Inadvertent Arterial Trauma during Internal Jugular Vein Catheterization

Kenji Kayashima

Chief Director, Department of Anesthesia, Kyushu Kosei Nenkin Hospital, Kitakyushu, Fukuoka, Japan

Summary

To ensure safe placement of a central venous catheter (CVC), the potential accidents that may occur due to inadvertent arterial puncture through the internal jugular vein (IJV), should be carefully considered. Inadvertent common carotid arterial puncture during IJV catheterization is well recognized. However, other arteries including the subclavian, vertebral, transverse cervical and inferior thyroid arteries may be located behind the IJV, and are at risk of mispuncture. In the present study, we searched for case reports related to arterial trauma during IJV catheterization. In the present report, we describe information regarding CVC placement, including the historical and anatomical background, and the need for using ultrasonography during placement.

Through our search, we obtained 9 cases of vertebral arterial, 7 cases of subclavian arterial, 1 case of thyrocervical trunk, 4 cases of transverse cervical arterial, and 1 case of inferior thyroid arterial insults that were caused inadvertently around the IJV. Of the 22 cases, 2 involved insults in children. Real-time ultrasonographic guidance was employed in 5 recent cases, and surgical repair was required in 12 of the 22 cases.

In most of the cases of arterial puncture not involving the CCA, the surgeons did not use ultrasonography. Static ultrasonography via the anatomic landmark approach for locating the IJV, and combining the pre-procedural ultrasonographic assessment with a real-time ultrasound-guided venipuncture are recommended during CVC placement. The ultrasound-guided insertion technique requires education, training and practice. The presence of small arteries located behind the IJV should be carefully considered, and their presence in this position should be examined, prior to puncturing of the IJV. However, it should be noted that rare complications develop during CVC placement with or without ultrasonographic guidance. Therefore, the technique involving ultrasonographic guidance is not completely reliable.

Introduction

To ensure safe placement of a central venous catheter (CVC), the potential accidents that may occur due to inadvertent arterial puncture through the internal jugular vein (IJV), should be carefully considered. A previous review study has described the manner in which mispuncturing of the common carotid arteries (CCAs) or subclavian arteries during IJV catheterization can be avoided. Moreover, arterial punctures can be avoided during arterial cannulation by using a tube manometer to verify venous access [1]. Studies investigating the relationships between the CCAs and IJVs indicated that these vessels overlapped in 70–90% of cases [2–6]. Neck rotation increases overlapping ratio between the CCA and IJV [7]. Therefore, prior to performing IJV punctures, it is essential to assess the overlapping of these arteries using ultrasonography.

Only limited information on the puncture of IJV or subclavian veins has been mentioned in reports related to arterial trauma during CVC insertion [8,9]. However, studies have reported on the presence of small arteries such as the vertebral artery [10,11], thyrocervical trunk [12,13], suprascapular artery, transverse cervical artery [14–18], and inferior thyroid artery [19], that are occasionally located just behind the IJV [11,13].

We performed an extensive literature search through PubMed, Google, science journals and textbooks to identify such studies, using key words such as internal jugular vein, subclavian artery, vertebral artery, thyrocervical trunk, transverse cervical artery and inferior thyroid artery. In the present report, we describe information regarding CVC placement, including the historical and anatomical background, and the need for using ultrasonography during placement.

Case Presentations

Table 1 demonstrates summary of case reports. Through our search, we noted 9 cases of vertebral arterial [10,20–27], 7 cases of subclavian arterial [28–34], 1 case of thyrocervical trunk [12], 4 cases of transverse cervical arterial [14,15,17,18], and 1 case of inferior thyroid arterial [19], insults that were caused inadvertently around the IJVs. These cases were associated with needle punctures [10,15,19], catheter cannulations [14,20,21,26,29–33], hemotherax [12,21,28–31], pseudoaneurysms [12,17,18,23,24], arteriovenous fistulas [18,22,25,26,33,34], and a dissection [27]. In 2 of the 22 cases, the patients were children and the insults resulted from needle punctures [10,15].

