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Application of the "Three Threes" Method in Clinical Teaching of Internal Jugular Vein Puncture

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Abstract

Objective: To clarify the role of the "Three Threes" method in clinical teaching of internal jugular vein puncture and explore improvements in teaching methods. **Methods:** A doctor was assigned to the induction room of the Second Affiliated Hospital of Naval Medical University (Shanghai Changzheng Hospital) for two months. The time required for catheterization, the first puncture success rate, and occurrence of puncture-related complications were compared before and after learning the "Three Threes" method. **Results:** Using the "Three Threes" method reduced the catheterization time by 43%, increased the first puncture success rate by 17%, and led to fewer puncture-related complications. **Conclusion:** The application of the "Three Threes" method not only improves the success rate of internal jugular vein puncture but also reduces complications, making it easier for students to master the technique.

Keywords

Internal Jugular vein Puncture, "Three Threes" Method, Deep Vein Catheterization, Teaching Practice

1. Introduction

Deep vein catheterization is a fundamental surgical skill widely employed in cardiac surgery intensive care units. It plays a crucial role in the treatment of critically ill patients for a young cardiothoracic specialist, mastering the technique of deep vein catheterization is not an easy task. During the one-year internship and three-year standardized surgical training, rotations in cardiothoracic surgery, emergency and critical care, and anesthesiology may offer limited opportunities

for hands-on experience. Even with abundant theoretical knowledge and exposure to standardized instructional videos, young doctors often find it challenging to execute the procedure flawlessly when confronted with diverse patient scenarios. In the context of performing deep vein catheterization in the cardiothoracic surgery ward, where patients may exhibit unstable vital signs while remaining conscious, the stakes are high. Failure in the procedure could lead to severe complications jeopardizing the patient's life and impacting subsequent treatments. The transformation of a novice without deep vein catheterization experience into an experienced practitioner poses a significant teaching challenge in the training of young cardiothoracic surgeons. Hence, providing systematic and efficient training becomes crucial in facilitating their journey towards becoming proficient physicians.

This article delves into the learning curve of a surgical doctor in mastering deep vein catheterization, emphasizing the "three-three method". This method involves initially selecting the Sedillot triangle in the neck, adjusting the needle insertion angle to 30 degrees, and ensuring the probe's depth does not exceed 3 cm. In teaching, a comprehensive approach that combines traditional surface anatomy markers with the "three-three" method is employed to explore effective ways of cultivating students' skills in deep vein catheterization.

2. Experimental Subject

According to the standardized training requirements for resident doctors in Shanghai, the specialty of surgery does not mandate proficiency in deep vein puncture techniques. In this experiment, a young doctor with a standardized training certificate in Shanghai, possessing a foundational surgical skillset but no prior experience in deep vein puncture, undergoes theoretical training first. The theoretical course covers key elements such as the anatomy of the internal jugular vein, selection of puncture points, needle angle, and depth. The trainee must grasp the significance of deep vein puncture and its applications in different contexts, laying a solid foundation for practical skills.

Subsequently, utilizing advanced simulation techniques, realistic clinical scenarios are created. Simulation training helps translate theoretical knowledge into practical skills. Using simulated human models in a lifelike surgical environment, the trainee practices deep vein puncture, building confidence and proficiency for real patient scenarios. Through simulated assessments, the trainee's mastery of the skill is evaluated. Timely guidance and correction are provided for any issues that may arise during the simulation, assisting the trainee in continuous improvement.

After completing simulation training, from February to March 2023, the trainee will be assigned to the Induction Room of the Anesthesiology Department at the Second Affiliated Hospital of Naval Medical University of PLA (Changzheng Hospital, Shanghai). Here, they will perform real deep vein puncture procedures after obtaining informed consent from patients.

As shown in Figure 1, the IJV is located within the Sedillot triangle in the neck, approximately 1 cm below the skin's surface. The standard procedure involves positioning the patient in a head-down, feet-up tilt with the head turned to the left at an angle of about 30 degrees. The puncture site is identified by first palpating the pulsation of the carotid artery and selecting a point 0.5 cm to the outer side of arterial pulsation in the upper part of the Sedillot triangle. Standard precautions, including draping, wearing sterile clothing, and sterile gloves, are followed. A small needle (22-23G) is used for a trial puncture along the selected point, maintaining an angle of 30 - 45 degrees in the direction of the ipsilateral nipple. The subsequent steps involve confirming the needle's entry into the vein through slight negative pressure on the syringe, observing for blood reflux, and adjusting the needle accordingly. The procedure includes fixing the needle, introducing a guide wire, and confirming smooth insertion. The guide wire is not inserted beyond 20 cm to avoid cardiac stimulation. Subsequent steps involve using a dilator, inserting the deep vein catheter along the guide wire, ensuring blood withdrawal through the syringe, and confirming successful catheter placement. The catheter is typically inserted to a depth of 12-13 cm, sealed with heparinized saline, and sutured in place.

