Brief Report

Ultrasound detection of guidewire position during central venous catheterization

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Abstract

Introduction: Ultrasound guidance decreases complications of central venous catheter (CVC) placement, but risks of arterial puncture and inadvertent arterial catheter placement exist. Ultrasound-assisted detection of guidewire position in the internal jugular vein could predict correct catheter position before dilation and catheter placement.

Methods: Ultrasound examinations were performed in an attempt to identify the guidewire before dilation and catheter insertion in 20 adult patients requiring CVC placement. Central venous pressures were measured after completion of the procedure.

Results: Guidewires were visible within the lumen of the internal jugular vein in all subjects. Central venous pressures confirmed venous placement of catheters. Ultrasound visualization of the guidewire predicted venous CVC placement with 100% sensitivity (95% confidence interval 80-100%) and 100% specificity (95% confidence interval 80%-100%).

Conclusions: Ultrasound reliably detects the guidewire during CVC placement and visualization of the wire before dilation and catheter insertion may provide an additional measure of safety during ultrasound-guided CVC placement.

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1. Introduction

Real-time ultrasound guidance for central venous cannulation has been shown to dramatically reduce complications [1-3]. Arterial puncture rates have been reduced with the use of real time ultrasound guidance, but cases still exist of inadvertent arterial cannulation [4]. Central venous pressure (CVP) monitoring can confirm venous cannulation in cases when differentiation between arterial and venous puncture cannot be determined [5]. Unfortunately, CVP monitoring can be labor- and time-intensive and may require equipment that is not immediately available to the provider. Because inadvertent arterial puncture and resultant arterial cannulation can have disastrous consequences, various techniques have been reported that can confirm venous cannulation without the use of CVP monitoring. Arndt et al [6] detailed a technique in which the presence of flow of a column of fluid in sterile tubing attached to the catheter can indicate venous cannulation. Sawchuk et al noted the role of transesophageal echocardiography (TEE) in visualization of the guidewire in the venous system to confirm appropriate cannulation [7].
Both techniques seem valid, but require extra equipment or specific expertise not commonly available to the emergency medicine or critical care physician.

We have previously reported a single case of guidewire identification using equipment available to the physician performing ultrasound-guided central venous catheter (CVC) placement [8]. We planned to investigate the ability to reliably localize the guidewire and determine arterial or venous placement with the same ultrasound probe commonly used for venous puncture. We hoped to demonstrate a technique that could allow providers a rapid and simple method for confirmation of venous cannulation before dilation and catheter placement during central venous access.

2. Methods

After approval from our institutional review board, a prospective observational study was initiated at a level I trauma center with an emergency medicine residency and emergency ultrasound fellowship. Emergency department patients older than 18 years who required central venous access, as determined by their treating physician, were eligible for enrollment. Patients were excluded if they were unable to give informed consent for the procedure.

Five clinicians performed all ultrasound guidewire visualizations during CVC placement. Before the study, all investigators had performed more than 25 ultrasound-guided CVCs and were shown a brief ultrasound video demonstrating the appearance of a correctly placed guidewire in the internal jugular vein. All central lines were placed in the internal jugular vein using the standard Seldinger technique under ultrasound guidance using a 10-5 MHz linear transducer (SonoSite MicroMaxx, Bothell, Wash). After vessel puncture was confirmed by aspiration of blood into the syringe, a standard flexible j-tip guidewire was advanced into the vessel. The ultrasound probe was then placed 2 to 5 cm proximal to the puncture site in a transverse orientation. The internal jugular vein and carotid artery were identified, and the guidewire was localized as a hyperechoic structure with a reverberation artifact in the vessel (Fig. 1). After completion of CVC placement, all patients received an upright chest radiograph to determine catheter location and to assess for the presence of a pneumothorax. Central venous pressure monitoring was subsequently performed on all CVCs by nursing staff and was used as the gold standard to determine venous placement of CVCs. Central venous pressure measurements were recorded by research assistants not present during the line placement and therefore blinded to previous ultrasound imaging. Sensitivity and specificity of guidewire visualization within the internal jugular vein as a predictor of subsequent venous CVC placement were calculated.

