Effect of Patient Position on Size and Location of the Subclavian Vein for Percutaneous Puncture

John B. Fortune, MD; Paul Feustel, PhD

Hypothesis: Large-bore subclavian intravenous access is important during trauma resuscitation and to provide central access in the intensive care unit. Controversy exists as to the patient position that best facilitates the insertion of this line. Duplex scanning of the subclavian vein in different body positions may help define which provides the largest vein size and distance from the clavicle.

Design: Prospective comparison study in healthy humans.

Setting: Clinical research laboratory.

Subjects: Ten healthy volunteers.

Interventions: We examined the left subclavian vein diameter, position from clavicle, and flow in subjects placed in 5 different positions advocated for subclavian vein puncture. A duplex scanner was used to image the subclavian vein with B-mode ultrasonography and to detect flow rates with a Doppler probe. The different subject positions were as follows: (1) flat (or supine), head and shoulders neutral; (2) flat, head neutral, shoulders arched; (3) flat, head opposite, shoulders arched; (4) Trendelenburg, head opposite, shoulders arched; and (5) Trendelenburg, head and shoulders neutral.

Results: The mean (SEM) diameter of the subclavian vein is largest in position 5 (0.99 [0.06] cm) and smallest in position 2 (0.84 [0.05] cm). The distance of the vein from the clavicle is greatest in position 1 (0.94 [0.08] cm) and least in position 4 (0.75 [0.07] cm). Using an analysis of variance with Dunnett’s comparison, all positions were compared with position 5. For vein diameter, all positions had significantly smaller size. In position 4, the vein was significantly closer to the clavicle. There was no statistical difference in flow rates among all positions.

Conclusions: These data demonstrate that arching of the shoulders and turning of the head may reduce target size and provide an unsatisfactory position for subclavian puncture. The Trendelenburg position with no other positioning maneuvers may be helpful.

Arch Surg. 2003;138:996-1000

During a trauma resuscitation, intravenous (IV) access is usually gained with 2 large-bore IV lines placed in peripheral veins. Occasionally, however, emergency access to the central veins will be necessary because of the nature of the injury or severe hypovolemic shock that will preclude adequate access to peripheral veins. Additionally, central vein cannulation is frequently necessary for hemodynamic monitoring in the intensive care unit for the surgical patient whose condition is unstable or as access for the administration of total parenteral nutrition or adjunctive chemotherapeutic agents for cancer.

Since the introduction and popularization of the infraclavicular subclavian vein approach for central line placement in the early 1950s, a controversy has existed as to the best patient position that will facilitate the insertion of this IV line. The elements of this controversy center around whether the Trendelenburg position should be used, whether the head should be turned toward the ipsilateral or contralateral side, and whether the shoulders should be arched with a pillow placed between the scapula. A review of the related literature (Table 1) does not offer a dominant opinion to help answer this question.

The size and location of the subclavian vein has been previously examined in different patient positions with the use of venograms and magnetic reso-
nance imaging scans.\textsuperscript{15} We felt that the use of the duplex scan that uses a combination B-mode ultrasonogram and Doppler measurement might be helpful in analyzing the position and flow of the subclavian vein in the different patient positions. Specifically, we were interested in examining the size and the position of the left subclavian vein in healthy volunteers placed in various positions that have been advocated for the placement of these central venous lines.

**METHODS**

A duplex scanner (model DRF-400; GE Diasonics, San Jose, Calif) was used to determine the size of the subclavian vein. The duplex scanner images the vein with B-mode ultrasonography and can measure the time average velocity of flow through the vein using the Doppler signal. Flow can be quantified by multiplying the time average velocity (centimeters per second) by the calculated area (square centimeters) of the vessel. This results in a measurement of flow in milliliters per second that can be converted to milliliters per minute. For the measurement of the size and location of the subclavian vessel, a 10-MHz probe was used. The same operator performed all measurements.

