ORIGINAL ARTICLE

An Effective Method of Teaching Advanced Cardiac Life Support (ACLS) Skills in Simulation-Based Training

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Purpose: In this study, we compared the effects of constructivist and traditional teaching strategies in teaching advanced cardiac life support (ACLS) skills during simulation-based training (SBT).

Methods: A randomized, pre- and post-test control group study was designed to examine this issue in 29 third-year emergency medical technician (EMT) students. Participants received SBT through constructivist SBT (CSBT) or traditional lecture-based SBT (TSBT) teaching strategies. We evaluated the effects of the simulation training on ACLS knowledge, and performance immediately after practice and at retention.

Results: The knowledge and performance of the CSBT group were higher than compared with the TSBT group (mean knowledge 33.3±5.03 vs. 29.5±5.33, p=0.36; and mean performance 12.20±1.85 vs. 8.85±3.54, p=0.010). However, there was no difference between two groups in retention between groups 1 month later (mean knowledge 31.86±4.45 vs. 31.50±4.65, p=0.825; and mean performance 12.13±0.99 vs. 12.57±1.78, p=0.283).

Conclusion: CSBT is more effective with regard to knowledge acquisition and performance than TSBT. Further studies are needed to explore ways of improving retention and transfer of knowledge from simulated to real situations with SBT.

Key Words: Simulation, Simulator, Teaching strategies, Advanced cardiac life support, Training

INTRODUCTION

There are many benefits and rationale for incorporating simulation into medical education on educational and social grounds [1]. Several studies have found an effectiveness of simulation-based training (SBT) across various clinical disciplines, continuum of medical education, specific skills/performances, and personal/team training [2,3,4,5,6,7,8].

McGaghie et al. [9] identified and discussed 12 features and best practices of simulation based medical education as follows: feedback, deliberate practice, curriculum integration, outcome measurement, simulation fidelity, skill acquisition and maintenance, mastery learning, transfer to practice, team training, high-stakes testing, instructor training, and educational and professional context. According to the studies mentioned above, SBT is not only effective in improving the knowledge, skills, and attitudes of learners, but it also has a positive effect on application in actual clinical treatments. However, while the findings explained the effects of SBT, they did

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not sufficiently address how SBT should be carried out?

Training methods for SBT can be largely classified into two types. The first type is provided to students through lectures or videos so that students can obtain basic knowledge; students then repeatedly undergo SBT. This method enables teachers to deliver pre-arranged knowledge to learners and then allows students be given SBT according to what they were taught. In the second type, students are situated in collaborative learning environment without any advanced education. This method allows the learners themselves to improve their knowledge and performance through the feedback of their teacher or fellow students.

This study compared the responses and the extent of the accomplishments of the students after using SBT based on the traditional lecture and constructivist methods. This trial took the two SBT methods and put them into practice so as to present a teaching model for SBT to the teachers of health professions, and to present which teaching methods are more effective in SBT.

SUBJECTS AND METHODS

1. Study design

A randomized, controlled pre- and post-test study was conducted. In order to ensure that the groups were homogeneous, a pre-written test was executed. A Mann-Whitney test confirmed that both groups were homogeneous (mean scores, out of a possible score of 43, were 19.9±3.98 for group A and 20.1±4.10 for group B; $p>0.05$). In order to execute the training using a simulator (ECS® Emergency Care Simulator; Medical Education Technologies Inc., Sarasota, USA) in small groups of 4 to 5, the experimental group of 15 and the comparison group of 14 were divided into 3 sub-groups each.

2. Participants

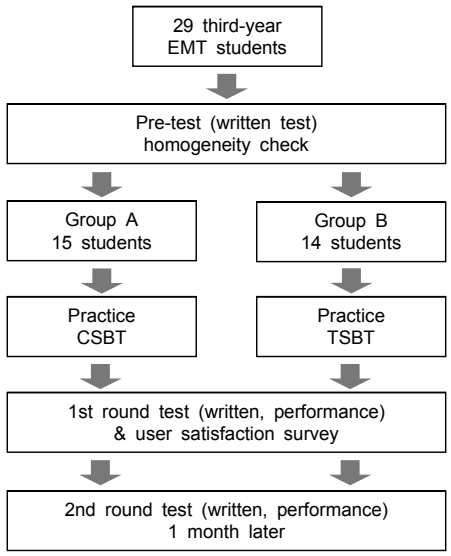
After Institutional Review Board (IRB) approval, the third-year emergency medical technician (EMT) students of Kijeon College in Jeonju were selected for this study. There were 30 third-year students in total; however, one student did not agree to participate in the study, leaving 29 participants. The participants of the research had no experience with SBT. They were divided into an experiment group of 15 and a comparison group of 14 by

Table 1. Baseline Demographic Data

Characteristic	TSBT group	CSBT group
Age, yr		
Mean	24.57	25.13
SD	1.80	1.92
Gender, No. (%)		
Male	6 (43)	8 (53)
Female	8 (57)	7 (47)
Total	14 (100)	15 (100)

TSBT: Traditional lecture-based simulation training, CSBT: Constructivist simulation-based training, SD: Standard deviation.

