Ultrasound in Emergency Medicine

OBLIQUE-AXIS VS. SHORT-AXIS VIEW IN ULTRASOUND-GUIDED CENTRAL VENOUS CATHETERIZATION

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Abstract—Background: Ultrasound (US) guidance during central venous catheterization (CVC) reduces complications and improves success rates compared to landmark-guided techniques. A novel “oblique view” (US transducer held at approximately 45° with respect to the target vessel) has been suggested to be superior to the standard short-axis approach usually used during US-guided CVC. Objectives: The purpose of this study was to compare the rates of posterior vessel wall puncture (PVWP) between the short-axis and oblique-axis approaches to US-guided CVC. Methods: This was a prospective observational trial of emergency medicine residents and attending physicians, using gelatin models to simulate short-axis and oblique-axis US-guided CVC. Participants were blinded to the primary outcome of PVWP. Data collected included year in training/practice, number of central lines placed, time to successful “flash,” and self-reported confidence of needle tip position using a Likert scale. After CVC simulation, models were deconstructed and inspected for PVWP. Results: The rate of PVWP was 14.7% using short axis vs. 2.9% using oblique axis, resulting in a difference of 11.8% (95% confidence interval [CI] = 4.7–28.3%, p = 0.10) and an odds ratio of 0.2 (95% CI 0.004–1.79). This difference was not statistically significant (p = 0.10). Mean time to flash was 11.9 s using short axis, and 15.4 s using oblique axis (p = 0.14). Confidence in needle tip location was 3.63 using short axis, and 4.58 using oblique axis (p < 0.001). Conclusions: We found decreased PVWP using the oblique axis approach, though the difference was not statistically significant, and participants felt more confident in their needle tip location using the oblique axis view. Further research into the potential benefits of the oblique axis approach is warranted. © 2014 Elsevier Inc.

Keywords—ultrasound; vascular access; central venous catheterization

INTRODUCTION

Ultrasound guidance has been demonstrated to reduce complications and improve success rates compared to the landmark-guided technique during central venous catheterization (CVC), and is recommended by the Agency for Healthcare Research and Quality (1–3). Nonetheless, complications such as arterial injury and cannulation despite real-time ultrasound guidance have been reported (4,5). Prior work comparing short-axis and long-axis approaches to ultrasound guidance have shown higher success rates with short axis by novice ultrasound (US) users, but improved visibility of needle tip in the long-axis view (6,7).

The limitations of US guidance were demonstrated in recent investigations of the incidence of posterior vessel wall puncture (PVWP) during simulated US-guided CVC. PVWP is considered a proxy for complications from central line placement, as puncturing the back wall of the vein may mean inserting the needle into an underlying artery or other vital anatomic structure. In prior studies of simulated US-guided central line placement,
the short-axis approach resulted in PVWP rates of 34–64% (8,9).

In 2011, Phelan and Hagerty described the “oblique view” for central venous catheterization (10). The oblique view involves placing the US probe at approximately a 45° angle to the vessel (see Figure 1), allowing the operator to visualize the needle tip while approaching the target vessel without sacrificing the ability to visualize the artery and the vein in the same view. To our knowledge, however, there have been no comparisons of the oblique view to the short-axis view during central line placement.

The objective of this study was to compare the rate of PVWP during simulated central line placement using the oblique view vs. the short-axis view. We also measured the 1) time to “flash” and 2) confidence in needle tip location using the two different approaches.

MATERIALS AND METHODS

Study Design

This was a prospective, single-blinded study to evaluate rates of posterior vessel wall puncture during simulated US-guided CVC using the short-axis and oblique view techniques. The simulation used tissue phantoms—gelatin-based models that are an established tool for teaching central line placement (11). The study was approved by the institutional review board, and each subject provided written consent to participate in the study.

Study Setting and Population

Subjects included resident (postgraduate year 2 or higher) and attending physicians at an urban, academic emergency medicine program with an active US program. All participants had placed at least five US-guided central lines using the short-axis view. No participants had experience performing US guidance using the oblique approach. Subjects were blinded to the outcome measure of PVWP.

