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Application of Ultrasound-Guided Nerve Block Anesthesia in the Teaching of Otolaryngology Head and Neck Surgery

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Abstract: *Objective:* To explore the application value of ultrasound-guided nerve block anesthesia in the teaching of otolaryngology head and neck surgery, and to provide evidence-based support for optimizing the anesthesia teaching model for standardized training residents and shortening the learning curve. *Methods:* A total of 65 standardized training residents participating in the anesthesia teaching for otolaryngology head and neck surgery at our hospital from September 2024 to September 2025 were selected and divided into an observation group (33 residents) and a control group (32 residents) using a random number table method. The observation group implemented an ultrasound-guided nerve block anesthesia teaching model, while the control group adopted a traditional anatomical positioning teaching model. Theoretical assessment scores, operational skill ratings, clinical practice indicators, and teaching satisfaction were compared between the two groups. *Results:* The theoretical assessment scores and operational skill ratings in the observation group were significantly higher than those in the control group (both $P < 0.001$). The anesthesia success rate and first-attempt puncture success rate in the observation group were higher than those in the control group, while the complication rate and average operation time were lower (all $P < 0.05$). The overall teaching satisfaction in the observation group was significantly higher than that in the control group ($P = 0.014 < 0.05$). *Conclusion:* The ultrasound-guided teaching model can enhance the anesthetic theory and operational skills of standardized training students through visualized training, improve the safety and efficiency of clinical practice, and receive high recognition from students, making it worthy of promotion in the anesthetic teaching of otolaryngology head and neck surgery.
Keywords: Ultrasound guidance; Nerve block anesthesia; Otolaryngology head and neck surgery; Medical education; Standardized training students

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1. Introduction

The surgical area of otolaryngology head and neck surgery concentrates critical anatomical structures such as the skull base and airway, with a dense interweaving of nerves and blood vessels. The precision of anesthetic procedures is directly related to surgical safety and patient prognosis. Nerve block anesthesia has become one of the preferred anesthetic methods for routine surgeries such as tonsillectomy and thyroid adenoma excision due to its advantages of minimal interference with the respiratory and circulatory systems and long-lasting postoperative analgesia[1]. However, traditional nerve block relies on anatomical landmarks for positioning, which is a "blind puncture" operation[2]. It is challenging to perform, requiring standardized training students to accumulate experience over a long period to master it. Initial operations are prone to issues such as vascular injury and incomplete block. The development of ultrasound technology has enabled nerve block to transition from "anatomical positioning" to "visualized operation," allowing real-time display of nerves, blood vessels, and the trajectory of the puncture needle, significantly improving operational safety and success rates[3]. However, there is no standardized protocol for systematically integrating ultrasound visualization technology into the anesthetic teaching of otolaryngology head and neck surgery. This study, involving 65 standardized training students, compares the application effects of two teaching models, aiming to provide practical references for optimizing the anesthetic teaching system.

2. Materials and methods

2.1. General information

A total of 65 anesthesia residents from the Department of Otorhinolaryngology Head and Neck Surgery in the hospital, who were undergoing standardized training in anesthesia from September 2024 to September 2025, were selected. \

2.1.1. Inclusion criteria were as follows

(1) Possession of a medical bachelor's degree or higher; (2) Lack of experience in nerve block procedures; (3) Voluntary participation in this study.

2.1.2. Exclusion criteria included

(1) Prior foundation in ultrasound operation; (2) Withdrawal from the teaching program midway; (3) Insufficient duration of clinical practice. Participants were randomly assigned to an observation group (33 residents) and a control group (32 residents) using a random number table method. No statistically significant differences were observed in baseline data such as gender, age, and educational background between the two groups ($P > 0.05$), indicating comparability **(Table 1)**.

Table 1. Comparison of general information between the two groups of residents

Group	Gender (Male/Female, n)	Age (years, Mean ± SD)	Education Level (Bachelor/Master, n)
Observation Group (n=33)	19 / 14	24.52 ± 1.41	23 / 10
Control Group (n=32)	18 / 14	24.71 ± 1.38	22 / 10
Statistical Value (χ^2/t)	0.012	0.549	0.007
P-value	0.914	0.585	0.934

2.2. Teaching methods

The control group underwent traditional anatomical localization teaching, with a total of 28 hours of instruction: ① Theoretical teaching (4 hours), where PPT presentations were used to cover topics such as nerve anatomy and block principles in otorhinolaryngology head and neck surgery, supplemented by diagrammatic explanations of puncture positioning; ② Practical training (8 hours), which involved demonstrating puncture angles and depths on a simulator, with residents mimicking the procedures and instructors providing visual error correction; ③ Clinical instruction (16 hours), during which residents observed surgical anesthesia procedures, participated in at least 32 cases, and received primarily verbal guidance.