3. Experimental Procedures

Following the conclusion of simulation training, a young doctor is scheduled for a 2-month practical training in the anesthesiology department. For the first month, they refrain from using the "three-three" method in catheterization, and for the subsequent month, they employ the "three-three" method during actual operations. This method involves selecting the Sedillot triangle in the neck, adjusting the needle insertion angle to 30 degrees, and ensuring the probe's depth does not exceed 3 cm. This approach is systematic and concise.

Ensuring 2 - 4 deep vein catheterizations are performed each working day,

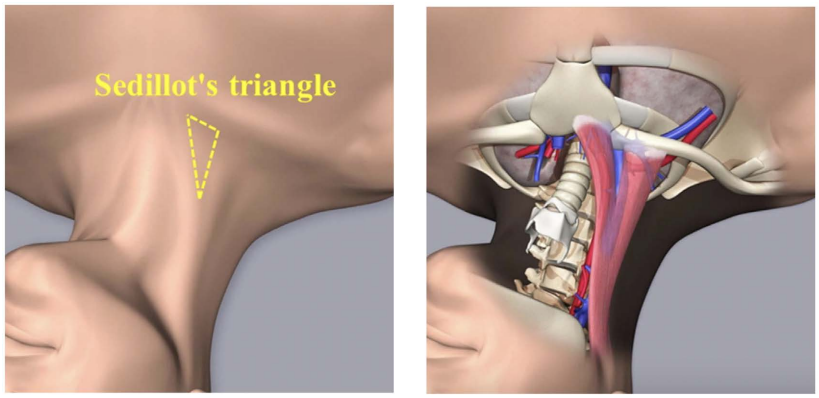

Figure 1. Sedillot's triangle [1] comprises the sternocleidomastoid muscle and the clavicle. The triangle can be visually approximated or palpated. In most cases, the internal jugular vein is located within the triangle. Furthermore, insertion and catheterization within the triangle have the benefit of easy handling of the needle and dilator because of the thin tissue layer between the skin surface and the vein.

recording the catheterization time, assessing whether aseptic principles are maintained during the operation, documenting the first-time success rate, and monitoring the occurrence of catheterization-related complications are vital aspects. Regular evaluations and feedback are critical steps in cultivating students' proficiency in deep vein catheterization. Analyzing the reasons for each unsuccessful catheterization, forming evaluative content, and comparing the mastery of deep vein catheterization skills in February and March, with a monthly timeframe as the assessment point, are integral components of the training program.

3.1. Evaluation Criteria

Puncture placement time was defined as the duration from skin disinfection to securing the catheter. The first puncture success rate represented the ratio of successfully performed initial punctures to the total number of patients punctured within a month, termed the first puncture success rate. Complications related to puncture include pneumothorax, hematoma, accidental injury to the artery, abnormal sensation of the brachial plexus, accidental insertion into the external jugular vein, and arrhythmia caused by excessive guide wire insertion in the patient.

Pneumothorax refers to the situation in which, during the process of internal jugular vein puncture, inadvertent puncture of adjacent tissues may lead to pneumothorax, causing compression of the lungs due to air entering the pleural cavity. Hematoma is defined as the potential occurrence of bleeding during deep vein puncture, resulting in the formation of a local hematoma. This could be due to damage to the vessel wall or improper procedural techniques. Arterial injury implies the accidental puncture of nearby arteries during the puncture process, potentially resulting in arterial bleeding and an increased risk of hematoma. Sensory abnormalities of the brachial plexus nerves signify the possibility of inadvertent injury to the brachial plexus nerves during the puncture process, leading to abnormal sensations or pain in the upper limbs. Misplacement into the external jugular vein refers to the occasional error of introducing the catheter into the external jugular vein instead of the internal jugular vein during the procedure, potentially causing unnecessary complications. Arrhythmia denotes the possibility of irregular heartbeats occurring during the puncture process, especially when the catheter penetrates too deeply into the right atrium.

3.2. Statistical Methods

This study employed statistical methods to analyze the data, aiming to validate the changes in deep venous puncture skills during different time periods. Statistical analysis was conducted using SPSS 19.0 software. For between-group comparisons of categorical data, the chi-square test was applied, while for continuous data following a normal distribution, means and standard deviations were calculated. The comparison between two groups was conducted using the t-test. The statistical significance level was set at $P < 0.05$ to ensure that differences had

clear statistical significance.

4. Experimental Results

As shown in Table 1, compared to the circumstances in February, the March evaluation showed improvements in deep vein catheter placement time, adherence to aseptic principles during operations, first puncture success rate, and a decrease in puncture-related complications. These differences were statistically significant, with March exhibiting a 43% reduction in catheter placement time and a 17% increase in the first puncture success rate. Incidents of puncture-related complications were notably reduced, with February experiencing 2 cases of arrhythmia.

As shown in Table 2, the comparison of complication rates during punctures in February and March 2023 revealed no occurrences of pneumothorax, hematoma, arterial injury, brachial plexus sensory abnormalities, or misplacement into the external jugular vein in both months. However, in February, two cases experienced patient arrhythmias due to the insertion of the guidewire being too deep. The analysis of the minimal occurrence of complications during deep vein puncture suggests that, when the experimental subjects perform the procedure on patients and any signs of operational errors emerge, supervising physicians promptly detect and halt the operation, allowing for a reassessment and a subsequent reattempt at the puncture.

