Ultrasound-guidance can reduce adverse events during femoral central venous cannulation

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Abstract—Background: Ultrasound-guidance for internal jugular central venous cannulation (CVC) has become the recommended best practice and has been shown to improve placement success and reduce complications. There is a dearth of studies that evaluate emergency point-of-care ultrasound guidance of femoral CVC. Objective: Our aim was to determine if point-of-care ultrasound guidance for femoral CVC decreases adverse events and increases the likelihood of successful placement when compared with the landmark technique. Methods: We conducted an Institutional Review Board–approved, prospective, observational study of consecutive patients who required CVC. Physicians who performed CVC completed a standardized, web-based data sheet for a national CVC registry. We evaluated single-institution data regarding CVC site, ultrasound usage, CVC indication, and mechanical complications (e.g., pneumothorax, arterial puncture, failed access, catheter misdirection, and hematoma). The study period was between January 2006 and June 2010. Analysis using Pearson’s $\chi^2$ and Agresti-Coull binomial confidence intervals was performed; significance was defined as $p < 0.05$. Results: We evaluated data for 143 patients who had femoral CVC in our institution. Sixty CVCs (42%) were performed under ultrasound guidance, 83 (58%) via landmark technique ($p = 0.0159$); 3.3% of femoral central venous lines placed by ultrasound guidance had recorded adverse events compared with 9.6% for the landmark technique ($p = 0.145$). There was no statistically significant difference in complications between ultrasound-guidance and landmark techniques. Our data showed a trend toward decreased rates of arterial puncture and reduced cannulation attempts resulting in improved placement success. Conclusions: Our experience shows that ultrasound guidance for femoral CVC might decrease complications and improve placement success, although we cannot recommend this approach without additional data. We recommend a larger study to further evaluate this technique. © 2014 Elsevier Inc.

Keywords—point-of-care ultrasound; bedside ultrasound; central venous catheterization; femoral; procedural guidance

INTRODUCTION

Physicians in the United States annually place an estimated 5 million central venous catheters in internal jugular, subclavian, and femoral veins (1). Common indications for central venous cannulation (CVC) include vasoactive medication infusions, hemodynamic monitoring, cardiac pacing, cardiopulmonary resuscitation, parenteral nutrition, and poor peripheral venous access. Although often necessary and beneficial, CVC is associated with significant risks that include arterial puncture, hematoma formation, pneumothorax, guidewire loss, line misdirection, and infection (1). Direct ultrasound visualization of the needle
tip and guidewire entering the vessel can mitigate these complications.

Ultrasound guidance for internal jugular CVC has become the recommended best practice and has been shown to increase successful catheter placement and to reduce complications (2–4). A 2006 study published by Leung et al. demonstrated that ultrasound guidance for internal jugular CVC improved successful placement by 15.4% and reduced complications by 12.3% (5).

There is a dearth of studies that evaluate emergency point-of-care ultrasound guidance for femoral CVC. We sought to determine if ultrasound guidance for femoral CVC decreased adverse events and increased successful placement when compared with the standard landmark technique in the emergency department.

METHODS

We evaluated data from 143 patients who had femoral CVC performed. Emergency department attending, fellow, and resident physicians placed a femoral central line using maximal sterile barrier precautions, except in code or emergent situations. Choice of CVC location was at the discretion of physicians. Clinicians then completed a standardized, web-based data sheet for the Central Line Emergency Access Registry (CLEAR). The CLEAR registry comprised 13 academic centers that maintain an annual census of at least 35,000 patients. The centers were staffed by American Board of Emergency Medicine practitioners around the clock. Patients at least 18 years of age who had attempted CVC by an emergency medicine resident or physician were eligible for database entry. Pertinent data recorded in the registry are listed in the Tables 1 and 2 (6).

Statisticians analyzed data using SPSS-17 statistical software developed by the SPSS Inc. (Chicago, IL). Pearson’s χ² and Agresti-Coull binomial confidence intervals were performed. Significance was defined as p < 0.05.