Of the 22 reported cases, real-time ultrasonographic guidance was employed only in 5 recent (2011–2013) cases [10,14,15,32,33]. In one case of vertebral arterial puncture [10], although the surgeon noted the presence of an artery behind the IJV, puncturing of the vertebral artery could not be avoided because of its position just behind the IJV. In one case of CVC placement through the transverse cervical artery with a 22-G metal needle using a guidewire [14], and another case of inadvertent puncture of a small artery located just behind the IJV [15], the presence of these arteries behind the IJV was not known. In cases involving cannulation of the subclavian artery [32,33], the position of the subclavian arterial relative to the IJV position may not have been determined, despite the use of ultrasonography.

*Corresponding author: Dr. Kenji Kayashima, Chief Director, Department of Anesthesia, Kyushu Kosei Nenkin Hospital, 1-8-1 Kishinoura, Yahatanishi-ku, Kitakyushu, Fukuoka 806-8501, Japan, Tel: +81-93-641-5111; Fax: +81-93-642-1966; E-mail: ken5ji5ka5ya5shi5ma@nifty.com

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Surgical repair was required in 12 of the 22 cases. In a case of a pseudoaneurysm of the thyrocervical trunk, the pseudoaneurysm was resected and the arterial branch was ligated [12]. In a case of a vertebral artery, a large amount of associated hematoma was removed, and a lacerated vertebral artery was tied off [21]. In a case of vertebral artery pseudoaneurysm, the site of hemorrhage was sutured [22]. In another case of vertebral and subclavian artery pseudoaneurysm, the pseudoaneurysms were resected [23]. Moreover, in a case of vertebral arteriovenous fistula, multiple small communicating veins draining into the vertebral vein, and a single communication between the vertebral artery and vein were ligated and divided [25]; thereafter, the vertebral arteriovenous fistula was excised. In another case of vertebral arteriovenous fistula, the anastomosis was completed using the triangulation technique [26].

Furthermore, in a case of a massive hemothorax, the right subclavian artery was found to be lacerated at its origin from the brachiocephalic artery [28]; the subclavian artery was disconnected from the internal carotid, and then re-anastomosed. In another case of hemomediastinum, 1.5 L of clotted blood was removed and the subclavian artery was identified and repaired by suturing [30]. In a case of hemomediatinum, 1.5 L of clotted blood was removed and 5-mm laceration of subclavian artery was repaired [29]. In a case of subclavian artery injury, 2 L of blood was removed via a thoracotomy; in addition, a puncture in the first part of the subclavian artery was identified and repaired by suturing [30]. In a case of hemomediatinum, 1.5 L of clotted blood was removed and 5-mm laceration of subclavian artery was repaired [31]. Moreover, in a case of subclavian arteriovenous fistula, a 7.5 French hemodialysis catheter was removed and the subclavian artery was successfully repaired [32]. Removal of a 12-gauge double lumen catheter and subclavian artery repair were done successfully [33].

### Discussion

Through our search of the PubMed and other database, we identified 22 cases of inadvertent arterial punctures that did not involve the CCA during IJV cannulation, which were noted primarily in adults. In 12 cases with severe injury, surgical interventions were required. Therefore, we believe that the presence of small arteries, other than the CCA, located behind the IJV should be carefully considered, and their presence in this position should be examined prior to puncturing of the IJV.

Static ultrasonography with the anatomic landmark approach for locating the IJV [35,36], and combining the pre-procedural ultrasonographic assessment with a real-time ultrason-guided venipuncture [37], are recommended during CVC placement. The anatomical structures of the vertebral [11] and transverse cervical [13,15,16] arteries can be observed by using ultrasonography, including color flow Doppler imaging.

Multiple published guidelines and recommendations support the clinical utility of ultrasound-guided IJV puncture [35–41]. However, these guidelines and recommendations on vascular access have not referred to the small vascular structures located around the IJV. Only O’Leary and Bodenham [42] have suggested that confirmation of the presence of small arteries using color flow Doppler imaging is vital.

