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The Investigation of the Effect of Computer-Based Simulator on the Functional Error of Undergraduate Students of Anesthesia in Patient Preparation for Intubation and Improvement of Laryngoscopy Skill in Tehran University of Medical Sciences

Dr. Mitra Zolfaghari [*1], Saba Abbasi [2], Dr. Pejman Pourfakhr[3]

1- Associate Professor, Department of e-Learning in Medical Education, Virtual School, and Nursing and Midwifery Care Research Center Tehran University of Medical Sciences, Tehran, Iran

2- Master e-learning planning, Virtual School, Tehran University of Medical Sciences, Tehran, Iran.

3- Assistant Professor, school of Medicine, Department of Anesthesiology, Sina Hospital. Tehran University of Medical Sciences, Tehran, Iran

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Abstract

Introduction: Endotracheal intubation, as one of the most important methods of airway management, is of great importance and can lead to saving the patient's life. Hence, the training of this skill is highly considered. The present study aimed to design an educational simulator software in this field and to determine its impact on improving the performance of undergraduate students of anesthesia in Tehran University of Medical Sciences.

Methods: In this experimental study, 17 undergraduate anesthesia students were selected from Tehran University of Medical Sciences in the second semester of 96-97 (2017-18) and randomly divided into control and intervention groups. The control group was evaluated without any intervention, while the intervention group was evaluated after receiving the simulated content and its reviewing several times in the skill lab. The data were collected by a demographic questionnaire and a validated and relied evaluation checklist. The scores of both groups were evaluated using the SPSS-22 software, descriptive statistics (absolute and relative frequency, mean and standard deviation), and t-test, in order to determine the effectiveness of the simulator in improving the performance of anesthesia students in this regard.

Results: The results indicated that the average score of students' performance in patient preparation for intubation was (22.22±10.17) and (36.75±6.78) in the control and intervention groups, respectively, indicating a significant difference (P=0.004). In addition, the average score of students' performance in laryngoscopy skill was (24.09±9.02) and (41.16±12.1) in the control and intervention groups, respectively, which was a significant difference (P=0.008). Finally, the average total score of students' performance in patient preparation for intubation and improvement of laryngoscopy skill was (48.67±20.09) and (78.50±17.78) in the control and intervention groups, respectively, indicating a significant difference (P=0.006).

Conclusion: Based on the results, the use of computer-based simulator could improve students' performance in patient preparation for intubation and improvement of laryngoscopy skill by up to 50%. Therefore, this method can be used as a complementary training method to improve the students' performance in similar clinical skills in medical sciences..

Keywords

Simulator Software, Electronic Learning, Endotracheal Intubation, Psychomotor Skill.

Introduction

Airway management is regarded as one of the most important skills in patient anesthesia. If difficulty or failure in managing airway causes mortality and complications in patients requiring

*Corresponding Author: zolfaghm@tums.ac.ir

an airway, endotracheal intubation is one of the methods of airway management and is considered as the most reliable and safest way to build and maintain airway [1]. Endotracheal intubation as the first and most important step in resuscitation, this method can largely decrease the failure rate of the resuscitation operation and increases the survival rate if it is performed speedily and correctly [2]. Endotracheal intubation may cause complications such as aspiration, laryngospasm, tachycardia, hypertension, etc. [1]. Therefore, when requiring intubation, either in emergency or electively, it is necessary to perform measures such as patient monitoring and proper venous access and to have access to options such as emergency medications, equipment such as laryngoscopes, tracheal tube in proper sizes, and airway, as well as auxiliary equipment such as suction to prevent or minimize these complications. Nurses and anesthesiologists are responsible for patient preparation in the hospital sector and operating rooms, as well as the preparation and control of the equipment in terms of performance correctness for performing endotracheal intubation. In addition, the airway management is one of the key skills in managing and treating patients and nurses are responsible for this task in the hospital departments before the arrival of an anesthesiologist or experienced team [3]. Nurses are usually the first to help patients in critical situations and the golden time to save the patient's life may be lost, if they are not able to take the necessary interventions to maintain airways until a physician arrives. Thus, nursing experts (as well as anesthesiologists) should increase their skills and knowledge before confronting patients [3]. Hence, the training of laryngoscopy and endotracheal intubation skills is of great importance in educating anesthesia undergraduate students who will be part of an anesthetic team in the future. Currently, this training is performed through written notes and lectures by the professor to improve the level of knowledge in this field and through participation in the Skill Lab to promote the psychomotor skills in medical science universities. The use of skill labs can be very beneficial because of lowering the risks for the patient and observing the standards of medical ethics [4]. However, regarding the lack of access to the Skill Lab for all medical faculties, as well as the lack of its proportion to the number of students, it is necessary to find a way to facilitate the training of this skill and increase the quality of the training course. Considering the much experience of the researcher in the operating room as an anesthetic expert and continuing interaction with students in this field, it seems that students are still unfamiliar with the operating room environment and are not able to detect the correct reaction in sensitive situations related to airway management, even after completing the Skill Lab course. According to the recommendation of anesthesiologists, this study seeks a way to increase students' awareness relative to their needs and performance in this regard.

