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Convergence Effect of Simulation Training on Bleeding Amount Estimation in Trauma

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시뮬레이션 교육이 외상성 출혈의 출혈량 추정에 미치는 융합적 영향

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Abstract The purpose of the study is to examine the visual evaluation of bleeding amount in hemorrhagic shock in paramedic students. Through manikin simulation training, paramedic students were able to have confidence with estimation of bleeding amount in the prehospital settings. Three rescue training manikins were placed in supine position and artificial blood was poured between the abdomen and pelvis. The bleeding evaluations of 700 mL, 1200 mL, and 1700 mL were performed before and after simulation training. Paramedic students underestimated the amount of bleeding in the trauma situation, and it was found that it was difficult for the students to evaluate the accurate amount of bleeding with a single simulation.

Key Words : Bleeding evaluations, Hemorrhagic shock, Simulation training, Paramedic students, Confidence

요 약 본 연구의 목적은 응급구조학과 학생들을 대상으로 출혈성 쇼크와 관련된 출혈량을 시각적으로 평가하는 것이다. 마네킹 시뮬레이션 교육을 통해 응급구조학과 학생들은 병원 전 환경에서 출혈량을 추정하는 데 자신감을 가질 수 있었다. 세 개의 구조용 훈련 마네킹을 바로누운자세로 놓고 인공 혈액을 복부와 골반 사이에 부운 후 시각적으로 측정하게 하였으며 출혈량 관련 시뮬레이션 교육 전과 후에 700mL, 1200mL 및 1700mL의 출혈 평가를 수행하도록 하였다. 응급구조학과 학생들은 출혈량을 과소 평가했고, 한 번의 출혈량 시뮬레이션으로는 정확한 출혈량을 평가하는 것이 어려웠다.

주제어 : 출혈 평가, 출혈성 쇼크, 시뮬레이션 교육, 응급구조학과 학생, 자신감

1. Introduction

Pre-hospital bleeding is the leading cause of death world wide[1]. It is also a major cause of paramedics coming to the scene. There are many reasons for bleeding due to trauma. In particular, injuries causing soft tissue damage, such as assault due to bluntness and open damage due to sharp objects, are increasing day by day. Statistics released by the World Health

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Organization(WHO) reported that 5 million people died from injuries in 2002 and it is expected to increase to 8 million by 2020[2]. In addition, paramedics dispatched to the scene are confuse by the splendid appearance of the disformed musculoskeletal system, and lose the priority of evaluation and treatment of trauma patients, making it difficult to respond quickly. And hemorrhagic shock is the leading cause of death in more than 30% of deaths due to injury[3]. Comprehensive assessments, such as vital signs and skin tests, can more clearly show the shock from bleeding, but many situations in the field often require prioritization for transfer with only the first impression. So, grasping the first impression of a traumatic bleeding patient in the field naturally affects the severity of the trauma and the length of stay in the field.

The bleeding progresses gradually into four stages with decrease blood volume. Normally stage 1 bleeding is based on 750 ml of blood loss in men weighing 70 kg, stage 2 occurs at 750-1500 ml, stage 3 occurs at 1,500-2,000 ml, and stage 4 occurs at 2,000 ml of excess blood loss[4]. Especially after the stage 3 of bleeding, which is a typical symptom of hypovolemic shock, there is a need for rapid evaluation and coping, because no survival can be guaranteed without prompt treatment. This amount of bleeding prediction, in the field is important for patient assessment as well as for proper first aid and transport prioritization. However, the evaluation of bleeding in out of hospital trauma patients is simply estimated by the dispatched paramedics, or by the paramedics measuring the number of hours consumed after applying gauze or pads to the bleeding site for emergency patients. Although the measurement method using advanced equipment is recommended for accurate evaluation of the amount of bleeding, the bleeding measurement method using the equipment in a pre-hospital emergency where a large amount of bleeding has occurred has practical limitations such as manpower and time required. Accurate estimation of the amount of bleeding is a crucial step in preventing death and morbidity from external bleeding. Therefore, there has been a need to improve the accuracy and reliability of bleeding estimation[5-7].

