

Exploration on the Training Path of Basic Operation Ability in the Standardized Training of Residents in Ultrasound Medicine

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Abstract: This study aims to evaluate the effectiveness of the stratified teaching method in the standardized training of ultrasound medicine residents. A total of 40 residents who underwent training in the Department of Ultrasound Medicine at our hospital from January 2020 to December 2024 were enrolled and assigned to either a control group (n=20) receiving conventional teaching or an observation group (n=20) receiving stratified teaching. Teaching outcomes were compared between two groups. Post-training evaluation revealed that the observation group achieved significantly higher scores in both fundamental operational skills—including probe handling and manipulation, instrument interface operation, identification and acquisition of core anatomical sections, image optimization and correction, and measurement procedures—and examination performance (theoretical and practical exam scores and pass rates) compared to the control group (all $P < 0.05$). These findings indicate that implementing a stratified teaching approach in the standardized residency training program within the ultrasound medicine department effectively enhances residents' fundamental operational competencies and academic examination results.

Keywords: ultrasound medicine; resident; standardized training; basic operation ability; examination results

1. Introduction

Imaging is the main means of modern clinical diagnosis and treatment, and the accuracy of ultrasound diagnosis is directly affected by the operator's standardized and skilled operation techniques and accurate image acquisition ability. Therefore, the basic operation ability of residents in ultrasound medicine is the core content and primary training goal of standardized training^[1]. At present, the training of residents in ultrasound medicine is facing the following challenges: the initial foundation and learning curve of residents before training are significantly different, and the conventional "one-size-fits-all" teaching mode is difficult to meet the needs of personalized advancement; The conventional teacher-following learning mode has strong randomness and lacks standardized and progressive training paths from cognitive understanding, simulation exercises to clinical practice, which leads to non-standard operation of some physicians and low efficiency in obtaining standard sections, affecting their confidence in independent practice and the improvement of follow-up diagnostic ability^[2]. Stratified teaching method is based on the differences of students' learning stages and ability levels, and designs individualized teaching and assessment objectives and contents, aiming at helping students make a smooth transition from novice to proficient. This study analyzed the effect of hierarchical teaching method in the standardized training of residents in ultrasound medicine, in order to form a standardized training path that can be replicated and evaluated, and provide practical basis for improving the basic operation ability of residents in ultrasound medicine. Elaborated as follows.

2. Data and Methods

2.1 General information

Forty residents who participated in the standardized training in the Department of Ultrasound Medicine of our hospital from January 2020 to December 2024 were included in the study and grouped

according to different teaching methods. The control group (20 cases) was 23-45 years old, the average was (34.48 ± 3.35) years old, male/female (14/6); the observation group (20 cases) was 25-42 years old, the average was (33.16 ± 3.29) years old, male/female (13/7). There were no statistically significant differences in general data between the two groups ($P > 0.05$).

Inclusion criteria: residents who have received standardized training in the Department of Ultrasound Medicine in our hospital, who have completed the basic education as required and have entered the stage of clinical rotation practice; Participate in the study voluntarily and sign the informed consent form.

Exclusion criteria: those who had studied in the department of ultrasound medicine for more than 3 months, those who were interrupted due to various reasons during the training period, and those who had upper limb fine manipulation disorders. Those who are unable to complete all the periodic skill examinations and questionnaires set in this study.

2.2 Method

2.2.1 Control group

The control group was taught with conventional teaching method. Implement the "apprenticeship" follow-up mode with teachers as the core. On the day of training, the basic theory and operation specifications of ultrasound equipment were explained to residents; the instructor led the trainees to observe the operation when they entered the examination, and advised them to observe the standard scanning techniques, section acquisition and instrument adjustment of different parts; After a period of observation, the teacher supervised and guided the students to operate on the patients, and the teacher corrected the problems in holding the probe, finding the section and optimizing the image orally.