3. Results

After written informed consent was obtained, 20 adult patients were enrolled. Patient characteristics are presented in Table 1. After vessel puncture and guidewire introduction, providers were able to visualize the guidewire within the lumen of the internal jugular vein in all patients. Central venous pressure measurements confirmed venous placement of central venous catheters in all cases. There were no CVC-associated pneumothoraces. Guidewire visualization within the internal jugular vein predicted subsequent venous catheter placement with a sensitivity and specificity of 100% (95% confidence interval 80%-100%) and 100% (95% confidence interval 80%-100%), respectively.

4. Discussion

Although the use of real-time ultrasound guidance decreases complications associated with central venous catheterization, it does not eliminate the possibility of line-associated complications. Puncture of the internal jugular vein during central venous catheterization can result in bright red blood or briskly flowing blood, particularly in the setting of patients receiving mechanical ventilation with a high fraction of inspired oxygen and patients with

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**Table 1** Characteristics of the 20 study patients

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
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<tr>
<td>Age (y)(^a)</td>
<td>64 ± 7</td>
</tr>
<tr>
<td>Male (%), female (%)</td>
<td>7 (35), 13 (65)</td>
</tr>
<tr>
<td>Heart rate (bpm)(^a)</td>
<td>98 ± 22</td>
</tr>
<tr>
<td>Blood pressure (mm Hg)(^a)</td>
<td>98 ± 22/56 ± 14</td>
</tr>
<tr>
<td>CVP (cm H(_2)O)(^a)</td>
<td>11 ± 7</td>
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\(^a\) Mean ± SD.
elevated CVPs, respectively. Providers may consider the possibility of arterial puncture when bright red or briskly flowing blood is encountered, and this may result in unnecessary additional attempts at vessel puncture, thereby increasing the risk of procedural complications [1]. To our knowledge, no prior study has investigated the accuracy of guidewire visualization as an indicator of venous puncture and a predictor of successful placement of a catheter into the internal jugular vein.

5. Limitations

Although guidewires were visualized in all subjects and subsequent venous placement of catheters was confirmed by CVP measurements, there are limitations to this study. There were no patients in whom carotid artery puncture and subsequent arterial wire placement occurred, so we are unable to describe the sonographic appearance of arterial guidewire placement. Given the low risk of carotid puncture (and subsequent arterial wire placement) using ultrasound guidance, this is likely due to our study’s small sample size. Although it is possible that the guidewire is more difficult to visualize when placed in the artery, there is no reason to suspect that this is the case. Furthermore, regardless of the imaging characteristics of arterially placed guidewires, the inability to visualize the guidewire within the internal jugular vein should be sufficient evidence to raise suspicion of ectopic wire placement. Another limitation to our study is that all studies were performed by ultrasound fellows or ultrasound fellowship-trained attending physicians. Although possible that novice sonographers would obtain different results, it is unlikely as the study technique is simple and easy to learn.

6. Conclusion

The ability to confirm guidewire location in the internal jugular vein before dilation and catheter placement could represent an additional safety measure during ultrasound-guided central venous catheterization. This technique would be of greatest benefit when the provider suspected possible arterial puncture due to bright red or briskly flowing blood (both of which can be observed with either venous or arterial puncture). Prior research has demonstrated that the risk of complications increases with the number of attempts at vessel puncture [1], and guidewire visualization may decrease unnecessary puncture attempts by confirming venous puncture in the setting of bright red or briskly flowing blood. In addition, guidewire visualization may detect inadvertent arterial puncture before dilation and catheter placement, therefore decreasing the risk of arterial injury. Of note, ultrasonographic guidewire visualization is not time-consuming: all guidewires in this study were visualized in less than 1 minute using the same ultrasound transducer used to guide vessel puncture. In conclusion, ultrasonographic guidewire visualization represents a rapid, noninvasive method for confirming venous puncture and may provide an additional measure of safety during central venous catheterization.

References