5. Discussion

In the cardiac surgery intensive care unit, patients present complex conditions, and venous access established through deep vein puncture plays an increasingly vital role in resuscitation and monitoring of critically ill patients [1]. Therefore, the skill of establishing venous access through deep vein puncture has become a fundamental requirement for cardiac surgeons. However, the lack of visualization

Table 1. Comparison of catheter placement assessments between February and March 2023.

Puncture Assessment	February	March	p
Total Cases (n)	57	64	<0.05
Average Puncture Placement Time (min)	12.67	7.18	<0.05
First Puncture Success Rate	77.20%	90.60%	<0.05
Puncture-Related Complications (cases)	2	0	<0.05

Table 2. Comparison of complication rates during punctures in February and March 2023.

Group	Cases	Pneumothorax	Hematoma	Arterial Injury	Brachial Plexus Sensory Abnormalities	Misplacement into External Jugular Vein	Arrhythmia
February	2	0	0	0	0	0	2
March	0	0	0	0	0	0	0

techniques for deep vein puncture, coupled with significant variability in surface landmarks and deep veins, poses challenges and high risks, making it a persistent difficulty in the training of cardiac surgery professionals.

Currently, in domestic medical student clinical skills training [2], ultrasound-assisted teaching has been introduced. Ultrasound-guided deep vein puncture and catheterization offer advantages such as real-time accuracy, cost-effectiveness, and safety. This method is not limited by patient positioning. In case of complications after puncture, ultrasound enables observation of the catheter placement, diagnosis of complications, facilitating timely intervention, and thereby improving patient comfort and satisfaction. However, mastering traditional deep vein puncture techniques based on surface anatomy landmarks remains crucial. For beginners, success in deep vein puncture relying on ultrasound guidance significantly decreases in the absence of ultrasound equipment. Success in traditional surface anatomy landmark-based deep vein puncture depends on the operator's experience and skills.

In this clinical practice [3], we initially conducted standardized simulation training, followed by a comparison of the experimental subjects using the "three threes" method for puncture in practical training. We assessed indicators such as puncture catheterization time, first puncture success rate, and puncture-related complications before and after training. Despite limitations such as a relatively small sample size and a short training period, analyzing the existing data reveals a notable improvement.

Through training with the "three threes" method, the first puncture success rate has increased from 77.2% one month ago to 90.6%. Simultaneously, puncture time has decreased, and occurrences of puncture-related complications have reduced. This reflects the increasing proficiency of the experimental subjects in mastering deep vein puncture through the "three threes" method [4].

Analysis of 121 procedures over two months identified the most common violation of aseptic principles [5]: the trailing end of the guidewire crossing the sterile field during guidewire removal after inserting the deep vein catheter. Knotting the guidewire during removal was recommended to prevent contamination [6].

The primary reasons for puncture failure were analyzed [7], including incorrect puncture site selection. Puncturing too close to the inner side risked hitting the internal carotid artery [8], while choosing a site too far to the outer side risked puncturing the external jugular vein [9]. Variability in patient head tilt angles during positioning influenced the success rate, with greater angles leading to larger arterial-venous divergences [10]. Simultaneously, pressing forcefully when detecting carotid artery pulsation compressed the internal jugular vein, increasing the difficulty of puncture. The larger size of the puncture needle compared to the probe made penetration of the venous anterior wall more challenging, often resulting in slightly deeper punctures. Even if the expected depth was reached without blood reflux, the likelihood of penetrating both the anterior

and posterior walls was high.

If this occurred, withdrawing the needle slowly while applying negative pressure was advised. If the posterior wall was penetrated, blood reflux could still occur once the needle returned to the venous cavity [11]. Difficult guidewire insertion prompted considerations such as the puncture needle not being within the internal jugular vein. Immediate withdrawal of the guidewire, reconfirmation of blood backflow after connecting the needle to the syringe, and maintaining a fixed angle during reinsertion were recommended [12]. For patients with short necks, placing a pillow under the shoulders highlighted the sternocleidomastoid muscle more effectively.

Cardiac surgeons demonstrate strong hands-on abilities, resulting in a shorter learning curve for mastering deep vein puncture. Through the application of the "Three Threes" method in clinical teaching [13], students can proficiently acquire basic operational skills [8]. However, continuous experiential learning, analyzing failures, and extensive practice are essential for skill refinement and clinical application. In addition to technical training, emphasizing teamwork and communication is also crucial. Deep vein puncture is usually performed in complex clinical environments, and collaboration with other healthcare team members is essential. Fostering students' awareness of their roles within a team enables effective communication and coordination, enhancing overall workflow efficiency. Overall, through systematic theoretical training, realistic scenario-based simulations, the application of the "three-three-three method," practical hands-on experience, and an emphasis on teamwork, clinical medical students can rapidly and comprehensively master the technique of deep vein puncture. This integrated training approach not only elevates students' technical proficiency but also cultivates the teamwork and communication skills required in actual clinical practice [14].

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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