Comparing Simulation Based and Lecture Based Education on Knowledge Acquisition and Long Term Retention in Medical Students

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ABSTRACT

This study aimed to compare the effectiveness of simulation-based versus lecture-based education in improving immediate knowledge acquisition and long-term retention among medical students. Forty second-year medical students were randomly assigned to two groups: Group A (simulation) and Group B (lecture). Both groups were taught the same four topics, and students completed a pre-test, post-test, and a delayed post-test five weeks later to assess immediate knowledge gain and retention. Both groups showed significant improvement from pre-test to post-test ($p < 0.001$), with no significant difference in immediate knowledge acquisition ($p = 0.24$). However, Group A demonstrated significantly better long-term retention ($p = 0.02$), particularly in topics like hyperkalemia and STEMI. While both educational methods were effective in the short term, simulation-based education led to superior long-term retention, especially for clinical decision-making topics. The results suggest that incorporating simulation into education may enhance students' preparedness for clinical practice. Further studies are recommended to refine the balance between these educational approaches.

ARTICLE HISTORY
Received 12 June 2024
Accepted 1 October 2024

KEYWORDS: Simulation-based education, Lecture-based education, Knowledge retention, medical students.

Volume 2 issue 1

Introduction

Traditional methods of medical education have long relied on didactic lectures and textbook learning. However, with the rapid advancements in technology, there has been a significant shift towards the integration of simulation-based learning in medical training. Simulation, encompassing a range of modalities from standardized patients to high-fidelity patient simulators, offers an immersive learning experience that enhances students' ability to apply theoretical knowledge in practical settings. The ability to recreate real-life scenarios in a controlled environment presents an opportunity for learners to engage in active learning without the risks associated with real patient care [3, 9, 13, 16].

The use of simulation in medical education has grown exponentially, driven by its potential to improve both immediate knowledge acquisition and long-term retention. Research has shown that simulation not only enhances the development of explicit memory, crucial for recalling facts, but also facilitates implicit learning, where students develop skills and decision-making capabilities by repeatedly practicing clinical scenarios. These advantages are particularly valuable in education, where students are in the early stages of applying their knowledge to clinical practice [1, 3, 12, 15].

Despite the widespread adoption of simulation, there remains a need for rigorous evaluation of its efficacy compared to traditional lecture-based methods. The majority of studies have focused on clinical skills training for medical residents, with fewer investigations exploring the impact of simulation in the preclinical setting. Furthermore, existing research has primarily examined short-term knowledge gains, with limited emphasis on long-term retention, which is crucial for ensuring that foundational concepts are carried forward into clinical practice [4, 6, 10, 14].

The current study aims to address this gap by comparing the effectiveness of simulation-based education with traditional lecture-based methods in teaching key clinical topics. By adopting a randomized controlled design, we assess both immediate knowledge acquisition and long-term retention across a range of subjects. The findings from this study have the potential to inform future curriculum design and optimize the learning strategies employed in medical education.

Materials and Methods

Population and Setting

Forty fourth year medical students enrolled in the Cardiovascular course at Samarkand State Medical university were invited to participate in this randomized, controlled study on a voluntary, extracurricular basis. Recruitment was conducted via an electronic mailing list. The Samarkand State Medical University approved the study, and all students provided informed consent before participation.

Study Design

All students were randomly allocated into two study groups of 20 participants each. Students in group A completed simulation-based education, while those in group B received only lecture-based education. There were four topics selected: hyperkalemia, ST-elevation myocardial infarction (STEMI), atrioventricular nodal reentry tachycardia (AVNRT), and Torsades de Pointes.

Each group attended two 45-minute sessions for each topic, spread over four weeks. We utilized high-fidelity patient simulation (Leonardo, EIDOS) in educational sessions of Group A, while Group B participated in traditional lecture sessions. Both groups were taught identical learning objectives, and each session was designed to cover four key teaching points. The same instructors taught all sessions to minimize inter-instructor variability.

Simulator Sessions

The high-fidelity patient simulation used was a Medical Education mannequin, capable of simulating a wide range of clinical scenarios, physiological responses, and examination findings. Each simulation session began with a case scenario, during which students performed physical examination maneuvers and made clinical decisions, including ordering diagnostic tests and administering treatments. Faculty members provided real-time feedback and facilitated a 10-minute debriefing session after each scenario to emphasize key learning points.

Lecture Sessions

In the lecture-based group, students received traditional didactic instruction with outlines and diagrams presented on a whiteboard. Each lecture session lasted 45 minutes, during which instructors focused on the same four teaching points covered in the simulation group. Students were encouraged to ask questions and engage with the material during the sessions.

Assessment

A set of 10 multiple-choice questions was developed for each of the four topics. Each question addressed one of the pre-determined key teaching points. These questions were randomized and used for both a pre-test and a post-test to assess immediate knowledge gain, as well as a delayed post-test administered five weeks after the sessions to assess long-term knowledge retention.

The pre-test was administered before the start of the educational sessions, and the post-test was given immediately after the sessions concluded. Both the pre- and post-tests were conducted in a closed-book, proctored setting. The delayed post-test was administered online, and students were incentivized with a small gift for completing it. All tests were scored anonymously, and students' identities were protected throughout the process.

