ORIGINAL RESEARCH

Application research on critical care ultrasound training based on dual mobile platforms in improving knowledge about disaster rescue

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ABSTRACT

Objective: To explore the application effect of a multidisciplinary collaborative Critical Care Ultrasound (CCUS) training system integrated with a mobile learning platform in improving nurses' ultrasound assessment and mass casualty treatment capabilities during disasters.

Methods: Targeting the fragmented application, non-standardized operation and interpretation of CCUS in primary hospitals, training needs were identified via research. A systematic training plan was developed, including expert lectures, question bank construction, video recording, development of a dual mobile platform (WeChat mini-program), and establishment of a standardized assessment system.

Results: Post-training, trainees' theoretical scores rose from (67.0 ± 8.5) to (83.2 ± 6.1) ($p < .01$); standardized operation scores increased significantly from (56.3 ± 10.2) to (89.1 ± 4.7) ($p < .01$); image interpretation accuracy improved from (74.1 ± 9.8)% to (92.3 ± 5.1)% ($p < .01$). A questionnaire survey showed 96.2% of trainees were satisfied or very satisfied with the training mode and mobile platform.

Conclusions: The multidisciplinary collaborative CCUS training system combined with a mobile learning platform effectively enhances military medical personnel's CCUS theoretical knowledge, operational standardization, and image interpretation ability. It significantly improves the efficiency of rapid and accurate assessment and disposal of mass casualties in disasters, with important application value and promotion significance for disaster rescue.

Key Words: Critical care ultrasound, Mobile learning platform, Mass casualty treatment

1. INTRODUCTION

Special environments such as disaster sites are characterized by urgency, suddenness, complexity, harsh conditions, and high risk.[1] Rapid assessment and treatment of mass casualties is a core challenge faced by medical institutions.[2] Critical Care Ultrasound (CCUS), with its advantages of portability, speed, non-invasiveness, and high repeatability, plays an irreplaceable role in the real-time assessment and dynamic monitoring of critically ill patients. It is especially suitable for resource-limited disaster sites and primary medical facilities.[3] Extensive literature reviews have shown that portable ultrasound equipment has become a key tool in improving the efficiency of triage, rapid diagnosis, and life support during disaster rescue operations.[4] However, there are significant deficiencies in the application of CCUS among nursing staff in many hospitals: fragmented operational skills and lack of systematic training; inconsistent image interpretation capabilities, making standardized as-

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sessment difficult; and scattered learning resources with insufficient guidance.[5–7] These issues severely limit the potential of CCUS in enhancing the efficiency of emergency medical rescue in hospitals. To address these challenges, the Nursing Department of our hospital, in collaboration with multidisciplinary teams—including the Ultrasound Department, Medical Engineering Department, and Information Technology Department—innovatively developed a systematic, standardized, and mobile-based CCUS training model aimed at comprehensively improving the core CCUS competencies of medical personnel. This paper reports on the implementation process and outcomes of the training program.

2. Materials and methods

2.1 Training objects

A total of 185 nurses from the Emergency Department and Intensive Care Unit of the hospital were selected for training. All had basic nursing qualifications, no systematic ultrasound training experience, aged 22-45 years, with working experience of 1-20 years.

2.2 Training organization and preparation

2.2.1 *Multidisciplinary team establishment*

A training team was established under the leadership of the hospital's Nursing Department, consisting of 5 senior nurses, 2 ultrasound physicians, 2 medical engineering technicians, and 1 information technology specialist. Responsibilities were clarified: the Nursing Department was responsible for overall coordination and plan implementation; senior nurses focused on sorting out clinical scenario needs; ultrasound physicians undertook professional content design and teaching, providing image interpretation standards and case banks; the Medical Engineering Department optimized the performance of portable ultrasound equipment in extreme environments; the Information Technology Department recorded and edited teaching videos, and was responsible for mini-program development and technical maintenance.