2.2.2 Observation group

The stratified teaching method was used in the observation group. (1) Initial assessment and scientific stratification: the initial assessment and precise positioning of the multi-dimensional competence of the residents participating in the training were carried out from the theoretical knowledge of ultrasound physics and anatomy, as well as the core skills of image acquisition, standard section recognition and probe technique. Their clinical thinking and communication skills were evaluated. Based on the above evaluation results, it is divided into: the basic level (unfamiliar operation, focusing on consolidating theory), the advanced level (mastering routine operation, focusing on improving complex cases and interpretation ability), and the advanced level (skilled technology, focusing on training teaching and difficult case handling ability). (2) Define the hierarchical objectives and match the personalized content: define the phased objectives of each level of training and design modular and personalized training content. The basic level focuses on "standardization", strengthening "muscle memory" training such as probe holding and standard section scanning, and using a large number of simulator exercises to consolidate the foundation. The advanced level focuses on "proficiency and initial integration", focusing on the training of ultrasound diagnostic pathways for common diseases, and beginning to learn basic operations such as interventional ultrasound. The focus of the improvement layer is "mastery and expansion", deep participation in consultation of difficult cases, leading complex operations such as ultrasound-guided puncture, and undertaking some teaching tasks for junior students. (3) Implement differentiated teaching method: implement "small class, high interaction" tutor follow-up system at the basic level, correct the operation details by hand, and ensure the action standard. Case-based learning and group discussion are used in the advanced level, and the teacher guides them to complete the whole process from scanning to report writing independently, and discusses the problems of differential diagnosis. The advanced level implements project-based learning and makes them responsible for a micro-project of "the application of ultrasound in the rapid screening of acute abdomen causes" to cultivate their clinical research and problem-solving abilities. (4) Dynamic evaluation and hierarchical advancement: "Skill passport" is introduced to record the key operation cases completed by each trainee, the results of simulated examination and the evaluation of the tutor. Clinical examinations are conducted regularly, and examinations are set up from basic section scanning to interventional operation. Define the advanced quantitative standard (the basic level students independently and normatively complete 100 cases of ultrasound scanning of liver, gallbladder, pancreas and spleen and pass the examination), and the qualified students can apply to enter the next level of study. Those who fail to meet the standards should analyze the reasons, adjust their personal training plans, and realize the dynamic management of "being able to go up and down".

2.3 Index observation

(1) Score of basic operation ability: The improved scale of our hospital evaluated the basic operation ability of residents from the aspects of probe holding and movement, instrument interface operation, identification and acquisition of core anatomical sections, section optimization and correction, and measurement operation, with 10 points for each item, and the score was positively correlated with the ability. (2) Examination results: statistical theory and operation examination results.

2.4 Statistical analysis

SPSS26.0 processing data, ($\bar{x} \pm s$) and (%) represented the measurement and enumeration data, which were tested by t value and χ^2 respectively, and ($P < 0.05$) were statistically significant.

3. Results

3.1 Comparison of basic operation ability scores

Before the training, the scores of basic operation ability of the two groups were compared ($P > 0.05$), and after the training, the observation group was higher than control group ($P < 0.05$), as shown in Table 1.

Table 1. Comparison of Basic Performance Scores [$\bar{x} \pm s$ (Minutes)]

Grouping	Number of cases	Probe holding and moving		Instrument interface operation		Identification and acquisition of core anatomical section		Section optimization and correction		Measurement operation	
		Before training	After training	Before training	After training	Before training	After training	Before training	After training	Before training	After training
Observation group	20	6.34±0.62	8.65±0.84*	6.45±0.61	8.61±0.83*	6.31±0.73	8.69±0.85*	6.43±0.67	8.63±0.82*	6.32±0.70	8.64±0.81*
Control group	20	6.41±0.64	7.58±0.72*	6.39±0.60	7.54±0.75*	6.36±0.71	7.57±0.73*	6.38±0.69	7.52±0.76*	6.37±0.72	7.53±0.74*
T-value	-	0.351	4.325	0.313	4.277	0.219	4.470	0.232	4.440	0.222	4.524
P value	-	0.727	0.000	0.755	0.000	0.827	0.000	0.817	0.000	0.825	0.000

Note: Compared with the group before training*, $P < 0.05$.

3.2 Comparison of assessment results

The theoretical and operational examination scores and passing rate of the observation group were higher than those of the control group ($P < 0.05$), as shown in Table 2.