With the growing expansion of e-learning, the use of educational simulator and interactive electronic content can be effective and increase the productivity of physical education environments such as Skill Lab, by providing easier access and the ability to review important points by the student for several times. Recently, the American Academy of Medicine has recommended the use of this method to reduce human errors [5]. In recent years, simulation has been increasingly used in various fields, especially in the field of education and learning, as one of the most important applications. By using simulators and simulating real-life situations, professors can more engage the student, give feedback to them, and thus, modify the individual behavior [6].

Simulation is a technique or device in order to create the features of real phenomena [7]. As a teaching method, simulation is a series of activities that imitate a real clinical environment and is designed to demonstrate processes, decision-making, and critical thinking by using methods such as role-playing and instruments such as educational films and mannequins [8]. Simulation attempts to close learning conditions to real ones such that the learned concepts can be transmitted to the real world [9]. Simulation is not only limited to the use of mechanical simulators, but also methods such as role-playing, scenario setting, case study, and computer

training programs [10]. This method proposes a hypothetical problem, similar to the realities of life, to the students, who are asked to experience that situation and solve the problem, by observing the educational principles and rules [11].

Applying the simulation method in medical sciences leads to the development of knowledge, skills, and performance of students. Students gain high levels of critical thinking through practice and acquire new professional skills without harming real patients [12]. The implementation of simulated scenarios by students under specific conditions makes them develop their skills while gaining experience and obtaining the necessary competency without fear and anxiety caused by harming the patient. As a result, the use of this method in medical sciences leads to safe care and desirable results for the patient [8]. Exercise and repetition in simulated environments can make students acquire the right skills and present proper care in dealing with real patients in the clinical environment [13]. It is evident that the use of this method, along with using Skill Lab for learning skills, can improve and increase safe clinical services.

Despite the benefits of using computer simulators in relation to medical science field, few studies have been conducted in this regard, especially an increase in learning rate in the field of psychomotor skills. In other words, most studies have focused on multimedia and video content. The current Farsi simulators are very limited and there is no endotracheal intubation simulation. By designing and constructing a simulator for training endotracheal intubation, the present study aims to evaluate the effect of this simulator on improving the performance of undergraduate students of anesthesia regarding patient preparation for performing endotracheal intubation and the improvement of laryngoscopy skills in Tehran University of Medical Sciences.

Methods

This experimental study, which consisted of two groups of control and intervention, was conducted in 2018. The research area of Skill Lab was Sina super specialty hospital. Further, the research community was 17 undergraduate anesthesia students in the faculty of paramedics in Tehran University of Medical Sciences, who passed standard and routine courses in airway management education through lectures (the theoretical part of this topic was presented in two theoretical units of the anesthesia principles) and participated in a two-hour Skill Lab session at Tehran University of Medical Sciences, as well as the evaluation. The students were randomly divided into two groups of control and intervention. Initially, the content and scenario were designed based on the educational goals of the curriculum and the lesson plan under the supervision of the anesthesia advisor. The educational content was provided based on e-Learning principles using the Storyline software built by the Information Technology and Content Compilation of the virtual school at the Tehran University of Medical Sciences. In order to build a simulator, the 3D models of devices and their equipment, color and texture were designed using the Blender free source software (blender.org) and the ready models were located in their right place via the cross-platform game engine (Unity) program to form the operating room (including the patient bed, patient, ventilator, suction, and trolley containing the required equipment). The coding process was written using Visual Studio 2015 and finally, the final output of the simulator was derived from the Unity software. This simulator is able to provide the student with appropriate feedback, in addition to placing the student in a problem-solving situation. In this way, the student first familiarizes himself with the general concepts and techniques of airway management, as well as how to use the equipment through video and video images, along with the explanation of the introduced points, and then, they enter the simulation space to evaluate their knowledge. This space is designed in such a way that the student can imagine himself in an operating room environment and apply his/her knowledge according to his necessity. This capability is intended to prevent the student from completing the next step with error notification if the required skill is performed incorrectly. Students can

use the simulator many times and evaluate their performance according to the rating of the software. Furthermore, they can review educational content if needed. The design of all stages in Persian facilitates the use of software for students. The appendix section presents an example of the simulator.