Practical training based on clinical experience is essential to improve the accuracy of out of hospital bleeding estimates in practice. however, there are not many opportunities to meet and train patients directly in the hospital. And even if you meet a bleeding patient in a out of hospital emergency, there are many limitations such as worsening the patient's condition and complaints due to additional time to learn to estimate the bleeding amount. Therefore, the necessity of recent simulation education is increasing as a way to improve the accuracy of visual evaluation of blood loss. Simulation education is effective in improving students' critical thinking ability and problem solving ability[8-11].

Simulation training has proved useful in out of hospital trauma patients, but little research has been done on traumatic bleeding including injuries. So we reproduced the experiment to help determine priorities for transfer by grasping the first impressions of bleeding.

The purpose of this study is to determines how visually the paramedic students can evaluate the amount of bleeding associated with hemorrhagic shock. Also, it is to evaluate the effectiveness of simulation training to improve the accuracy of prehospital bleeding estimation by comparing the accuracy before and after simulation training and the confidence scale.

2. Materials and Methods

This study was conducted from September to October 2019 and was conducted for 2nd, 3rd and 4th grade students who are attending a department of paramedic science at a Korea

national university of transportation. Subjects were recruited by notifying the description of the study, and all subjects participated in the experiment after obtaining a voluntary consent after receiving a sufficient explanation of the study and seeking understanding. Students who did not wish to participate in the study were not included. Comparison of single group means using G*power 3.1.9 program for this, when the effect size(d)=0.05, power(1-β)=0.95, and significance level(α)=0.05 were taken as reference to the similar study, the sample size was 54 subjects, and the subjects participating in this study agreed it was 73 people. Blood used in the study was a mixture of warm water and coffee, red food coloring, sugar syrup, and starch in a ratio of 5: 3: 1: 1: 0.5 and used to prepare artificial blood. For the study, a rescue training manikin (W44514, 167 cm 75 kg) was laid in supine position with a plain white cotton t-shirt and blue jeans. Three mannequins are dressed in the same t-shirt and jeans, because the visualization can vary depending on the t-shirt's fabric and the color of the jeans. Artificial blood was poured into the abdomen and pelvis by the same researcher. So the same was visualized on three mannequins. After putting on clothes, artificial blood was poured, so it was absorbed into T-shirts and jeans and naturally poured on the floor according to the amount of artificial blood.

First, in order to know the prior knowledge level of the subjects, 10 short-term questions related to hemorrhagic shock were presented and solved within 1 hour. Test contents is paramedic care, principles & practice 4th edition; p.76 Stages of bleeding and PHTLS 8th edition; In the book p.240 Classification of hemorrhagic shock, 10 problems related to bleeding and shock were presented. The same problem was presented without any difference between grades, and the question was presented within the scope of the regular curriculum. After evaluating knowledge related to hemorrhagic shock, subjects underwent bleeding evaluation without prior information. Three questions were presented: 700 mL, 1,200 mL, and 1,700 mL. The blood loss level boundary was set based on the blood loss amount of class 1,2,3 of the hemorrhagic shock. A one-minute time limit was given for each problem and the estimated blood volume was recorded. In addition, one(very low) to five (very high) measures of confidence in the accuracy of the estimated blood volume felt by the subjects were included. Immediately after the evaluation, visual data for bleeding evaluation were presented when 100 mL, 500 mL, 1,000 mL, and 2,000 mL of artificial blood were absorbed into white cotton tee and jeans respectively. Immediately after the simulation training, a second evaluation was conducted. The evaluation did not present visuals used in the training. During the whole process, three identical questions were presented: 700 mL, 1,200 mL, and 1,700 mL, and a confidence questionnaire for bleeding estimation accuracy was included with each assessment. The examinee could touch the mannequin at will, and the drying time of the artificial blood could be prevented because the experiment time was not long. All subjects were tested in the same order and three mannequins were identified and recorded. In order to evaluate the sustainability of the educational effect, the subjects were not able to know the correct answer during the simulation training and evaluation period.