For CVC placement, anatomical information of arteries around

<table>
<thead>
<tr>
<th>No</th>
<th>Year</th>
<th>Injured artery (A)</th>
<th>Types of trauma</th>
<th>Age</th>
<th>Cath or needle</th>
<th>Meth or Appr</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>2012</td>
<td>Vertebral A</td>
<td>Needle puncture</td>
<td>12 m</td>
<td>24G needle</td>
<td>USG</td>
<td>Pressure</td>
</tr>
<tr>
<td>20</td>
<td>2007</td>
<td></td>
<td>Cath cannulation</td>
<td>40 y</td>
<td>–</td>
<td>–</td>
<td>Remov</td>
</tr>
<tr>
<td>21</td>
<td>1981</td>
<td></td>
<td>Cath cannulation Hemorrhax</td>
<td>55 y</td>
<td>Bard I-Cath</td>
<td>14G Introducer</td>
<td>Surgery after Remov</td>
</tr>
<tr>
<td>22</td>
<td>1992</td>
<td></td>
<td>AV fistula</td>
<td>72 y</td>
<td>22G needle</td>
<td>–</td>
<td>Surgery</td>
</tr>
<tr>
<td>23</td>
<td>2011</td>
<td></td>
<td>Pseudoaneurysm</td>
<td>48 y</td>
<td>–</td>
<td>LM</td>
<td>Medical</td>
</tr>
<tr>
<td>24</td>
<td>2011</td>
<td></td>
<td>Pseudoaneurysm</td>
<td>36 y</td>
<td>–</td>
<td>14G needle</td>
<td>20G</td>
</tr>
<tr>
<td>25</td>
<td>1980</td>
<td></td>
<td>AV fistula</td>
<td>36 y</td>
<td>14G needle</td>
<td>–</td>
<td>Surgery</td>
</tr>
<tr>
<td>26</td>
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<td></td>
<td>Cath cannulation AV fistula</td>
<td>54 y</td>
<td>S-G</td>
<td>Posterior</td>
<td>Surgery after Remov</td>
</tr>
<tr>
<td>27</td>
<td>2004</td>
<td></td>
<td>Dissection</td>
<td>63 y</td>
<td>–</td>
<td>–</td>
<td>Remov Pressure</td>
</tr>
<tr>
<td>28</td>
<td>1990</td>
<td>Subclavian A</td>
<td>Hemothorax Laceration</td>
<td>56 y</td>
<td>14G DL</td>
<td>Boulanger</td>
<td>Surgery</td>
</tr>
<tr>
<td>29</td>
<td>1998</td>
<td></td>
<td>Cath cannulation Hemorrhax</td>
<td>47 y</td>
<td>7F TL</td>
<td>Seldinger</td>
<td>Surgery after Remov</td>
</tr>
<tr>
<td>30</td>
<td>2002</td>
<td></td>
<td>Cath cannulation hemotorax</td>
<td>66 y</td>
<td>TL</td>
<td>Anterior</td>
<td>Surgery after Remov</td>
</tr>
<tr>
<td>31</td>
<td>2003</td>
<td></td>
<td>Cath cannulation Hemorrhax, laceration</td>
<td>61 y</td>
<td>8.5F sheath</td>
<td>22G needle</td>
<td>Surgery after Remov</td>
</tr>
<tr>
<td>32</td>
<td>2012</td>
<td></td>
<td>Cath cannulation</td>
<td>65 y</td>
<td>7.5F</td>
<td>USG</td>
<td>Remov at surgery</td>
</tr>
<tr>
<td>33</td>
<td>2011</td>
<td></td>
<td>Cath cannulation AV fistula</td>
<td>63 y</td>
<td>12F DL</td>
<td>USG</td>
<td>Remov at Surgery</td>
</tr>
<tr>
<td>34</td>
<td>2013</td>
<td></td>
<td>AV fistula</td>
<td>45 y</td>
<td>11.5F</td>
<td>LM</td>
<td>Medical</td>
</tr>
<tr>
<td>12</td>
<td>1998</td>
<td>Thymocervical trunk</td>
<td>Hemothorax Pseudoaneurysm</td>
<td>57 y</td>
<td>11.5F DL</td>
<td>–</td>
<td>Surgery after Remov</td>
</tr>
<tr>
<td>14</td>
<td>2011</td>
<td></td>
<td>Cath cannulation</td>
<td>50 y</td>
<td>12G DL</td>
<td>USG</td>
<td>Remov and Pressure</td>
</tr>
<tr>
<td>15</td>
<td>2013</td>
<td></td>
<td>Needle puncture</td>
<td>15 m</td>
<td>24G needle</td>
<td>USG</td>
<td>Pressure</td>
</tr>
<tr>
<td>18</td>
<td>2000</td>
<td>Transverse cervical A</td>
<td>Pseudoaneurysm AV fistulas</td>
<td>46 y</td>
<td>–</td>
<td>USG</td>
<td>TCA occlusion</td>
</tr>
<tr>
<td>19</td>
<td>2007</td>
<td>Inferior thyroid A</td>
<td>Needle puncture</td>
<td>54 y</td>
<td>–</td>
<td>–</td>
<td>Embolization</td>
</tr>
</tbody>
</table>

