Influence of shoulder position on central venous catheter tip location during infraclavicular subclavian approach

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Editor’s key points

- Influence of the shoulder position on the placement of infraclavicular subclavian catheters was studied.
- The neutral shoulder position was compared with the lowered shoulder position.
- Aberrant placement of the catheter tips was more frequent in the lowered position.
- Neutral position of the shoulder minimizes catheter misplacements during infraclavicular right subclavian catheterization.

Background. Infraclavicular approach of the subclavian veins is commonly used for central venous access. However, aberrant catheter tip locations are frequently quoted for this approach. It was hypothesized that with the shoulder pulled downwards, the angle between the internal jugular and subclavian veins may increase, directing subclavian catheters into the internal jugular vein. This prospective study assessed the influence of the shoulder position on proper placement of right infraclavicular subclavian catheters.

Methods. Patients who required subclavian central venous catheterization for major neurosurgical and thoracic procedures were randomly divided into two groups: neutral (n=180) vs lowered (n=181) shoulder position. The right shoulder was placed and maintained in the neutral or lowered position during venipuncture and guidewire insertion. Postoperative chest radiographs were obtained to identify the location of catheter tips.

Results. There were no differences in gender, age, body weight, and height between the two groups. There were five failures in the neutral position [5/180 (2.8%)] and eight failures in the lowered shoulder position [8/181 (4.0%)] (P=NS). The occurrence of immediate complications such as pneumothorax or arterial puncture was not different. Aberrant placement of the catheter tips was more frequent in the lowered shoulder position [2/173 (1.2%) vs 14/173 (8.1%)] (P<0.01).

Conclusions. The neutral shoulder position minimizes the number of needle passes and the incidence of catheter misplacement during the infraclavicular approach of the right subclavian vein catheterization.

Keywords: complications, catheter misplacement; vascular access; veins, subclavian, cannulation

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Subclavian vein (SCV) catheterization via infraclavicular approach has been well established as a relatively safe method. However, this procedure may result in serious or even life-threatening complications such as arterial puncture, pneumothorax, haemothorax, hydrothorax, or myocardial damage.¹ ² In addition, aberrant locations of the catheter tip such as the internal jugular vein (IJV) and the contralateral SCV are frequently quoted when using the infraclavicular approach for SCV catheterization.³ ⁴ Various bedside manoeuvres for avoiding aberrant location of the catheter with regard to the patient’s position have been suggested, but consensus regarding the optimal technique is still lacking.⁵ ⁷ ⁸

In the neutral position with the arms by the side, gentle traction may be needed to counter the cephalad tendency of the shoulders in the Trendelenburg position.⁵ On the basis of the abovementioned study, proper shoulder position during SCV cannulation was sought by using computed tomography.⁶ Contrary to the elevated shoulder position, the neutral and lowered shoulder positions similarly produced a constant anatomic relationship between the clavicle and the subclavian vein, increasing the safety and reliability of subclavian venipuncture.⁸ ⁹ However, because the lowered shoulder position reduced the angle between the SCV and brachiocephalic vein,⁹ this may increase the risk of directing SCV catheters into the ipsilateral IJV.⁵

Although there are a few studies that assessed the position of the head or the shoulder to facilitate SCV catheterization,⁵ ⁷ ¹⁰ there are no studies about the relationship between the shoulder position and SCV catheter tip location. This prospective, randomized study was performed to investigate the influence of the shoulder position on proper placement of central venous catheters (CVCs) during the right infraclavicular subclavian approach.
Methods

Approval from the Institutional Review Board (Seoul National University Hospital, Seoul, Republic of Korea) and informed consent from patients were obtained. The study protocol was registered with clinicaltrials.gov (NCT01024881).

Infraclavicular catheterization of the right subclavian vein using the modified Seldinger technique was attempted using a double-lumen CVC (Arrow International Inc., Reading, PA, USA). Patients between the age of 16 and 81, who required central venous catheterization owing to scheduled major procedures such as neurosurgery or thoracic surgery between December 2008 and August 2009, were included. Subjects with chest deformities, coagulopathy, diaphragmatic dysfunction, major vascular anomaly, history of prior clavicle fracture or prior thoracic surgery, or infection over the puncture site were excluded from the study. All cannulations were performed by anaesthesiologists with more than 3 yr of experience.