Fig. 1. Procedure of Study



EMT: Emergency medical technician, CSBT: Constructivist simulation-based training, TSBT: Traditional lecture-based simulation training.

conducting a knowledge test prior to the training. There were no group differences in age and gender distribution (Table 1). Advanced cardiac life support (ACLS) was selected as the content for the SBT. The experimental group received constructivist SBT (CSBT) teaching strategies, while the comparison group received traditional lecture-based SBT (TSBT) teaching strategies. After receiving the training, each group completed a survey, knowledge test, and performance test. In addition, their knowledge and performance were re-evaluated 1 month later to measure the retention effect (Fig. 1).

In order to control the learning effect by instructor variability, one researcher conducted the training for both the experimental group and the comparison group. The training was conducted from August 2009 to October 2009.

3. Educational intervention

1) TSBT

PowerPoint slides, pictures, and videos were used as teaching materials. Based on the principle of Ausubel's meaningful reception learning theory [10], the content of the each materials was organized from a general overview into detailed information and was demonstrated based on common principles and regulations in order to effectively deliver the content to the learners.

Before the simulation training, 2-hour lecture was held. The lecture materials included videos, pictures, and a vignette of an ACLS crisis. At the end of the lecture, the 14 participants were divided into three groups of 5; each group received 1 hour of simulation practice. In the simulation practice session, to provide the learners with opportunities to practice what they learned, the same cases that were presented to the CSBT group were provided. At the end of each scenario, the instructor allowed the participants to ask questions, review algorithms (Table 2). After completion of training for each group, knowledge and performance evaluations were conducted.

2) CSBT

The situation scenario and teaching materials applied to the teaching program were developed by the researcher. The development of the situation scenario used images that re-created actual emergency situations and books containing other emergency situations. Cases

Table 2. Teaching Methods and Strategies

	CSBT group	TSBT group
Teaching methods		
Materials	Simulator, internet utilities, and textbook etc.	Lecture, simulator
Instructor: Student	1 : 5	1 : 4 or 5
Timetable	A-1 group: SBT 100 min A-2 group: SBT 100 min A-3 group: SBT 100 min	All students: lecture 120 min B-1 group: SBT 60 min B-2 group: SBT 60 min B-3 group: SBT 60 min
Class time per learner	100 min	180 min
Class time per instructor	300 min	300 min
Teaching strategies	1) Provide actual case and context 2) Support collaborative and student-led problem solving 3) Provide coaching and scaffolding 4) Provide feedback to their colleagues and instructor	1) Give a lectures 2) Use of audiovisual materials 3) Provide opportunities to practice

CSBT: Constructivist simulation-based training, TSBT: Traditional lecture-based simulation training, SBT: Simulation-based training.

were developed to provide various possible situations. Teaching materials were developed as cases to help improve student learning and to provide context, and drawings or photos were used to help the learners to solve the situations. Two medical professors of Emergency Medicine verified the feasibility and content validity of the developed situation scenarios and the content of the teaching materials. Before beginning the study, a 2-hour pilot test was conducted on second-year EMT students allowing any errors in the procedure to be discovered, corrected, and supplemented.

The participants were divided into three groups of 5 and each group received 100 minutes of training. To apply the constructivist teaching strategies, 15 actual cases were presented in order to allow the students to solve the situations using collaborative approach. The participants used referential books and the Internet to solve the situations while the instructor observed the process of problem solving and conducted the role of facilitator, providing coaching and scaffolding students faced difficulties, as well as providing feedback (Table 2). After completion of training for each group, knowledge and performance evaluations were conducted.

4. Instruments

A satisfaction survey was developed to evaluate satisfaction with the SBT, which was previously described [11]. The survey comprised 36 items that were rated using a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The following parameters were rated: overall course usefulness, stress of the course, realism of the case scenario and simulator, quality of the training and assessment, need for more chances to practice, and teaching methods.

