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Exploring the Application of *in Situ* Simulation in Cardiovascular Emergency Training for Resident Physicians

Mingliang Du[1], Xiangfei Liu[2], Haibing Du[3], Hui Hui[1], Jun Wu[2*]

[1]Department of Coronary Heart Disease, Central Hospital of Dalian University of Technology (Dalian Municipal Central Hospital), Dalian, China
[2]Clinical Skills Training Center, Central Hospital of Dalian University of Technology (Dalian Municipal Central Hospital), Dalian, China
[3]The 91913th Unit of the People's Liberation Army of China, China
Email: *wujun197103@163.com

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Abstract

Purpose: Explore the use of in situ simulation (ISS) in cardiovascular first aid training for resident physicians and its impact on trainees' satisfaction, theoretical knowledge, and skill assessment scores. **Method:** 100 general practice residents undergoing standardized training at Central Hospital of Dalian University of Technology (Dalian Municipal Central Hospital) from September 2023 to January 2025 were selected as research subjects and divided into a research group and a control group, with 50 participants each, using random assignment. The control group used standardized patient (SP) training, while the research group used ISS. The theoretical and skill assessment scores of the two groups were compared, along with their satisfaction with the training. **Results:** The research group scored higher in both theoretical and skill assessments than the control group, with statistically significant differences ($P < 0.05$). There was no statistically significant difference in teaching satisfaction between the two groups ($P > 0.05$). **Conclusion:** ISS is highly valuable in cardiovascular emergency training for residents. It enhances theoretical knowledge and practical skills, significantly benefiting their clinical practice, and can be further promoted and applied.

Keywords

In Situ Simulation, Standardized Resident Training, Cardiovascular Emergency

1. Introduction

With the aging population and increased risk factors for cardiovascular diseases

such as coronary heart disease and heart failure, the incidence of cardiac arrest is rising annually. It is urgent to enhance the level of cardiovascular first aid among medical staff, especially to improve the training of doctors in cardiovascular first aid. Studies show that the survival rate of patients with cardiovascular incidents can increase from 30.8% to 58.7% in medical centers with rapid response and comprehensive treatment levels, and the proportion of patients with a good neurological prognosis has nearly tripled (Hasslacher et al., 2022). Currently, standardized patients (SPs) are mostly used to provide training to resident doctors. An SP is a person who, after specialized, standardized, and systematic training, can accurately represent the actual condition of clinical patients, placing students in contact with "patients" and effectively training their ability to integrate theoretical knowledge with clinical practice (Yang et al., 2019). However, this method lacks a real working atmosphere, and repeated practice can lead to boredom, resulting in low active participation from resident doctors. In recent years, in situ simulations (ISS) have been widely used in medical education, achieving remarkable results. Also known as "on-site simulation," ISS places participants in real clinical situations. It is a new teaching model that better integrates theoretical knowledge and operational skills into clinical practice. It allows for observation, evaluation, and training of participants' basic medical theories, practical skills, doctor-patient communication, emergency activation, team service, and coordination and management capabilities (Binder et al., 2023). This study selected 100 resident doctors from Central Hospital of Dalian University of Technology (Dalian Municipal Central Hospital) between September 2023 and January 2025 to explore the application effect of ISS teaching methods in cardiovascular first aid training.

2. Materials and Methods

2.1. General Information

100 doctors who received standardized training at our hospital were selected as research subjects. They were randomly divided into a control group and an experimental group based on the odd and even numbers of their student IDs, with 50 doctors in each group. In the control group, there were 16 males and 34 females, aged 22 to 31 years, with an average age of 26.20 ± 1.99 years. In the experimental group, there were 22 males and 28 females, aged 24 to 31 years, with an average age of 25.94 ± 1.45 years. Comparing the general information of the two groups, the difference was not statistically significant ($P > 0.05$), indicating comparability.

2.2. Inclusion and Exclusion Criteria

Inclusion criteria: Continuous rotation in the Department of Cardiovascular Medicine for at least 2 months; voluntary participation in this study.

Exclusion criteria: Continuous rotation in the emergency department for less than 2 months; participation in similar training in the past.

2.3. Method

The control group uses the traditional teaching method. The instructor assigns teaching tasks in advance based on the residential training syllabus, covering causes, clinical manifestations, diagnosis, differential diagnosis, and treatment plans for common critical and severe cardiovascular emergencies. Resident doctors preview this material beforehand. In class, the instructor explains the necessary content using a PowerPoint presentation. Skills training is conducted by the instructor in the simulation center, where resident doctors practice skills according to demonstrated steps. The instructor guides those who do not perform the operations correctly.

The observation group adopted the ISS teaching method: first, the training objectives and evaluation standards were explained to the resident doctors according to the training syllabus. Then, a scenario was created based on the actual patient treatment situation. The scenario provided standardized or simulated patients, emergency beds, equipment, and medicines. Students were divided into groups, with each group responsible for handling one or more simulated scenarios. Resident doctors could assume multiple roles in the scene, such as patients, family members, and treating physicians. Instructors observed in real-time, provided timely feedback, and shared treatment experiences and existing issues with the resident doctors after the training.

2.4. Observation Indicators

Compare the theoretical knowledge scores, practical skills scores, and teaching satisfaction scores of the two groups. Theoretical knowledge is assessed using a unified test question bank, including multiple-choice and judgment questions, with a total score of 100 points. A higher score indicates better mastery of theoretical knowledge. The practical skills assessment includes emergency response ability, overall operation process, and teamwork ability, with a total score of 20 points. The scores are given by two senior resident training physicians (with over 3 years of teaching experience), and the average is taken as the practical skills score. A higher score indicates better practical ability. Training satisfaction is evaluated using a custom satisfaction rating scale from four aspects: teaching content, teaching methods, learning initiative, and problem-solving ability. The total score is 10 points. A higher score indicates greater satisfaction among resident training doctors with the teaching model.