Patients were assigned by a computer-generated randomization to one of the two groups. In Group 1, the right shoulder was kept in the neutral position during venipuncture and guidewire insertion. In Group 2, the right shoulder was pulled downward firmly by grasping and pulling the right wrist of the patient during venipuncture and guidewire insertion.

After tracheal intubation following induction of general anaesthesia, patients were placed in the supine position with the arms kept by the side and the head in the neutral position. With the operating table in the flat position, a 1 litre saline bag was placed between the scapulae. After sterile preparation and draping, the skin was punctured at a point just below the right clavicle lateral to the mid-clavicular line towards the suprasternal notch, and the puncture needle attached to a syringe was advanced until the clavicle was met. The right shoulders of the patients were positioned according to the allocated group. While maintaining a slight constant negative pressure, the needle was advanced under the inferior border of the clavicle until the right subclavian vein was punctured. After confirming ‘flashback’ of non-pulsatile blood, the guidewire was advanced with the J-tip of the guidewire facing downward.11 On the basis of this previous study, sample size was calculated with a type 1 error of 0.05 and a desired power of 0.95, regarding a 10% difference in the incidence of catheter misplacement between the groups as significant. The calculated sample size was 173 in each group.

Data were expressed as mean (SD) (range) or median (IQR). SPSS for Windows 17.0 software (SPSS, Chicago, IL, USA) was used for statistical analysis. Unpaired t-test was performed for comparison of patient data between the two groups. The Mann–Whitney U-test was used to compare the number of needle passes between the two groups. \( \chi^2 \) test was performed to compare the sex difference, the incidences of complications, and catheter tip malpositions between the two groups. A \( P \)-value of \( <0.05 \) was considered significant.

Results

Of the 361 patients enrolled for randomization, 180 patients were randomized to the neutral shoulder position (Group 1) and 181 patients were randomized to the lowered shoulder position (Group 2). There was no difference in gender, age, body weight, and height between the two groups (Table 1). SCV catheterization was successful in 348 of 361 patients (96.4%). There were five failures in Group 1 (2.8%) and eight failures in Group 2 (4.4%) (\( P=\text{NS} \)). CVC were inadvertently removed in two patients of Group 1 before obtaining postoperative chest radiographs, and therefore, the position of the catheter tip could not be checked. These two patients were excluded from the main analysis of the study (Fig. 1).

The occurrence of immediate complications such as pneumothorax or arterial puncture was not different (Table 2). Aberrant placement of the catheter tips was more frequent in Group 2 [2 out of 173 (1.2%) vs 14 out of 173 (8.1%) \( (P<0.01) \)] (Table 2). The misplaced catheter tips were in either the ipsilateral IJV or the contralateral brachiocephalic vein.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Patient characteristics. Data are expressed as mean (SD) (range) or number of patients. There were no significant differences between the two groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder position</td>
<td>Neutral (( n=180 ))</td>
</tr>
<tr>
<td>Male:female</td>
<td>92:88</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>50.1 (15.6) (16–81)</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>62.7 (11.1) (36.8–112.8)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>162.9 (8.8) (143.9–185.0)</td>
</tr>
<tr>
<td>Surgical procedures (n)</td>
<td></td>
</tr>
<tr>
<td>Craniotomy</td>
<td>161</td>
</tr>
<tr>
<td>Oesophageal surgery</td>
<td>19</td>
</tr>
</tbody>
</table>

The reported incidence of catheter tip misplacement during infraclavicular subclavian catheterization was 3%, when the J-guidewire tip was directed downward.11 On the distal SVC or the SVC and right atrial junction.11 Catheter tips located in the IJV, brachiocephalic vein, or contralateral SCV were considered as misplacement.
Discussion

The IJV is the most frequently used site for direct central venous access, and ultrasound guidance reduces mechanical complications during IJV catheterization.\textsuperscript{12} However, in addition to the fact that SCV is most feasible for hypovolaemic patients, SCV catheterization carries lower risks of catheter-related thrombosis and bloodstream infection.\textsuperscript{12}

Therefore, despite the potential risk of pneumothorax and arterial puncture and the difficulty of ultrasound guidance,\textsuperscript{12} SCV may be favoured over the other sites in patients expected to require central venous access for a longer period.

