Asploro Journal of Biomedical and Clinical Case Reports
(ISSN: 2582-0370)
Review Article
DOI: https://doi.org/10.36502/2022/ASJBCCR.6273

A Review of Current Situation of Ultrasound-Guided Nerve Block in Anesthesiologists' Skill Training

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Received date: 18 July 2022; **Accepted date**: 12 August 2022; **Published date**: 17 August 2022

Citation: Yang X, Chen C. A Review of Current Situation of Ultrasound-Guided Nerve Block in Anesthesiologists' Skill Training. Asp Biomed Clin Case Rep. 2022 Aug 17;5(2):105-12.

Abstract

In recent years, ultrasound-guided neuronal block had gradually become an indispensable skill for anesthesiologists in clinical work. Its visualization in operation makes the puncture more accuracy and anesthesia more effect, which effectively reduced the occurrence of related complications. However, it is not easy to master the ultrasound-guided neuronal block skill. Since the complexity of the knowledge system of ultrasound-guided nerve block, it makes the learning process cost more and learning period longer. So that the related teaching and training are facing great challenges. With the continuous innovation of teaching and training concepts and methods, a large number of teaching and training methods related to nerve block ultrasound-guided neuronal block had emerged, but there was still lacking a standardized, scientific and systematic teaching and training system in this field of medical education. Our review systematically summarized the current situation of ultrasound-guided nerve block training and reported the emergence of new forms and new methods in each link of teaching and training. We aimed to provide a sufficient and powerful reference for the reform and optimization of teaching system in this field.

Keywords

Ultrasound-Guided Nerve Block Technique, Skill Teaching, Anesthesiologists' Medical Education

Introduction

Ultrasound-guided nerve block was a new multidisciplinary technique combining anesthesia, pain, anatomy and ultrasound. It was also an important part of multi-mode analgesia strategy [1]. Compared with the traditional blind puncture method, the operator did not rely solely on the anatomical location of the body surface to locate the target nerve. Instead, by recognizing the image of the anatomical structure near the puncture target area that was digitally processed by ultrasound, the local anesthetic was injected into the target location accurately [2]. In addition, when using ultrasonic technology, the operator can also observe whether anesthesia was fully diffused around the target nerve in real time, avoiding the problem of excessive injection of anesthetic drugs by traditional puncture methods to ensure the anesthetic effect and reducing the occurrence of related complications. However, we can also see that the emergence of ultrasound assisted technology had brought great challenges to the teaching and training of anesthesiologists in nerve block. A qualified operator

should be not only familiar with the basic knowledge of ultrasound and the usage of ultrasonic instruments, but also skilled in image optimization techniques and hand-eye coordination skills, which made the longer training times and higher learning cost.

At present, a scientific, standardized and systematic teaching and training system about this technology had not been established. Based on this, from the perspective of a young anesthesiologist who needed to be skilled in ultrasound-guided nerve block operations, our review first elaborated and summarized the current training situation of ultrasound-guided nerve block from the aspects of training content and mode systematically, and also reported new teaching modes and method emerging in each module, providing sufficient and powerful reference for the future teaching mode and system reform in this field.

Overview of Ultrasound-Guided Nerve Block Training

In recent years, the demand for ultrasound-guided local block was increasing in the preoperative anesthesia management, but paradoxically, the popularization of this technique has been greatly hindered. To become proficient in ultrasound-guided nerve block required extensive training and clinical practice. In the case of specialist ultrasound training, for example, the American Academy of Family Medicine recommended that students practice 150 to 300 routine ultrasound scans and 5 to 10 scans for invasive ultrason-guided procedures based on emergency situations [3]. It seemed that ultrasound specialists will take a lot of training and clinical practice to master this skill, let alone younger anesthesiologists who needed to perform nerve block. In fact, the content of skill training received by anesthesiology residents was uneven, and the training on nerve block was also obviously insufficient. Baydar et al. found that training coverage for lumbar anesthesia, epidural and peripheral nerve blocks was 98%, 92.5% and 62.3%, respectively, from the training base for anesthesiologists in Turkey [4]. Even though some hospitals had carried out ultrasound-guided nerve block, due to the lack of mature teaching guidance and standardized clinical training, the final learning effect of anesthesiologists may be patchy, which may lead to their uneven effects of intraoperative nerve block with different proficiency levels. Therefore, due to the differences in faculty, teaching philosophy, clinical resources and policies, the level of ultrasound-guided nerve block and the quality of relevant teaching and training of anesthesiologists in various hospitals were uneven, which seriously hindered the promotion of this technology. So the teaching and training of ultrasound-guided nerve block had been a great challenge in the field of anesthesia education.