A multiple-choice test was developed to assess student knowledge of ACLS. The multiple-choice items (n=43) were selected and adapted from the lesson assessment items of the American Heart Association (AHA) ACLS provider manual [12]. Identical items were used on both the pre- and post-test. The maximum score on the test was 43.

Table 3. Test Scenario Format

Case	Test scenario
1	Unstable bradycardia → V·fib→Asystole
2	Narrow QRS, regular, stable tachycardia → V·fib→PEA
3	Unstable tachycardia → Pulseless VT → PEA
4	Unstable bradycardia → Pulseless VT → Slow PEA rate
5	Wide QRS, regular, stable tachycardia → Pulseless VT → Asystole

V·fib : Ventricular fibrillation, PEA: Pulseless electrical activity, VT: Ventricular tachycardia

All students were randomly assigned to one of five test scenarios, each with a different arrhythmia scenario and modeled in the typical ACLS format (Table 3). The performance checklists use 2005 AHA protocols [12]. The checklists were developed and tested using rigorous standards and yielded highly reliable data [5,13]. Two instructors observed the procedures and used the checklist to independently score each student's performance. All testing session were video-recorded to conduct standardized assessment and feedback. After each performance test, the instructors' checklists were compared for consistency. If an inconsistency occurred, a third instructor reviewed the video for final determination of the score [14]. The performance items (n=17) were scored using a rating scale ranging from 0 (not performed) to 1 (performed). The maximum performance score that any student could receive was 17.

5. Statistical analysis

Statistical analysis used the Mann-Whitney U test; a p-value of less than 0.05 was considered significant.

RESULTS

1. Responses of learners about SBT

Regarding the course usefulness and interest of the simulator, both the CSBT group (4.3±0.5) and the TSBT group (4.4±0.6) showed high satisfaction. The TSBT group (3.9±1.1) had greater feelings of stress or burden than the CSBT group (3.4±0.9). However, considering that the deviation in both groups was large, it seems that there are large differences between individuals. The CSBT group and the TSBT group rated the section regarding the realism of the scenario and simulator as 4.0±0.7 and 4.2±0.5, respectively. Both the CSBT group (4.1±0.5) and the TSBT group (4.1±0.5) rated the quality of training and assessment as being quite high. Both the CSBT group (4.2±0.6) and the TSBT group (4.4±0.5) rated the effectiveness of the teaching methods as being relatively high. Regarding the need for more chances to practice, the TSBT group (4.7±0.4) showed a higher desire for more learning or practice than the CSBT group (4.1±0.9).

2. Knowledge and performance tests

The results of the initial knowledge test of the CSBT group (mean, 33.3) were higher than that of the TSBT group (mean, 29.5). According to the Mann-Whitney test, the average ranks of both groups were 11.57 and 18.20, respectively. The z value was -2.101 and the significant probability value was 0.036. It was found that there was a significant difference between the two groups ($p<0.05$); consequently, CSBT is more effective in regards to acquiring knowledge than TSBT (Table 4). The initial performance of the CSBT group (mean, 12.20) was higher than the TSBT group (Mean, 8.85) by 3.35 points. Based on the Mann-Whitney test, the average ranks of both groups were 10.82 and 18.90, respectively, while the z value was -2.578 and the significant probability value was 0.010. There was a significant difference between the two groups ($p<0.05$); thus, it is possible to acknowledge that CSBT is more effective in regards to performance than TSBT (Table 4).

3. Retention

There was no difference in the knowledge of the TSBT group (mean, 31.50) and the CSBT group (mean, 31.86) after 1 month. Based on the Mann-Whitney test, the

Table 4. Results of Study Groups by ACLS Knowledge & Performance Test

		Mean	SD	Average rank	Rank sum	Mann-Whitney U	Z	p-value
Initial knowledge	TSBT	29.5	5.33	11.57	162.00	57.000	−2.102	0.036
	CSBT	33.3	5.03	18.20	273.00			
Initial performance	TSBT	8.85	3.54	10.82	151.50	46.500	−2.578	0.010
	CSBT	12.20	1.85	18.90	283.50			
One month later, knowledge	TSBT	31.50	4.65	14.64	205.00	100.000	−0.221	0.825
	CSBT	31.86	4.45	15.33	230.00			
One month later, performance	TSBT	12.57	1.78	16.71	234.00	81.000	0.283	0.283
	CSBT	12.13	0.99	13.40	201.00			

Maximum Knowledge test score 43. Maximum Performance test score 17.
ACLS: Advanced cardiac life support, SD: Standard deviation, TSBT: Traditional lecture-based simulation training, CSBT: Constructivist simulation-based training.

average ranks of both groups were 14.64 and 15.33, respectively, while the z value was −0.221 and the significant probability value was 0.825. There was no significant difference between two groups ($p<0.05$); therefore, there was no difference in the knowledge of learners after 1 month for both CSBT and TSBT (Table 4).

