usefulness and relative ease of use of each simulator.

Results: In test 1, all tracheal intubations were successful. There were also no significant differences in T1, T2, or T3 among the practice simulators. In test 2, however, T1 and T2 took significantly longer with simulator A than with simulators B and D. The T3 intubation was also longer with simulator A than simulator B ($P<0.05$). Simulator A was more difficult to intubate than B or D ($P<0.05$).

Conclusions: Test 1 results indicated that there were no differences in intubation times, and all intubations were successful. Evaluation of the simulators showed differences in their ease of use, although no differences were found in their usefulness for training.

Keywords: Simulator, Tracheal intubation, Training, Video laryngoscope

Introduction

Airway management is a critical component of emergency procedures to save patients under life-threatening conditions. Among airway management methods, tracheal intubation remains the most reliable for securing the airway in emergency settings. This procedure, however, carries a risk of severe adverse events if it is not performed correctly [1]. Its providers must therefore be technically competent in its performance. It is difficult, however, to provide sufficient on-the-job training for this procedure because of the unpredictability and the small number of critically ill or injured patients who require emergency tracheal intubation in the field [2,3]

For these reasons, various video-laryngoscopes have been developed and marketed in recent years. Studies have demonstrated the advantages of video-laryngoscopes over the traditional Macintosh laryngoscope, such as the ease of tracheal intubation performed by unskilled personnel and their usefulness in difficult airways [4].

Technological advances have made it possible to develop variously designed simulators that are suitable for specific purposes. Among them are airway training mannequins developed particularly for emergency airway management. Several studies have used these mannequins to train personnel to insert supraglottic airway devices and to teach airway management procedures in difficult airways [5-7]. To the best of our knowledge, however, there have been no comparative studies of laryngoscopic simulators, particularly for video-laryngoscopes.

As the importance of off-the job training using simulators has become more widely accepted, we aimed to evaluate available simulators on their features, advantages, and disadvantages for training personnel in the use of laryngoscopes. In this study, we compared three simulators with regard to nonclinical airway training of paramedics in using a video-laryngoscope. We also determined the effectiveness and ease of use of these simulators.

Methods

We tested three simulators in this study: the DAM simulator (Kyoto Kagaku, Kyoto, Japan), Save Man (Koken, Kakegara, Japan), and Heartsim 4000 (Laerdal Medical, Stavenger, Norway). The DAM simulator and Save Man have been used for difficult intubations (Figure 1). SimMan (Laerdal Medical) was used as a reference model because it is a widely available high-fidelity simulator in Japan. A previous report noted that the SimMan full-scale patient simulator's airway is generally acceptably realistic, although it significantly differs from the human airway in some important aspects [8].

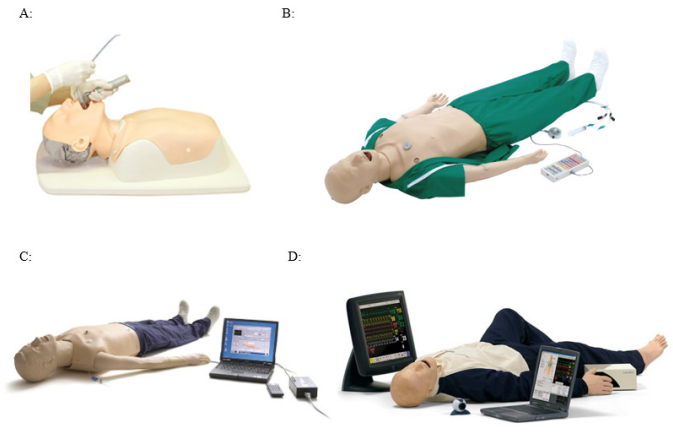

Figure 1: Simulators evaluated in this study. **Simulator A:** Difficult Airway Management (DAM); **Simulator B:** SaveMan®; **Simulator C:** Heartsim4000®; **Simulator D:** SimMan®.

Paramedics who were qualified for tracheal intubation using the Macintosh laryngoscope participated in this study. Written consent was obtained from each of them before the study. We chose the AirwayScope® (AWS; Pentax, Tokyo, Japan) video-laryngoscope for this study because, as of this report, it is the only video-laryngoscope allowed for use by paramedics in Japan.

Following a prestudy lecture and e-learning using a designated digital textbook and audio-visual materials, the participants were divided into three groups and underwent laboratory practice using the simulators as follows: group a used DAM simulator (simulator A), group b used Save Man (simulator B), and group c used Heartsim 4000 (simulator C). For each group, experienced physicians and paramedics provided instruction on the AWS. After 80 min of practice, the participants undertook timed trial tests in which they all had to achieve tracheal intubation within 30 s. Following an additional 60 min of practice using the same simulator, a final evaluation test (test 1) was undertaken using the SimMan (simulator D) for reference. The times to achieve certain goals, described below, were recorded. The scenarios presented in this test included a normal airway, limited mouth opening, limited cervical-spine movement, and a swollen tongue. The scenarios were presented in randomized order.

