

Analysis of the Practical Value of Virtual Simulation Technology in the Teaching of Critical Care Nursing for Systemic Lupus Erythematosus

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Abstract: *Objective:* To explore the application effect of virtual simulation technology in the teaching of critical care nursing for systemic lupus erythematosus (SLE), and to provide a basis for optimizing the nursing teaching model in the Department of Rheumatology and Immunology. *Methods:* Twenty nursing interns who interned in the Department of Rheumatology and Immunology of the hospital from July 2024 to August 2025 were selected as the research subjects, and they were given a 4-week “virtual simulation + traditional teaching” intervention. The theoretical assessment scores, practical assessment scores, and clinical decision-making ability scores were compared before the intervention (baseline) and after the intervention (end of teaching). Meanwhile, the ability to simulate the handling of adverse events (identification time, emergency implementation time, and correct handling rate) before and after the intervention was compared. Combined with the teaching satisfaction survey after the intervention, the practical value of virtual simulation technology was analyzed. *Results:* After the intervention, the theoretical assessment scores, practical assessment scores, and clinical decision-making ability scores of the 20 research subjects were significantly higher than those before the intervention, with statistically significant differences ($P < 0.05$). After the intervention, the identification time of adverse events and the implementation time of emergency measures for the 20 research subjects were significantly shorter than those before the intervention, and the correct handling rate was significantly higher than that before the intervention, with statistically significant differences (all $P < 0.05$). After the intervention, among the 20 research subjects, 15 (75.0%) were “very satisfied”, 4 (20.0%) were “generally satisfied”, and 1 (5.0%) was “unsatisfied”, with an overall satisfaction rate of 95.0% (19/20). *Conclusion:* Virtual simulation technology can improve the teaching quality of critical care nursing for SLE, enhance the theoretical mastery, practical ability, and clinical decision-making ability of intern nurses, and is worthy of promotion and application in the nursing teaching of the Department of Rheumatology and Immunology.

Keywords: Virtual simulation technology; Systemic lupus erythematosus; Critical care nursing; Nursing teaching; Clinical decision-making ability

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1. Introduction

Systemic Lupus Erythematosus (SLE) is an autoimmune disease that can affect multiple systems throughout the body. When critical conditions such as lupus encephalopathy, severe lupus nephritis, and hemolytic anemia arise, the disease progresses rapidly and is associated with a high mortality rate, posing extremely high demands on the professional competence of nursing staff^[1]. However, clinical cases of critical SLE are relatively rare, making it difficult for nursing interns to gain sufficient hands-on experience through traditional teaching methods. Additionally, the “high uncontrollable risks” and “numerous ethical constraints” in real clinical settings lead to issues in nursing education, such as a “disconnect between theory and practice” and “inadequate training in emergency response capabilities.” Virtual simulation technology, by constructing highly realistic clinical scenarios, can simulate the onset, symptom progression, and emergency treatment processes of critical SLE, providing nursing interns with a “repeatable and risk-free” training environment^[2–3]. In recent years, this technology has demonstrated significant advantages in fields such as emergency nursing and surgical nursing, but there has been limited research on its application in specialized nursing education within the rheumatology and immunology departments. This study systematically analyzes the practical value of this technology in SLE critical care nursing education by comparing the effectiveness of traditional teaching methods with virtual simulation teaching.

2. Materials and methods

2.1. General information

Twenty nursing interns who completed their internships in the rheumatology and immunology department of our hospital from July 2024 to August 2025 were selected as the study subjects. Among them, there were 2 males and 18 females, with an average age of (22.35 ± 0.82) years. Sixteen interns held a bachelor's degree, while 4 held a master's degree. Eleven interns had prior internships in internal medicine, and 9 had internships in surgery. The baseline data (theoretical foundation and operational skills) of all study subjects were assessed and found to have no significant differences, meeting the consistency conditions for self-comparison before and after the study.