The observation group adopted an integrated ultrasound-guided teaching model with a total of 34 class hours, incorporating the concept of simulated teaching. ① Theoretical instruction (8 hours): Building on the foundation of the control group, content such as the principles of ultrasound imaging, probe operation protocols, and identification of nerve ultrasound images (e.g., the "honeycomb sign" nerve feature) was added. This was combined with video analysis of five clinical cases to illustrate the corresponding relationships between "image - anatomy - operation". ② Practical training (12 hours): Utilizing portable ultrasound equipment and ultrasound phantom models, a "three-stage training" approach was implemented. In the first stage (4 hours), training focused on ultrasound image acquisition and anatomical identification; the second stage (4 hours) involved simulated visualization exercises for puncture needles; and the third stage (4 hours) consisted of integrated practical operations of "positioning - puncturing - drug injection". Teachers assessed the accuracy of operations in real-time through ultrasound images. ③ Clinical instruction (14 hours): Under the supervision of supervising physicians, students used ultrasound equipment to complete operations, observing the dynamic relationship between nerves and puncture needles in real-time. After each operation, the pathway was optimized through a review of ultrasound images, with students participating in a cumulative total of no fewer than 34 operations.

2.3. Observation indicators

2.3.1. Theory and Skill Assessment

A closed-book theoretical examination (full score: 100 points) was conducted after the teaching period. Three experts with the title of associate chief physician or above evaluated the operational skills using a blinded method (full score: 100 points). The assessment items included typical operations such as cervical plexus nerve block and great auricular nerve block, with scoring dimensions covering positioning accuracy, operational compliance, and awareness of complication prevention.

2.3.2. Clinical practice indicators

Record the clinical operation data of 34 cases (observation group) and 32 cases (control group) independently completed by the trainees, and calculate the anesthesia success rate, first-attempt puncture success rate, complication rate, and average operation time.

2.3.3. Teaching satisfaction

A Likert 5-point scale questionnaire survey was conducted, including 8 items such as the practicality of teaching content, the effectiveness of teaching methods, and the effect of skill improvement. The responses were categorized as very satisfied, generally satisfied, and dissatisfied. Satisfaction rate = (number of very satisfied + number of generally satisfied)/ total number of cases × 100%.

2.4. Statistical methods

Data were analyzed using SPSS 26.0 software. Measurement data were expressed as ($\bar{x}$ ±s), and comparisons between groups were made using the independent samples t-test. Count data were expressed as rates (%), and comparisons between groups were made using the χ^2 test. A P-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of assessment scores between the two groups of trainees

The theoretical assessment scores and operational skill scores of the observation group were significantly higher than those of the control group (both P < 0.001) **(Table 2)**.

Table 2. Comparison of assessment scores between the two groups of trainees ($\bar{x}$ ±s, points)

Group	Theoretical Assessment Score	Clinical Skills Score
Observation Group (n=33)	90.24 ± 3.86	92.11 ± 3.52
Control Group (n=32)	82.15 ± 4.97	84.33 ± 4.28
t-value	7.343	8.015
P-value	<0.001	<0.001

3.2. Comparison of clinical practice outcomes between the two groups of trainees

The anesthesia success rate and the success rate of initial puncture in the observation group were both higher than those in the control group, while the incidence of complications and the average operation duration were both lower in the observation group (all $P < 0.05$) **(Table 3)**.

Table 3. Comparison of clinical practice outcomes between the two groups of trainees

Group	Anesthesia Success	First-Attempt Success	Complications	Mean Procedure Time (min)
Observation Group (n=33)	33 (97.06)	32 (94.12)	1 (2.94)	8.35 ± 1.24
Control Group (n=32)	26 (81.25)	24 (75.0)	8 (25.0)	12.67 ± 1.89
Statistical Value (χ^2/t)	4.763	4.861	4.861	10.928
P-value	0.029	0.028	0.028	<0.001

3.3. Comparison of teaching satisfaction between the two groups of trainees

The overall teaching satisfaction in the observation group was significantly higher than that in the control group ($P = 0.014 < 0.05$) **(Table 4)**.