Study Protocol

Gelatin models were prepared according to a previously described method, with a compressible Penrose drain simulating the vein and noncompressible rubber tubing simulating the artery (Figure 2). Prior to using the models, all subjects participated in a 20-min lecture introducing the oblique method. Each participant then made two separate attempts at CVC on the model, first using the short-axis technique, and then using the oblique view. A SonoSite M-turbo (SonoSite Inc., Bothell, WA) was used for US guidance, and 18-g, 2.5-inch Arrow spring-wire guide catheter assemblies (Teleflex Medical, Research Triangle Park, NC) were used for accessing the simulated vein. After each successful “flash” of simulated blood in the syringe, subjects were asked to

Figure 1. Left: Proper placement of linear ultrasound probe for oblique orientation over right neck vessels. The ultrasound probe indicator is pointed toward the patient’s left. Right: Ultrasound image of a simulated vein shown in the oblique orientation with the needle in long axis.

Figure 2. Partially constructed gelatin tissue models with exposed Penrose drain simulating the vein and non-compressible rubber tubing simulating the artery.
rate their confidence in needle tip location within the lumen of the vein on a scale from 1 to 5. Other variables collected included year in training/practice, self-reported number of central lines placed, number of aspiration attempts (i.e., number of introductions of needle into tissue phantom), and time to “flash” measured from the start of the successful aspiration attempt.

After subject enrollment and participation, models were deconstructed by the authors and evaluated for PVWP as evidenced by needle punctures in the anterior and posterior walls as described in the Moon et al. study (Figure 3) (9). Presence or absence of PVWP was confirmed by two authors.

**Data Analysis**

Based on prior reported frequency of 34% PVWP in a prior study, we estimated a sample size of 27 to detect a difference of 10% in the main outcome of PVWP based on an alpha of 0.05 and a beta of 0.2 (power of 80%) (9). Comparison of PVWP rates between short-axis and oblique view approach was performed using McNemar’s test for paired sample with Stata version 10.0 (College Station, TX), and comparisons of time to “flash” and confidence in needle position were performed using unpaired t-tests.

**RESULTS**

Thirty-five participants were enrolled in this study, including 23 residents and 12 attendings (see Table 1). One participant was excluded for not having performed US-guided CVC before. The range of experience with CVC ranged from 5 to > 200.

PVWP occurred in 5 of 34 (14.7%) attempts in the short-axis group, and 1 of 34 attempts (2.9%) in the oblique group, resulting in a difference of 11.8% (95% CI −4.7–28.3%) and an odds ratio of 0.2 (95% CI 0.004–1.79). This difference was not statistically significant ($p = 0.10$). Mean time to “flash” was 11.9 s in the short-axis group, and 15.4 in the oblique-axis group ($p = 0.14$). Confidence in needle tip location within the lumen of the vein (on a scale from 1 to 5, with 1 being least confident and 5 being most confident) was 3.63 in short-axis vs. 4.59 in oblique view ($p < 0.001$). Number of attempts (defined as having to completely withdraw and reintroduce the needle into the tissue phantom) did not differ between groups. Table 2 summarizes these results.

**DISCUSSION**

There was an observed decreased PVWP using the oblique-axis approach, though the difference did not achieve statistical significance. No significant difference was found between the two techniques in terms of number of attempts or time to initial “flash” of simulated blood in the syringe, and participants reported greater confidence in needle tip position when using the oblique view.

Previous studies have reported higher rates of PVWP during simulated CVC than we found in our population. There are several factors that could explain the much

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**Table 1. Participants and Self-reported Central Line Experience**

<table>
<thead>
<tr>
<th>Level of Training</th>
<th># Participated</th>
<th>Average # Central Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attending</td>
<td>12</td>
<td>201.6</td>
</tr>
<tr>
<td>PGY4</td>
<td>7</td>
<td>69.2</td>
</tr>
<tr>
<td>PGY3</td>
<td>7</td>
<td>40</td>
</tr>
<tr>
<td>PGY2</td>
<td>9</td>
<td>20.4</td>
</tr>
</tbody>
</table>

PGY = postgraduate year.
lower rate of PVWP that we found compared to previous investigations. First, it is possible that our cohort of operators was more experienced with US guidance than previously studied populations. Also, we simulated only the first portion of venous catheterization, obtaining a flash of simulated blood. Participants were not asked to thread a wire or a catheter, and it is likely that PVWP occurs not only during initial aspiration, but also during the subsequent manipulation of the assembly while threading the wire. This difference in rates of PVWP may have affected our results, as our sample size was calculated based on a higher rate of PVWP.

