The Influence of Arm Positioning on Ultrasonic Visualization of the Subclavian Vein: An Anatomical Ultrasound Study in Healthy Volunteers

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We hypothesized that placing the arm in 90° abduction, through 90° flexion and 90° external rotation, could improve ultrasound visualization of the subclavian vein. In 49 healthy volunteers, a single operator performed a view of the subclavian vein in neutral position and abduction position. A second blinded operator measured the cross-sectional area of the subclavian vein. Abduction position increased the cross-sectional area of the subclavian vein from 124 ± 46 (mean ± SD) to 162 ± 58 mm^2 ($P = 0.001$). An increase of the cross-sectional area of ≥50% was observed in 41% volunteers (95% confidence interval, 27%–56%, $n = 20$); this technique offers an alternative approach (maybe safer) for ultrasound-guided catheterization of the subclavian vein. (Anesth Analg 2016;123:129–32)

In critically ill patients, catheterization of the subclavian vein is associated with fewer catheter-related infections but can lead to life-threatening mechanical complications such as pneunmothorax.[1–4] Because ultrasound guidance for subclavian vein catheterization decreases failure and complication rates,[5–7] we hypothesized that optimizing the visualization of the subclavian vein would facilitate its venipuncture. The probe positioning onto the infraclavicular fossa, parallel to the clavicle, is a proposed technique that paradoxically can cause a more difficult approach of the vein.[6,8–11] Arm abduction can modify the anatomical relationship of the subclavian vein with its adjacent anatomical structures[12,13] and can enhance the visible cross-sectional area of the vein lumen. This could facilitate subclavian venipuncture. The present ultrasound anatomical study of healthy volunteers sought to show that arm abduction could increase the cross-sectional area of the subclavian vein lumen compared with neutral position.

METHODS

Our local ethics committee approved the study (# 2012 06 06; clinical trial no: NCT01647815), and all participants provided written informed consent. Healthy nonpregnant volunteers aged 18 to 50 years participated in this study. Volunteers with a history of local surgery and/or trauma, as well as arm deep venous thrombosis, were not included. The same trained anesthesiologist performed all ultrasound examinations. The images were recorded and stored anonymously. Blinded from the arm position and the order of the image, a second independent ultrasound vascular expert read and performed the different measurements.

Ultrasound Technique

All measurements were performed in supine position on the right side with the 7.5 MHz linear probe of Vivid S6 machine (GE Healthcare, 9900 Innovation Drive, Wauwatosa, WI). A positive compressive pressure test and a typical venous flow recorded by pulse-wave Doppler identified the subclavian vein. The cross-sectional area of the subclavian vein lumen was measured in neutral position (arm kept along side the body) and in abduction position (abduction [90°] + flexion [90°] + external rotation [90°]; Fig. 1). To hold the abduction position, the arm was placed in a specific device. The probe was placed under and parallel to the clavicle at 1/3 medial and 2/3 lateral and kept perpendicular to the skin (Fig. 1).

Measured Parameters

Morphologic characteristics of the volunteers were recorded. By using the planimetry method, we measured the cross-sectional area of the subclavian vein. The long (greater length) and short (greater width) axis of the subclavian vein were measured.

The relative variation of the cross-sectional area was calculated by the following formula:

$$\frac{(\text{CSA vein lumen in AP} - \text{CSA vein lumen in NP})}{(\text{CSA vein lumen in NP})},$$

where AP = abduction position; CSA = cross-sectional area; and NP = neutral position.

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Accepted for publication March 3, 2016.

Funding: This work was supported by academic grants from the University Hospital of Nimes, France. The authors involved in this study did not receive any external funding.

The authors declare no conflicts of interest.

Reprints will not be available from the authors.

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DOI: 10.1213/ANE.0000000000001327