Aberrant placement of the catheter tip is reported to occur in 3–29% of infraclavicular subclavian venous catheterizations.\textsuperscript{13–17} SCV catheters are commonly directed to the ipsilateral IJV or the contralateral brachiocephalic vein.\textsuperscript{18} A misplaced catheter tip may increase the risk of vascular perforation, local venous thrombosis, catheter dysfunction, and faulty central venous pressure reading.\textsuperscript{19} Previous studies\textsuperscript{15,20,21} reported that the malposition rate of SCV catheters was higher in the right-sided approach rather than that in the left-sided approach. The right SCV catheter may be frequently misplaced to the right IJV because the right SCV forms an acute angle with the brachiocephalic vein.\textsuperscript{22}

The optimal shoulder position during SCV catheterization has been investigated, but is yet to reach a conclusion. The anatomical changes produced by different shoulder positions should be kept in mind when performing SCV catheterization. It has been shown that shrugging the shoulder displaced the right SCV more medially in relation to the clavicle, increasing the angle formed between the SCV and the clavicle,\textsuperscript{23} whereas a lowered shoulder position produced a more constant relationship between the SCV and the clavicle.\textsuperscript{8} However, the lowered shoulder position decreases the SCV diameter and narrows the space between the clavicle and the first rib,\textsuperscript{8} which is consistent with our data, in that the number of needle passes was higher with the shoulder lowered.

Table 2 Incidences of exclusion, complication, and catheter tip misplacement. *P<0.01 between the two groups; **P=0.053; †P<0.05 between the two groups

<table>
<thead>
<tr>
<th>Shoulder position</th>
<th>Neutral (n=180)</th>
<th>Lowered (n=181)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exclusions and their causes</td>
<td>5/180 (2.8%)</td>
<td>8/181 (4.4%)</td>
</tr>
<tr>
<td>Failure to puncture the subclavian vein</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Change to the other sites (because of arterial puncture)</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Failure to thread the guidewire</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Failure to thread the catheter over the guidewire</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Complications</td>
<td>5/180 (2.8%)</td>
<td>5/181 (2.8%)</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Arterial puncture</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Catheter tip misplacements*</td>
<td>2/173 (1.2%)</td>
<td>14/173 (8.1%)</td>
</tr>
<tr>
<td>Ipsilateral internal jugular vein**</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Contralateral brachiocephalic vein†</td>
<td>0</td>
<td>6</td>
</tr>
</tbody>
</table>

Fig 1 CONSORT flowchart. Group 1, neutral shoulder position; Group 2, lowered shoulder position; SCV, subclavian vein.
In our study, the total malposition rate was increased, most frequently into the ipsilateral IJV, when the shoulder was lowered. The lowered shoulder position may increase the angle between the SCV and ipsilateral brachiocephalic vein as demonstrated in a previous study. In addition, we speculate that with the shoulder lowered, the right brachiocephalic vein may join the left brachiocephalic vein at an increased angle, and subsequently direct the SCV catheter into the contralateral brachiocephalic vein.

Controversy exists as to the patient’s positions during SCV catheterization. Turning the head to the opposite side in the Trendelenburg position has been traditionally recommended. While Jesseph and colleagues stated that turning the head Trendelenburg position has been traditionally recommended. Turning the head to the opposite side in the Trendelenburg position has been traditionally recommended. While Jesseph and colleagues stated that turning the head to the opposite side may promote catheter malpositioning into the IJV, Land stated that maximal rotation of the head to the contralateral side did not change the relationship of the SCV to the clavicle. In infants, the position of the head is also expected to alter the relationship between the SCV and IJV. In addition, there is a natural tendency for the shoulders to slide the cephalad in the Trendelenburg position and this may alter the anatomic relationship. Since tight downward pulling of the shoulder may promote malposition of the CVC as shown in our study, shoulder traction should be applied gently and only as much as to counter the cephalad tendency in the Trendelenburg position.

There are some limitations to our study. First, the anesthesiologists performing the SCV catheterization were not blinded to the groups. However, the nature of the study makes it nearly impractical to apply a double-blind study design. Secondly, although all catheterizations were randomly performed by the experienced anaesthesiologists, there may be small variations in skill and experience between the anaesthesiologists when performing the procedure.

In conclusion, our study suggests that the neutral shoulder position reduces the incidence of catheter malplacements during the infraclavicular approach of the right SCV catheterization.

Conflict of interest
None declared.

Funding
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