Region - Educational Research and Reviews, 2024, Volume6, Issue5
DOI: 10.32629/rerr.v6i5.2114
ISSN Online: 2661-4634
ISSN Print: 2661-4626

The effectiveness of simulation-based learning on enhancing anaphylactic shock management skills in standardized training for anesthesiology residents

Huixuan ZHOU, Junbei WU*

Department of Anesthesiology, The First Affiliated Hospital of Nanjing Medical University, Nanjing 210029, China
*Corresponding author.
Email address: wujunbei88@126.com

Abstract: Background: Simulation-based learning is an effective pedagogical approach that allows learners to practice in realistic scenarios. It is particularly valuable for preparing anesthesiologists to manage rare but critical events, which demand immediate interventions and team collaboration. This study aims to assess the effectiveness of a simulation-based learning module in equipping anesthesia residents with the adequate knowledge and skills for effectively managing anaphylactic shock. Methods: All students were randomly divided into two groups. One group was educated with traditional case-based learning (CBL) method. The other group was educated with simulation-based learning method (SBL). Both groups underwent a baseline testing (pre-test). Following the teaching session, the students completed a second test (post-test). Multiple choice questions (MCQ) for knowledge assessment and clinical skills were used in this study. After four weeks, all students in both groups participated in a simulation scenario test involving a different case. The performance of each student was derived from direct observation of procedural skills (DOPS). The "team skills score" employed the initial eight items of the Mayo High Performance Teamwork Scale (MHPTS). Results: Post-test MCQ scores showed a significant improvement in the SBL group compared to the CBL group ($p = 0.02$). After four weeks, a simulation scenario test was administered, and the SBL group performed significantly better on individual DOPS and team MHPTS evaluations ($p = 0.02$ and $p = 0.04$ respectively). Questionnaire responses indicated that SBL fostered higher learning motivation and satisfaction among students compared to CBL ($p < 0.05$). Conclusion: SBL was more effective than CBL in improving both individual and team performance, as well as student satisfaction and motivation, making it a valuable addition to medical education curricula.

Key words: simulation-based learning; education; anaphylactic shock; simulation

1 Introduction

Simulation-based learning is a pedagogical approach that provides learners with the opportunity to practice learned skills in real-life situations. It provides experiential learning, improvement in quality of care, and reduction in errors [1]. The use of simulation in healthcare education dates back to the 18th century in Europe. Obstetric simulators were developed to train midwives and obstetricians in managing childbirth complications and using forceps effectively [2]. Over time, technology advancements have made simulation a standard component of healthcare education. In the last two decades, there has been a remarkable surge in the development, application, and overall recognition of simulation within the healthcare industry. Its purpose extends beyond skill acquisition to training healthcare professionals, enhancing patient outcomes, promoting teamwork, and addressing various healthcare challenges [3].

The field of anesthesia presents a relatively high likelihood of encountering critical situations or crises. These may involve airway emergencies, cardiac events, anesthesia-related complications, or potentially life-threatening situations. Given the dynamic nature of anesthesia practice and the rapid patient deterioration that can occur, anesthesiologists must possess necessary skills, knowledge, and experience to handle and resolve crises promptly. Consequently, anesthesia professionals must undergo extensive training, often including simulation-based learning, to enhance their crisis management abilities, decision-making skills, and teamwork capabilities. Simulation training provides realistic scenarios that allow learners to practice in a safe environment, identifying crises, prioritizing their response, and taking appropriate actions. This approach is invaluable in preparing anesthesiologists for rare events that are infrequently encountered during surgeries but can have critical consequences if not managed appropriately. By repeatedly practicing in simulated crises, anesthesiologists can build confidence and improve proficiency, ensuring that they are ready to respond effectively when faced with real-life emergencies.

One such critical event is anaphylactic shock, a severe allergic reaction with immediate risk to patients. Anaphylaxis has rapid onset and progression, necessitating immediate treatment. It emphasizes prevention, preparedness, and collaboration among the healthcare team [4][5]. Being well-prepared and vigilant in the operating room can help mitigate risks and ensure optimal patient outcomes when faced with allergic reactions. However, gaining sufficient expertise solely through clinical experience can be challenging for many health-care professionals. Therefore, additional training in anaphylaxis management beyond clinical practice is essential. Simulation scenarios focused on anaphylaxis have been used for years to improve diagnosis, management, and patient outcomes. Thus, our aim is to evaluate the effectiveness of a training module in providing residents with adequate knowledge to deal with anaphylactic shock patients who face such challenges.