Inclusion criteria: (1) Possession of a bachelor's degree or higher in nursing, with their first internship in the rheumatology and immunology department; (2) No prior work experience in SLE nursing; (3) Voluntary participation in this study and signing of an informed consent form. Exclusion criteria: (1) Taking leave for personal reasons exceeding 2 weeks during the internship period; (2) Presence of cognitive dysfunction or communication impairment.

2.2. Teaching methods

All 20 study subjects underwent a 4-week intervention combining “virtual simulation and traditional teaching.” The curriculum was designed around the core competency requirements for critical care in Systemic Lupus Erythematosus (SLE), covering topics such as the etiology, clinical manifestations, nursing assessments, emergency interventions (including intracranial pressure monitoring, blood purification coordination, and immunosuppressant administration care), and complication prevention for conditions like lupus encephalopathy, lupus nephritis with renal failure, severe infections, and hemolytic anemia. The specific implementation process is outlined below:

2.2.1. Basic module of traditional teaching (Throughout the 4-week period)

(1) Theoretical Instruction: Conducted through “PPT lectures and case analysis”, held twice weekly for 60 minutes each session. Clinical instructors with the title of head nurse or above from the Rheumatology and Immunology Department delivered the lectures, focusing on explaining the diagnostic criteria for critical SLE, nursing standards, and guideline-recommended content; (2) Clinical Practice: Bedside teaching was conducted in real wards, where instructors demonstrated basic procedures such as intravenous catheter insertion and vital sign monitoring. Intern nurses practiced in the demonstration room and then performed limited hands-on procedures on patients under the supervision of instructors (three times weekly for 60 minutes each session); (3) Weekly Review: At the end of each week, theoretical Q&A sessions and case discussions were held to reinforce knowledge retention and clinical thinking integration.

2.2.2. Virtual simulation intervention module (Conducted concurrently with traditional teaching)

The “Rheumatology and Immunology Disease Virtual Simulation Teaching System”, developed by a medical technology company in Beijing, was employed. It featured three core intervention modules, implemented in three stages: (1) Pre-class Preview (15 minutes per session, twice weekly): Study subjects viewed animations on the pathological mechanisms of critical SLE conditions (e.g., glomerular damage caused by immune complex deposition) and virtual case symptom demonstration videos (e.g., the progression of consciousness blurring in lupus encephalopathy patients) through the system. They then completed pre-class knowledge tests (with a passing score of 80). (2) In-class Training (60 minutes per session, twice a week): Group-based scenario simulation training is conducted, focusing on six types of typical critical scenarios in systemic lupus erythematosus (SLE) (such as convulsions due to lupus encephalopathy, renal failure due to lupus nephritis, and septic shock), with interactive tasks to be completed ^[4]. For example, in the “Convulsions due to Lupus Encephalopathy Emergency” scenario, participants are required to sequentially complete tasks such as “calculating the dosage of sedative drugs, standard use of restraints, and intracranial pressure monitoring.” The system provides real-time feedback on operational errors (e.g., “The dosage of sedative drugs is too high, indicating a risk of respiratory depression”) and generates immediate scores. (3) Post-class Reinforcement (30 minutes per session, twice a week): The system automatically pushes specialized training tasks (such as blood purification circuit connection and ventilator parameter adjustment) based on the weak areas identified during in-class training and generates personalized error collections ^[5]. The research subjects are required to review and correct the errors until the accuracy rate reaches $\geq 90\%$.

2.2.3. Integration of virtual and real scenarios (Once a week, 45 minutes)

By comparing typical cases from virtual simulation scenarios (such as “Lupus Nephritis Complicated with Septic Shock”) with real-life clinical cases, the differences in nursing care (e.g., the difference between “real-time fluctuations in patient vital signs” in virtual scenarios and the “insidious nature of the condition” in real-life scenarios) are highlighted. This approach aims to guide the research subjects in developing a transferable mindset from “virtual training” to “clinical practice.”