RESULTS

We evaluated data for 143 patients who had femoral CVC in our institution. Residents placed the majority of femoral lines (n = 139). Attending physicians performed three lines and supervised a medical student who placed one femoral CVC. Sixty CVCs (42%) were placed under ultrasound guidance and 83 (58%) were placed via landmark technique (p = 0.0159); 3.3% of central venous lines placed by ultrasound guidance had recorded adverse events compared with 9.6% for the landmark technique (p = 0.145). Ultrasound guidance might have reduced the total number of needle sticks, arterial punctures, and failed access; however, the study lacked power to show this effect. Table 3 and Figure 1 delineate adverse events associated with each technique.

DISCUSSION

A review of our institution’s data from the CLEAR registry indicates that 99.3% of internal jugular vein CVCs was performed using ultrasound guidance, reflecting the national best practice. Femoral CVC stands in stark contrast: 43% of femoral CVCs were guided by ultrasound. Ultrasound-guided femoral CVCs had a 3.3% complications compared with 9.6% in the landmark technique group. This was not statistically significant, most likely due to the low number of femoral CVCs during the study period.

Clinicians might prefer the femoral location for CVC as opposed to the internal jugular or subclavian veins in several clinical situations. During cardiac or respiratory
arrest, femoral veins can offer easier access and free the chest for compressions. Femoral CVC eliminates risk of pneumothorax in patients with thoracic disease and provides a compressible vessel in patients with coagulopathy. In addition, temporary hemodialysis catheters can be placed in the femoral location to preserve access points above the diaphragm for tunneled catheters.

General barriers to ultrasound-guided CVC include access to equipment, inadequate amount of time to power up recording media, and proper training. Ultrasound guidance for CVC, however, is easy to teach. Research has shown that novice clinicians who employ ultrasound-guidance for CVC can readily acquire the skill set, resulting in decreased attempts and improved success (7). Residents performed the vast majority of femoral catheterizations in our study.

Ultrasound guidance for central venous catheterization offers several benefits over the landmark technique. It enables the clinician to detect anatomic variations and exact vessel location, directly visualize needle tip and guidewire, identify pre-existing vessel thrombosis, avoid arterial puncture, and reduce needle sticks (8). Figure 2 shows a transverse view of the femoral artery and femoral vein. The femoral vein is compressed in Figure 3, indicating absence of thrombosis and a viable location for CVC placement. A good reference for femoral CVC can be found in a 2008 article, “Videos in Clinical Medicine” published in the New England Journal of Medicine (9).

Table 3. Femoral Central Venous Cannulation Adverse Events

<table>
<thead>
<tr>
<th>Adverse Event</th>
<th>Landmark</th>
<th>% AE Landmark</th>
<th>US Guidance</th>
<th>% AE US guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial puncture</td>
<td>5</td>
<td>13.9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Failed access</td>
<td>3</td>
<td>8.3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Catheter or guidewire misdirection</td>
<td>4</td>
<td>11.1</td>
<td>2</td>
<td>13.3</td>
</tr>
<tr>
<td>Hematoma formation</td>
<td>3</td>
<td>8.3</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>New site required</td>
<td>5</td>
<td>13.9</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Three or more sticks</td>
<td>16</td>
<td>44</td>
<td>4</td>
<td>26.6</td>
</tr>
<tr>
<td>Total adverse events</td>
<td>36</td>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AE = adverse event; US = ultrasound.

The additional information provided by ultrasound guidance translates to improved patient safety. Decreased arterial punctures and decreased needle sticks are recommended to reduce catheter-associated infections (10). In addition, avoiding arterial punctures can decrease the risk of developing arteriovenous fistulas (11). Ultrasound guidance has been shown to decrease the number of attempts and needle sticks, which can decrease these complications (1). Ultrasound guidance for femoral CVC has been studied mostly in relation to hemodialysis (HD) catheter placement. A meta-analysis published in 2011 showed that real-time ultrasound guidance for HD catheter placement decreased arterial punctures, risk of placement failure, and risk of failed first-time access (12). This analysis, however, included only one study that evaluated real-time ultrasound guidance for femoral CVC placement. This single-center trial in India demonstrated that real-time ultrasound guidance for femoral HD CVC improved first-attempt success and decreased complications (13).

