Head Rotation During Internal Jugular Vein Cannulation and the Risk of Carotid Artery Puncture

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We undertook a prospective laboratory study to examine the effect of head position on the relative positions of the carotid artery and the internal jugular vein (IJV). Volunteers (n = 12) from departmental staff, 18–60 yr of age, who had never undergone cannulation of the IJV underwent imaging of their IJV and carotid artery. With the subject in a 15° Trendelenburg position, two-dimensional ultrasound images of the IJV and the carotid artery were obtained on the left and right sides of the neck at 2 and 4 cm from the clavicle along the lateral border of the sternocleidomastoid muscle at 0°, 40°, and 80° of head rotation from the midline. The percent overlap of the carotid artery and IJV increased significantly at 40° and 80° head rotation to both the right and left (P < 0.05). Data from 2 and 4 cm above the clavicle did not differ and were pooled. The percent overlap was larger on the left than the right only with 80° of head rotation (P < 0.05). The increased overlap of carotid artery and IJV with head rotation >40° increases the risk of inadvertent puncture of the carotid artery associated with the common occurrence of transfixion of the IJV before it is identified during needle withdrawal. The IJV frequently collapses with needle insertion. This may result in puncture of the posterior wall of the vessel, and thus of the carotid artery when the two vessels overlap. To decrease this risk, the head should be kept in as neutral a position as possible, that is <40° rotation, during IJV cannulation.

Compared with the subclavian approach, percutaneous cannulation of the internal jugular vein (IJV) has a lower incidence of complications. The most common of these is carotid artery puncture, the incidence of which ranges from 3% to 10% (1–4). Although usually benign, for example, when an inconsequential hematoma results, accidental carotid artery puncture can be life-threatening when it results in accidental intraarterial cannulation, cerebrovascular accident, hemothorax, IJV-carotid artery fistula, or airway compromise secondary to hematoma (5–7). Although the incidence of accidental puncture of the carotid artery decreases with practitioner experience, the risk of this complication is never eliminated (4).

When the IJV requires cannulation, its exposure is commonly facilitated by rotating the head away from the side being cannulated. The recommended amount of rotation from midline ranges from 30° to 90° (8–11). This practice presumes that rotation either enhances, or does not significantly affect, the relative position of the IJV and the carotid artery. If this presumption is wrong, and the technique results in new overlap or increasing overlap, this would increase the risk of accidental puncture. During IJV cannulation, venous blood return may not be achieved until the needle is withdrawn because the pressure of the advancing needle can cause the IJV to collapse, the incidence of which is reported to be 50% (12). This, in turn, causes the needle to puncture the posterior wall of the IJV and the carotid artery, if it is lying behind the IJV.

The anatomic position of the IJV is generally lateral and anterior to the carotid artery (Fig. 1). Variations in the relative positions of the IJV and carotid artery that could result in accidental puncture of the carotid artery have been documented by ultrasound (13–15). In one series of 77 ultrasonographically visualized IJVs, in three cases, the IJV overlapped the carotid artery; head position, however, was not specified (14). Therefore, we designed a study to examine, by ultrasound imaging, the influence of head position on the relative positions of the IJV and the carotid artery.
Methods
The research protocol was approved by our institutional review board, and informed consent was obtained from subjects who were volunteers recruited from departmental staff. The subjects (n = 12) ranged in age from 18 to 60 yr, and had never undergone IJV cannulation. For testing, each subject was placed supine in a 15° Trendelenburg position. Images were made of the right and left sides of the neck at 2 and 4 cm from the clavicle along the lateral border of the sternal head of the sternocleidomastoid muscle and at 0, 40, and 80° rotation of the head from midline. The same, experienced, vascular laboratory technician obtained all images by ultrasound (Ultramark® 9 HDI; Advanced Technology Laboratories, Inc., Bothell, WA) with a 38-mm-linear-array (L10-5), 7.5-MHz transducer, which was held perpendicular to the long axis of the body and applied gently, so as not to distort the underlying low-pressure venous structure. Images were displayed on a B-mode scan with color flow, and color prints were developed for off-line analysis. The diameter of both the IJV and the carotid artery and the percent overlap between the two vessels were measured from the prints by two independent observers. Percent overlap was calculated as follows:

\[ \% \text{ overlap} = \frac{\text{overlap (mm)}}{\text{carotid artery diameter (mm)}} \times 100. \]

Table 1. Percent Overlap of Carotid Artery by Internal Jugular Vein at Three Different Degrees of Head Rotation