The Contents of Ultrasound-Guided Nerve Block Teaching and Training

According to the guidelines, the teaching and training contents of ultrasound-guided nerve block mainly included three parts: theoretical teaching, simulated puncture and clinical thinking training. This section elaborates on three aspects of the training content:

Theoretical Teaching:

The theoretical teaching content included ultrasonic principle, ultrasonic related anatomy, pharmacology.

Ultrasonic Principle:

For a novice anesthesiologist, only by fully mastering the principles of ultrasound imaging and the imaging characteristics of different tissues in the human body under ultrasound can the corresponding structures be identified in the process of puncture to target area [5]. Therefore, it was necessary to learn the relevant theoretical knowledge of ultrasound before operation. The traditional mode of ultrasonic theory teaching was tutor lecture and student reception. The knowledge contained in courses can only be memorized by rote in a short time. Due to the lack of experience in operating ultrasonic instruments, students will lack specific impression of ultrasonic principle, leading to a lot of time to understand and get familiar with the operation in subsequent practice. In view of such problems, Wang et al [6] proposed that systematic courses should be established to teach ultrasonic guidance technology involving the function and selection of ultrasonic probe, basic ultrasonic physics, ultrasonic imaging principles in clinical practice, practical scanning technology and other

fields, so that students can have a more comprehensive understanding of ultrasonic related technology after training. In addition to the curriculum, excellent teaching methods can stimulate students' potential learning motivation and thus greatly improve the teaching effect and quality. The introduction and promotion of Peyton's four-step teaching method in 1998 made the student-centered, teacher-guided and problem-oriented interactive feedback learning model gradually accepted in the field of pedagogy. This method can greatly stimulate students' interest and creativity and shorten learning time through the process of students' independent operation, repeated demonstration and step disassembly by tutors [7]. Although Peyton and its improved teaching method had been widely used in the teaching and training courses of first-aid resuscitation and other disciplines [8], the comparison of its teaching effect with traditional methods in ultrasound teaching had been controversial. In 2019, Gradl-Dietsch compared the application of Peyton method and traditional teaching methods in musculoskeletal ultrasound courses for undergraduate medical students and found no significant difference in teaching effects between the two methods [9]. However, Christopher found in his later studies that Peyton method could greatly improve the attitude and motivation of non-ultrasound students towards learning ultrasound and thus improve the learning effect [10].

Ultrasonic Related Anatomy:

Local and sectional anatomy was the basis for learning ultrasound-guided nerve block. On the one hand, local anatomical knowledge can help the operator to know the anatomical structure of blood vessels, bones, muscles and adjacent tissues around the target area, so as to avoid damage in the puncture process. On the other hand, the knowledge of sectional anatomy enabled the operator to accurately identify the anatomical plane of the puncture needle with the help of ultrasonic imaging and make the correct choice of subsequent operation. Therefore, teaching basic knowledge of ultrasonic-related anatomy purposefully can greatly improve students' understanding of clinical practice of ultrasonic-related skills.

Traditional anatomical knowledge presented by words or pictures cannot make anesthesiologist trainees feel the hierarchical sense among structures in the target area of puncture. On the one hand, ultrasonic operation not only had a fixed image plane, but also needed to change the image plane flexibly according to the situation in actual operation. The angle of needle insertion was different, and the plane structure of the field of vision presented under the ultrasound image was also different. These complex clinical situations cannot be demonstrated by text description and atlas. On the other hand, in the face of complex vascular neural structure out of shape, many students often did not know how to comb, screen, memory related anatomic structures, leading to their fear of difficulty in clinical operation. In recent years, 3D printing, problem based learning (PBL), flipped classroom and other Learning tools and classroom teaching modes to help understand anatomy-related structures had been emerging [11-13]. These teaching "sharp tools" had also been proved by studies to help students better understand the three-dimensional anatomical structure in the puncture process. At the same time, many scholars also suggested that the practice part in basic ultrasound anatomy courses should be increased or ultrasound simulators should be used. Besides, the simultaneous explanation of the anatomical structures presented by ultrasound in the operation can help students deepen their understanding of the imaging of human anatomical structures under ultrasound [14-16].