For the accuracy evaluation and statistical analysis of the bleeding amount estimation, the bleeding estimate was calculated as [(predicted-actual amount) / actual amount × 100] by comparing with the actual amount and defined as the percentage error value for the result value [12]. For each item, we analyzed whether there was a tendency to underestimate or overestimate the amount of bleeding. We compared the accuracy of bleeding estimation

before and after training and changes in confidence. We also analyzed whether there were statistically significant differences between grades.

SPSS 21.0 for Windows was used for statistical analysis. The mean and standard deviation was used to analyze confidence in percent error values and bleeding estimation accuracy before and after simulation training. One-way ANOVA was used to analyze subjects' grade differences. If p value is less than 0.05, it is defined as statistically significant.

3. Results

3.1 General Characteristics of Subjects

A total of 73 subjects were 20 in second grade, 31 in third grade, and 22 in fourth grade. In the second grade, there were 10 men and women, respectively, and in the third grade, 17 men and 14 women. And the fourth grade was 10 men and 12 women. The average age of the subjects was 23.08±1.32. In the second grade, students completed only basic traumatology through the regular curriculum. In the third grade, they completed both basic traumatology and advance traumatology, but no on-the-clinical practice. in the fourth grade completed all traumatology and clinical practice. All subjects did not receive simulation lessons related to bleeding and did not receive any certifications related to trauma.

3.2 Comparison of Knowledge Level Results with Hemorrhagic Shock

The overall average of the three short-term questions related to hemorrhagic shock was 3.38. And there were statistically significant results of 1.30 in 2nd grade, 3.90 in 3rd grade, and 4.55 in 4th grade($p < .001$). The comparison of knowledge level results and hemorrhagic shock are summarized in Table 1.

Table 1. Level of knowledge of Hemorrhagic shock before Simulation-based Education

Variables (Paramedic students)	Mean±SD*	F	*p*
2 grade(n=20)	1.30±.979		
3 grade(n=31)	3.90±1.350	45.36	<.001*
4 grade(n=22)	4.55±1.057		

* SD = standard deviation

3.3 Visual Accuracy of Bleeding Volume and Effect of Simulation Training

The comparative analysis before and after the simulation training showed statistically significant results only in 700 mL questions with 627.78 mL for 700 mL questions, 940.97 mL for 1,200 mL questions, and 1,371.81 mL for 1,700 mL questions ($p = .010$). The visual accuracy of bleeding volume and effect of simulation training are summarized in Table 2.

Table 2. Analysis of Blood Loss Estimation before and after Simulation-based Education

Variables	Mean±SD	F	*p*
700 mL	627.78±335.76	2.63	.010*
1,200 mL	940.97±450.14	1.87	.065
1,700 mL	1,371.81±766.86	0.44	.655

3.4 Accuracy Comparison of Bleeding Estimation by Grades

When presenting three items of bleeding models for paramedic students, the median percent error before simulation training was 16.72 mL for 700 mL questions, -8.40 mL for 1,200 mL questions, and -15.92 mL for 1,700 mL questions. Only 700 mL of the three items showed positive percent error value, and the percentage error of the other two items showed negative value. In the grade-level bleeding evaluation, 2nd graders showed positive percent error values only in 700 mL questions, 3rd graders showed negative percent error values for all three questions, and 4th graders showed

positive percent error values for all three items. The accuracy of blood loss estimation before simulation-based education are summarized in Table 3.

In the same bleeding model after simulation training the median percent error was -10.72 mL for 700 mL questions, -20.74 mL for 1,200 mL questions, and -18.43 mL for 1,700 mL questions. The percentage error value of all three items was negative, and the largest error was found in 1,200 mL of the three items. In grade-level hemorrhage evaluation, Grade 2 showed positive percent error for all three questions, and Grade 3 and Grade 4 showed negative percent error for all three questions. The accuracy of blood loss estimation after simulation-based education are summarized in Table 4.

