Ultrasound validation of trendelenburg positioning to increase internal jugular vein cross-sectional area in chronic dialysis patients

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Aims and objectives

Hemodialysis is the most frequently utilized therapy and the right internal jugular vein (IJV) is a commonly used cannulation site for central venous access in chronically dialyzed patients (1,2). The safe and successful placement of the central venous line correlates with the cross-sectional area (CSA) of the veins and the degree of overlap between the carotid artery (CA) and the IJV (3-5). Successful placement of an IJV catheter is difficult in patients whose veins have small CSA (2, 4). Small CSA veins may lead to jugular vein collapse, resulting in puncture of both the anterior and posterior walls of the vein and an increased risk of CA puncture if the two structures overlap (4, 5). Inadvertent CA puncture is seen in up to 21% (6) of patients during IJV catheterization and may result in serious morbidity, and even mortality, in high-risk hemodialysis patients (7, 8). Ultrasound guidance has been recommended to increase the success of IJV catheterization and decrease the incidence of complications but it is not always routinely used (4). Thus, it would be of great interest to clinicians if one approach could be shown to increase the CSA and decrease the overlap with the CA in order to improve patient safety.

Trendelenburg positioning is a common approach for puncture of the IJV (8, 9). No evidence indicates that changing the body position of dialysis patients to the Trendelenburg position significantly increases the CSA of the IJV or decreases the overlap between the CA and the IJV. Recently, Wu et al. (2) conducted an ultrasound study to investigate the efficacy of the use of the Trendelenburg position during tunneled dialysis catheter insertion via the right IJV in patients with chronic kidney disease. The overlap rate of the CA and the IJV was not evaluated in their study. They found that, in contrast to healthy volunteers, there was no increase in the CSA of the right IJV when dialysis patients were in the Trendelenburg position. Wu et al. (2) suggest that the use of the Trendelenburg position for dialysis catheter insertion may not be appropriate and should not be encouraged, although it continues to be widely used for central venous catheterization in with or without chronically dialyzed patients. However, this requires further evaluation before a final conclusion can be made.

The primary aim of this study was to investigate the effects of the Trendelenburg position on the CSA of the IJV and the overlap rate between the CA and the right IJV in dialysis patients.
Methods and materials

The study protocol was approved by the Institutional Review Board of the Medical Faculty Hospital, and written informed consents were obtained from all participants prior to the start of the study. Between July, 2013 and December, 2013, a total of 37 consecutive hemodialysis patients older than 18 years of age were enrolled. All ultrasound examinations were performed by the same radiologist (A.N.) in order to maintain consistency. Patients with a history of prior right IJV cannulation or neck surgery were not included in this study. Patients with stenotic or thrombosed right IJVs were also excluded from the study.

The right IJV and its relationship with the CA were ultrasonographically measured using a 13.5 MHz linear array transducer (Acuson, Antares, Siemens). Ultrasound images of the IJVs were obtained in a transverse orientation at the cricoid level. The IJVs were depicted in the middle of the ultrasound image. Probe pressure was kept as low as possible to avoid compression of the IJV. All of the patients were positioned with their neck in extension and head rotated left at approximately 20° to 30°. Patients were studied in State 0, table flat (no tilt), with the patients in the supine position, and State T, in which the operating table was tilted 15° to a Trendelenburg position. A goniometer was used to measure the tilt angle of the table from the horizontal plane. After images were obtained for State 0, the patients were positioned to State T. Images of the right IJV were obtained at most one minute after changing the patient's body position to the 15° Trendelenburg position. The images for each state were obtained at end-expiration at the level of the cricoid cartilage. After freezing the real-time image, the circumference of the IJVs were delineated using an electronic marker, and the CSA of the IJVs were calculated using a program pre-loaded into the ultrasound unit. The following measurements were carried out at each position: (1) the cross-sectional area of the right IJV. (2) the degree of overlap between the IJV and the CA. (3) the transverse and anteroposterior diameters of the right IJV. (4) the margin of safety. Demographic data of the studied patients was also collected. The overlap between the IJV and the CA was categorized on the basis of the percentage of overlap: with (1) being an overlap <25% of the diameter of the CA; and (2) being an overlap of ≥25% of the diameter of the CA (Fig. 1).
Fig. 1: Ultrasound image of the right IJV and relationship with CA. Interrupted white arrow represents the overlap between CA and IJV. Short open arrow shows 25% diameter of CA and long open arrow shows 50% diameter of CA. IJV = internal jugular vein; CA = carotid artery.