Pharmacology:

The main purpose of the pharmacology course was to enable students to understand the mechanism and principle of action of nerve blocking drugs, so that they can correctly choose drugs and compatibility to prevent adverse events. However, due to the complex and abstract knowledge of pharmacology and the limited teaching model, students had a difficulty in learning pharmacology. Chen et al [17] discussed the application of "guided teaching" in pharmacology teaching. "Guided teaching" mainly included teaching in the form of problem and case - oriented. The teaching process was as follows: The teacher gave brief information about the case and raises questions. The students studied after class in the form of a team to set learning goals for the problem, and then solved the

problem through group discussion. The teacher provided supplementary information and raised new questions according to the development of team discussion. New questions will lead students back into the cycle of "ask questions - self research - discussion - solve problems - ask new questions". Their study results showed that compared with the traditional teaching mode, the "guided teaching" method can significantly improve the teaching effect, stimulating the students' passion for exploration and the overall academic performances of pharmacological theory were better.

Simulated Puncture:

Even if a beginner had a complete body of theoretical knowledge after adequate learning, it did not guarantee that he can successfully perform ultrasound-guided nerve block. Daily repeated training was the prerequisite for safe and successful operation. In a study of brachial plexus block anesthesia, perioperative complications such as slow heart rate, headache, and nausea occurred in 8 to 10% of patients and may be related to the block procedure or medication [18]. Another experiment using the learning curve of ultrasound-guided nerve block as the research subject showed that the operation confidence of residents increased with the increase of the number of operations, and the error rate and the incidence of post-puncture related complications also decreased [19]. Therefore, in order to minimize the adverse events caused by nerve block, a certain amount of simulation training before practice was necessary.

Practice also needed to follow a clear, scientific training purpose or principle. After reviewing a large amount of literature, John Vozenilek et al [20] suggested that the training of medical clinical skills should follow the teaching principle of "repeated simulation training for proficiency". Hand-eye coordination ability was the core point of simulation training [21], and it was the most difficult to grasp the process of visual tracking needle and make the correct processing during operation, so young anesthesiologists needed to conduct hand-eye coordination ability training repeatedly on the model. At present, the materials commonly used to make puncture model mainly included gelatin, blue glue and tofu. Each of these materials had its own advantages and disadvantages. The puncture training mold made of blue glue was convenient to use, reusable, had large operating area and clear image in ultrasonic scan. However, it was expensive and the operable puncture site was relatively single, which cannot simulate multiple operation scenarios [22]. Tofu models were easy to use and had low production cost. They can also be embedded with various objects to simulate various puncture environments, but the models were fragile and not durable [23]. Gelatin model had the advantages of blue glue and tofu material model, but it also had poor bearing capacity and left stitches after each training [24]. Therefore, the choice of puncture model should be made comprehensively according to the funds and training objectives of educational institutions.

Clinical Thinking Training:

Since the individual differences in patients, a variety of uncertain events may occur in the puncture process. And these uncertain scenarios may interfere with the operator's judgment and thus affect the entire process of the operation. Only theoretical knowledge and model simulation puncture training cannot make young doctors had good clinical strain ability. For example, what should the anesthesiologist do if the blocking effect is insufficient for surgery after an operation? For experienced anesthesiologists, they will plan how to operate each step before operation and communicate with the surgeon and the patient about the treatment and remedy plan after failure of block before operation. However, this ability to deal with clinical problems needed to be trained by clinical thinking courses for beginners.

The intensive training of clinical thinking not only required the accumulation of a large number of practical experiences, but also depended on the use of new teaching forms and technologies to simulate and replay the real events in practice to broaden the clinical thinking and deepen the impression of clinical operation. A study in 2016 showed that the clinical analytical ability assessment results of ultrasound-guided nerve block teaching for anesthesiology residents using simulation training combined with PBL teaching method were much better than those of the

traditional training and teaching group [25]. Zhang et al. also confirmed that the application of medical video combined with PBL teaching method can effectively improve students' ability to analyze clinical problems during the nerve block operation [26].

