Observational Study

Medicine®

OPEN

The impact of SimMan on resident training in emergency skills

Yu Liu, MD, PhD[a], Yanshu Zhang, PhD[a], Lei Zhang, MD, PhD[a], Hongliang Bai, MD, PhD[b], Gang Wang, MD, PhD[c,*], Litao Guo, MD, PhD[a,*]

Abstract

The purpose of this study was to analyze the role of SimMan in resident training of emergency skills.

Forty-five 1st year medical residents were selected for this study. All participants were divided into groups and each participant performed different roles during training. Clinical cases were selected using the tutor mode/auto mode in the SimMan computer system in order to train and assess each group. A pre-test was administered to the 45 residents before emergency medical technician (EMT) skill training. Finally, a post-test was conducted with SimMan after training. Tutors scored the student's performance and recorded the overall time for the procedure.

Before training, the overall qualification rate was 44.44%. The average score of the 9 groups was 62.78 ± 8.84 and the average 1st aid duration was 519.22 ± 34.35 seconds. After the training, the overall qualification rate was 100%. The average score of the 9 groups was 80.89 ± 7.39. The average 1st aid duration was 453.56 ± 24.40 seconds. The *P* values in comparing pre- and post-training data were .009, <.001 and <.001.

An integrated learning approach using SimMan as a tool for training and examination can help training residents develop emergency skills, teamwork, and communication.

Abbreviations: CPR = cardio pulmonary resuscitation, ECG = electrocardiogram, EMT = emergency medical technician, ICU = intensive care unit.

Keywords: EMT skills, SimMan, Standardized Training Resident

1. Introduction

Resident training is a key stage in the process of developing medical specialists; it requires that resident doctors possess a substantial theoretical basis, exceptional clinical skills, and the ability to handle severe emergency diseases. China is implementing "resident standardizing training" (referred to as "standardizing training" hereafter) in order to improve overall clinical ability. Doctors attending standardizing training (referred to as "standardizing training doctors" hereafter) have rare opportunities to practice in complex clinical. However, for doctors who are shifting from traditional clinical qualification to standardized training, the development of comprehensive emergency skills is very important and directly affects the outcome of emergency treatment and prognosis. Traditional training and teaching models do not meet the training requirements of the contemporary clinical education environment; therefore, there is a large gap between training and clinical practice.

Chinese medical education reform and the development of computer simulation technology in the medical field have influenced an increase in simulated clinical situation teaching by applying high-fidelity patient simulators.[1] For example, various symptoms can be simulated using software and pre-prepared clinical cases, while a lifelike clinical scenario can be created using actual medical equipment. Many medical colleges and hospitals in China have successfully incorporated patient simulators such as SimMan and Istan. A clinical skill center has been established in order to keep up with the growing integration of clinical simulation technology. The high-fidelity patient simulator SimMan (manufactured by Laerdal) is integral to this development. The aim of this analysis was to identify whether training with a high-fidelity patient simulator improves residents' emergency skills.

2. Objects and methods

2.1. Research object and grouping

Forty-five 1st year medical residents (standardized training residents) who participated in foundational training for intensive care unit (ICU) physicians and passed the after-department examination in the First Affiliated Hospital, Xi'an Jiaotong University (from January 2015 to July 2016), were selected for participation in this study. All participants were divided into groups (9 groups in total with 5 residents in each group). In each group, participants simulated the 3rd-line physician (1 person), the 2nd-line physician (1 person), the 1st-line physician

Editor: Abdelouahab Bellou.

Yu Liu and Yanshu Zhang and Lei Zhang contributed equally to this paper.

The authors have no conflicts of interest to disclose.

[a] Department of Critical Care Medicine, [b] Clinical Skills and Experiment Center, The First Affiliated Hospital of Xi'an Jiaotong University, [c] Department of Critical Care Medicine, The Second Affiliated Hospital of Xi'an Jiaotong University, Xi'an, China.