2 Methods

2.1 Participants

The study was conducted at The First Affiliated Hospital of Nanjing Medical University, which is a tertiary teaching hospital. Participants included anesthesiology residents who were in the initial year of their training. The inclusion criteria were as follows: no previous simulation experience, and committed to completing the training. Students who had already taken part in other instructional programs at the same time or had no interest in simulation were excluded. Each group was randomized to one teaching methods: simulation-based learning (SBL group) or traditional case-based learning (CBL group). The topic was the management of an acute anaphylactic shock patient at the operating room.

2.2 Study design

In a case-based team learning scenario for 4-5 students (CBL group), the team analyzed a case of anaphylactic shock during surgery. They generated hypotheses regarding the underlying cause, made diagnostic decisions, and planned appropriate treatment strategies. The team then reflected on their decision-making process and engaged in debriefing to enhance their overall understanding of managing this critical situation. To further enhance the training, a rescue protocol training checklist for anaphylactic shock, developed under the guidance of the Stanford Emergency Manual, was utilized. This checklist provides a structured approach to managing anaphylactic shock in the perioperative setting, ensuring swift and effective intervention.

In the SBL group, a human-sized, high-fidelity mannequin was utilized to effectively represent the surgical patient. The mannequin was programmed to display vital signs and physical manifestations of anaphylaxis. Real-time vital signs were displayed on a bedside monitor during the simulation, providing immediate feedback and enhancing the realism of the exercise. Small groups consisting of 4 to 5 individuals were formed. Before the simulation, participants received comprehensive pre-briefing instructions that clearly delineated their assigned roles as attending physician, senior resident, junior resident, nurse, or surgeon. Adequate time was allocated for the groups to familiarize themselves with the simulated environment, the mannequin, the equipment, and the medication. Additionally, a detailed clinical script was provided, introducing specific details such as the scenario's location, patient demographics, and the simulated surgical procedure. During the simulation, participants engaged in a 30-minute allergy scenario specifically designed to review potential emergencies that may arise in the operating room. Within this scenario, participants were required to demonstrate their ability to respond effectively by repeating the epinephrine dose, administering intravenous fluids, monitoring vital signs, and initiating advanced cardiovascular life support techniques. The complexity of the scenarios gradually increased, challenging participants, and reinforcing their knowledge and skills in managing anaphylactic shock. An experienced instructor, serving as a faculty supervisor, played a pivotal role in controlling the scenario's progression, adjusting the mannequin's vital signs based on participants' interventions, thereby creating a dynamic and lifelike simulation experience.

In both groups, key points were summarized by instructors to improve the team's performance in the diagnosis and treatment process. Continuous monitoring and adaptation of the management approach, along with thorough documentation and appropriate follow-up measures, were emphasized to enhance their workflow, clinical decision-making, and overall effectiveness in managing complex medical scenarios.

2.3 Data collection and outcomes

Both groups underwent a baseline testing (pre-test). Following the teaching session, the students completed a second test (post-test). This involved answering 20 multiple choice questions (MCQ) within 20 minutes. After a 4-week period of the two teaching procedures, all students participated in a simulation scenario test involving a different case from the previous training scenario. The performance of each student during the simulation scenario test was by direct observation of procedural skills (DOPS). The "team skills score" employed the initial eight items of a previously authenticated behavioral rating scale, known as the Mayo High Performance Teamwork Scale (MHPTS). Each item was scored as 0 if not performed, 1 if imperfectly performed, and 2 if performed correctly. The team skills score ranged from 0 to 16.

2.4 Statistical analysis

All statistical analyses of the collected data were conducted using IBM SPSS Statistics for Windows, Version 26.0. Categorical data were presented as frequency and analyzed using the Pearson's chi-squared or Fisher's exact test. Data were analyzed by the Kolmogorov–Smirnov test (K-S test) to assess normality and were expressed as mean ± standard deviation or median and interquartile range (IQR). The independent samples student's t-test was used to analyze differences between the two groups in pre-training test scores and post- training test scores. The Mann–Whitney test was used to analyze differences between the two groups in DOPS and MHPTS. Statistical significance was set at $p < 0.05$.