Data Analysis

Test scores were collected and analyzed to assess the improvement in knowledge between the pre-test, post-test, and delayed post-test for both groups. The average percentage of correct responses was calculated for each group. Statistical analysis was conducted using the two-tailed Student's t-test, with a p-value of less than 0.05 considered significant. The comparison focused on evaluating differences in immediate knowledge gain and long-term retention between the two educational modalities.

Results

A total of 40 second-year medical students were enrolled in the study, with 20 students assigned to each group. All students completed the pre-test and post-test assessments. However, three students from Group A and two from Group B were lost to follow-up and did not complete the delayed post-test. These students were included in the pre- and post-test analyses but excluded from the delayed post-test analysis.

Both groups showed significant improvement in their scores from the pre-test to the post-test. Group A (simulation-based education) had an average pre-test score of 42.5% ± 15.3%, which increased to 78.5% ± 12.4% on the post-test ($p < 0.001$). Group B (lecture-based education) had an average pre-test score of 40.8% ± 14.7%, which increased to 74.2% ± 13.1% on the post-test ($p < 0.001$). There was no significant difference between the two groups in terms of post-test improvement ($p = 0.24$).

Five weeks after the intervention, the delayed post-test was conducted. Group A demonstrated a greater retention of knowledge, with an average delayed post-test score of 70.6% ± 11.9%, showing only a modest decline from their post-test scores ($p = 0.04$). Group B, however, experienced a larger drop in scores, with an average delayed post-test score of 61.3% ± 13.5% ($p = 0.03$). The difference in retention between Group A and Group B was statistically significant ($p = 0.02$), indicating better long-term knowledge retention in the simulation-based education group.

When stratified by topic, both groups showed significant improvement from pre-test to post-test across all four topics (Table 1). However, the retention of knowledge differed between groups for specific topics. For hyperkalemia and STEMI, Group A exhibited significantly higher retention in the delayed post-test compared to Group B ($p < 0.05$). On the other hand, for the topics of AVNRT and Torsades de Pointes, there was no significant difference in retention between the two groups ($p > 0.05$).

While both educational modalities (simulation and lecture) were effective in improving immediate knowledge acquisition, Group A (simulation) demonstrated superior long-term retention of knowledge compared to Group B (lecture). The results suggest that simulation-based education may be more effective in sustaining students' understanding of certain clinical topics over time.

Table 1. Subject-Specific Performance Comparison

Subject	Group A (Simulation)	Group B (Lecture)
Hyperkalemia	85.4	74.2
STEMI	80.2	69.8
AVNRT	67.3	65.1
Torsades de Pointes	71.5	70.8

Discussion

This randomized controlled study comparing simulation-based education (Group A) and lecture-based education (Group B) among second-year medical students demonstrated significant improvements in knowledge acquisition immediately following both interventions. However, the most notable finding was the superior long-term knowledge retention observed in the simulation-based group compared to the lecture-based group.

Both Group A and Group B showed significant improvement from pre-test to post-test across all topics, indicating that both educational methods are effective in delivering short-term knowledge. The lack of a significant difference between the groups immediately after the intervention suggests that traditional lectures, despite being passive, can still convey important factual knowledge as effectively as simulation in the short term. This finding aligns with previous studies comparing these two modalities, which also reported similar short-term gains between lecture-based and simulation-based learning [2, 8, 9, 11, 14].

The most significant finding of this study lies in the long-term retention of knowledge, where Group A (simulation) outperformed Group B (lecture). Five weeks after the interventions, Group A's delayed post-test scores were significantly higher than those of Group B, suggesting that simulation-based learning may foster better retention of material. This result supports the hypothesis that simulation, by engaging students in active learning, enhances implicit memory and enables students to internalize knowledge more deeply than passive lecture-based methods [3, 5, 14].

The concept of implicit memory, which is developed through experiential learning such as simulation, is likely a key factor in the improved retention observed in the simulation group. Students in Group A were exposed to realistic clinical scenarios, requiring them to apply their knowledge in decision-making processes, thus reinforcing their understanding. The "priming" effect, wherein students are more sensitive to future stimuli after experiencing realistic scenarios, may also have contributed to the enhanced retention seen in the simulation group. These mechanisms have been previously highlighted as advantages of simulation-based education [2, 11, 16].

When analyzing the subject-specific performance, we observed that for topics such as hyperkalemia and STEMI, students in the simulation group retained knowledge significantly better than those in the lecture group. These topics, which involve critical clinical decision-making and real-time interventions, may benefit more from experiential learning. In contrast, for subjects such as AVNRT and Torsades de Pointes, the differences in retention between the two groups were not significant. This may suggest that topics which require more diagnostic interpretation, rather than immediate clinical action, might be equally suited to both lecture and simulation modalities [6–8, 14].

Conclusion

In conclusion, both simulation-based and lecture-based education were effective in enhancing short-term knowledge among medical students. However, simulation demonstrated a clear advantage in fostering long-term retention, particularly in topics requiring clinical decision-making. This study suggests that incorporating simulation into curricula may offer a more robust educational experience, better preparing students for clinical practice. Further research is needed to explore the optimal balance between simulation and traditional lecture-based learning to maximize educational outcomes.

Conflict of interest

None reported.

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