Then, the control group was assessed in the skill lab through a checklist and without any intervention by an experienced anesthesiologist, who was unaware of the students' classification. This assessment involves patient preparation and the selection of right equipment for intubation, correct laryngoscopy, and airway control. The simulated content was provided to the intervention group and students were able to view this content many times before entering the Skill Lab. The submission of this content to the intervention group was performed after the assessment of the control group such that there was no access to the content for the control group). The simulator software was provided to the students of the intervention group for two weeks so that there was enough time to use the software regarding the students' learning speed. After a week, students were contacted to ensure they had no problems in using the software. Previously, the call number was available to the students to resolve any problems with software implementation. Then, the same expert assessed the intervention group in the skill lab through the checklist. The scores obtained from both groups, as well as the number of errors in patient preparation, laryngoscopy process and the sum of both skills (total performance score), were compared to determine the effectiveness of using the simulator software. Table 1 presents the frequency of all measured variables. Finally, the effect of other variables was adjusted to determine the effect of the intervention on learning, using linear regression.

The data collection tool was a demographic questionnaire for gathering information such as age, gender, grade, residency in a dormitory, previous experience in training through computer and computer access rate per day. The Objective Structured Assessment of Technical Skills (OSATS) checklist was used to assess students. In this criterion, performing each part of the skill consisted of 1 to 5 points (from full dependence to performing without an assistant), which was used for scoring according to the skills studied in the similar study [14]. Among the items listed in these tables, we selected the items used to evaluate undergraduate students and trained in electronic content and used as a measurement tool in the new table, which six anesthetist experts evaluated and verified its validity and its reliability was 0.80 based on the Cronbach's alpha. Based on this checklist, the maximum and minimum score obtained in the total score can be 105 and 21, respectively.

The SPSS-22 software, descriptive statistics (absolute and relative frequency, mean and standard deviation), and t-test were used to analyze the findings.

All ethical considerations were observed in this research and reviewed at the Ethics Committee of the Vice Chancellor for Research at Tehran University of Medical Sciences.

Results

The results indicated that both groups were equal in terms of average age, the number of men and women, and the mean, and there was only one person in both control and intervention groups, who had computer-based training experience.

Table 2 represents the significance of the effect of the intervention (computer simulator) on students' functional error in patient preparation for intubation and improvement of laryngoscopy skills (P-value=0.006).

Regarding the parameters that merely examined the patient's preparation and equipment needed for performing intubation, the calculated mean scores (Table 2) and the use of t-test demonstrated that intervention was significant and effective in this regard (P-value=0.004)

The criteria, which evaluated the second goal of this study, namely, the improvement of laryngoscopy skills, were assessed, indicating the significance and effectiveness of the intervention in this regard (P -value=0.008)

The linear regression model was used to study the effect of training on learning. Based on the

results, after adjusting the effect of other variables including (age, gender, residence, having previous experience, access to a computer), the effect of the intervention on learning was significance (B=0.541, p-value=0.015).

Table 1. Distribution of absolute and relative frequency of demographic characteristics in the control and intervention groups

Demographic characteristics		Intervention group		Control group	
		Number	Percentage	Number	Percentage
Gender	Male	3	37.5	3	33
	Female	5	62.5	6	67
Residency in the dormitory	Residency in the dormitory	2	25	4	44.5
	Along with the family	6	75	5	55.5
Access to the computer	Less than one hour	5	62.5	4	44.44
	Between one to three hours	2	25	2	22.22
	More than three hours	1	12.5	3	33.33
Previous training experience through computer	Yes	1	12.5	1	11
	No	7	87.5	8	89
Average	Above 18	4	50	5	55.5
	Lower 18	4	50	4	44.5
Age		Average	Standard deviation	Average	Standard deviation
		19.12	1	19.22	1

Table 2. Comparing the students' performance in control and intervention groups regarding patient preparation for intubation and improvement of laryngoscopy skills

	Control group		Intervention group		Test result	
	Mean	SD	Mean	SD	t-student value	p-value
Total performance score	48.66	20.087	78.500	17.784	-3.223	**0.006**
Performance score in patient preparation and equipment for intubation	22.22	10.170	36.750	6.777	-3.416	**0.004**
Laryngoscopy skill score	24.09	9.02	41.69	12.1	-4.08	**0.008**