3 Results

A total of 52 potential participants were assessed for eligibility, with 25 allocated to the CBL group and 27 to the SBL group. There were no significant differences between these two groups regarding age, gender, degree, and pre-training scores on the MCQ tests (Table 1). After the teaching session, we discovered significant differences between the CBL group and the SBL group ($p = 0.02$) when we compared the post-training test score differences between the 2 groups.

Table 1. Comparison of age, gender, degree, pre-training test score, and post-training test score between two groups

	CBL	SBL	p-value
Age	26.5±2.0	26.6±2.0	0.95
Gender (Male/Female)	16/9	16/11	0.73
Degree (Bachelor/ Master/ Doctor)	8/8/9	7/13/7	0.49
Pre-training test score	63.4±11.0	66.7±9.4	0.26
Post-training test score	80.0±9.0	85.6±7.8	0.02

After a four-week implementation of both instructional methods for each group, all students participated in a simulation scenario test. When comparing the performance of each student (DOPS), it was found that the students in SBL group performed significantly better than the CBL group ($p = 0.02$). For team performance, the MHPTS scores in SBL group were significantly higher than the CBL group ($p = 0.04$). (Figure 1)

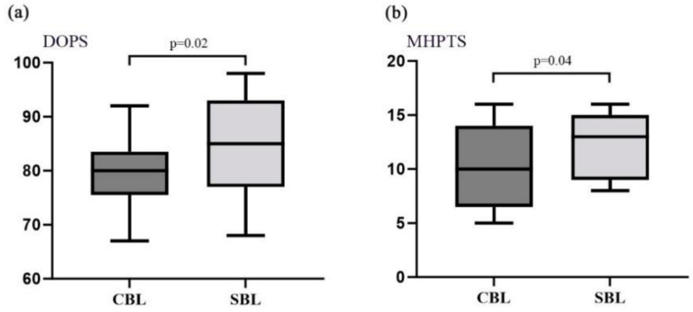

Figure 1. Performance in a simulation scenario test

In Figure 1, (a) The performance of each student was measured by direct observation of procedural skills (DOPS). (b) The performance of the team was measured by eight items of Mayo High Performance Teamwork Scale (MHPTS). The median value is indicated by the horizontal bar inside the box, the borders of the boxes represent the 25th and 75th percentiles and the whiskers show the min and max.

Through the questionnaire (Figure 2 and Figure 3), the variation of answers demonstrated the valuation and satisfaction of students. Students thought that SBL inspired more learning motivation ($p < 0.05$). They are more satisfied with SBL and hope to use this approach in future learning endeavors ($p < 0.05$).

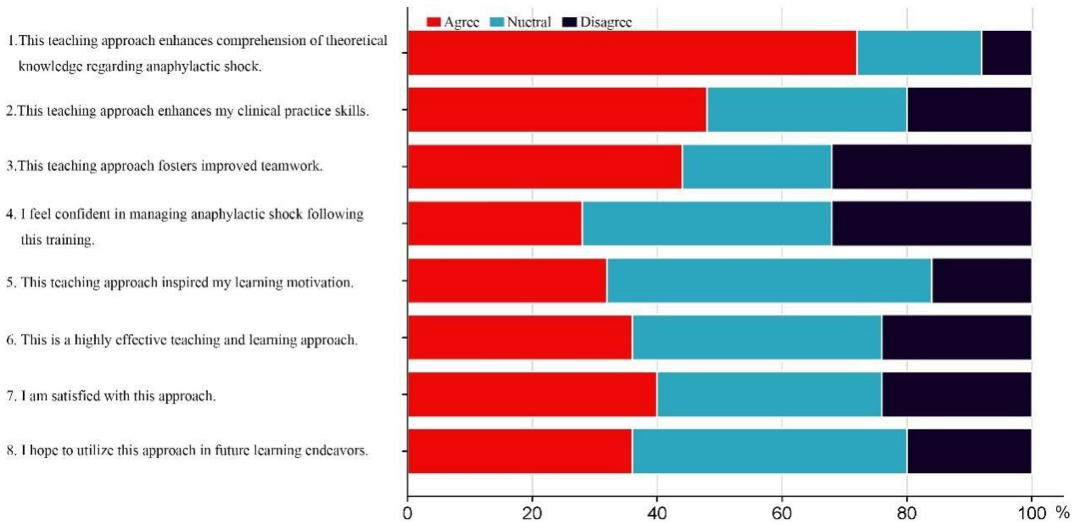

Figure 2. A questionnaire assessing residents' experiences and opinions about the teaching modes in the case-based learning group