Another confounder that may have affected our results was the fact that by design, all participants used the short-axis technique first, prior to attempting the oblique view approach. We had designed the study this way, reasoning that because the participants were all already familiar with the short-axis view, using it in their first attempt would allow them to focus more on getting used to the model rather than having to attempt a new technique in a new model at the same time. It is possible, however, that using the short-axis view first meant that some of the incidences of PVWP were due to difficulty adjusting to the model rather than a true drawback of the technique. Despite this lack of experience with the oblique view, there was a strong trend towards decreased PVWP using the oblique view among our participants. It is possible that a cohort with previous exposure to the oblique view, or greater experience with other “in-plane” US applications (such as long-axis view or US-guided nerve blocks), would have had an even lower rate of PVWP when using the oblique view than observed in our cohort. Moreover, our participants reported significantly greater confidence about needle tip location when using the oblique approach, suggesting that the theoretical advantage of the oblique view actually translates into operator comfort.

Limitations

The major limitation of this study is its small sample size. Specifically, due to the lower-than-expected overall incidence of PVWP in our series, our sample was underpowered to detect a 10% difference in the rate of PVWP between groups. Additionally, the use of tissue phantom models can approximate in vivo conditions only during CVC placement, and our study only examined the first step of CVC placement—placement of the needle into the vein and aspiration of blood into the syringe. We did not examine threading a guide wire or catheter, which may have changed the rates of PVWP or revealed other unexpected challenges associated with the oblique-view approach.

CONCLUSION

US guidance during CVC has become standard of care, but questions about how best to use US for this purpose remain. Previous studies have examined rates of PVWP using short- and long-axis techniques, but this is the first formal evaluation of rates of PVWP using the oblique view described by Phelan and Hagerty (10).

We found decreased PVWP using the oblique-axis approach, though the difference was not statistically significant, and participants felt more confident in their needle location with the oblique view compared to the short-axis view. The overall rate of PVWP was much lower in our series than previously described. Based on our findings, further research is needed to investigate the potential benefits of the oblique view, including studies of higher-fidelity simulation of complete CVC placement in anatomic models.

Acknowledgements—We would like to acknowledge Rob Rodriguez, MD for his help with this study. We would also like to thank Kim Roberts for the generous loan of SonoSite machines. This study was funded through The Clinical & Translational Science Institute (CTSI) Resident Research Fund at University of California San Francisco.

REFERENCES


Table 2. Total Number of Observations, Number with PVWP, Mean Time to Flash, Mean Confidence in Needle Tip Location at Time of Flash, and Mean Number of Attempts Using Each Approach

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Short Axis</th>
<th>Oblique</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number</td>
<td>34</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Number with PVWP (%)</td>
<td>5 (14.7)</td>
<td>1 (2.9)</td>
<td>0.10</td>
</tr>
<tr>
<td>Mean time to flash</td>
<td>11.9</td>
<td>15.4</td>
<td>0.14</td>
</tr>
<tr>
<td>Confidence (1–5)</td>
<td>3.63</td>
<td>4.59</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Mean number of attempts</td>
<td>1.29</td>
<td>1.29</td>
<td>1.00</td>
</tr>
</tbody>
</table>

PVWP = posterior vessel wall puncture.
ARTICLE SUMMARY

1. Why is this topic important?
   Use of ultrasound has been shown to reduce complications and improve success of central venous catheterization, though damage to adjacent structures and inadvertent arterial cannulation can still occur.

2. What does this study attempt to show?
   This study investigated the difference in posterior vessel wall puncture (PVWP), a proxy for damage to adjacent structures, in models using the short axis vs oblique axis view, hypothesizing that the oblique axis approach would result in less PVWP than the short axis approach. Other outcomes included time to flash, confidence in needle location, and number of attempts.

3. What are the key findings?
   There was a strong trend towards decreased PVWP using the oblique axis view compared to the short axis view, however it did not reach statistical significance. Participants were more confident in needle location with the oblique axis view. This finding supports the idea that the oblique axis view offers better visualization of needle tip during central venous placement when compared to the short axis view.

4. How is patient care impacted?
   Further research regarding the oblique view is needed with higher fidelity models and patients to determine whether the oblique axis technique would decrease complications of central venous catheterization.