Training Model of Nerve Block Under Ultrasound Guidance

A mature training mode was the essential link connecting the whole training content and the premise of ensuring the efficient and scientific training process. It included four steps: determining the needs, making plans, implementing plans and evaluating the results. After determining the training needs and plans, how to implement and evaluate the plans was an important part of training. The traditional ultrasound-guided neural block training mode was a teacher-led passive mode in implementation planning and evaluation steps was as follows: "theoretical learning -- demonstration led by teachers -- a little clinical practice". This teaching mode existed many problems, such as the lack of two-way communication feedback between teachers and students, the inability of students to think and make decisions independently in the learning process, the lack of sufficient clinical case study and targeted simulation operation training, and the inability of students to get the "reality" of clinical practice from teaching.

In recent years, teachers were constantly exploring models that led students to have a "sense of participation" during the process of teaching and training. Immersive teaching was a "student-centered" teaching mode [27], which constructed knowledge into richer realistic specific situations by using simulated environment or simulation teaching software, so that students can fully immerse themselves in "anesthesiologist" roles and take the initiative to practice. Studies had shown that the use of immersive teaching training mode in the skills training of ultrasound, surgery and obstetrics can improve students' interest in learning and achieve better learning effects [27-29]. Immersive teaching optimized the implementation of the plan, while PDCA (plan-do-check-act) management method combined with PBL, CBL (Case Based Learning) or other multi-mode training system not only optimizing the implementation of the plan, but also further strengthened the feedback evaluation mechanism. As a bystander, teachers not only needed to guide, review and summarize in the training process of PBL, CBL and other new teaching forms, but also collect students' feedback in each training course through questionnaires, spot checks and interviews, so that they can timely adjust their teaching and training programs after each training. The multi-teaching mode combined training mode with PDCA as the core had achieved excellent teaching and training effects in the standardized training of residents in the departments of ultrasound and medical laboratory [30,31].

Therefore, we believed that the student-centered teaching mode with the help of standardized and scientific feedback system of management is a new direction for the future development of ultrasound-guided neural block teaching and training.

Discussion

Although medical education and training institutions around the world were constantly trying new teaching and training models to improve teaching quality and training effects, each clinical operation skill training and promotion has its own difficulties to be targeted. We believe that the following core problems still exist in the current ultrasound-guided nerve block training:

A. Insufficient number of teachers: due to busy work, experienced anesthesiologists spare little time to teach students.
B. Teaching quality cannot be guaranteed: being able to operate did not mean being able to teach. At present, there was still a lack of unified standard training of teaching skills for teachers.
C. There was little connection between basic theory, training and clinical practice. Although teaching process combining basic theoretical knowledge and simulated operations were performed in many teaching hospitals and medical skills training bases, these courses were often unable to combine sufficient clinical cases to conduct drills and explanations in the teaching of nerve block under ultrasound since the lack of teaching experience or poor coordination between department support policies and teaching

courses. Young anesthesiologists were still stuck in books and simulated people and may be helpless in the face of complex clinical changes after training.

In view of the development trend of ultrasound-guided nerve block teaching, we advised that in order to promote and teach this clinical skill, the following improvements and measures should be taken:

A. Emphasize the teaching of ultrasound technology, local anatomy and other basic knowledge.
B. While making full use of teaching models such as puncture simulation flexibly, the teachers should also conduct review and targeted training after completion to deepen students' understanding of this skill.
C. Make full use of new teaching forms represented by PBL and flipped classroom during teaching and training to stimulate students' subjective initiative in learning and improve teaching effects.
D. Establish a sound teaching feedback system. The interactive feedback between teachers, students and students should be emphasized in the teaching and training process, and the opinions of students and teachers should be fully investigated after the training, then targeted adjustments should be made to the follow-up training plan in time.

To sum up, how to establish a standardized, scientific and systematic teaching and training system for nerve block under the guidance of ultrasound still needs to be considered and explored by anesthesia teachers in the future.

Funding and Acknowledgements

All authors declare that there was no financial support that have the potential to be deemed as a source of competing interest in relations to our submitted manuscript.

Conflict of Interest

The authors have read and approved the final version of the manuscript. The authors have no conflicts of interest to declare.

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