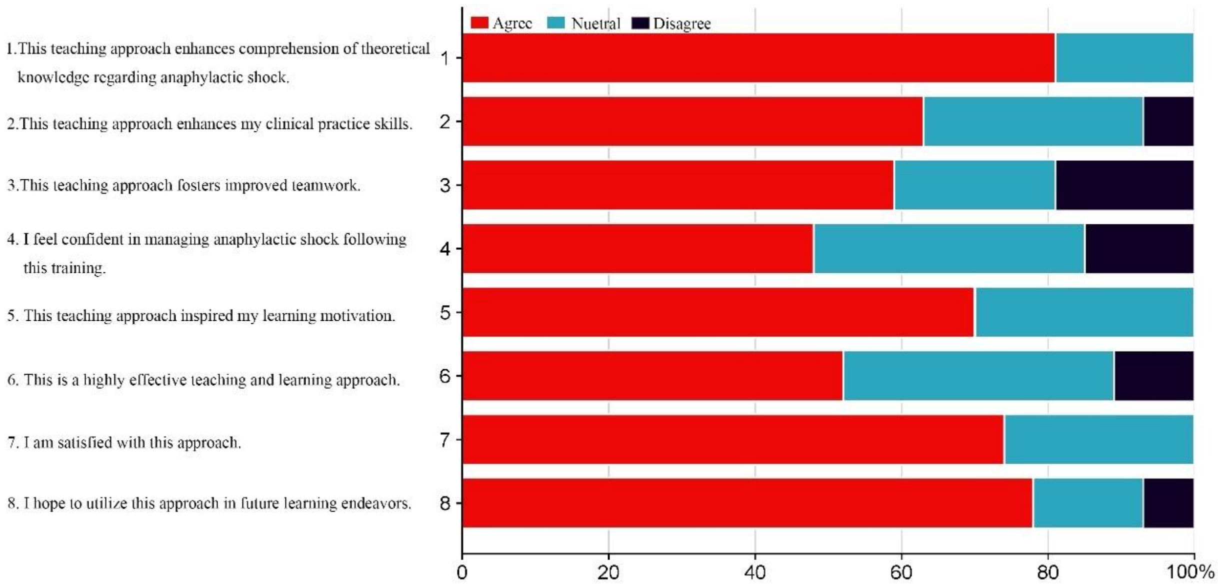

Figure 3. A questionnaire assessing residents' experiences and opinions about the teaching modes in the simulation-based learning group

4 Discussion

Simulation has long been integrated into anesthesiology training. It surpasses no intervention (except for patient outcomes) and is non-inferior to non-simulation instruction. Moreover, it demonstrates moderate to large statistically significant effectiveness for all outcomes except patient effects [6]. A recent meta-analysis reveals that simulation-based learning not only improves knowledge and skill scores but also enhances teaching effectiveness and non-technical ability, including cooperative ability, problem-solving abilities, and situational awareness [7]. Through simulation-based learning, students gain valuable experience in handling challenging clinical scenarios without jeopardizing actual patient. This approach provides insights into the current state of simulation-based learning and identifies areas for further study and improvement [8].

Anaphylaxis serves as a widely used scenario in simulation training and competency assessment. Simulating anaphylaxis incidents has proven practical and effective in teaching new graduate nurses how to manage clinical situations involving anaphylactic shock. By actively participating in these simulations, new graduate nurses can gain confidence, ultimately enhancing their ability to provide safe, patient-centered care [9]. Critical qualitative data support the use of high-fidelity simulations to improve anaphylaxis management in allergy clinic, boosting team confidence. This approach has also reduced staff reluctance in handling high-risk challenges in ambulatory settings [10]. Furthermore, situ simulation, which involves conducting simulations in the actual clinical environment, has successfully identified common medication errors during anaphylaxis management in the pediatric emergency department [11].