Practitioners must also realize that merely using ultrasound to guide CVC placement might not be enough. Proper technique is important; however, this was not a data point collected in the CLEAR registry. Using an in-plane needle-guidance technique and a sagittal view

![Figure 1. Graphical representation of adverse events associated with femoral central venous cannulation placement. AE = adverse event.](image1)

![Figure 2. Transverse view of femoral artery (FA) and femoral vein (FV).](image2)
of the target vessel might be beneficial compared with a transverse view only. A prospective, observational study published by Blaivas and Adhikari in 2009 showed a high incidence of posterior-wall penetration and carotid puncture when emergency medicine residents used transverse vessel views and an out-of-plane ultrasound needle-guidance technique for internal jugular CVC cannulation of mannequin torsos (14). This technique is pertinent to femoral cannulation as well. An in-plane sagittal method enables visualization of the needle and needle tip during the entire procedure. The authors recommend that operators use an in-plane view to guide appropriate CVC placement and reduce the incidence of posterior wall puncture (14). In addition, it is beneficial to ensure that the guidewire is located within the target vessel lumen before dilatation. Using ultrasound to confirm guidewire placement can add an additional safety measure (15). Figure 4 is a sagittal view of a great vessel showing a guidewire present in the lumen.

Limitations

This was a nonrandomized, observational study of consecutive patients who had CVC at our institution, a two-hospital health system. The flagship hospital is a tertiary referral, Level I trauma center with an annual census of >120,000 patients. The second site is an urban hospital with an approximate annual census of 55,000 patients. We have an active emergency medicine residency and an emergency/point-of-care ultrasound fellowship program. It is possible that our experience cannot be extrapolated to other environments.

Clinicians performing the procedure self-reported their complications, which might introduce a reporting bias. In addition, recall bias might have resulted if data were not entered immediately after procedure completion. Physicians might have forgotten minor complications or estimated the number of attempts.

The data regarding ultrasound-guided femoral CVC complications, however, suggest veracity of the self-reporting. Practitioners noted a higher incidence of hematoma formation in the ultrasound group, most likely because they could visualize this complication using ultrasound. It is unlikely that clinicians would self-report a complication more frequently.

Data regarding technique for ultrasound guidance only looked at real-time guidance vs. site marking. The database did not include information on transverse or sagittal views of the vessel, or use of an in-plane or out-of-plane methodology for needle guidance. In addition, we did not track data concerning body habitus, which influences practitioners’ CVC site selection.

CONCLUSIONS

Our experience shows that ultrasound-guidance for femoral CVC can decrease complications and improve placement success, although we cannot recommend this approach without additional data. We recommend a larger study to further evaluate this technique.

REFERENCES

ARTICLE SUMMARY

1. Why is the topic important?
   Femoral central venous cannulation (CVC) placement is a common task. Ultrasound guidance for internal jugular access is the recommended best practice to prevent complications. This standard can apply to catheter placement in femoral central veins.

2. What does this study attempt to show?
   Ultrasound guidance improves femoral CVC placement success and decreases complications associated with femoral CVC procedures.

3. What are the key findings?
   Ultrasound guidance for femoral CVC placement decreased number of cannulation attempts and complications associated with placement at our institution; however, this was not statistically significant.

4. How is patient care impacted?
   Ultrasound guidance can improve the likelihood of successful femoral CVC placement. It illustrates anatomical abnormalities such as thrombosis, enabling the practitioner to choose another site. In addition, decreased placement attempts can translate to decreased infection rates.