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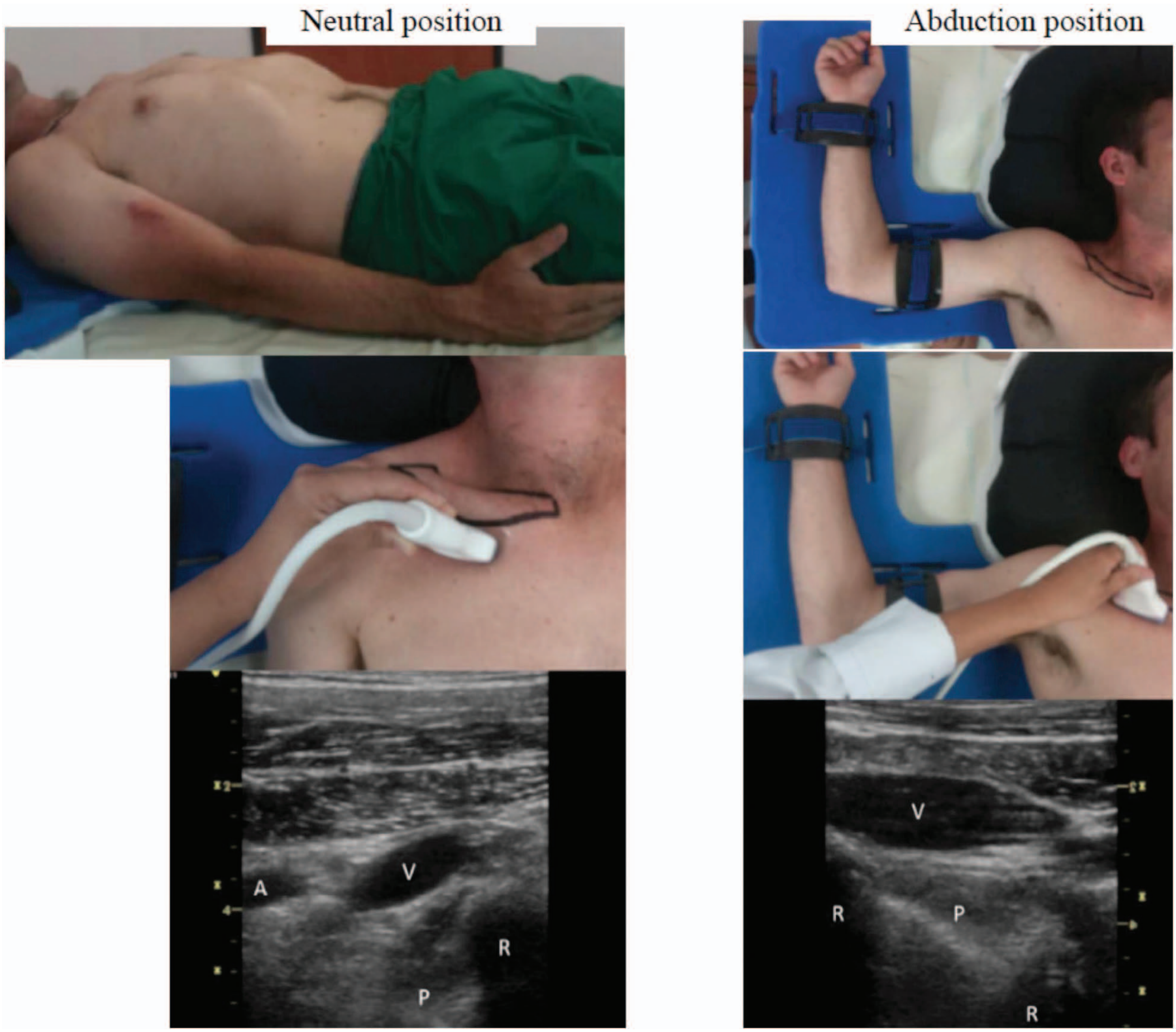

Figure 1. Two studied positions of the arm with probe positioning and view of the subclavian vein. Arm in the abduction position: 90° abduction, 90° flexion, and 90° external rotation, standardized by a specific device. A = subclavian artery; P = pleura; R = rib; V = subclavian vein.

The minimal distances between the subclavian vein to the skin, adjacent subclavian artery, pleura, and brachial plexus were measured.

Statistical Analysis

The primary objective was the comparison of the cross-sectional area of the subclavian vein in neutral position versus abduction position. With the hypothesis that abduction position leads to a ≥50% increase in the cross-sectional area of the subclavian vein lumen in 50% of volunteers with a half 95% confidence interval of 15%, 43 volunteers were necessary for our study. We enrolled 50 volunteers.

Quantitative variables were expressed as mean (±SD) or median with interquartile range. Qualitative variables were expressed as frequency (percentage). Confidence intervals for proportions were calculated by use of the Clopper-Pearson method. Comparisons used paired Student *t* test for quantitative variables and McNemar χ^2 test for paired binary variables. All analyses were done using SAS version 9.3 (SAS Institute Inc., Cary, NC). A *P* value <0.05 defined statistical significance.

RESULTS

Measurements were available in 49 of 50 volunteers (age = 34 ± 11 years, height = 170 ± 9 cm, weight = 66 ± 14 kg, body mass index = 22.7 ± 4.1 kg m^{-2}, 29 female patients) leading to 98 pictures analyzed.

The abduction position increased the cross-sectional area in 75% of volunteers and increased the cross-sectional area by ≥50% in 20 volunteers (41%; 95% confidence interval, 27%–56%). Abduction position increased the cross-sectional area from 124 ± 46 to 162 ± 58 mm^2 (difference = 36 ± 75 mm^2, *P* = 0.001) and long axis from 17 ± 7 to 23 ± 8 mm (difference = 6 ± 11 mm, *P* < 0.001), whereas short axis did not change (9 ± 2 vs 9 ± 2 mm; difference = 0 ± 2 mm, *P* = 0.11). The relative variation in the cross-sectional area was 50% ± 88% (median relative variation = 27%; IQR, 3%–76%; Fig. 2).