Ten healthy volunteers participated in this study. They were brought to the noninvasive vascular laboratory and placed in the supine position on a firm stretcher. They were told to lie comfortably on the table, breathe normally, and avoid any contraction or abnormal movements of the shoulders. The left subclavian vein was imaged by placing the probe in the supraclavicular space at a point between the medial one third and the midportion of the clavicle. The probe was directed inferiorly and anteriorly so that the vein could be visualized under the clavicle. For each evaluation of the vein, the anteroposterior diameter was measured. Because there appeared to be no significant change in the diameter of the vessel with respiration, respiratory fluctuations in size were not considered. After the anteroposterior diameter had been determined, the distance from the vein to the clavicle as well as the flow through the vein were measured. Measurement of the distance from vein to clavicle was performed by defining the wall of the vein closest to the clavicle and the edge of the clavicle closest to the probe. The radial measurement of this distance was then noted. The posterior border of the clavicle could not be used because this was hidden in the acoustic shadow of the bone.

Measurements were made in 5 different positions that involved differences in body tilt, head position, and shoulder position. For the Trendelenburg position, the subject was placed flat (or supine) with the entire stretcher in a 15° head down position. For the head opposite position, the subject was asked to turn his or her head 45° to the right. For the shoulders arched position, a rolled firm sheet was placed between the scapula that provided 8.0 cm (about 3 in) of elevation of the midscapular spine. With the sheet between the shoulders, the subjects were asked to relax their shoulders and not to actively arch their shoulders or voluntarily contribute to any exaggeration of this position. Additionally, in this position with the head on the stretcher, the neck became slightly extended.

The 5 different subject positions in which the subclavian vein was studied were as follows: (1) flat (or supine), head and shoulders neutral; (2) flat, head neutral, shoulders arched; (3) flat, head opposite, shoulders arched; (4) Trendelenburg, head opposite, shoulders arched; and (5) Trendelenburg, head and shoulders neutral.

Comparison between the data points used an analysis of variance with Dunnett’s comparison that compared position 5 to all of the other 4 positions. Position 5 was chosen as the reference point because it was ultimately shown to have the largest mean diameter.

**RESULTS**

The subject pool consisted of 5 male and 5 female subjects with a mean age of 30 years (age range, 23-40

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**Table 1. Review of the Literature for Best Position for Placing an Intravenous Clavicle Line**

<table>
<thead>
<tr>
<th>Source</th>
<th>Supine (Flat)</th>
<th>Trendelenburg</th>
<th>Head Neutral</th>
<th>Head Turned</th>
<th>Shoulders Arched</th>
</tr>
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<tbody>
<tr>
<td>American Heart Association\textsuperscript{2}</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>-</td>
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<tr>
<td>American College of Surgeons\textsuperscript{3}</td>
<td>-</td>
<td>-</td>
<td>X</td>
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<tr>
<td>Baue et al\textsuperscript{4}</td>
<td>X</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Bernard and Stahl\textsuperscript{5}</td>
<td>Reverse Trendelenburg</td>
<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
<td>Bonia and Hinschaw\textsuperscript{6}</td>
<td>X</td>
<td>X</td>
<td>-</td>
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<tr>
<td>Casentino\textsuperscript{7}</td>
<td>X</td>
<td>X</td>
<td>-</td>
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<tr>
<td>Cowley and Dunham\textsuperscript{8}</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Duke and DuArick\textsuperscript{9}</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Fischer et al\textsuperscript{10}</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Galli et al\textsuperscript{11}</td>
<td>X</td>
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<td>Gill and Long\textsuperscript{12}</td>
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<td>Jesseph et al\textsuperscript{15}</td>
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<td>Keifer-Szanto\textsuperscript{16}</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Mogil et al\textsuperscript{17}</td>
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<tr>
<td>Moosman\textsuperscript{18}</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Shires et al\textsuperscript{19}</td>
<td>X</td>
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<tr>
<td>Shuck and Neaman\textsuperscript{20}</td>
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<tr>
<td>Sitzmann et al\textsuperscript{21}</td>
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<tr>
<td>Smith\textsuperscript{22}</td>
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<td>X</td>
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<tr>
<td>Vander Salm\textsuperscript{23}</td>
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<td>X</td>
<td>-</td>
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<tr>
<td>Wilson et al\textsuperscript{24}</td>
<td>X</td>
<td>X</td>
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</tbody>
</table>
years). The mean height was 172.6 cm; the mean weight was 76.5 kg.