[*] Correspondence: Gang Wang, Department of Critical Care Medicine, The Second Affiliated Hospital of Xi'an Jiaotong University, Xi'an, China and Litao Guo, Department of Critical Care Medicine, The First Affiliated Hospital of Xi'an Jiaotong University, Xi'an, China (e-mails: dr.g.wang@qq.com and glt02@163.com).

Medicine (2019) 98:2(e13930)

Received: 5 August 2018 / Received in final form: 20 October 2018 / Accepted: 7 December 2018

http://dx.doi.org/10.1097/MD.0000000000013930

(2 persons), and the nurse (1 person), each participant rotates performed each role in training. The group members was identical in pre-test and post-test. This study was reviewed and approved by the The First Affiliated hospital of Xi'an Jiaotong University Ethics Committee.

2.2. Training method

The clinical emergency medical technician (EMT) skills training for the 45 1st year standardized training residents was executed with the combined use of SimMan and actual clinical equipment. In each group, the training period was 4 hours; during this time, 1 group member served as the on-scene commander. Therefore, every medical resident has enough time to experience each role. The testing procedures were arranged by the commanders in accordance with the actual conditions of the rescue process. SimMan simulated different clinical scenarios controlled by relevant software and various therapy/treatment measures were directly performed by trained residents.

2.3. Assessment method

Clinical scenarios involving emergency skills, such as ventricular fibrillation, pulseless ventricular tachycardia and cardiac arrest, were prepared using the tutor mode/auto mode in the SimMan computer system. However, the in-training, pre-training, and post-training assessments for each group shared the same simulated scenarios. Relevant operations, including cardio pulmonary resuscitation (CPR), defibrillation, endotracheal intubation, and invasive/non-invasive ventilation, were assessed by 2 ICU physicians with intermediate or higher titles. They were responsible for scoring in strict accordance with the testing standards. The scoring standards were identical in the pre-test and post-test. The pre-training assessment was time-limited; the time limit for the later assessment was 8 minutes. The duration and success of 1st aid were intelligently identified by SimMan software. If the treatment procedures were performed correctly then the patient simulator returned to spontaneous circulation which was deemed successful and qualified.

2.4. Preparation of the scoring standard and key points for assessment

The assessment scoring standard (total score of 100; scores of >70 required for qualification) was prepared by 2 ICU physicians with senior professional titles in reference to the 2015 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care,[2] Standard for College Students' Skill Training and Assessment, and Scoring Standard for Skill Operation Assessment of National Certified Physicians according to relevant clinical cases. Key points of assessment included electrocardiogram (ECG) interpretation, CPR operation, electric defibrillation operation, endotracheal intubation operation, invasive ventilator use, medicine and 1st aid recording use, on-site commanding ability, judgment of critical condition and potential risk, 1st aid awareness, humanistic concern, medical professional norms, and teamwork awareness.

2.5. Questionnaire content

Upon completion of training and assessment, I conducted an investigation of the 45 physicians that utilized a questionnaire that assessed participant involvement in similar training programs, necessity of such a course, helpfulness and effectiveness of the training program, the benefits of training with SimMan (intelligence-simulated human), and the main problems experienced during the training. The questionnaire was designed by 2 senior ICU physicians, mainly to investigate the training courses, training effects, and the personal experience of the trainers. The questionnaire comprised open-ended items that provided relevant options for participants to choose freely. The results provided a reference for further training courses and implementation.

2.6. Statistical processing

The measurement data were expressed as the mean ± standard deviation ($\bar{x}\pm S$). The assessment results and the comparison of 1st aid duration were analyzed using a paired *t* test. The rate comparison was analyzed using a Chi-square test. All statistical analysis was performed with SPSS 22.0. A 2-sided *P*-value < .05 was considered statistically significant.

3. Results

3.1. Pre-training assessment of each group

Each group's EMT skills were assessed before training using clinical scenarios prepared by SimMan and were scored in strict accordance with the scoring standard. The average score of the 9 groups was 62.78 ± 8.84; the lowest score was 49 while the highest was 74. The average 1st aid duration was 519.22 ± 34.35 seconds. Four groups qualified, with an overall qualification rate of 44.44%. All four qualified groups required more than 8 minutes to perform the assessment procedure. The average 1st aid duration of qualified groups was 500.33 ± 16.96 seconds and the average score was 72.22 ± 1.86 scores.