2.3. Observation indicators

2.3.1. Evaluation of teaching effectiveness

(1) Theoretical Assessment: A unified test paper (with a full score of 100 points) is used before and after the

teaching to assess the understanding of the etiology, clinical manifestations, and nursing measures of critical SLE conditions. The test includes multiple-choice questions (both single and multiple answers) and short-answer questions.

- (2) Practical Assessment: Before and after the teaching, a three-member assessment team consisting of head nurses from the rheumatology and immunology departments conducts practical assessments (with a full score of 100 points) using “standardized patients + simulation teaching aids.” The assessment items include “intravenous puncture (25 points), vital sign monitoring (20 points), implementation of emergency measures (35 points), and nursing documentation (20 points).” The average score given by the three assessors is taken as the final result.
- (3) Scoring of clinical decision-making ability: The Nursing Clinical Decision-Making Ability Scale (CDMNS) was employed, which encompasses four dimensions: “Problem Identification (20 points)”, “Plan Formulation (30 points)”, “Implementation and Evaluation (30 points)”, and “Reflection and Improvement (20 points).” The scale has a total score of 100 points. Scores were assigned by the supervising teacher based on the performance of the intern nurses during teaching, with higher scores indicating stronger decision-making abilities.

2.3.2. Assessment of adverse event handling ability

After the completion of teaching, both groups underwent simulated tests for adverse events in critical SLE cases. Two scenarios were set up: “Sudden convulsions in a patient with lupus cerebritis” and “Abrupt drop in blood pressure in a patient with lupus nephritis.” The following were recorded for both groups: (1) Adverse event identification time (from the start of the scenario to the time of definitive diagnosis); (2) Time to implement emergency measures (from the time of definitive diagnosis to the initiation of emergency measures); (3) Accuracy rate of handling (scoring criteria were developed based on the “SLE Diagnosis and Treatment Guidelines (2020 Edition)”, with a total score of 100 points and ≥ 80 points considered accurate).

2.3.3. Teaching satisfaction survey

A self-made satisfaction questionnaire (total score of 100 points) was used to evaluate four dimensions: “Practicality of Teaching Content (30 points)”, “Interest of Teaching Methods (25 points)”, “Effectiveness of Ability Enhancement (25 points)”, and “Quality of Teacher Guidance (20 points).” Scores ≥ 80 points were considered satisfactory, and the satisfaction rate was calculated (number of satisfied individuals/total number of individuals $\times 100\%$).

2.4. Statistical methods

Data analysis was performed using SPSS 26.0 statistical software. Continuous data were expressed as (Mean $\pm$ SD), and paired *t*-tests were used for pre- and post-intervention comparisons within the same group. Categorical data were expressed as [n (%)], and descriptive statistics were used for satisfaction analysis. A *P*-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of teaching effects before and after intervention

After the intervention, the theoretical assessment scores, practical assessment scores, and clinical decision-

making ability scores of the 20 study subjects were significantly higher than those before the intervention, with statistically significant differences (all $P < 0.05$) (Table 1).

Table 1. Comparison of teaching effectiveness scores before and after intervention (Mean $\pm$ SD)

Indicator	Theoretical assessment score	Practical assessment score	Clinical decision-making ability score
Before intervention	65.32 $\pm$ 7.15	68.45 $\pm$ 6.92	62.18 $\pm$ 8.34
After intervention	89.62 $\pm$ 5.37	91.25 $\pm$ 4.81	88.73 $\pm$ 6.12
<i>t</i> -value	17.187	17.111	16.232
<i>P</i> -value	0.000	0.000	0.000

3.2. Comparison of adverse event handling capabilities before and after intervention

After the intervention, the adverse event identification time and emergency measure implementation time of the 20 study subjects were significantly shorter than those before the intervention, and the correct handling rate was significantly higher than before the intervention, with statistically significant differences (all $P < 0.05$) (Table 2).