**Figure 1** shows a typical ultrasonogram from the duplex scanner of an individual in position 2. The subclavian vein can easily be seen running transversely across the figure with the markers showing the points at which the vein’s diameter was measured. In this particular example the subclavian vein was 0.89 cm in diameter. **Figure 2** is a ultrasonogram showing the relationship between the vein and the clavicle with markers for measurement demonstrated at the top of the vein and the top of the clavicle. The measurement in this case performed in position 1 demonstrates a distance of 1.21 cm from vein to the closest point of the clavicle.

**Table 2** gives the mean and SEM of the values for subclavian diameter, area, flow, and distance from the clavicle in all 10 subjects in the 5 positions. These results show that the vein diameter appears to be largest in position 5 and smallest in position 2 with a maximum difference of about 15%. The distance from the clavicle is greatest in position 1 and least in position 4 with a difference of about 18%. The differences in vein area in the position with the largest (position 5) and smallest (positions 2 and 3) vessels are 28%.

**Figure 3** shows the mean changes in diameter of the vein when compared with position 5 in all subjects. By using Dunnett’s comparison, it can be seen that all subject positions result in a significantly smaller size vein than position 5. Similarly, **Figure 4** shows that only in position 4 is there a significant change in the vessel’s relationship to the clavicle compared with position 5. In this particular case it is closer to the clavicle. Dunnett’s comparison shows no significant change in venous flow when all positions were compared with position 5.

**COMMENT**

The subclavian vein is a direct continuation of the axillary vein and begins at the outer border of the first rib and runs transversely behind the clavicle. It lies anterior to the subclavian artery that it accompanies in its course and is separated from the artery by the anterior scalene muscle. The anterior wall of the subclavian vein is united to the fascia of the subclavian muscle. Posteriorly, on the medial aspect, the vein is invested with the pretracheal fascia, and it is thought that these anterior and posterior fascial attachments maintain the caliber of the vein with respiration. However, these fascial attachments may also alter the size of the vein with movement of the shoulder and the neck.

A review of the literature concerning optimal patient position for subclavian puncture does not yield a strong consensus. Table 1 is a partial list of references advocating a preferred position for this procedure. It seems from this compilation that the most popular position is with the patient in Trendelenburg position with the head opposite and shoulders arched. However, the lack of agreement remains striking.

While many positions have been strongly advocated to facilitate puncture of the subclavian vein, very little rationale can usually be given. The Trendelenburg position has been thought to increase vein diameter owing to venous distention secondary to an increase in venous pressure brought about by hydrostatic pressure. In addition, the head down position has been thought to aid in the reduction of air embolus. Some authors believe that the head should be turned to the opposite side to place traction on the vein to secure its position, while others advocate head turning to reduce the angle of the subclavian vein into the superior vena cava.
so as to encourage the catheter to go inferiorly rather than superiorly into the jugular vein. Arching of the shoulders is thought to increase the distance between the vein and clavicle as well as to allow the surgeon to place the needle in a more coronal plane of the body for puncture.

Few studies have been performed to document the anatomy and size of the subclavian vein in various patient positions. In 1971, Land examined the subclavian vein radiographically after the injection of dye into a peripheral arm vein. The purpose of Land’s study was primarily to examine the relationship of the subclavian vein to the clavicle and the influence of shoulder abduction on the position of the vein. He found that shoulder abduction resulted in an increase in the angle formed by the subclavian vein and the clavicle. Shrugging of the shoulders resulted in the same finding. He found no change in vein position with head turning or Trendelenburg position. Jesseph et al. used magnetic resonance image scanning and cadavers to examine the vein in the following 3 positions: (1) the neutral anatomical position, (2) head turned to one side, and (3) shoulders retracted by placing a rolled towel between the shoulder blades. These authors reported that retraction of the shoulders produced a significant anteroposterior compression of the subclavian vein between the clavicle and the first rib. Additionally, turning the head to the opposite direction increased the angle between the jugular vein and subclavian vein. Elevation of the legs in this study did not increase the subclavian vein diameter. These investigators concluded that the optimal position for vein puncture was the neutral position.