2.2.2 *Expert consultation*

At the initial stage of the project, 8 experts were invited to form an expert group. Opinions and suggestions on the quality improvement of CCUS were collected through a combination of online and offline methods.

2.2.3 *Design of standardized training content*

Based on expert opinions, the standardized training content was designed as follows: (1) Establish theoretical learning materials, sort out CCUS-related knowledge points, and determine the direction of the theoretical question bank, including basic ultrasound theory, operation specifications, and clinical applications. The question bank contained 500 questions in five types: single-choice, multiple-choice, true/false, fill-in-the-blank, and short-answer. According to the current knowledge reserve of the department staff, combined with relevant literature and books, experts were invited to guide and review the compilation of Basic Theoretical Manual of Critical Care Ultrasound. The content included basic ultrasound physics, operating principles, application in disasters, and clinical application specifications, serving as basic learning materials for nurses. Ultrasound-related books were also purchased to form a complete theoretical learning framework. (2) Based on expert opinions and training needs, a detailed expert teaching plan was formulated. 21 well-known experts were invited to develop a phased teaching plan, totaling 26 class hours. The plan included training content covering different stages and themes. Specific content is shown in the Table 1. (3) 20 high-quality teaching videos were recorded and edited, with all teaching modules and corresponding key technical points detailed in Table 2. The video content focuses on practicality, with detailed explanations of ultrasound images as the key part. Each video is 4-8 minutes long, focusing on operational difficulties and key points of image interpretation. (4) Development of Digital Learning Tools: To facilitate the learning of clinical and battlefield rescue technologies, two mobile-accessible websites and mini-programs for critical ultrasound applications were developed, with detailed specifications shown in Table 3. One is a "learning platform" mini-program, whose main functions include integrating question banks, literature, practical operation videos, and expert lecture clips, supporting online learning. The other is a "clinical image support platform" mini-program, which mainly realizes continuous storage of ultrasound images. It can automatically record the image upload time, edit and record relevant information of images, and compare and store ultrasound images with those taken by mobile phones, facilitating disease tracking, consultation, teaching and scientific research. The mini-programs are logged in via mobile phone numbers with confidentiality. In the "clinical image support platform" mini-program, department or hospital groups can be established as needed. Image information sent in the groups can be viewed by all members, playing an important role in consultation, teaching and daily application. Moreover, each group is unique with confidentiality functions. The IP address of the "Critical Care Ultrasound Training System" website is: `http://124.223.56.157.8989/home/Pubindex.html`.

2.3 Training implementation and assessment

2.3.1 *Training methods*

The training was conducted from June 2023 to June 2025, with each cycle lasting 3 months. The "centralized teaching +

online self-study + practical drill" model was adopted: 1 session of expert centralized teaching (4 class hours) per month, trainees completed 30 minutes of daily online learning via the mini-program, and 1 group practical drill was carried out every 2 weeks. A total of 185 nurses from the hospital's Emergency Department, Intensive Care Unit (ICU), and Coronary Care Unit (CCU) participated in the training.

2.3.2 *Assessment*

The assessment consisted of three parts: theory, standardized operation, and image judgment, each with a full score of 100. The theoretical examination was a closed-book test, with 100 questions randomly selected from the question bank; the operation assessment was practical operation in simulated scenarios, scored according to the formulated evaluation criteria, and adopted a 5-point Likert scale covering probe manipulation/image acquisition/measurement specifications; the image judgment test was image reading and answering, with 50 standard images including 20% interference items.

2.4 Questionnaire survey

After the training, 209 questionnaires were distributed. The survey content included the practicality of training content, resource quality, ease of use of the mini-program, and improvement suggestions.

