

Individualized Blind Techniques for Puncture of Intrathoracic and Extrathoracic Subclavian Vein: Three Simple Experience Tips

ABSTRACT

Background: Although several procedures of subclavian venipuncture have been reported, no standard method has been established yet. The purpose of this study was to investigate some more accurate and improved blind puncture tips.

Methods: A prospective study was conducted on patients who underwent cardiac radio-frequency ablation with the blind technique of subclavian venipuncture from August 2018 to June 2022. All patients were randomly assigned to an intrathoracic approach group or extrathoracic approach group. Each group of patients followed their own specific puncture scheme and tips.

Results: About 371 punctures were included. Blind subclavian venipunctures were performed with 98.9% technical success and without complications in all patients. The overall success rate with an intrathoracic and extrathoracic approach was equivalent (96.7% vs. 98.3%, $P = .23$). The intrathoracic group showed a higher first-pass success compared with the extrathoracic group (91.9% vs. 80.2%, $P = 0.003$, respectively).

Conclusion: We localized the landmark/reference and skin puncture site of an intrathoracic and extrathoracic subclavian venipuncture individually and quantitatively. These experiences make blind techniques more accurate and faster.

Keywords: Blind technique, subclavian venipuncture, intrathoracic approach, extrathoracic approach

INTRODUCTION

Since Aubaniac first described the technique for subclavian venipuncture in 1952,^{1,2} this technic has been commonly performed in central venous catheterization, cardiac ablation, and pacemaker implantation. Although a procedure guided by ultrasound has been proved to reduce complications and improve patient safety and comfort compared with anatomical landmark guidance,^{3,4} blind puncture is still a regular alternative in clinical. When carried out by experienced operators, it is generally a safe procedure with a high success rate, but it can be challenging sometimes.

It is well known that the axillary vein, subclavian vein (SCV), and brachiocephalic vein are different segments of the same vein. At the lateral border of the first rib, the axillary vein becomes the extrathoracic part of SCV where it passes over the first rib.⁵ That is, the SCV is divided into extrathoracic part and intrathoracic part. Therefore, the needle needs to insert the costoclavicular interspace for the intrathoracic SCV puncture, while the extrathoracic SCV (subclavian vein on the surface of the first rib) puncture does not. Moreover, the proper position of the skin entry point and puncture techniques of the 2 approaches are quite different.^{6,7}

A detailed description of our technique for blind intrathoracic and extrathoracic SCV punctures is presented. This work, based on prior anatomical studies of subclavian venography and costoclavicular scalene triangle of the specimen from us, was undertaken to develop changes in the subclavian venipuncture technique, which could make the blind procedure more accurate, safe, and rapid.

ORIGINAL INVESTIGATION

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METHODS

Patient Population

Patients who underwent left-side subclavian venipuncture for cardiac radiofrequency ablation were enrolled at a single specialized cardiac-care center from August 2018 to June 2022. Patients were randomized 1:1 to an intrathoracic SCV puncture group (intrathoracic approach group) or an extrathoracic SCV puncture group (extrathoracic approach group). The study was approved by the Xijing Hospital Institutional Review Board.

Anatomical Characteristics

The SCV lies just below the posterior aspect of the clavicle and its medial third and just above the pleura. But beyond that, the more accurate anatomical relationship between the SCV and the clavicle is the intrathoracic SCV lays posteriorly and the extrathoracic SCV lays inferiorly. According to our previous angiographic results, the intrathoracic SCV and the clavicle in front of it generally overlap on the image viewed from the anterior, and this part of the clavicle is the segment attached by the sternocleidomastoid, including the sternal head and the clavicular head. We defined this part of the clavicle as a Blue zone in this study. In other words, it is our opinion that the whole Blue zone can mostly be taken as an individualized external projected zone of the intrathoracic SCV. Rarely, of course, there may be an upper or lower positional variation around this segment of clavicle viewed from the anterior. Furthermore, based on our observation of specimens, the needle is not always easy to reach the sternal notch direction, especially for patients with narrow costoclavicular interspace (Figure 1).

Left-Side Puncture by Intrathoracic Approach

To avoid pneumothorax, the needle should be advanced with the syringe should parallel to the chest wall. However, this orientation is difficult to maintain because the patient's shoulder usually is in the way. To address this problem, a pad is placed along the vertebrae from the seventh cervical vertebra (C7) to the twelfth thoracic vertebra (T12). Its width is between 2 scapulae. The ideal height is that the greater tuberosity of the humerus does not hinder the right hand and does not cause discomfort to the patient.