The benefits of simulation-based learning in preparing healthcare students for future practice have also been well-established. Research has consistently shown that simulations not only enhance staff skills and boost confidence but also foster collaboration in addressing issues related to the facility equipment, work environment, and medical procedures. Regular simulations play a crucial role in ensuring optimal patient care during life-threatening medical emergencies [12]. However, despite the undeniable advantages of simulation-based learning, there are also drawbacks to consider. These include the high cost of simulation equipment and the need for a dedicated area and staff to facilitate simulation-based learning. To further enhance students' preparedness for real-world clinical practice, it is recommended to integrate simulation with other instructional methods. Furthermore, more investigation is needed to understand the long-term effects of simulation-based learning on clinical outcomes and patient safety. There is a growing suggestion to prioritize research on situ simulation, focusing on improvements in team and system performance rather than solely on individual behavior [13].

5 Conclusion

The research revealed that simulation-based learning surpassed traditional case-based learning in enhancing anesthesia residents' proficiency in managing anaphylactic shock, including their knowledge, clinical aptitude, and teamwork capabilities. Moreover, it has significantly bolstered residents' motivation to learn and their overall satisfaction. These findings suggest the potential of simulation-based learning as an effective pedagogical method for anesthesiologists to use in the management of anaphylaxis.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Campbell KK, Wong KE, Kerchberger AM, et al. 2023. Simulation-based education in US undergraduate medical education: a descriptive study. *Simulation in Healthcare*, 18(6): 359-366.

[2] Owen H. 2012. Early use of simulation in medical education. *Simulation in healthcare*, 7(2): 102-116.

[3] Salimova ND, Salaeva MS, Mirakhmedova ST, et al. 2023. Simulation training in medicine. *Journal of Modern Educational Achievements*, 3(3): 138-142.

[4] Yusupovna CZ, Mirzaali o'g'li AJ, Sobir o'g'li XA, et al. 2023. Anaphylactic shock. *Journal of Universal Science Research*, 1(1): 47-50.

[5] Zhang ZW, Luo B, Yu F, et al. 2022. Distribution and changing trend of literatures related to anaphylactic shock from 2011 to 2020. *Herald of Medicine*, 41(3): 344-348.

[6] Lorello GR, Cook DA, Johnson RL, et al. 2014. Simulation-based learning in anaesthesiology: a systematic review and meta-analysis. *British Journal of Anaesthesia*, 112(2): 231-245.

[7] Su Y, Zeng Y. 2023. Simulation based training versus non-simulation based training in anesthesiology: a meta-analysis of randomized controlled trials. *Heliyon*,9(8): e18249.

[8] Kolawole H, Guttormsen AB, Hepner DL, et al. 2019. Use of simulation to improve management of perioperative anaphylaxis: a narrative review. *British Journal of Anaesthesia*, 123(1): e104-e109.

[9] Ren Q, Chen F, Zhang H, et al. 2022. Effects of a standardized patient-based simulation in anaphylactic shock management for new graduate nurses. *BMC nursing*, 21(1): 209.

[10] Copaescu AM, Graham F, Nadon N, et al. 2023. Simulation-based education to improve management of refractory anaphylaxis in an allergy clinic. *Allergy, Asthma & Clinical Immunology*, 19(1): 1-11.

[11] Price K, Cincotta DR, Spencer-Keefe FR, et al. 2023. Utilising in situ simulation within translational simulation programmes to evaluate and improve multidisciplinary response to anaphylaxis in the paediatric emergency department. *Emergency Medicine Australasia*, 35(2): 246-253.

[12] Kachulis CL, Breda KL, Karl CA. 2023. Using simulation-based learning to increase outpatient staff confidence in emergency skills. *Nursing*, 53(11): 16-18.

[13] Kolawole H, Guttormsen AB, Hepner DL, et al. 2019. Use of simulation to improve management of perioperative anaphylaxis: a narrative review. *British Journal of Anaesthesia*, 123(1): e104-e109.