Table 1. Training plan

Phase	Content	Catalog
1	Basic Theory	Physical Basis of Ultrasound; Basic Principles for Optimizing Image Acquisition in Critical Care Ultrasound; Adverse Reactions and Prevention of Critical Care Ultrasound
2	Specialized Knowledge	Theoretical Basis of Cardiac Ultrasound; Theoretical Basis of Airway and Lungs; Theoretical Basis of Pulmonary Ultrasound; Theoretical Basis of Kidneys; Theoretical Basis of Abdominal Ultrasound; Theoretical Basis of Craniocerebral Ultrasound; Theoretical Basis of Vascular Ultrasound
3	Clinical Assessment	Airway and Pulmonary Assessment; Inferior Vena Cava and Fluid Volume Assessment; Vascular Assessment and Thrombus Screening; Focused Assessment with Sonography for Trauma; Gastrointestinal Assessment; Bladder Assessment; Skeletal Muscle Assessment; Pressure Injury Assessment
4	Operation	Ultrasound-Guided Vascular Assessment; Ultrasound-Guided Chest Physiotherapy; Ultrasound-Guided Nutrition Tube Placement; Ultrasound and Drainage Tube Nursing
5	Research and Transformation	Patent Design; Clinical Research Outputs

Table 2. Training module

Module	Key Technical Points
Lung Assessment	B-line Sign/Lung Sliding Sign/Pleural Effusion
Inferior Vena Cava (IVC) Assessment	Diameter Measurement/Respiratory Variability
Lower Extremity Venous Thrombosis Assessment	Compression Ultrasound/Blood Flow Signal Detection
Ultrasound-guided Puncture	Vascular Localization/Real-time Needle Guidance
Gastrointestinal Assessment	Gastric Residual Volume Measurement/Intestinal Peristalsis Observation
Bladder Assessment	Three-dimensional Volume Calculation
Basic Cardiac Assessment	Pericardial Effusion Screening/Ventricular Wall Motion

Table 3. Digital learning tools

Learning Platform	Clinical Image Support Platform
Random Self-Assessment from Question Bank	DICOM Image Storage and Annotation
Chaptered Video Learning	Automatic Timestamp Generation (Accurate to Seconds)
Expert Lecture Video Playback	Wound/Pressure Injury Image Comparison and Viewing Function
Literature and Guidelines Library	Encrypted Cloud Storage (Compliant with Medical Information Security Standards)

3. Results

3.1 Comparison of assessment scores before and after training

For statistical analysis, paired *t*-test was performed using SPSS 25.0. A value of $p < .05$ was considered statistically significant. The assessment scores showed a significant increase, and the detailed statistical results are presented in Table 4.

3.1.1 *Satisfaction with training methods*

A total of 185 questionnaires were effectively recovered. The main feedback showed that the satisfaction rate with training methods reached 100%. Specifically, 95% of respondents considered the practical operation videos “intuitive and easy to learn” and the teaching courseware “logically clear”. Regarding the mini-program: 98% recognized the convenience of the learning-oriented mini-program, and 95% believed the videos “significantly reduced the learning curve”. As for improvement suggestions: 2% proposed adding content on ultrasonic assessment in extreme environments such as disasters, 3% suggested supplementing complex medical record analysis, and 5% recommended optimizing the interactive functions of the mini-program (e.g., adding online Q&A).

Table 4. Comparison of assessment scores before and after training

Indicator	Before Training (Score)	After Training (Score)	Improvement Margin	t	p
Theoretical Assessment	67.0 ± 8.5	83.2 ± 6.1	+24.2%	-25.371	< .001
Operational Standardization	56.3 ± 10.2	89.1 ± 4.7	+58.3%	-38.624	< .001
Image Interpretation Accuracy	(74.1 ± 9.8)%	(92.3 ± 5.1)%	+24.6%	-22.893	< .001

3.1.2 *Platform application and satisfaction*

• Usage rate of the learning platform: 98.6% of trainees logged in at least 3 times per week.
• Storage capacity of the clinical platform: A total of 854 images were stored in the mini-program after its use.
• Satisfaction feedback: 89% of respondents stated that the clinical support platform "improved the efficiency of injury recording", and 96% believed the image storage mini-program was significantly helpful for medical consultation on patients’ conditions.