The Discussion

The present study aimed to develop an educational simulator system for training airway management and endotracheal intubation for patients selected for surgery. Accordingly, we evaluated the laryngoscopy and patient preparation skills of undergraduate students of anesthesia for performing intubation. Based on the results, the use of a computer-based simulator improves students' performance in patient preparation for intubation and laryngoscopy skills by 50%, indicating that the replicating actual condition and exposing students in the position of problem-solving and decision-making, as well as giving feedback to them can help reduce the functional error. By plotting realistic situations in the simulator and providing feedback, similar results have been reported in the field of education by some studies such as De Lazzari et al. [15], Safdari et al. [16], Russell Smith et al. [17], and Jaana-Maija Koivisto et al. [18]. In the study of De Lazzari et al. (15), although only two-dimensional images and numbers were used to depict different cardiovascular pathologic positions in the simulator, the post-test results were improved in 80% of cases. The simulator software was provided to the intervention group students for two weeks so that there is enough time to use the software in terms of student learning speed. The simulator could be easily implemented on personal and home computers, and the student could use it at any time of the day, without the need for the Internet. Regardless of this important advantage of the simulator, it might have led to a different result in the study. However, Haidarzadeh et al. (19) failed to find a significant difference in the learning of the two groups, by randomly allocating the two groups of traditional training and training through the simulator and only two hours to use the simulator by radiology students. Alijanpour et al. [20] suggested that the use of only multimedia content for cardiopulmonary resuscitation could not be effective compared to the practical training of this skill in the clinical skill center. In another study, Russell Smith et al. [17] used independently the interactive content of knee and elbow examination in the intervention group and represented the effectiveness of using this interactive content in relation to the knee examination, although no significant difference was observed between the two groups regarding elbow examination. Thus, the present study used the simulator as complementary training along with traditional education, and it seems that there is still a need for applying Skill lab and Clinic to train clinical skills, due to the huge difference between reality and simulators space, despite available facilities and technologies. However, it is possible to increase the learning rate of students using computer-based simulators and interactive content, along with traditional education. Safdari et al. [16] suggested that the use of simulator software along with the traditional methods of lecture for clinical topics improve the level of student knowledge and resolve many of the shortcomings faced in the lecture method and attending in the hospital.

Further, the use of this simulator software could reduce the student's functional error regarding the patient preparation and equipment needed for intubation by more than 1.6 times, which could be due to the creation of simulator and educational content using text integration, speech, and animation, in order to stimulate various sensory ways, observe temporal contiguity and create visual attractiveness for enhancing the motivation of students. It seems that the emphasis on the issues which most students ignore in the clinical environment such as monitoring and patient’s venous line, selecting the type and size of the essential equipment (airway, mask, laryngoscopy, etc.), as well as the performance review of suction and ventilator have been a factor in increasing students' learning.

The use of software for improving laryngoscopy skills has been effective and reduced the student's performance error by 1.7 times. After examining the common mistakes of students in this field and regarding the experience of the researcher as an anesthetic expert, surveying anesthesiologists, and focusing on these mistakes, all of these points, such as the correct use of the laryngoscope, the final control of the airway, and how to use the auxiliary equipment were considered in designing the simulator. The design of the scoring system as an interactive factor

identifies the student's error while creating a kind of competition for the student and increasing his motivation to review content several times. Since students are forced to correct their errors to continue, this system keeps the correct operation in their mind and thus, they are able to correctly react in the same clinical situation.
Despite the initial welcome of the students to participate in designing and using the simulator, some of the students were not able to participate in the project due to the distance, administrative constraints, and the lack of suitable space for assessment at the faculty. Therefore, the number of samples did not reach the predetermined number, which could affect the outcome of the research. The simulator could include other parts of the airway management, which was neglected due to the high financial and time cost.
In the present study, the design of a simulator in the field of training endotracheal intubation, especially in Farsi, was performed for the first time, which can motivate the student by combining the training and playing processes. The implementation of this software does not require special hardware or accessories, and it will not cost too much to students despite the expected desirable results.

Conclusion

The use of a computer-based simulator is effective on the performance error of the undergraduate students of anesthesia regarding the patient preparation for intubation and the improvement of laryngoscopy skills and can reduce their functional error by more than 1.5 times.
This computer-based simulator and other similar software can be used as complementary training for training undergraduate students of anesthesia and other related disciplines. Furthermore, considering the important points in this software, it can be used to retrain nurses and other clinical staffs, who are less confronted with these cases but need to have this skill.
Despite attempts to resolve the limitations in the study, fewer students were willing to participate in the study compared to the early expectations of researchers. In future studies, it is suggested that students should be encouraged to participate in the study and the research should be performed with a larger number of samples.
Given the limited studies on the impact of computer-based simulators on clinical skills, more similar studies should be conducted on other clinical and psychomotor skills, as well as medical sciences groups.
Since the creation of motivation and educational attraction from simulator software may vary in students of different levels, investigating the impact of the simulator on improving the performance of students in lower and higher grades is another topic for future research.
It seems that the use of physical simulators, which can be used in cyberspace without the need for a particular location, has a greater impact on clinical skills, consequently, future studies can evaluate their impact on learning by designing such simulators.

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