Tip 1: Take the Midpoint of the Blue Zone as the Target Direction

Before anesthesia, identify the curve of the clavicle, the position of the extremitas sternalis of clavicle, and the lateral edge of the clavicular head of the sternocleidomastoid, which could be easily palpated when the patient's head was

HIGHLIGHTS

- This study proposes a very practical and individualized landmark/reference for the intrathoracic and extrathoracic subclavian venipuncture.
- This study quantified the skin entry point of the intrathoracic and extrathoracic subclavian venipuncture.
- This study demonstrated the practical skills of subclavian venipuncture.



Figure 1. A photograph showing a course and inclination angle of the first rib and its anatomical relationship with the clavicle. Sided BCV descending almost vertically and the right. Sided BCV descending obliquely to the left. BCV, brachiocephalic vein; SVC, superior vena cava.

turned away and raised in a supine position. Confirm the length, width, and midpoint of the Blue zone. The position of skin entry point depended on the individualized width and angle of the clavicle. The wider the clavicle is, the farther the skin entry point is from the clavicle. The skin entry point was located by using an isosceles triangle, the 2 equal legs had a length of 1.5-2.0 times the clavicle width, and the midpoint of the base was the position of the skin entry point. One leg of this isosceles triangle was perpendicular to the midsternal line, and the other leg was perpendicular to the long axis of the Blue zone. Put the left middle finger on the midpoint of the Blue zone and use the left thumb to help guide an 18-gauge needle underneath the clavicle inserting it toward the top of the middle finger until venous blood was freely aspirated (Figure 2A).

Tip 2: Bend the Needle

The extrathoracic SCV is actually located at the back of the clavicle. Puncture is easy to fail and very dangerous when the needle is bent toward the pleural by the chest wall and the first rib during passing through the costoclavicular interspace. To keep the needle hugs the posterior aspect of the clavicle and is advanced parallel to the anterior chest wall, or nearly so. We bent the first third of the needle slightly. Using the numbers on the syringe as a reference, we oriented the bevel of the needle tip toward these numbers. When the curved part of the needle was inserted into the costoclavicular interspace, the needle would be easily directed to the back of the clavicle with safety.

LEFT-SIDE PUNCTURE BY EXTRATHORACIC APPROACH

Tip 3: Take the Subclavian Artery as a Reference

Palpate the subclavian artery (Red zone) near the lateral edge of the clavicular head of sternocleidomastoid, posteriorly to the clavicle. Often, an upright position was better for palpation than a supine position. Determine the corresponding point (point V) of Red zone beneath the clavicle, where the extrathoracic SCV passes. Create a line perpendicular to the deltopectoral groove and pass the highest point

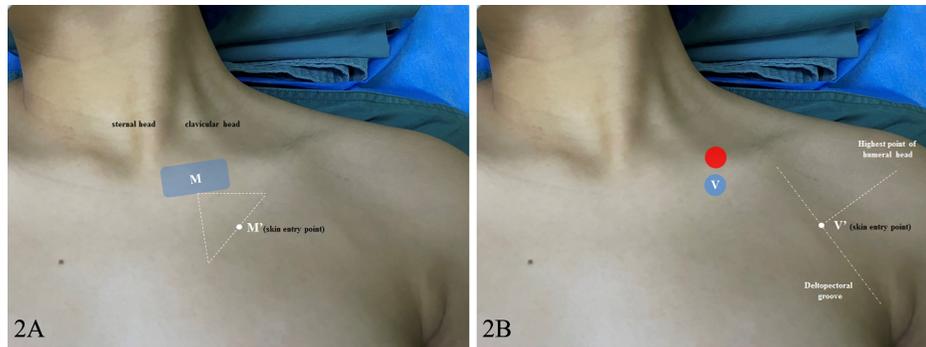


Figure 2. Illustrations of our approach to subclavian venipuncture. (A) Intrathoracic approach. Point M indicates the midpoint of the segment of the clavicle attached by the sternocleidomastoid (Blue zone) while point M' defines the midpoint of the base of an isosceles triangle. M', skin entry point. (B) Extrathoracic approach. Palpate the subclavian artery at the red point behind the clavicle, place the left thumb at point V, and the 2 white lines are perpendicular to each other. V', skin entry point.

of the humeral head. The intersection (point V') of 2 lines is the position of the skin entry point. Press the left thumb into the soft tissue at point V. Pressure from the passage of the needle could be felt by the left thumb and helped the operator to press the needle deep into the soft tissues toward extrathoracic SCV and the underlying first rib. It should be emphasized again that the extrathoracic SCV lies inferior to the clavicle, so the needle often does not need to be inserted too deeply (Figure 2B).