4. Discussion

4.1 Multidisciplinary collaboration ensures professionalism and practicality of training

Critical care ultrasound training in medical institutions must balance “professional depth” and “battlefield applicability.” In this study, ultrasound physicians ensured the professionalism of theories and operations; nursing backbone sorted out core technologies in combination with disaster rescue scenarios; and the dual mini-programs developed by the medical engineering department catered to the needs of primary medical personnel for “learning in fragmented time” and “field rescue recording.” The collaboration of these three parties ensured that the training content not only met professional standards but also directly addressed practical pain points.

4.2 Dual mini-program platform enhances training sustainability and clinical value

The “learning platform” mini-program broke the constraints of time and space, solved the problem of “difficulty in centralized training” for primary military units, and made systematic learning possible. The “clinical image support platform” mini-program extended training outcomes to clinical practice. Through standardized image recording and comparison functions, it not only improved the continuity of condition assessment but also accumulated valuable data for teaching and research, forming a closed loop of “training-application-improvement.”

4.3 Standardized system promotes homogenization of rescue capabilities

Previously, the “fragmented learning” of ultrasound applications among military medical personnel led to uneven capabilities. However, this study significantly improved the overall level of the team by unifying teaching content, operating procedures, and assessment standards. The 33-point increase in operational standardization scores and the 92-point accuracy rate in image judgment indicate that in the rescue of mass casualties in disasters or wars, different medical personnel can reach consistent assessment conclusions, laying a foundation for collaborative rescue.

4.4 Improvement directions

In response to the demand for "extreme environment assessment" proposed in the questionnaire, subsequent content can be supplemented, such as equipment debugging and image interference elimination in special scenarios. Following the suggestion of "complex medical record analysis," a "case library" module can be added to the mini-program to enhance trainees' clinical adaptability.

4.5 Innovations: Constructing a "trinity" capability improvement closed loop

Link ⟶ Defects of Traditional Models → Solutions in This Study

Theoretical Learning Outdated/Slowly updated textbooks ⟶ Question bank + manual + books + expert lectures + dynamic updates via mini-program

Skill Training ⟶ Lack of standard demonstrations 20 high-definition videos + correct/incorrect comparisons

Clinical Support Unordered image management ⟶ Time-sequential storage

4.6 Prominent value in disaster rescue

Through subjects such as simulated disaster site rescue, the timeliness of treatment has been improved. The 58.3% increase in operation scores shows that the standardized process has shortened the FAST assessment time to within 3 minutes. Optimization of mass casualty disposal: The clinical support platform realizes three-dimensional correlation of "images-injuries-time," facilitating priority judgment of mass casualties. Adaptation to special scenarios: The 2% demand for extreme environment assessment suggests directions for subsequent research, such as ultrasound assessment of high-altitude injuries.

4.7 Analysis of promotion feasibility

High cost-effectiveness: Development costs are less than 50,000 yuan, replacing traditional simulation equipment investment. In daily use, the clinical support platform has been applied to routine wound management, expanding nursing application scenarios. Moreover, it has potential for military-civilian integration and is suitable for promotion in disaster rescue teams and medical alliances in remote areas.[8,9]

5. Conclusion

The systematic training system for critical care ultrasound constructed in this study forms a standardized resource library through multidisciplinary collaboration, dual mini-program platform support, and standardized assessment. It has significantly improved the ultrasound application capabilities of hospital nurses, especially those in emergency departments and intensive care units. This system is of great significance for improving the efficiency of rescuing mass casualties in disasters and can be promoted in medical institutions.[10–12] The next step will involve developing an extreme environment CCUS module and exploring the upgrading of AI-assisted interpretation functions.

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Authors contributions

XLZ and JZ conceived and designed the research. XLZ, YH and NZ collected and analyzed the data. XLZ and ZQW wrote the manuscript. YXL and SHL revised the manuscript. JZ is responsible for the overall content. All the authors read and approved the final manuscript.

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Obtained.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

DATA SHARING STATEMENT

No additional data are available.

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