Table 2. Comparison of assessment results ($\bar{x} \pm s, n$)

Grouping	Number of cases	Theory test			Operation test		
		Score (points)	Pass	Pass Rate (%)	Score (points)	Pass	Pass Rate (%)
Observation group	20	81.68±8.42	19	95.00	83.34±8.12	18	90.00
Control group	20	72.15±7.69	14	70.00	74.61±7.58	12	60.00
χ^2/t value	-	3.737	-	4.329	3.514	-	4.800
P value	-	0.000	-	0.037	0.001	-	0.028

4. Conclusion

The results of this study showed that the score of basic operation ability in the observation group was higher than that in the control group after the training ($P < 0.05$), which indicated that the application of stratified teaching method in the standardized training of residents in ultrasound medicine department could improve the basic operation ability of residents. The core teaching idea of hierarchical teaching method is to realize the step-by-step development of residents' basic operation ability through systematic and personalized path^[3]. By scientifically evaluating the theoretical knowledge and core skills of residents participating in the training, and combining their clinical thinking and communication skills, the hierarchical teaching method can accurately stratify them,

ensure that the starting point of teaching matches individual abilities, and lay the foundation for follow-up targeted intervention^[4]. Based on the results of stratification, a clear stage goal was formulated and personalized training content was matched, and differentiated teaching was implemented. In the basic level, "small class, high interaction" tutor follow-up system was adopted; in the advanced level, case-based learning and group discussion were used; in the advanced level, project-based learning was implemented, so as to comprehensively improve the basic operation ability of each resident. The hierarchical teaching method emphasizes dynamic evaluation and hierarchical advancement mechanism, continuously optimizes the training path and content, records each resident's operation cases, simulation assessment, tutor evaluation, combines with regular clinical examinations and quantitative advancement standards, realizes the dynamic management of "being able to go up and down", and ensures that each resident participating in the training steadily improves in feedback and adjustment^[5]. Through the combination of precise assessment, goal-oriented content design, adaptive teaching method and flexible advanced system, the hierarchical teaching method constructs a coherent training path from basic consolidation to proficiency expansion, thus effectively promoting the systematic improvement of residents' basic operation ability.

The theoretical and operational examination results and the pass rate of the observation group were higher than those of the control group ($P < 0.05$), which confirmed the role of stratified teaching method in the standardized training of residents in ultrasound medicine department in improving the examination results of residents. Stratified teaching method emphasizes the design of structured and individualized training objectives and contents based on the actual situation of residents participating in the training, precise docking and systematic strengthening of the theoretical knowledge, skills and comprehensive application dimensions covered by the assessment, so as to lay the foundation for improving their theoretical and operational skills assessment results. It is based on multi-dimensional evaluation of the students' foundation (ultrasound theory, core operation skills, clinical thinking) and scientific grouping (foundation, advancement, improvement) to ensure that the starting point of teaching matches the real level of each student, and to avoid the conventional "one-size-fits-all" teaching method leading to some students' slack or low starting point due to the high starting point of training content. This helps to establish a fair and solid foundation, ensuring that all students can make progress in subsequent assessments. According to the characteristics of each level, the phased objectives are formulated and the personalized training contents directly corresponding to the different levels of difficulty and focus of the assessment are matched: the basic level emphasizes the "standardized" muscle memory training, which directly consolidates the basic operation items that account for a large proportion in the assessment of the trainees at this level; The advanced level emphasizes the diagnostic path of common diseases and basic interventional operation, and improves the scoring points in the assessment of case analysis and basic application ability; the refined level emphasizes the treatment of difficult cases and micro-subject research, and strengthens the higher clinical thinking and the ability to solve complex problems in the assessment. The hierarchical teaching method efficiently transforms the training content into examinable ability through differentiated teaching: the "hand-in-hand" follow-up system at the basic level ensures the accuracy of operation details and directly reduces the technical loss in the assessment; the case discussion and complete process practice at the advanced level improve the comprehensive ability to independently complete scanning, interpretation and report writing in the assessment scenario; Project-based learning at the advanced level promotes systematic analysis and innovative thinking in the face of complex and open problems in the assessment. The dynamic evaluation and hierarchical advancement mechanism in the hierarchical teaching method constructs a continuous feedback and positive incentive cycle, so that students at all levels can continuously obtain clear feedback on their own weaknesses and adjust their learning strategies in time. This dynamic management of "being able to go up and down" can not only stimulate students' internal learning motivation to strive for advancement, but also ensure the achievement of learning goals at all stages through continuous leak detection and vacancy filling. Thus, in the final assessment, the theoretical knowledge, operational proficiency, clinical adaptability and comprehensive analysis ability of all trainees were comprehensively strengthened, and the final performance was significantly improved.

To sum up, the application of hierarchical teaching method in the standardized training of residents in ultrasound medicine is conducive to improving the basic operation ability and assessment results of residents.

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