2.5. Statistical Methods

SPSS 24.0 statistical software was used to analyze the assessment results, and the measurement data were tested for normality. Normally distributed data were expressed as mean ± standard deviation, and non-normally distributed data were expressed as median (interquartile range). An independent sample t-test or Wilcoxon rank-sum test was used to compare the groups. A p-value of <0.05 indicated that the difference was statistically significant.

3. Results

3.1. Comparison of the Assessment Results between the Two Student Groups

The theoretical and skill assessment scores of students in the experimental group were higher than those in the control group, with the differences being statistically significant ($P < 0.05$) (Table 1).

Table 1. Comparison of assessment scores between the two groups of students (M (P25, P75) points).

Group	Theoretical scores	Practical results
experimental group	96 (92, 100)	19 (18, 20)
control group	92 (83, 96)	19 (17, 20)
Z-value	−3.44	−2.34
P-value	0.001	0.018

3.2. Comparison of Training Satisfaction between Two Groups of Trainees

There was no difference in overall training satisfaction between the experimental and control groups ($P > 0.05$) (Table 2).

Table 2. Comparison of assessment scores between the two student groups (M (P25, P75) points).

Group	Overall Satisfaction
experimental group	10 (10, 10)
control group	10 (10, 10)
Z value	−1.38
P value	0.168

4. Discussion

The results of this study show that after *in-situ* simulation training, the cardiovascular emergency proficiency scores of resident doctors significantly improve, making it an effective and feasible teaching strategy. *In-situ* simulation is conducted in a real clinical environment, allowing students to acquire knowledge and skills through real-life simulations. It significantly enhances the comprehensive abilities of resident doctors, including clinical skills, clinical thinking, teamwork, communication skills, and other essential qualities for medical professionals. A recent review showed (Martin et al., 2020) that *in-situ* simulation training for medical staff can help improve self-confidence, clinical orientation, preparation, understanding of one's role, and patient outcomes.

The *in-situ* simulation teaching method can enhance the teaching process by improving interaction and enthusiasm in learning. Compared to traditional meth-

ods, interactive and participatory teaching better stimulate interest and motivation in resident doctors. *In-situ* simulation in a safe, realistic environment builds professional confidence and improves clinical skills (Josse-Eklund et al., 2022; Abdullah & Chan, 2018). Through *in-situ* simulation, physicians in training can connect theory with practice, developing confidence in clinical skills. Adding *in-situ* simulation to clinical practice is an effective way to teach cardiovascular first aid.

Simulations in healthcare settings can disrupt patients and healthcare workers. Therefore, before conducting ISS, the training team and treatment area leaders must establish "cancellation" criteria. If serious illness or large-scale medical treatment occurs during the ISS, and medical staff cannot effectively respond, the ISS should be suspended or postponed, which can risk suspending training activities. Literature shows the ISS suspension rate can be as high as 29% (Bredmose et al., 2021). To minimize the suspension rate and reduce conflicts with patient care, ISS training should occur during periods with fewer patients. This should be communicated to patients in advance to prevent anxiety and fear.

Additionally, some special or unannounced ISS may cause resident doctors to feel uneasy and stressed, worrying that their performance could negatively impact patient diagnosis and treatment. Some resident doctors also fear that unfamiliarity with other team members might affect their simulation training results, leading to avoidance or aversion to participating in ISS (Freund et al., 2019). Therefore, project organizers should clearly communicate the training objectives to resident physicians and explain that participation in ISS is not linked to personal performance, nor will personal performance be made public. These measures can effectively reduce anxiety and increase enthusiasm for participation. With repeated ISS training, the technical and non-technical abilities of resident trainees will continuously improve, and tension and stress will be effectively alleviated.

The results of this study show no difference in student satisfaction between *in-situ* simulation training and traditional training methods, suggesting certain flaws in *in-situ* simulation training and teaching. In future training, we should focus on the following two improvements: 1) **Real environment reproduction: ① Physical scene**: Conduct training in a real emergency room or ambulance environment. Retain background sound effects such as monitor alarms and family members crying, and simulate time pressure by setting a countdown. **② Device consistency**: Use the same clinical equipment (such as defibrillators and portable ultrasounds) to avoid difficulties in skill transfer due to equipment differences. **③ Case authenticity**: Based on real cardiac arrest case scenarios, such as ST-segment elevation myocardial infarction combined with ventricular fibrillation, the study covers typical errors like misjudgment of heart rhythm and delayed drug administration. 2) **Technology-enhanced experience: ① Mixed reality**: Use AR glasses to superimpose coronary artery anatomy images, helping students understand the location of myocardial infarctions. For example, an anterior descending artery occlusion corresponds to ST-segment elevation in leads V1-V4 of the electrocardiogram. **② Physiological data visualization**: Real-time display of CPR quality

(compression depth, rebound rate) and hemodynamic parameters (such as ETCO2, arterial waveform) for immediate strategy adjustment.

5. Conclusion

The application of *in-situ* simulation training in cardiovascular emergency care can enhance the teamwork, clinical judgment, practical abilities, and other competencies of resident trainees. It can also increase training satisfaction among trainees in professional settings. It is an effective and feasible teaching strategy. However, this study has certain limitations: the sample size is small, the evaluation method for teaching satisfaction is limited, and the results may not represent the views of all physicians who receive *in-situ* simulation training. Additionally, participants were from the same university, which may limit the replicability of the findings.

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Conflicts of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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