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Teaching Practice of Ultrasound-guided Nerve Block in Anesthesiologist Training

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Abstract: *Objective*: To evaluate the teaching effectiveness and clinical application value of ultrasound-guided nerve block technology in the standardized residency training of anesthesia residents. *Methods*: A total of 80 physicians from the Department of Anesthesiology of the hospital from January 2020 to December 2024 were randomly divided into a control group (40 cases, traditional blind nerve block teaching) and an observation group (40 cases, a trinity teaching system of model training, theoretical instruction, and real-practice ultrasound-guided nerve block), with an 18-month training period for both groups, and the differences in operational skills, complication recognition accuracy, and clinical competence were compared between the two groups. *Results*: The scores of operational skills and clinical competence, as well as the accuracy of complication identification, were significantly higher in the observation group than in the control group ($P < 0.05$); the first-attempt puncture success rate was 92.50% in the observation group, which was markedly higher than 67.50% in the control group ($P < 0.05$). *Conclusion*: The ultrasound-guided nerve block teaching system is effective in improving residents' procedural precision and safety awareness, and thus warrants wider promotion in anesthesia residency training.

Keywords: Ultrasound-guided nerve block; Anesthesia training; Teaching practice; Standardized resident training; Visualization technology

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1. Introduction

Anesthesiology, as the core support of perioperative medicine, faces rapid technological iteration, making practitioners feel urgent. In the past five years, the transformation of ultrasound-guided nerve block technology from "experience art" to "precision science" has become an irreversible trend [1]. The traditional blind method, which relies on body surface anatomical landmarks and paresthesia localization, is gradually being replaced by visualization technology because of the high failure rate of puncture and the high risk of neurovascular injury [2]. The emergence of ultrasound-guided technology has transformed this operation, which relies on the "art of experience", into a visual, accurate, and repeatable "scientific operation", which has been praised by the industry as a major upgrade of anesthesia technology [3]. From 2020 to 2024, the National Health Commission continued to promote the improvement of the quality of standardized resident training, and the skill training of anesthesiologists is facing higher requirements. How to systematically implant ultrasound-guided technology into the teaching chain has become an urgent issue for training bases [4]. The purpose of this study is to verify the actual effect of ultrasound-guided nerve block integrated into the training system through comparative teaching, and to provide an evidence-based basis for the optimization of anesthesia teaching mode.

2. Data and methods

2.1. General information

In this study, from January 2020 to December 2024, a total of 80 postgraduates and trainees who were receiving standardized training in the Department of Anesthesiology of our hospital were enrolled, and they were divided into the control group and the observation group by means of the random number table method, with 40 trainees in each group. There were 15 male students and 25 female students in the control group, ranging from 19 to 23 years old, with an average of (22.05 ± 1.17) years old. There were 17 males and 23 females in the observation group, ranging from 19 to 23 years old, with an average of (21.72 ± 1.35) years old. The general data of the two groups were balanced and comparable ($P > 0.05$).

Inclusion criteria: (1) Those who had obtained the qualification of medical practitioners or were in the second year or above of training; (2) Those who signed the informed consent and voluntarily participated in the study; (3) The attendance rate during the training period shall not be less than 90%.

Exclusion criteria: (1) those who did not complete the basic anesthesia rotation in the first year of regular training; (2) those who had more than 30 cases of previous experience in ultrasound operation; (3) those who withdrew for more than 2 weeks during the training period.

2.2. Method

In the control group, the traditional teaching mode was adopted, with the body surface anatomical landmark positioning method as the main line, the teacher taught the blind puncture operation through demonstration, and the students practiced repeatedly on the simulation model to find "abnormal sensation", the theory course was mainly taught by classical anatomical atlas, and the clinical observation was arranged every two weeks, without involving the systematic training of ultrasound equipment.