Table 2. Comparison of adverse event handling capabilities before and after intervention (Mean $\pm$ SD)

Indicator	Adverse event recognition time (s)	Emergency measure implementation time (s)	Correct handling rate (points)
Before intervention	68.75 $\pm$ 11.32	105.38 $\pm$ 12.67	81.62 $\pm$ 5.73
After intervention	45.23 $\pm$ 8.67	78.56 $\pm$ 10.24	92.35 $\pm$ 4.18
<i>t</i> -value	10.433	10.412	9.568
<i>P</i> -value	0.000	0.000	0.000

3.3. Comparison of teaching satisfaction before and after intervention

After the intervention, among the 20 study subjects, 15 (75.0%) were “very satisfied”, 4 (20.0%) were “generally satisfied”, and 1 (5.0%) was “dissatisfied”, resulting in an overall satisfaction rate of 95.0% (19/20). The primary reason for dissatisfaction was “slight dizziness after wearing VR equipment for 1 hour” (1 case).

4. Discussion

This study employed a pre- and post-intervention self-control design, effectively controlling for the interference of individual baseline ability differences on teaching effectiveness. The results showed that the “virtual simulation + traditional teaching” model significantly improved the teaching quality of critical care nursing for SLE, which is closely related to the “visual, repeatable, and risk-free” characteristics of virtual simulation technology. In terms of core competency enhancement, both theoretical and practical assessment scores significantly improved after the intervention. The reasons for this improvement are as follows: On one hand, the virtual simulation system transforms abstract pathological mechanisms into visual symptom evolution through “dynamic scenarios + interactive training”, aligning with the cognitive laws of “visual learning” [6]. On the other hand, the system’s “real-time feedback” function promptly corrects operational errors made by nursing interns, avoiding the issue of “difficulty in tracing errors after incorrect operations” in traditional teaching and

enhancing the precision of practical training.

Furthermore, the scores for clinical decision-making abilities also significantly improved after the intervention, thanks to the “multi-variable emergency scenario” design of the virtual simulation system. For instance, scenarios such as “a lupus nephritis patient experiencing concurrent drops in blood pressure and electrolyte imbalances” forced the study subjects to prioritize critical issues within a limited timeframe, gradually cultivating “structured clinical thinking.” This addressed the shortcomings of traditional teaching methods, which often involve “passive knowledge acquisition and a lack of independent decision-making training”^[7].

In terms of adverse event management capabilities, both the identification time and emergency response time significantly decreased after the intervention, while the accuracy of handling improved markedly. This directly validated the value of virtual simulation technology in cultivating “emergency response capabilities.” The core challenges in clinical teaching for severe SLE cases lie in the “scarcity of cases and risk constraints”: trainee nurses find it difficult to access various critical care scenarios, and the fear of making mistakes in real-life operations leads to insufficient training^[8]. However, the virtual simulation system encompasses six categories of severe SLE scenarios, allowing study subjects to repeatedly practice high-risk procedures (such as administering high doses of immunosuppressants) without real-world consequences, even if errors occur. Through “deliberate practice”, they accumulate clinical experience. In this study, one subject initially had a low accuracy rate in handling cases due to a “calculation error in sedative dosage” before the intervention. After undergoing 10 specialized training sessions in the virtual system, their post-intervention accuracy rate exceeded 90 percent, demonstrating the typical effect of “risk-free repetitive training.”

From the perspective of teaching satisfaction, the 95.0% satisfaction rate surpassed that of traditional teaching methods (previous studies indicate satisfaction rates of approximately 70%–80% for traditional teaching)^[9]. This can be attributed to the enhanced “interactivity and targeted nature” of teaching facilitated by virtual simulation technology. On one hand, immersive VR experiences (such as simulating the drop in blood oxygen levels when a patient experiences dyspnea) and group competition-based training (comparing emergency response speeds) transformed “passive learning” into “active participation”, reducing learning aversion. On the other hand, the “personalized learning reports” generated by the system helped study subjects identify their weaknesses (such as low scores in intracranial pressure monitoring procedures), enhancing their sense of learning accomplishment^[10]. Only one subject expressed dissatisfaction due to VR device-induced dizziness, suggesting that future improvements could involve optimizing the weight of VR devices and adjusting scene brightness to enhance the user experience.