3.2. Post-training assessment of each group

The EMT skills in each group were assessed after training using the clinical scenarios prepared by SimMan and scored in strict accordance with the scoring standard. All participants signed an agreement to ensure that there was no unauthorized communication and entered a special room waiting for assessment. Upon completion of the assessment and questionnaire, participants left through a special channel. There was no interaction among the groups to ensure fairness of the assessment. The average score of the 9 groups was 80.89 ± 7.39; the lowest score was 70 while the highest was 91. The average 1st aid duration was shorter than the pre-training value at 453.56 ± 24.40 seconds and all 9 groups completed the operations within 8 minutes. The overall qualification rate was 100%. The performance scores obtained at this stage were higher than the pre-training values. The *P* values in the pre-training and post-training data were .009, <.001, and <.001, respectively (Table 1). The 4 qualified groups in the pre-training assessment achieved an average score of 89.50 ± 1.54 and the average 1st aid duration of 437.89 ± 20.74

Table 1

Pre-training and post-training data comparison with all groups.

Project	Pre-training	Post-training	*P*
Score (scores)	62.78 ± 8.84	80.89 ± 7.39	<.001
Time (seconds)	519.22 ± 34.35	453.56 ± 24.40	<.001
Qualification rate (%)	44.44%	100.00%	.009

Table 2

Pre-training and post-training data comparison with qualified groups in pre-training assessment.

Project	Pre-training	Post-training	*P*
Score (scores)	72.22 ± 1.86	89.50 ± 1.54	<.001
Time (seconds)	500.33 ± 16.96	437.89 ± 20.74	<.001

seconds in the post-training assessment, showing an improvement ($P < .001$; $P < .001$) from the pre-training score. (Table 2).

3.3. Questionnaire results

A total of 45 questionnaires were distributed and 45 were recovered. Hence, the recovery rate was 100%. The questionnaires were analyzed by 2 doctors participating in the training. The results showed that 93.3% of participants had not been involved in similar training before, 100% were satisfied with the training method and believed it was necessary to set up such a course, 95.6% believed it was beneficial to their future learning and work, and 100% believed that such training improved clinical practice and teamwork. Participants also believed that the training helped enhance their 1st aid awareness and improved interest in learning, comprehensive 1st aid, clinical thinking, theory-practice combination, and doctor-patient communication (Table 3).

Table 3

Questionnaire results.

project	Constituent ratio [n (%)]
1. Whether they have been involved in similar training	
Yes	3 (7.1)
No	42 (93.3)
2. Whether it is necessary to set up such a course	
Very necessary	38 (84.4)
Necessary	7 (15.6)
Unnecessary	0 (0.0)
3. Whether the training is helpful for future learning and work	
Very helpful	43 (95.6)
Somewhat helpful	2 (4.4)
Unhelpful	0 (0.0)
4. The benefits obtained from the training by applying SimMan (multiple selections)	
Improved the learning interest	43 (95.6)
Strengthened the consciousness of 1st aid	37 (82.2)
Improved the ability to provide comprehensive 1st aid	44 (97.8)
Improved clinical thinking	39 (86.7)
Improved clinical operation	45 (100.0)
Improved theory-practice combination	40 (88.9)
Enhanced doctor-patient communication	29 (64.4)
Cultivated teamwork spirit	45 (100.0)
5. Main problems in the training (multi-select)	
Insufficient recognition of the critical patient's potential condition changes	36 (80.0)
Insufficient familiarity with the 1st aid process	25 (55.6)
Not familiar with emergency drug use	22 (48.9)
Insufficient recognition of the potential disease risk	41 (91.1)
Insufficient diagnosis/differential diagnosis when the disease condition changes	30 (66.7)
Rescue measures not timely	19 (42.2)
Non-standard 1st aid operations	23 (51.1)
Poor teamwork	22 (48.9)