Next, we evaluated the ease of intubation of each simulator by timing the period required for the tracheal intubation (normal airway scenario) using a simulator different from that used for the laboratory practice including simulator D (test 2). Group a was tested on simulators B, C, and D; group b on simulators A, C, and D; and group c on simulators A, B, and D. The times measured in tests 1 and 2 included the following intervals: from insertion of the blade to visual confirmation of the glottis (T1), to insertion of a tracheal tube through the glottic opening (T2), and to confirmation of the chest rising with ventilation (T3). A maximum interval of 30 s was allowed to T3. Following tests 1 and 2, the participants were asked to evaluate the difficulty of the intubations using a Visual Analogue scale (VAS), from 0 (very easy) to 100 (extremely difficult). They were also asked to evaluate the usefulness of the simulators in laboratory training for AWS from 0 (useless) to 100 (extremely useful). The average value±standard deviation or the median (interquartile range) showed the numerical results. One-way layout analysis of variance and the Kruskal-Wallis test were used for statistical analysis. The Tukey-Kramer post-hoc test was performed as well. Percentage of risk was regarded as significant at $P<0.05$.

Results

A total of 70 paramedics (24 in group a, 24 in group b, 22 in group c) participated in the study. No significant differences were observed regarding the years of experience since they had been authorized to perform tracheal intubation, the total number of tracheal intubations experienced, or the number of tracheal intubations performed per year per group (Table 1).

	group a	group b	group c	p value
age (years)	47±4	44±4	42±6	0.0017
height (cm)	171±4	171±6	172±6	0.7569
weight (kg)	72±7	67±6	72±11	0.0716
Intubation authorization period (months)	49±28	46±22	43±13	0.7048
Intubation cases (case)	3 (1-6)	3 (1-4.25)	6 (2.25-10)	0.0882
Intubation cases per year (case)	1.2 (0.4-2.0)	0.9 (0.4-1.3)	2.2 (0.6-3.6)	0.1938
Results are given as the mean±SD or the median (interquartile range)				

Table 1: Backgrounds of the participants.

During test 1, which used simulator D for reference, all participants were intubated successfully in all scenarios (i.e., normal airway, limited mouth opening, cervical spine immobilization, and swollen tongue) without any incidents of esophageal intubation. Regarding the time for intubation, there were no significant differences in T1, T2, and T3 among the groups. In the difficult airway scenarios, T1, T2, and T3 were slightly prolonged compared with times in the normal airway, but no significant differences were observed among groups (Table 2).

		group a	group b	group c	p value
Normal airway	T1	6±2	6±2	5±2	0.5986
	T2	11±3	11±4	10±3	0.946
	T3	22±5	22±5	22±5	0.9909
Limited mouth opening	T1	6±3	14±19	9±10	0.0795
	T2	13±6	20±21	16±10	0.2115
	T3	25±9	32±21	26±10	0.2276
C-spine immobilization	T1	10±10	14±21	8±6	0.3677
	T2	18±13	22±34	13±6	0.3913
	T3	31±12	34±33	23±7	0.2451
Swollen tongue	T1	9±6	12±11	12±11	0.5454
	T2	17±15	19±15	20±16	0.8044
	T3	29±17	32±15	31±18	0.9001
Results are given as the mean±SD					

Table 2: Results of test 1.

The time required for intubation during test 2-difficulty of intubation and usefulness of the simulators in laboratory training for AWS using the VAS-are shown in (Table 3). T1 and T2 were significantly longer using simulator A than when using simulators B and D. T3 was longer using simulator A than when using simulator B. Regarding difficulty during intubation, simulator A had a statistically significantly higher VAS than simulators B and D. Simulator D had the highest VAS regarding ease of use, although the difference from the other simulators failed to achieve significance (P=0.055) (Table 3).

Intubation time, and difficulty VAS and usefulness VAS data of each simulator				
	A	B	C	D
T1	11±10[∫]	6±5	9±15	6±3
T2	16±10[∫]	11±5	13±15	11±3
T3	24±11[∫∫]	19±6	22±15	22±5
Difficulty: VAS (mm)	28±24	16±15	21±19	19±17
Usefulness: VAS (mm)	66±25	70±21	68±23	76±21
Results are given as the mean±SD [∫]Versus B, D: P<0.05. [∫∫]Versus B: P<0.05. Versus B, D: P<0.05. Versus B, D: P=0.055.				

Table 3: Results of test 2.

Discussion

Emergency tracheal intubation may result in serious life-threatening conditions unless appropriately performed. However, it is difficult to maintain the appropriate skills for tracheal intubation in the prehospital setting because of an insufficient number of experiences on the job. Therefore, it is imperative to maintain appropriate skill levels by off-the job practice using simulators.