Statistical Analysis

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 20 (IBM, Armonk, NY, USA). Data are presented as mean \pm SD. *t*-test was used to compare differences in each parameter between 2 groups. A *P*-value below .05 was considered statistically significant.

RESULTS

Of the 371 patients with 42.3% being male, randomization placed 185 in the intrathoracic approach group and 186 in the extrathoracic approach group. Ages ranged from 11 to 74 years, with an average age of 43.7 years (SD 19.5). Using both approaches, a lead was placed through the SCV in all but 3 patients, resulting in an overall success rate of 98.9%. No complication was found in 2 groups.

Although we found there are about 5 types of clavicle viewed from the anterior (Figure 3), these 3 tips were applicable to any of them. The success rate for the intrathoracic group and extrathoracic group was 96.7% and 98.3%, respectively. There was no difference between the 2 groups regarding success rate (*P* = .23). Four patients failed to puncture in the intrathoracic group finally achieved successful subclavian venipuncture by switching to the extrathoracic approach, and one patient failed to puncture in the extrathoracic group finally achieved successful subclavian venipuncture by switching to the intrathoracic approach. However, the first-pass success for the intrathoracic approach and extrathoracic approach was 91.9% and 80.2%, respectively (*P* = .003). Besides that, tip 2 was applied in 5 patients (2.7%) during intrathoracic SCV puncture. In the intrathoracic group, there were 15 initial failures (8.1%). Of these failures, 6 were caused by failure to puncture the vein and 9 were caused by

difficulty in threading the needle through narrow costoclavicular interspace. In the extrathoracic group, there were 37 initial failures (19.8%). Of these failures, 36 were caused by failure to puncture the vein and 1 was caused by the absence of palpable subclavian arterial pulsations.

DISCUSSION

With 2-dimensional ultrasound, the target vessel, needle, and adjacent structures can all be clearly identified. However, ultrasonography is not currently available in all catheter rooms, operating rooms, or emergencies, so there are still many cases where blind puncture technique is still the modality of choice in routine clinical practice. With good patient and procedure design, and experienced technique, many potential complications can also be reduced without adding to the procedure duration. It is also noteworthy that although the risk rate with ultrasound SCV access is low, severe complications, such as pneumothorax, lung injuries, hematoma, and arterial puncture may still occur.⁸⁻¹⁰

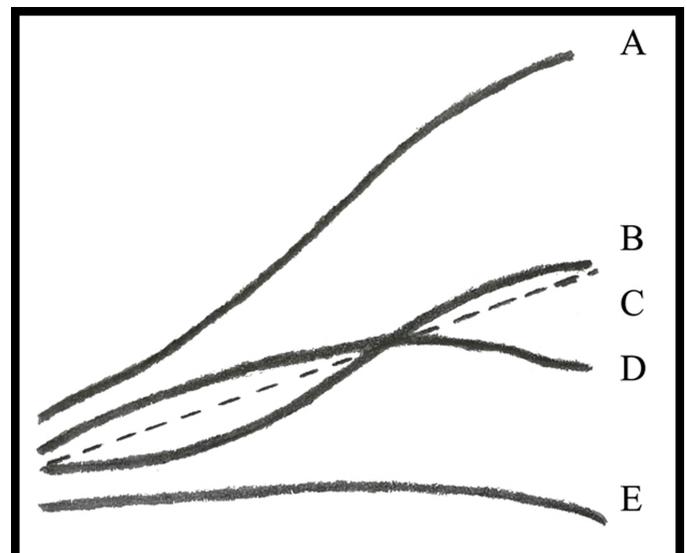


Figure 3. Illustration showing 5 different morphologies of the clavicle viewed from the anterior.