References: Radiology, Selçuk University, School of Medicine - Konya/TR

The transverse and anteroposterior diameters of the right IJV were measured by drawing a line between the furthest two points of the vein wall in the transverse and anteroposterior planes. The margin of safety was defined as the distance from the lateral-most border of the right IJV and the lateral-most border of the CA at which the right IJV could be punctured without contacting the CA (Figs. 2 and 3).
**Fig. 2:** Ultrasound image of the right IJV and relationship with CA. CSA = cross sectional area of right IJV, CA = carotid artery.

**References:** Radiology, Selçuk University, School of Medicine - Konya/TR
Fig. 3: Ultrasound image of the right IJV and relationship with CA. 1. Transverse diameter of IJV 2. A-P diameter of IJV 3. Safety margin, CA = carotid artery; A-P = anteroposterior; IJV = internal jugular vein.

References: Radiology, Selçuk University, School of Medicine - Konya/TR

Statistical analysis was performed using SPSS version 17.0 (SPSS Inc., Chicago, IL). The data were tested for normality using the Kolmogorov-Smirnov test. The paired sample t-test was used to compare the diameters and CSA changes between the State 0 and the State T in all patients. Categorical data were analyzed using the McNemar test. A p-value <0.05 was considered statistically significant.
Results

Data were collected for all of the 37 patients (25 male and 12 female) enrolled in the study. No stenotic or thrombosed right IJVs were noted during the ultrasound measurements. The characteristics of the patients are shown in Table I.

Table I - Characteristics of 37 dialysis patients.

<table>
<thead>
<tr>
<th></th>
<th>Male (female)</th>
<th>25 (12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>63.6 ± 9.8</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>70.9 ± 13.5</td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>1.7 ± 0.9</td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.5 ± 4.3</td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>7 (18.9 %)</td>
<td></td>
</tr>
<tr>
<td>Coronary heart disease</td>
<td>6 (16.2 %)</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>16 (43.2 %)</td>
<td></td>
</tr>
</tbody>
</table>

Values are presented as mean ± standard deviation or No. Comorbidities are expressed as the absolute number of patients and percentage of their groups.

The study measurements are summarized in Table II.

Table II - Outcome measurements in the State 0 and State T.

<table>
<thead>
<tr>
<th></th>
<th>State 0 (n=37)</th>
<th>State T (n=37)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSA (cm²)</td>
<td>1.6 ± 1.0</td>
<td>1.7 ± 1.0</td>
</tr>
<tr>
<td>Transvers Diameter (mm)</td>
<td>16.2 ± 5.8</td>
<td>16.5 ± 5.7</td>
</tr>
<tr>
<td>A-P Diameter (mm)</td>
<td>12.5 ± 5.8</td>
<td>12.8 ± 4.8</td>
</tr>
<tr>
<td>Safety margin (mm)</td>
<td>10.8 ± 5.5</td>
<td>11.1 ± 5.1</td>
</tr>
<tr>
<td>Overlap of IJV n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25% or no overlap</td>
<td>9 (24.3)</td>
<td>7 (18.9)</td>
</tr>
<tr>
<td>&gt;25% overlap</td>
<td>28 (75.7)</td>
<td>30 (81.1)</td>
</tr>
</tbody>
</table>
State 0, table flat (no tilt), with the patient in the supine position and State T, in which the operating table was tilted to 15° of Trendelenburg positioning. Overlap ratios are expressed as the absolute number of patients and percentage of their groups. CSA, transverse diameter, A-P diameter and safety margin are expressed as mean ± standard deviation. CSA = cross sectional area; A-P = anteroposterior; IJV = internal jugular vein.

The CSA of the right IJV, the degree of overlap between the right IJV and the CA, the transverse and anteroposterior diameters of the right IJV, and the margin of safety from the supine to the Trendelenburg position was not significantly different. The CSA was paradoxically decreased in 11 of 37 patients (eight of 11 were male).
Conclusion

By studying the ultrasound images of the right IJV of dialysis patients, we determined that the Trendelenburg position changes neither the CSA of the right IJV nor the overlap rate between the CA and the IJV. In fact, the use of the Trendelenburg position for IJV cannulation may actually decrease the CSA and increase the risk of complications. Therefore, the Trendelenburg position can no longer be supported for IJV cannulation without ultrasound guidance.
References


9. Nassar B, Deol GRS, Ashby A, Collett N, Schmidt GA. Trendelenburg position does not increase cross-sectional area of the internal jugular vein predictablytrendelenburg does not increase jugular size. CHEST Journal 2013;144:177-182