This study has the following limitations: Firstly, the sample size is relatively small, and the research was conducted in only a single hospital, which may limit the generalizability of the results. Secondly, the follow-up period is relatively short, and the impact of virtual simulation teaching on the long-term clinical competence of nursing interns has not been evaluated. Thirdly, the “individual differences” among nursing interns were not taken into account.

Future research can be improved in three aspects: Firstly, expanding the sample size and conducting multi-center studies to verify the universality of virtual simulation technology. Secondly, extending the follow-up period to track the clinical performance of nursing interns within 1–2 years after graduation and evaluate the “long-term effects” of teaching. Thirdly, optimizing the virtual simulation system by incorporating a “personalized learning path” feature that automatically adjusts the training difficulty and content based on the

learning progress and ability level of nursing interns, achieving “precision teaching.”

In conclusion, virtual simulation technology holds significant practical value in the teaching of critical care nursing for systemic lupus erythematosus. It can overcome the limitations of traditional teaching methods, enhancing teaching quality and satisfaction. This technology provides new ideas and approaches for specialized nursing teaching in the rheumatology and immunology department.

Disclosure statement

The authors declare no conflict of interest.

References

- [1] Liu H, Xu J, Liu SL, 2025, The Impact of Specialist Medical Service Systems on Compliance and Nursing Satisfaction in Patients with Systemic Lupus Erythematosus. *Chinese Health Preservation*, 43(1): 124–127.
- [2] Fei HJ, Ye XF, 2025, Application Practice of a Virtual Simulation Experimental System Based on Immunological Diagnosis of Systemic Lupus Erythematosus in Higher Vocational Immunology Testing Courses. *Scientific Consulting*, 2025(10): 237–240.
- [3] Liu F, Wang FL, Wang X, et al., 2024, Virtual Simulation Experiment for Material Classification and Identification Based on Dual-Energy X-ray Transmission Imaging and Energy-Dispersive Diffraction. *Laboratory Research and Exploration*, 43(8): 35–40 + 46.
- [4] Wang Y, Tian JL, Jiao YH, et al., 2024, Application of Virtual Simulation Technology Combined with Rain Classroom in Practical Teaching of Enterostomy Nursing. *Journal of Nursing Science*, 39(2): 83–86.
- [5] Liu CF, Zhang QL, Xu LN, 2024, Application of Virtual Simulation Teaching Platform in Practical Training of Emergency and Critical Care Nursing. *China Higher Medical Education*, 2024(5): 129–131.
- [6] Wu DC, 2025, Application Effect of Human-Computer Interaction Mode in Virtual Simulation Experimental Teaching of Medical Nursing. *Journal of Hubei University for Ethnicities (Medical Edition)*, 42(2): 89–91 + 95.
- [7] Zhang Y, Li L, 2023, Application of Virtual Simulation Teaching in Internal Medicine Graduation Internship for Nursing Undergraduates. *Health Vocational Education*, 41(7): 85–88.
- [8] Cao N, 2021, Application of a Simulation Teaching Mode Based on Virtual Reality Technology in Higher Vocational Surgical Nursing. *Health Vocational Education*, 39(8): 87–89.
- [9] Xu F, Nie ZY, Jin L, et al., 2021, Design and Exploration of a Virtual Simulation Experiment Project for the Preparation and Detection of High-Potency Rabbit Anti-Sheep Red Blood Cell Antibodies. *Chinese Journal of Immunology*, 37(2): 231–234.
- [10] Zeng CX, Zhang XM, Zhang D, et al., 2021, Construction and Practice of a Flipped Classroom Teaching Mode Based on Virtual Simulation Experiments. *China Continuing Medical Education*, 13(16): 32–35.

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