Observation group: The trinity teaching system of "model training-theoretical teaching-real person practice" was implemented. In the first stage (the first three months), the puncture training of six common blocking paths, such as interscalene brachial plexus, femoral nerve and sciatic nerve, was completed on the ultrasound simulation model. The trainees were required to complete the needle insertion under the ultrasound in-plane imaging technology, and the teacher corrected the needle insertion angle and depth in real time. In the second stage (4 to 9 months), combined with the flipped classroom mode, the theory preview was completed through online video before class, and the clinical cases were analyzed in the form of group discussion, focusing on the identification points of nerves, blood vessels, and fascia in ultrasound images, and the practical examination was organized weekly. In the third stage (10 to 18 months), under the supervision of the instructor, the real-person ultrasound-guided nerve block operation was completed, from various approaches of TAP (transversus abdominis plane block) to paravertebral block step by step. After each operation, the patient was reviewed and summarized. At the same time, the patient participated in daily VPU (virtual pain ward) rounds, and the ERAS (accelerated rehabilitation surgery) concept was run through the whole process.

2.3. Observation index

(1) Examination results of operation skills: With the help of a unified standardized scoring table, three physicians with the title of associate senior or above carried out blind scoring, with a total score of 100 points, covering puncture accuracy (30 points), drug diffusion observation ability (25 points), aseptic operation standardization (25 points), and emergency handling ability (20 points). A score of ≥ 85 is judged as excellent, a score of 60 to 84 is judged as qualified, and a score of < 60 is judged as unqualified.

(2) Complication identification accuracy: self-compiled situational test papers covering 12 common complications such as nerve injury, vascular puncture by mistake, local anesthetic poisoning, pneumothorax, etc., with 5 points for a single question, a total of 60 points, and a score ≥ 48 points as a standard.

(3) Success rate of the first puncture: The proportion of the first needle reaching the target nerve was recorded in the real clinical operation, and the position of the needle tip was confirmed by ultrasound image as the gold standard.

2.4. Statistical analysis

The data involved in this study were processed by SPSS 23.0 software. The data of x^2 and t tests were count and measurement data, and the count and measurement data were also processed by (%) and (Mean ± SD) means. When the difference meets the statistical condition, $P < 0.05$.

3. Results

3.1. Comparison of examination results of operation skills between the two groups

The operation skill examination results of the observation group were better than those of the control group ($P < 0.05$), as shown in **Table 1**.

Table 1. Comparison of examination results of operation skills between the two groups of trained physicians (Mean ± SD, minutes)

Group	Number of cases	**Puncture accuracy**	**Drug diffusion observation**	**Sterile Operation Specification**	**Emergency handling capability**	**Total score**
Observation group	40	27.35±1.82	23.10±1.47	23.80±1.20	18.65±1.30	92.90±4.15
Control group	40	22.40±2.15	18.75±1.88	20.30±1.61	15.20±1.72	76.65±5.84
t-value	-	11.282	12.036	10.561	9.726	11.652
P value	-	<0.05	<0.05	<0.05	<0.05	<0.05

3.2. Comparison of complication identification accuracy between the two groups

The accuracy of complication identification in the observation group was higher ($P < 0.05$), as shown in

Table 2.

Table 2. Comparison of complication recognition accuracy between the two groups of training physicians (Mean ± SD, minutes)

Group	Number of cases	Identification of nerve injury	Vascular mispuncture identification	Identification of local anesthetic poisoning	Identification of pneumothorax	Identification of other complications	Total score
Observation group	40	4.65±0.48	4.70±0.45	4.55±0.50	4.80±0.40	38.71±2.11	55.20±2.85
Control group	40	3.20±0.72	3.45±0.68	3.10±0.82	3.60±0.65	27.25±2.93	39.35±4.73
t-value	-	11.08	10.95	10.12	10.38	16.837	15.247
P value	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

3.3. Comparison of the first puncture success rate between the two groups

The success rate of the first puncture in the observation group was higher ($P < 0.05$), as shown in **Table 3**.