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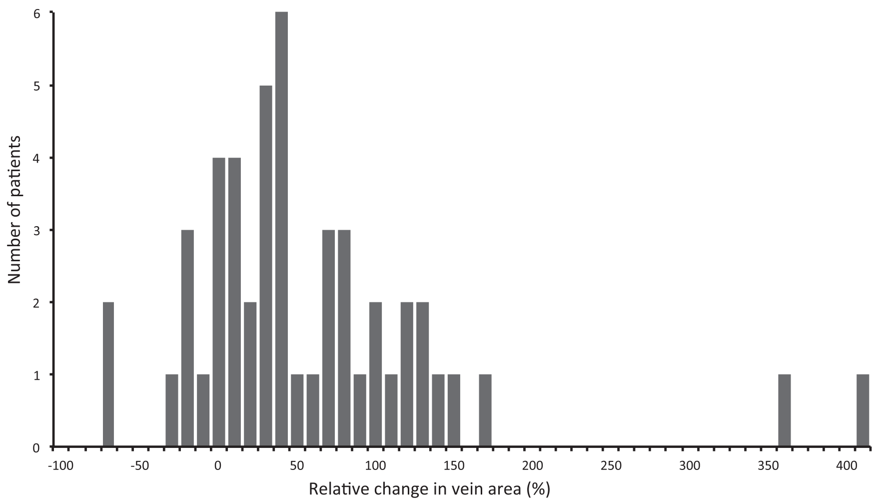

Figure 2. Distribution of the relative variation of the vein area after moving the arm from neutral position (NP) to abduction position (AP). Variation in vein area = 124 ± 46 to 162 ± 58 mm². Relative variation in vein area = 50% ± 88% (median relative variation, 27%; interquartile range, 3%–76%). Number of volunteers with an increase in vein area ≥50% = 20 (41%; 95% confidence interval, 27%–56%).

In abduction position, the depth of the vein was reduced from 20 ± 6 to 18 ± 5 mm (difference = −2 ± 4 mm, $P < 0.001$). The subclavian artery and brachial plexus were seen in 44 of 49 (89.8%) and 13 of 49 (26.5%) volunteers in both positions respectively. The pleura was seen in 37 of 49 (75.5%) volunteers in neutral position and 32 of 49 (65.3%) in abduction position ($P = 0.25$). The subclavian vein-artery distance was 2 ± 2 vs 2 ± 2 mm in neutral position and abduction position, respectively (difference = 0 ± 3 mm, $P = 0.58$). The vein-pleura distance was of 6 ± 2 vs 5 ± 2 mm in neutral position and abduction position, respectively (difference = −1 ± 3 mm, $P = 0.16$).

DISCUSSION

Placing the right arm in abduction (90°) completed by a flexion (90°), and external rotation (90°) increased the cross-sectional area of the subclavian vein from 124 ± 46 to 162 ± 58 mm², which allowed a ≥50% increase in the cross-sectional area in at least 27% volunteers, without altering subclavian vein relationships with adjacent structures.

The increase in the cross-sectional area of the subclavian vein in the abduction position was relevant clinically in at least 27% of volunteers. Interestingly, no alterations in the relationship of the subclavian vein with adjacent structures (artery, pleura, plexus) were reported, in contrast to previous studies in which authors reported slight alterations.[13,14] Therefore, the abduction position could improve subclavian vein visualization and facilitate venipuncture.

Our study had a few limitations. First, a volunteer population could be different from critically ill patients, even though O'Leary et al.[10] reported that findings obtained from a volunteer population are similar to those from large and heterogeneous patient populations. No obese volunteers were studied, whereas obesity is present in 10% to 32% of the overall population.[15,16] Second, the specific device used for placing the arm would not be applicable in patients with shoulder or upper limb trauma. Third, the vein size could differ from the right to left side, and this study cannot exclude different conclusions for the left side.[9] Fourth, we did not study the effect of other body positions such as Trendelenburg on vein size.

Although this study confirmed that placing the arm in 90° abduction could improve ultrasound visualization of the subclavian vein, further studies are needed to assess the safety and effectiveness of this alternative approach compared with standard techniques.

DISCLOSURES

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Contribution: This author helped in study design, patient recruitment, data collection, data analysis, and writing up the paper.
Attestation: Meriem Sadek approved the final version of the manuscript and attests to the integrity of the original data and analysis reported in the manuscript.
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This manuscript was handled by: Maxime Cannesson, MD, PhD.

ACKNOWLEDGMENTS

The authors thank Mariella Lomma and Christopher Scott, for their help in correcting the article.

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