3.5 Confidence in Accuracy of Bleeding Estimation

Confidence in the accuracy of bleeding estimation evaluated on a scale of 5 out of 3 items was 2.94 points for 700 mL questions, 2.86 points for 1,200 mL questions, and 2.86 points for 1,700 mL questions before simulation training. The median value for each question appeared after simulation training was 3.38 points for 700 mL questions, 3.30 points for 1,200 mL questions, and 3.30 points for 1,700 mL

Table 3. Accuracy of Blood Loss Estimation before Simulation-based Education

Variables	2 grade(n=20)		3 grade(n=31)		4 grade(n=22)		Mean (±SD)	F	*p*
	% error (±SD)	mL (±SD)	% error (±SD)	mL (±SD)	% error (±SD)	mL (±SD)			
700 mL	5.89 (75.95)	742.11 (530.79)	-7.71 (27.28)	646.77 (190.58)	60.50 (95.58)	1,122.73 (668.10)	16.72 (73.23)	6.82	.002*
1,200 mL	-23.89 (34.90)	913.16 (420.92)	-17.35 (27.29)	993.55 (326.02)	17.59 (52.05)	1,411.36 (625.24)	-8.40 (41.65)	7.46	.001*
1,700 mL	-34.26 (41.70)	1115.79 (709.66)	-26.65 (28.67)	1,245.16 (489.10)	15.05 (40.93)	1,956.82 (697.32)	-15.92 (41.49)	11.75	<.001*

Table 4. Accuracy of Blood Loss Estimation after Simulation-based Education

Variables	2 grade(n=20)		3 grade(n=31)		4 grade(n=22)		Mean (±SD)	F	*p*
	% error (±SD)	mL (±SD)	% error (±SD)	mL (±SD)	% error (±SD)	mL (±SD)			
700 mL	21.35 (51.63)	850.00 (361.64)	-18.72 (23.34)	570.31 (163.06)	-28.23 (57.29)	502.27 (401.92)	-10.72 (47.66)	7.62	.001*
1,200 mL	9.35 (41.78)	1,312.50 (502.06)	-29.53 (20.58)	848.44 (247.40)	-35.32 (43.91)	775.00 (527.29)	-20.74(39.18)	10.29	<.001*
1,700 mL	13.55 (61.91)	1,931.00 (1,052.54)	-29.94 (21.79)	1,189.06 (371.07)	-30.77 (43.00)	1,177.27 (732.20)	-18.43 (45.99)	7.90	.001*

Table 5. Difference of Confidence Level in Blood Loss Estimation before and after Simulation-based Education

Variables	2 grade(n=20)		3 grade(n=31)		4 grade(n=22)		F	*p*
	MBE* (±SD)	MAE† (±SD)	MBE (±SD)	MAE (±SD)	MBE (±SD)	MAE (±SD)		
700 mL	2.74 (1.36)	3.25 (1.07)	3.26 (0.85)	3.56 (0.75)	2.68 (1.21)	3.23 (1.06)	1.07	.348
1,200 mL	2.63 (1.16)	3.10 (1.11)	3.16 (0.77)	3.56 (0.84)	2.64 (1.13)	3.09 (1.01)	2.08	.132
1,700 mL	2.58 (1.21)	3.20 (1.19)	3.29 (0.78)	3.50 (0.84)	2.50 (1.05)	3.09 (1.01)	1.22	.301

* MBE = Mean of Before Education
†MAE = Mean of After Education

questions, which increased after the simulation training, but showed no statistically significant results. The difference of confidence level in blood loss estimation before and after simulation-based education are summarized in Table 5.

4. Discussion

In the level of knowledge related to blood loss, grade 4 was the highest, and grade 2 was the lowest. This is thought to be the result of an improved level of knowledge related to hemorrhagic shock as the grade progressed, and it would have been relatively difficult to solve the problem in the sophomore group who only completed basic traumatology.