4. Discussion

Traditional clinical skill training, which is dominated by the pattern of "teaching and single skill practice," mainly seeks to improve individual clinical operation skills. However, when entering the clinical field, medical students must address many complicated conditions requiring the integrated application of clinical skills. Although medical students master the basic operation steps in training, they often feel apprehensive in clinical operations due to the lack of 1st aid scene training, particularly in critical scenarios.[3] Working in the ICU requires the integration of strong theoretical, practical, and applicable multi-disciplinary knowledge and skills; hence, clinicians should be armed with solid basic theoretical knowledge, relatively strong operation skills, and comprehensive analytic skills.[4] The rapid development of critical care medicine has influenced greater requirements for doctors in the ICU and further improvement in clinical 1st aid skills and teamwork awareness.[5–6] In recent years, the state has carried out standardized training for resident physicians to improve their professional ability and operation skills. Medical students often show inadequate ability and experience in clinical practice and addressing the particularities of critical patients during the transitional period between medical training and clinical practice. Standardized training residents whose 1st aid skills and clinical thinking ability require further improvement rarely have the opportunity to participate in 1st aid treatment. Thus, high-fidelity patient simulators such as SimMan may be utilized in ICU physician training to address such deficiencies.

While intelligent integrated simulation technology is undergoing rapid development, medical teaching based on intelligent integrated simulation is playing an increasingly important role in clinical skill training for medical students.[1] Meta-analysis indicates that medical students and staff who participate in skill training based on high-fidelity patient simulators can achieve an improvement in their medical knowledge, skill operation ability, medical behavior, and care quality.[7] SimMan is a simulated adult male with explicit anatomical traits, realistic shape, easy operation and positioning, full voice prompts, and text prompts. It exhibits the following characteristics: life characteristic simulation including liquid crystal pupil scaling and carotid pulsation changes; simulated ECG display that responds to a pressing operation and successful rescue; full electronic monitoring of pressing position, pressing depth, and blowing volume; and student management including playback of the operation process, transcript saving, and printing. SimMan can simulate different psychological and pathological characteristics of patients as well as potential responses to different operations carried out by the trainees. The self-equipped monitoring equipment of SimMan can display changes in a timely manner and create a full-featured simulated teaching environment for comprehensive 1st aid.[8–9] SimMan can also simulate real clinical cases to provide lifelike operation environments and practical experiences for standardized training physicians. The preparation and simulation of clinical 1st aid cases and adoption of a new teaching model (an integrated practice of basic theory teaching, itemized skill practice, comprehensive simulation drilling, and recording, analysis and summarization) may influence standardized training physicians to take an active part in skill training, problem solving, developing critical thinking, and bridging the gap between classroom teaching and clinical practice.[10–11]

In this study, the standardized training residents' comprehensive 1st aid skills were assessed before and after training using SimMan. Results show statistically significant differences in pre-

and post-test scores, indicated by overall improvement in qualification rate, average score, and average 1st aid duration,. After the standardized training, the residents achieved a more accurate judgment of critical conditions and diseases, as well as an improvement in such aspects as 1st aid awareness, 1st aid efficiency, commanding ability, communication ability with the patient's family members, 1st aid equipment use, clinical thinking ability, and learning initiative and teamwork awareness. They also became more experienced in management of comprehensive 1st aid and application of special operation skills. All improvements fully embody the advantages of high-fidelity advanced patient simulator integration in clinical 1st aid skill training and the benefits of simulated teaching in improving practical operation ability and the clinical comprehensive treatment ability of the trained residents.[12–13] The questionnaire results show that the trained residents took great interest in novel training methods and expect more opportunities of involvement in similar training courses. They also believed that the training could help improve the judgment and treatment of critical conditions, improve clinical operation and comprehensive 1st aid abilities, stimulate interest in learning, cultivate teamwork skills, and enhance doctor-patient communication. At the same time, participants became aware of their problems, such as insufficient recognition of the critical patient's potential condition changes, insufficient familiarity with the 1st aid process, insufficient recognition of the potential disease risk, insufficient diagnosis/differential diagnosis when the disease condition changes, and non-standard 1st aid operations. All these insufficiencies should be continuously resolved through similar training programs in the future.