There was little difference in the performance of the TSBT group (mean, 12.57) and the CSBT group (mean, 12.13). According to the Mann-Whitney test, the averages ranks of the two groups were 16.71 and 13.40, respectively. The z value was −1.074 and the significant probability value was 0.283. There was no significant difference between the two ($p<0.05$); thus, there was no difference in the performance of learners after 1 month for both CSBT and TSBT groups (Table 4).

DISCUSSION

The purpose of this study was to discover which teaching method is more effective in SBT. To achieve this, this study had third-year EMT students undergo simulation training based on either the traditional teaching method or the constructivist teaching method.

The results of the study are as follows: First, CSBT was more effective in the initial knowledge acquisition of learners than TSBT. The CSBT increased the learning motive and interest of the learners by providing actual cases and led the learners to solve the problems for themselves, thus helping individual students accumulate meaningful knowledge based on their experiences. The learners also accumulated the knowledge necessary to solve the problems through cooperative learning with their fellow students, and were thus interested in the solutions to the problems, which helped them sustain their learning and affected their acquisition of knowledge. But this does not appear to be true at 1 month later.

Second, CSBT was more effective in raising the initial performance ability of the learners than TSBT. This suggests that the cooperative learning improved the problem-solving abilities of the learners as well as their communication abilities by forming a cooperative attitude through interaction between members. This agrees with the study by Qin et al. [15], who conducted a meta-analysis to verify the effect of cooperative learning on problem solving ability and reported that cooperative learning was effective in increasing the ability to solve problems. The comparison group received the information and knowledge necessary to solve problems and applied this knowledge to the simulator, while the experiment group discovered their learning issues with their fellow learners, confirmed and compared their performances with the others, and solved the issues in the course through discussions. Hence, it is thought that the experiment group grasped problems for themselves and increased their ability to solve problems. In the performance evaluation in this study, effective communication and mutual interaction among the team members were included. It is thought that the communication abilities of the learners improved as their cooperative attitudes through mutual exchanges among team members were strengthened.

Third, there were no differences in the learners' retention in CSBT or TSBT. We expected that CSBT would be more effective in retention than TSBT, but the resulting statistics showed no meaningful difference. This result may have been due to a bias that occurred in the course of the research. Since instructor had notified the learners that re-evaluation of knowledge and performance would take place after 1 month, there is a high possibility that the learners prepared for the examination. Looking at most studies on the effect of

retention, because the effect of memory decreases as time passes, the retention scores are lower than or similar to the scores of the examination that occurred immediately after a class [16,17,18]. However, the scores on the knowledge and performance test in Table 3 show that the experiment group had higher scores immediately after the class than they did on the test 1 month later, while the comparison group showed higher scores one month later than they did immediately after the class. This may have been because the comparison group felt more stress about the examination and prepared more for the examination than the experiment group.

Lastly, CSBT is a more efficient teaching method than TSBT. Looking at class time per learner in Table 1, the TSBT group spent 80 minutes more in class than the CSBT group did. When looking at the class time allotted by teachers, 300 minutes were allotted to both groups. However, when considering the time it took to prepare a lecture for TSBT, it can be concluded that CSBT is more efficient for teachers.

The focus of this study is to determine the effective teaching methods in the SBT. Kim et al. [19] compared the medical student response and course achievement according to different types of patient simulation in an introductory advanced life support course. And they could not find significant difference in post-test scores between the two groups that had either been given interactive simulation with verbal debriefing (interactive type) or full-mission, realistic simulation with video-assisted debriefing (realistic type). Further studies are needed to explore the effective teaching methods in the SBT.

This study had the following limitations: First, this study had limited targets from a small sized institution. Therefore, it was not possible to grasp the effect of simulator teaching for learners in a large group. Second, because the results of this study were produced using a short class time, there was not sufficient verification of the effect.

In conclusion, when considering the above results, the application of CSBT has a positive effect on the knowledge and performance of the learners and is efficient for teachers because it can reduce the amount of teaching time necessary.

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