<table>
<thead>
<tr>
<th>Side of neck</th>
<th>0°</th>
<th>40°</th>
<th>80°</th>
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<tbody>
<tr>
<td>Right</td>
<td>1.5 ± 0.8</td>
<td>6.5 ± 2.8</td>
<td>27.5 ± 7.4*†</td>
</tr>
<tr>
<td></td>
<td>(0-17.4)</td>
<td>(0-48)</td>
<td>(0-100)</td>
</tr>
<tr>
<td>Left</td>
<td>5.2 ± 2.9</td>
<td>11.5 ± 4.9</td>
<td>44.7 ± 7.2‡†</td>
</tr>
<tr>
<td></td>
<td>(0-54)</td>
<td>(0-76.5)</td>
<td>(0-100)</td>
</tr>
</tbody>
</table>

Values are means ± SEM; range given in parentheses.
* P < 0.05 compared with 0° rotation to same side of the neck.
† P < 0.05 compared with 40° rotation to same side of the neck.
‡ P < 0.05 compared with 80° rotation to the right.

The difference between percent overlap at the different degrees of head rotation were analyzed statistically by a multiple group comparison with a two-way repeated-measures analysis of variance followed by Student-Newman-Keuls testing, where P < 0.05 was considered significant.

Results
Overlap of the carotid artery by the IJV did not differ between 2 and 4 cm above the clavicle at the same degree of head rotation, and did not differ between the observers who analyzed the printed color images; therefore those data were pooled. Of the 12 subjects, 11 had some degree of overlap between the vessels with different degrees of rotation to either side. When compared with rotation from 0° to 40°, when head rotation to the same side was increased to 80°, percent overlap of the carotid artery by the IJV increased significantly (P < 0.05) (Table 1, Fig. 2). When overlap occurred, it was always more on the left than the right side, but this was significant only at 80° head rotation (P < 0.05). No overlap at any time—that is, a fixed relationship between the two vessels, even with 80° of head rotation—was observed in one subject on the left side, three subjects on the right side, and one subject on both sides, the relative positions of the two vessels in these subjects being normal (Fig. 3).

Discussion
The IJV is routinely cannulated for central venous access. Skin puncture and cannulation are facilitated by exposure of the neck with contralateral head rotation. Our data demonstrate that this maneuver alters the anatomic relationship of the IJV and the carotid artery. This has not previously been documented. Variation in the relative positions of these vessels, including extreme lateral and even medial positions of the IJV relative to the carotid artery, complicate cannulation when external landmarks are used as the sole guide to cannula placement. Interestingly, in one
study that used ultrasound imaging, with head rotation of approximately 30° from midline, an aberrant anatomic relationship between IJV and carotid artery was observed whereby, in 1% of patients, the IJV was more than 1 cm lateral to the carotid artery, and in 2% the IJV was medially positioned to the carotid artery (13). Head rotation did not correlate with the relationship between the two vessels (13). In an ultrasound study of pediatric cardiac patients, the carotid artery coursed posteriorly to the IJV in 10% of patients, which would predispose them to accidental carotid artery puncture (15). In the present study, an aberrant anatomic relation between the two vessels was not noted, but overlap between them was significant in all but one subject.

Cannulation of the IJV can be facilitated with ultrasound imaging. The use of ultrasound imaging has
decreased not only the number of attempts and the time needed to place the cannula but also the incidence of carotid artery puncture (14, 16–18). Ultrasound imaging is especially appealing in teaching situations, and in situations where carotid artery puncture should be avoided or external or anatomic landmarks to guide needle placement are distorted. Portable ultrasound equipment or echocardiography, however, are often not accessible.

Accidental carotid artery puncture is usually benign, but can result in serious complications (5–7). Therefore, we advocate neutral or near neutral head position during IJV cannulation to reduce the risk of carotid artery puncture. In spite of greater difficulty because of associated change in mandible position, and the more acute needle insertion angle required with a neutral head position, this method has been highly successful: In patients with cervical spine injury, in whom maintenance of neutral head and neck positions is mandatory, cannulation of the IJV had a 98% success rate (19).

In addition to the customary guidelines for IJV cannulation, we would add the following based on our data: 1) The head should be kept in as near a neutral position as possible to decrease the risk of carotid artery puncture associated with overlap of the two vessels caused or increased by head rotation. 2) The right IJV should be preferred for cannulation because this approach is associated with less overlap of carotid artery and IJV and with fewer cannula malpositions than cannulation on the left side (20).

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References