Table 4. Comparison of teaching satisfaction between the two groups of trainees [cases (%)]

Group	Very Satisfied	Satisfied	Dissatisfied	Overall Satisfaction
Observation Group (n=33)	20 (60.61)	12 (36.36)	1 (3.03)	32 (96.97)
Control Group (n=32)	11 (34.38)	12 (37.50)	9 (28.12)	23 (71.88)
χ^2-value				6.050
P-value				0.014

4. Discussion

The core challenges in anesthesia for otolaryngology, head and neck surgery lie in the complex anatomical structures and the dense distribution of nerves and blood vessels[4]. Traditional anatomical localization methods rely on trainees' memory of anatomical knowledge and accumulation of clinical experience, resulting in a long learning curve. Moreover, these methods are prone to positioning errors, which can lead to suboptimal anesthesia effects or complications. With the widespread adoption of ultrasound technology, ultrasound-guided nerve block anesthesia has achieved a transition from "blind puncture" to "visualization," providing new technical support for anesthesia teaching[5].

This study reveals that the observation group significantly outperformed the control group in both theoretical and practical scores, confirming the advantages of ultrasound visualization in teaching. The neuroanatomy of otolaryngology-head and neck surgery is characterized by its latent and concealed nature, making it difficult for traditional teaching methods to fully convey abstract anatomical relationships through atlases alone. As a result, learners often experience a disconnect between anatomical memory and practical operation[6]. In contrast, ultrasound-guided teaching utilizes "image-anatomy" correspondence training to visually present the "honeycomb-like" echo of the cervical plexus nerves and the "anechoic" features of blood vessels, thereby helping learners establish spatial orientation thinking. As highlighted in simulation teaching research, visual training can transform abstract knowledge into concrete cognition, significantly shortening the learning curve[7]. Additionally, the observation group demonstrated superior performance in operational skill assessments, benefiting from a stepwise training approach that combines "ultrasound phantom models with clinical practice." This approach allows learners to repeatedly practice hand-eye coordination in a risk-free environment, gradually mastering the technique of matching the puncture needle with the ultrasound plane.

Clinical practice data shows that the observation group achieved a 97.06% success rate in anesthesia and a mere 2.94% complication rate. This is because traditional anatomical positioning relies on "surface landmarks-depth estimation," which is prone to puncture deviation due to individual anatomical variations, such as the potential for inadvertent puncture of the vertebral artery during cervical plexus block, leading to hematoma formation. In contrast, ultrasound guidance enables real-time avoidance of critical structures such as blood vessels and nerves, ensuring precise injection of local anesthetics into the nerve sheath. This not only enhances the blocking effect but also reduces the risk of injury[8]. The average operation time in the observation group was significantly shorter than that in the control group. This was because ultrasound localization reduced the step of "repeated probing," and the success rate of the first puncture reached as high as 94.12%, meeting the requirements for improving clinical efficiency. Notably, one complication in the observation group was a minor hematoma caused by insufficient operational experience, which was alleviated after immediate identification by ultrasound and compression for hemostasis, further demonstrating the educational value of ultrasound in the prevention and management of complications.

The satisfaction survey revealed that 96.97% of the students in the observation group endorsed this teaching model, significantly higher than that in the control group. In traditional teaching, students often experience operational anxiety due to the inability to "visualize anatomical structures," which limits their learning enthusiasm.

In contrast, ultrasound-guided teaching provides real-time image feedback, enabling students to clearly perceive the effects of their operations and enhancing their learning confidence[9]. Additionally, the simulation training model adopted by the observation group offered students a low-pressure learning environment where they could correct errors through repeated practice, avoiding compromising patient safety due to operational mistakes[10]. This "safe trial-and-error" mechanism significantly boosted student participation. As indicated by research on gamified teaching, immediate feedback and safe practice can stimulate intrinsic learning motivation, which is the core reason why the proportion of "very satisfied" students in the observation group was significantly higher than that in the control group.

There are two limitations in this study: First, the sample size remains limited, and trainees from different institutions were not included; second, the follow-up period was relatively short, and the skill retention of trainees after one year was not evaluated. In the future, the sample size could be expanded to conduct multi-center studies, virtual reality technology could be integrated to optimize simulation training modules, and a long-term follow-up mechanism could be established to further validate the long-term effects of ultrasound-guided teaching.

In conclusion, the ultrasound-guided teaching model can enhance the anesthesia theory and operational skills of trainees through visual training, improve the safety and efficiency of clinical practice, and is highly recognized by trainees, making it worthy of promotion in the anesthesia teaching of otolaryngology head and neck surgery.

Disclosure statement

The author declares no conflict of interest.

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