No: reference number; Year: published year; m: months old; y: years old; Meth or Appr: method or approach.
Cath: catheter; G: gauge; F: French size; S-G: Swan-Ganz catheter; DL: double lumen catheter; TL: triple lumen catheter; AV: Arteriovenous; USG: ultrasonographic guidance; LM: landmark guidance; Remov: cath removal; –: not mentioned

Table 1: Cases of inadvertent arterial trauma through the internal jugular vein.
the IJV should be well known. The brachiocephalic artery bifurcates into the right subclavian and the right CCA. The right vertebral artery branches from the subclavian artery. In addition, the thyrocervical trunk arises from the subclavian artery adjacent to the vertebral artery and branches into the suprascapular artery, transverse cervical artery and inferior thyroid artery.

The use of appropriate cannulation techniques involving real-time ultrasonographic guidance for avoiding puncturing of the CCA has been widely reported in the literature [39,43]. However, in a previous study, video analysis indicated accidental arterial cannulation of 5 CCAs and 1 femoral artery, despite the use of real-time ultrasonographic guidance [44]. Simulation models have indicated that penetration of the posterior wall of the IJV is unavoidable in certain cases [45,46]. Therefore, the technique involving ultrasonographic guidance is not completely reliable.

The ultrasound-guided insertion technique requires education, training, and practice [35,36,39,40]. In most of the cases of arterial puncture not involving the CCA [12,17,31,34], the surgeons did not use ultrasonography. Moreover, the presence of arteries behind the IJV has not been completed studied [10,14,15].

Therefore, it is essential that the position of the arteries around the IJV should be confirmed using color flow Doppler imaging, prior to puncturing. It would be difficult to identify the small arteries located behind the IJV, without using color flow Doppler imaging [10,11,15,16,42]. In addition, it is recommended that the position of the catheter tip should be confirmed using chest radiography, fluoroscopy or continuous electrocardiography [36].

Of 12 cases of surgical repair, 4 cases involving subclavian arterial cannulations underwent pre-surgical removal of large bore catheters that were inserted into the arteries prior to surgical exploration, and 1.5–2 L of blood was removed from the thorax during the surgery. It is essential that vascular surgeons or endovascular specialists should be consulted, prior to the removal of catheters from the arteries [8].

In the present study, we described 7 cases involving subclavian arterial trauma. Guilbert et al. [8] state that the low IJV approach should be carefully considered, as it may injure not only the CCA, but also the subclavian artery or innominate vessels. However, the presence of the subclavian artery behind the IJV has not been examined using ultrasound imaging, and further studies are required in order to elucidate information on the manner in which puncturing of the subclavian artery can be avoided during IJV puncture.

In the United States alone, more than 5 million central venous catheter placement procedures were performed, with a mechanical complication rate of 5% to 19% [39,40]. Although the present study could not assess all the published reports concerning inadvertent arterial puncture related to the IJV, the rare complications that have occurred during placement of CVCs with or without ultrasonographic guidance should be carefully considered.

References