The results of bleeding evaluation before training and reassessment after training showed statistically significant results only in 700 mL questions and underestimated bleeding rates in all three questions. Underestimating bleeding volume delays the presumptive diagnosis of hemorrhagic trauma patients and interrupt rapid and adequate first aid. Accurately determining the amount of bleeding in a short time is of paramount importance to prevent mortality and morbidity from traumatic bleeding. Therefore, it is thought that education of paramedic students should be accompanied to accurately evaluate the level of bleeding by the hemorrhagic shock.

The accuracy of the bleeding estimation performed before the simulation training showed that 2nd graders underestimated 2 items except 700 mL, 3rd graders underestimated all 3 items, and 4th graders overestimated all 3 items. This is seen as a result of having each grade completed a course related to hemorrhagic shock. Grade 2 is thought to be the result of estimating the amount of bleeding without any evidence of bleeding patients. Although there is some knowledge level of hemorrhagic shock in the third grade, it is a result of not experiencing the bleeding patient directly through the field practice. This is consistent with a 2015 study published by Hancock et al. That medical practitioners tend to underestimate actual blood loss by 30-50% [5].

On the other hand, 4th graders overestimated the amount of bleeding in all three questions, as a result of directly experiencing bleeding-related patients through ambulance riding and clinical training. However, as in 2008, a study by Maslovitz et al. Informed that empirical learning alone cannot improve the accuracy of bleeding estimation[13]. The accuracy of bleeding estimation after simulation training was overestimated in all three questions by second graders and underestimated by all three questions in third and fourth graders. This is thought to be a result of the difficulty of obtaining sufficient educational effects to visually see 100 mL, 500 mL, 1,000 mL, and 2,000 mL of artificial blood absorbed by white cotton t-shirts and jeans respectively. Simulation training has the advantage of being able to repeatedly practice the necessary techniques in a virtual field situation and experiencing the results of their choice in advance. In other studies, simulation education showed a significant correlation between goal commitment[14-16]. If students continue to provide simulation lessons, it is expected that the bleeding estimates will be good.

Confidence in the accuracy of bleeding estimation for all three questions increased after training. This is the same result as the study in Ogilvie et al. In 2011 in the study that simulation lessons reduce the fear of clinical practice and give confidence to medical practitioners[17].

As a result of this study, the level of knowledge related to hemorrhagic shock is clearly improved as the grade is raised, but it is not accompanied by the judgment of bleeding estimation. It is clear that there is a difference between what is

learned in theory and what is encountered in the actual clinical field[14]. So, repeat simulation-based education may be solve this problem[18,19].

This study has limitations in that it is only for students of paramedic science departments at a university. Also, since it is a simulation evaluation using manikin and artificial blood in a non-real situation, it may not reflect all the accuracy of the bleeding estimation in the real situation. So, it cannot reproduce internal bleeding due to traumatic bleeding. And the importance of estimating blood volume may have been neglected because the subjects were aware of the hypothetical situation. In actual emergency situations, the bleeding estimates of trauma patients should be assessed urgently and continuously, so the accuracy of this study may differ from the results, and clothing and floor conditions should be considered. Based on the results of this study, if the education on the bleeding is continuously conducted, it will be having a positive effect on the rapid judgment of the bleeding evaluation and the improvement of first aid.

5. Conclusion

This study identified the tendency of paramedic science students to underestimate the amount of bleeding in a traumatic situation. Repeated training will be needed to improve the accuracy of bleeding evaluation, and if the bleeding evaluation and the trauma patient's evaluation and emergency treatment are accompanied by the education, it will help to improve the trauma patient's ability and skill of paramedic science department students. Therefore, it is necessary to repeat research on the simulation education of traumatic bleeding patients through various research designs in the future. In addition, it is suggested that the instructional design of simulation education based on the hemorrhagic shock criterion is necessary for all grades.

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