SimMan, which can improve the clinical EMT skills of standardized training physicians, is an effective way to bridge the gap between theory and clinical practice. However, the use of virtual patients creates a gap between the simulated clinical scenario and clinical practice. Therefore, SimMan should still be combined with practical clinical teaching, and standardized training physicians still need to continue learning, acquiring wider ranges of experience, and improving their clinical comprehensive 1st aid skills in their future clinical work.

Acknowledgments

Thanks to the Clinical Skills and Experiment Center for providing SimMan.

Author contributions

Conceptualization: yanshu zhang, lei zhang, gang wang, litao guo.
Data curation: yu liu, yanshu zhang, lei zhang, gang wang, litao guo.
Formal analysis: yanshu zhang, litao guo.
Investigation: yu liu, yanshu zhang, hongliang bai, gang wang, litao guo.
Methodology: yu liu, yanshu zhang, lei zhang, hongliang bai, gang wang, litao guo.
Project administration: yu liu, lei zhang, hongliang bai, gang wang, litao guo.
Resources: yu liu, hongliang bai, gang wang.
Software: yu liu, gang wang, litao guo.
Supervision: hongliang bai, litao guo.
Validation: lei zhang, gang wang, litao guo.
Visualization: yu liu.
Writing – original draft: litao guo.
Writing – review & editing: yu liu, yanshu zhang, lei zhang, gang wang, litao guo.

References

[1] Meenakshi Swamy , Bloomfield Thomas C, Thomas Robert H, et al. Role of SimMan in teaching clinical skills to preclinical medical students. BMC Med Educ 2013;13:20–5.
[2] Neumar Robert W, Michael Shuster , Callaway Clifton W, et al. 2015 American heart association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2015;132 (suppl 2):S315–589.
[3] Badir A, Zeybekoglu Z, Karacay P, et al. Using high-fidelity simulation as a learning strategy in an undergraduate intensive care course. Nurse Educ 2015;40:E1–6.
[4] Singer BD, Corbridge TC, Schroedl CJ, et al. First-year residents outperform third-year residents after simulation-based education in critical care medicine. Simul Health 2013;8:67–71.
[5] Edwards S, Siasakos D. Training teams and leaders to reduce resuscitation errors and improve patient outcome. Resuscitation 2012;83:13–5.
[6] Semler MW, Keriwala RD, Clune JK, et al. A randomized trial comparing didactics, demonstration, and simulation for teaching teamwork to medical residents. Ann Am Thorac Soc 2015;12:512–9.
[7] Cook DAI, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. JAMA 2011;306:978–88.
[8] Meenakshi Swamy , Marina Sawdon , Andrew Chaytor , et al. A study to investigate the effectiveness of SimMan® as an adjunct in teaching preclinical skills to medical students. BMC Med Educ 2014;14:231–8.
[9] Clinkard D, Stuart K, Stuart L, et al. Improving CPR training by tracking: a free open-source computer program to collect laerdal SimMan 3G CPR performance data. Prehosp Emerg Care 2015;19:342.
[10] Nuzhat AI, Salem RO, AI Shehri FN, et al. Role and challenges of simulation in undergraduate curriculum. Med Teach 2014;36(Suppll): S69–73.
[11] Patel P, Sockalingam I. Acute care simulation training for foundation doctors: the perceived impact on practice in the workplace. Acute Med 2013;12:151–8.
[12] Akaike M, Fukutomi M, Nagamune M, et al. Simulation-based medical education in clinical skills laboratory. J Med Invest 2012;59:28–35.
[13] Boet S, Sharma S, Goldman J, et al. Review article: medical education research: an overview of methods. Can J Anaesth 2012;59:159–70.