A clear understanding of the anatomy of the SCV is critical for successful venipuncture. The extrathoracic and intrathoracic SCV otherwise known as supraclavicular and infraclavicular SCV have completely different puncture techniques. Adult SCV is about 3-4 cm long and 1-2 cm in diameter. The mean width at the sternal end of the clavicle is 22.6 mm (SD 3.5; range 17.5-32.2 mm), and the mean thickness/depth at the sternal end of the clavicle is 21.1 mm (SD 2.9; range, 14.9-28.1 mm).¹¹ Thus, the Blue zone is nearly circular, and its depth can be estimated by its width. Besides that, the mean width at the sternal end of first rib was 14 mm (SD 2; range 9-18 mm).¹² It should be noted that the width of the clavicle is proportional to the width of the first rib in each individual. Therefore, the width of the clavicle must first be determined by palpation before the puncture.

The sternal notch is frequently mentioned as a reference point for SCV puncture in the literature, but operators have come to realize that it is difficult to achieve in each patient because of the individualized anatomical relationship between the clavicle and the first rib, and therefore propose other anatomical reference markers, such as the sternoclavicular joint, the cricoid, junction point of the medial and middle third parts of the clavicle, the triangle formed by the 2 heads of the sternocleidomastoid muscle.^{13,14} However, these landmarks are one-sided. In our opinion, the whole Blue zone (the segment of the clavicle attached by the sternocleidomastoid) can be taken as a bony landmark of the intrathoracic SCV, rather than a fixed direction. This conclusion is based on the analysis of previous venography of the SCV in our catheter center, which demonstrated that no matter how different the individual clavicular morphology and angle is, the intrathoracic SCV follows an oblique course along the length of the clavicle in anterior-posterior (AP) view and is close to the clavicle in 90° left anterior oblique view. That is, the intrathoracic SCV is usually coincident with the anterior Blue zone on the image in AP view. Several researchers have performed CT scan studies specifically for the distance between the SCV and the clavicle. Among them, Sinha reported that the mean distance of the SCV from the clavicle is 4.77 mm (range 0-15.9 mm) in the medial one-third of the clavicle.¹⁵ Steinmetz reported this average distance to be 3.51-5.76 mm on both the left and right sides.¹⁶ In this study, Tip 1 puncture technique was adopted with a first-pass success rate of up to 91.9%, and well adapted for patients with narrow costoclavicular interspace.

To date, there is a lack of normative recommendations for locating skin entry points in intrathoracic SCV puncture. We believe the choice of where to have skin insertion is an individualized one, depending on the width and thickness of the clavicle, and put forward an innovative isosceles triangle locating method. Our research indicates this quantitative method can work with any type of clavicle. Rarely, if the higher second rib resulted in the estimated skin entry point being located at the upper edge of the second rib, the entry point needs to be offset to the first rib gap.

When the needle was unavoidably bent and angled toward the pleural when passing through the costoclavicular

interspace, we applied the self-invented Tip 2 in this study. Because the intrathoracic SCV is situated behind the Blue (medial) zone, Tip 2 not only makes the needle easy to be reached the back of the clavicle but also makes the procedure safer. In practice, we also emphasize the need to mark the direction of the needle tip and to fix the needle against rotation during puncture.

The external locating strategies for the extrathoracic SCV described in the literature are complicated or limited, and can hardly be mastered in practical application. In addition, a bony landmark of extrathoracic SCV is also unreliable due to obvious variation of both the thoracic structure and shape of the clavicle. In our study, the extrathoracic SCV puncture was performed using the subclavian artery as a reference. Anatomically subclavian artery is defined from its origin to the lateral edge of the first rib, and the SCV runs under the clavicle and anterior to the artery of the same name. As a result, palpating the pulsation of the subclavian artery is a reliable and individualized strategy. Moreover, our study shows that an upright position may be preferred for subclavian artery palpation, considering its better clinical usefulness. However, we also found that the extrathoracic route provides a lower first-pass success than the intrathoracic approach, which may be associated with the individualized difference in oblique angle, width, and depth of the first rib.

Furthermore, these techniques we presented should work equally well in right-side SCV puncture in fact.

CONCLUSION

In our experience, the ease of these techniques and the reduced number of puncture due to precise positioning makes them techniques that are safe and simple to learn, even for less experienced operators. These techniques are also easily reproducible and can be extended to centers with less experience.

Ethics Committee Approval: This study was approved by Ethics Committee of Air Force Medical University (Approval No: QX20181014-1, Date: 3-7-2018).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

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