Our findings suggest that the target size of the subclavian vein will be greatest when the patient is in the Trendelenburg position with the shoulder and head in a neutral position. The difference in vein area in various positions can be as great as 28%. Our data also suggest that arching the shoulders brings the vein closer to the clavicle and that this may cause more difficult access to the vein itself. In a nearly identical study in children, Lukish et al. found surprisingly similar results. In that study, deviation of the head from the midline or arching the shoulders resulted in a 18% to 22% reduction in the cross-sectional area of the subclavian vein.

It seems as if the differences caused by changes in position are small. However, all of our volunteers were healthy and well hydrated. In the patient who after trauma or with critical illness may have hypovolemic shock and low central venous pressures, the vein will probably be less distended than in our subjects. Therefore, in this situation, changes in vein size induced by patient position may be magnified and more important.

Table 2. Comparison of Subclavian Diameter, Area, Flow, and Distance From the Clavicle in Each of the 5 Positions

<table>
<thead>
<tr>
<th>Position</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subclavian vein diameter, mean (SEM), cm</td>
<td>0.90 (0.07)</td>
<td>0.84 (0.05)</td>
<td>0.85 (0.05)</td>
<td>0.88 (0.05)</td>
<td>0.99 (0.06)</td>
</tr>
<tr>
<td>Subclavian vein area, mean (SEM), cm²</td>
<td>0.66 (0.09)</td>
<td>0.57 (0.08)</td>
<td>0.57 (0.06)</td>
<td>0.63 (0.08)</td>
<td>0.78 (0.10)</td>
</tr>
<tr>
<td>Flow, mean (SEM), mL/min</td>
<td>275 (50)</td>
<td>245 (37)</td>
<td>221 (32)</td>
<td>267 (39)</td>
<td>268 (38)</td>
</tr>
<tr>
<td>Distance from clavicle, mean (SEM), cm</td>
<td>0.94 (0.08)</td>
<td>0.84 (0.09)</td>
<td>0.77 (0.06)</td>
<td>0.75 (0.07)</td>
<td>0.69 (0.11)</td>
</tr>
</tbody>
</table>

*For the 5 positions see the “Methods” section in the text.
The use of duplex ultrasonographic scanning to determine vein size for this study seems justified. This modality allows frequent assessments of vessel size without the need for any invasive procedures or techniques involving irradiation.28 Every effort was made to avoid external compression of the vein by the probe that would have influenced the subsequent size of the vein in various body positions. Additionally, since the measurements could be made rapidly after changes in positions and since each series of studies could be completed within 30 minutes, this technique allowed accurate comparisons of vein size that were due only to position and not to other extraneous influences (ie, state of hydration).

Use of real-time ultrasonography has been proposed as a technology that could be used in the clinical setting to locate the vessel and maximize the target size. For jugular vein access, ultrasonography has been successful in increasing success rates and reducing complications.29,30 Its use for subclavian line insertion is not quite as clear. Branger et al31 showed that the use of pulsed Doppler sonography significantly increased the success rate of subclavian catheter insertion. However, a randomized prospective study showed that there was no difference in the number of skin punctures, time to catheterization, and immediate serious complication rate when real-time pulsed Doppler ultrasonography was used. The only benefit derived was the earlier identification of an improperly placed subclavian catheters.32 Additionally, the rapid requirement of IV access in a trauma resuscitation prohibits the use of ancillary imaging devices.

CONCLUSIONS

We have shown that the target size for subclavian puncture in healthy volunteers seems to be influenced by patient position. The largest vein size is obtained when the patient is in moderate Trendelenburg position with the head straight up and the shoulders lying flat on the bed. Arching of the shoulders and head turning may adversely alter vein size.

Accepted for publication February 23, 2002.

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REFERENCES