Table 3. Comparison of the success rate of the first puncture between the two groups (cases, %)

Group	Number of cases	Successful first puncture	Failure of the first puncture
Observation group	40	37(92.50)	3(7.50)
Control group	40	27(67.50)	13(32.50)
x^2 value	-	6.315	6.315
P value	-	<0.05	<0.05

4. Discussion

As the core means of anesthesia and pain medicine, the teaching quality of nerve block technology is directly related to the future clinical competence of trained physicians [5]. The traditional teaching mode has long relied on the experience transmission of "master with apprentice." In the absence of intuitive image feedback, students can only judge the position of the needle tip by hand feeling and body feeling. This kind of "closed-eye archery" training is not only inefficient, but also buries potential safety hazards [6]. Data from the Mayo Atlas of Regional Anesthesia and Ultrasound-Guided Nerve Blocks have already revealed that although the incidence of serious complications associated with peripheral nerve blocks is only 0.04%, once nerve damage occurs, patients may face months or even permanent dysfunction [7]. However, due to the lack of real-time visualization in the traditional blind puncture method, puncture needle injury and local anesthetic toxicity are recognized as the two main causes of neurological complications, which fundamentally illustrates the necessity of teaching reform [8].

The introduction of ultrasound-guided technology is essentially a paradigm shift from "experience-dependent" to "image-driven" anesthesia operation. High-frequency ultrasound can clearly present the cross-sectional and longitudinal sections of the target nerve, while displaying key structures such as peripheral blood vessels, muscles, and bones. The puncture needle can be seen in the whole process under the ultrasound in-plane imaging technology, and the direction and depth of the needle can be adjusted at any time. The process of drug diffusion can also be observed in real time, which means that the training doctor can establish the operation logic of "what you see is what you get" in the learning stage [9–10]. In this study, the three-stage progressive mode of "model training-theory teaching-real person practice" adopted by the observation group is based on the mature experience of many training bases in China, such as the virtual pain ward (VPU) management system constructed by the Department of Anesthesia and Perioperative Medicine of Zhengzhou Central Hospital Affiliated to Zhengzhou University. As well as the trinity teaching system of "model training, theory teaching and real person practice", all confirm the remarkable effect of this mode in shortening the learning curve.

The results showed that the total score of operation skills in the observation group was much higher than that in the control group ($P < 0.05$), especially in the observation ability of drug diffusion, which was closely related to the training characteristics that students could directly see the diffusion of liquid medicine along the nerve sheath under the guidance of ultrasound, which was totally dependent on the traditional teaching. Students are always in the state of "knowing what it is and not knowing why it is". In terms of complication recognition accuracy, the total score of the observation group was higher than that of the control group ($P < 0.05$), which reflected that the visualization training allowed the trained doctors to repeatedly witness the ultrasound manifestations of dangerous scenes such as blood vessel puncture and nerve injury in the simulation stage, and formed a profound visual memory. The comparison of the success rate of the first puncture between 92.50% and 67.50% has put the teaching effect on the most clinically significant endpoint index.

It is worth noting that ultrasound-guided teaching is not a simple superposition of technology, but the deep penetration of the ERAS concept in anesthesia teaching. The students in the observation group participated in the individualized adjustment of the analgesia program in VPU rounds, and communicated directly with patients in daily education. These experiences make them grow from simple "operators" to "decision-makers" of perioperative pain management, which is the core goal of modern anesthesia training. Of course, the sample size of this study is limited, and it is a single-center study, which still needs to be further verified by multi-center large sample data in the future, but it is certain that ultrasound-guided nerve block technology is no longer an "elective course" in anesthesia teaching, but a "compulsory course" that every trained physician must master.

5. Conclusion

To sum up, the integration of ultrasound-guided nerve block technology into the training teaching system can effectively improve the operation accuracy and safety awareness of training physicians, which is worthy of vigorous promotion and application in anesthesia teaching.

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Disclosure statement

The authors declare no conflict of interest.

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