In this study, we compared three types of simulator in an AWS training course for paramedics. Our results showed that all tracheal intubations were successfully accomplished despite the presence of difficult airways (test 1) regardless of the type of the simulator used for practice. No significant differences in T1, T2, and T3 were found among the simulators used for practice in the scenarios of limited mouth opening, neck immobility, and swollen tongue, although simulator C does not have any modes for simulating difficult airways. One of the reasons behind this appears to be the features of the AWS, not the type of the simulator. The L-shape of the AWS blade (called Introck) is different from that of the Macintosh laryngoscope as it fits the pharyngolaryngeal anatomy well (no force is required to manipulate the anterior portion of the upper airway, i.e., mandible and tongue). In addition, the blade of the AWS has a guide-groove that makes it easier to introduce the tube into the trachea. These unique features of the AWS might have contributed to the lesser effects on the difficult airway settings among the simulators.

In contrast, the comparison of the ease of intubation using each simulator including simulator D and their specificities (test 2) showed that the time for intubation using simulator A was prolonged compared with the times for stimulators B and D, whereas no significant differences were found among simulators B, C, and D. A similar result was observed in the VAS for ease of intubation. These findings may indicate that the specificity of simulator A as an airway simulator might be different from those of simulators B, C, and D. According to the manufacturer, simulator A was produced to simulate the human body more anatomically by taking into account the human anatomy and functionally and thus using softer materials for the tongue and larynx. In this study, the paramedics pointed out that simulator A required more accurate manipulation of the tongue and epiglottis during intubation attempts. Further studies are needed to evaluate differences in the anatomical structures and materials of the simulators.

Although most of the simulators used in this study could reproduce difficult airway settings (e.g., limited mouth opening, neck immobility, swollen tongue), scenarios such as the presence of secretions, blood, and/or vomitus in the airway-which would adversely affect visualization of the pharyngolaryngeal anatomy-are needed. We provided a scenario using coffee and rice gruel in the airway of the airway trainer (Airway Trainer, Laerdal, Norway) to simulate these situations (data not presented). To date, no simulators equipped with this function are on the market. To create more realistic situations, it would be advisable to have water-resistant features for a simulator.

Iglesias-Vazquez et al. demonstrated that the cost-effectiveness of an advanced life support course with standard mannequins was clearly superior to high-fidelity simulators, although advanced simulator systems may slightly increase the pass rate of the course [9]. The details of the simulators used in this study are shown in (Table 4). For mannequin practice with a laryngoscope such as the traditional Macintosh-type blade, it is desirable for the simulator to reproduce difficult airway settings [10]. As with the AWS, however, such settings are not necessarily needed. Rather, other functions, such as water-resistant capacity to simulate vomitus in the airway, would be more attractive for mannequin training with use of video-laryngoscopes, as described above. Finally, usability in other training and daily practices for skill maintenance needs to be considered when choosing appropriate simulators.

	Date released	Manufacturer	Difficult airway scenario	Approximate cost
Difficult Airway Management (DAM) Simulator	Aug-12	Kyoto Kagaku Co., Ltd, Japan	limited mouth opening, limited Jaw thrusts swollen tongue	240, 000 yen
SaveMan®	June 2011 (head) September 2003 (body)	Koken Co., Ltd, Japan	limited mouth opening, limited C-spine movement swollen tongue	Body: 1,700,000 yen Replaceable head: 450,000 yen
Heartsim4000®	Jan-98	Laerdal Medical, Stavanger, Norway	Not available	2,300,000 yen
SimMan®	Aug-01	Laerdal Medical, Stavanger, Norway	limited mouth opening, limited C-spine movement swollen tongue Laryngeal edema	5,980,000 yen

Table 4: Details of the simulators used for this study.

There is a major limitation of this study. We did not evaluate the structural aspects of the simulators in this report. Schebesta et al. evaluated four high-fidelity simulators and two low-fidelity airway trainers, including SimMan, by comparing the anatomical features of the simulators with human subjects using upper airway radiographic measurements obtained from computed tomography scans.10

They reported that the airway anatomy of these simulators did not adequately reflect the upper airway anatomy of patients. Therefore, it would be inappropriate to apply the results of this study directly to clinical situations. The roles of simulators in airway training, however, remain large because of the limited opportunities to obtain appropriate skills (e.g., for difficult airway situations) in the field. Thus, one must be aware of the aspects not only of the simulator but also of the device used for training.

In conclusion, we studied three types of simulator that could be used for training personnel in tracheal intubation using AWS. There was no difference in intubation times with regard to the different simulators used for skill training. All tracheal intubations were successfully accomplished despite the difficult airways. Although our evaluation of the simulators showed differences in the ease of intubation, there were no differences among them regarding their usefulness for training.

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