Ultrasound in Emergency Medicine

ULTRASOUND MEASUREMENTS OF THE SAPHENOUS VEIN IN THE PEDIATRIC EMERGENCY DEPARTMENT POPULATION WITH COMPARISON TO I.V. CATHETER SIZE

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Abstract—Background: Saphenous vein cutdown is a rare venous access procedure. Ultrasound (US) can assist with many vascular access procedures. Objectives: Our objective was to identify the saphenous veins (SVs) using US in pediatric emergency department (ED) patients, and to determine if the SV size allows for potential cannulation by different standard-size intravenous (i.v.) catheters. Methods: This study was a prospective, observational convenience sample of 60 pediatric patients at an urban, regional referral pediatric ED. Inclusion criteria were children ages 1 through 12 years categorized into four age groups: 1–<2, 2–4, 5–7, and 8–12 years, with informed consent and assent. Investigators performed US examination using a 10-MHz multi-frequency transducer to identify the SV on both legs and measure the SV in short-axis view. The US measurements were then used to calculate the SV areas. Diameters of typical pediatric gauge (G) catheters (24G, 22G, 20G, 18G) were used to calculate catheter areas. Results: Sixty patients were enrolled, with five SVs unable to be measured in 4 patients (1 patient with both SVs). For the remaining 115 (96%) SVs available for further analysis, the median age was 4 years (interquartile range [IQR] 2) and median weight was 22.7 kg (IQR 14.5). Mean area (mm²) of the right SV was 2.85 ± 1.9 and for the left SV, 2.88 ± 1.8. For our study group, the compatibility rates of different size i.v. catheters to fit the measured SV areas were as follows: 24G = 100%, 22G = 100%, 20G = 97.3%, and 18G = 86.1%. Conclusions: US can localize the SV in pediatric ED patients. US size of the SV in various pediatric age ranges suggests that the SV may be a potential US venous access site with multiple-size i.v. catheters up to 18G. © 2012 Elsevier Inc.

Keywords—US guidance; peripheral venous access; saphenous vein

INTRODUCTION

Peripheral intravenous (i.v.) access is often a critical component of emergency department (ED) patient care. In 2006 there were over 119 million ED visits in the United States, with over 21 million of those visits from children under the age of 15 years (1). Many of these visits may require i.v. access for various reasons, including i.v. volume resuscitation, phlebotomy, and medication administration. However, obtaining i.v. access in pediatric patients can be difficult for many reasons; their peripheral veins may not be palpable or visible at times. Failure to obtain i.v. access in a timely fashion can lead to delay in treatment and diagnosis.

Alternative routes and techniques have been sought to obtain rapid i.v. access. Ultrasound (US)-guided i.v. placement has been one of the alternatives to traditional
techniques for i.v. placement in patients with difficult i.v. access (2–9). In the pediatric literature, the saphenous vein (SV) is mostly identified with venous cutdown and not with US guidance i.v. access. Therefore, we sought to identify the SV using US in pediatric ED patients, and to determine if the vein size allows for potential cannulation by different standard-size i.v. catheters.

METHODS

Study Design

This study was a prospective observational study of a convenience sample of 60 pediatric ED patients. All patients enrolled in this study had parental informed consent and, in addition, gave assent for their participation if age 6 years or older. The Institutional Review Board at the study site approved this study.

Study Setting and Population

This study was done in a single urban, regional referral pediatric ED with approximately 30,000 annual visits. The pediatric ED is part of a 3-year emergency medicine (EM) residency program that has a pediatric EM and US fellowship. The study sonographers were an experienced third-year EM resident and a US fellow. Patients were enrolled when one of these sonographers were present. Patients age 1 through 12 years were eligible if parents were able to provide informed consent, and in addition, children 6 years or older provided assent. Patients were grouped into categories by age; 1–<2, 2–4, 5–7, and 8–12 years. Patients were excluded if there was evidence of pathologic changes to the leg, including fracture, amputation, congenital or acquired deformity/contractures, skin infection, and history of operative repair. In addition, unstable patients—defined as any one of these being present: hypotension, respiratory distress, altered mental status, and cardiorespiratory arrest—were excluded.

Study Protocol

Before the start of the study, study sonographers met the training requirements of being a faculty physician of the US division or an EM resident who had performed over 150 EM US scans and had completed a month of US intern rotation with dedicated peripheral vein training by the US director.

After consent and assent were obtained, demographic information (age, sex, height, weight, and chief complaint) was recorded directly on a paper form by the sonographer.

The patient was then placed in a supine position and a standard i.v. tourniquet was placed at the calf (Figure 1). The primary study objective was successful identification and measurements of the diameters of the SV in the transverse plane. The SV was identified using Ultrasonix CEP or Sonixtouch (Ultrasonix Corporations, Vancouver, BC, Canada) with the same 10-MHz multi-frequency transducer (Figure 1). The transducer was placed approximately 1 cm anterior and 1 cm superior to the medial malleolus to locate the SV. Once the SV was identified and confirmed to be anechoic and compressible, a still image in the transverse plane was obtained. The study sonographer measured the diameter in millimeters (mm) of the SV in transverse plane in both the horizontal and vertical axes (Figure 2). The same steps described above were repeated on the contralateral leg. The measurements were then recorded directly onto the same paper form that contained the demographic information. The director of EM US reviewed images and data collection forms to ensure quality and consistency and then entered the information into a Microsoft Access database (Microsoft Corporation, Redmond, WA).

Diameters of typical pediatric gauge (G) i.v. catheters—24G, 22G, 20G, and 18G—were used to calculate i.v. catheter areas using the standard geometric formula for a circle ($\pi r^2$). US measurements of the diameters of the SV in transverse plane were used to calculate SV areas using the standard geometric formula $\pi 1/2 D_1 1/2D_2$ for an oval. The calculated SV areas (per measured dimensions and with a 20% reduction in vein area) and the i.v. catheter areas were then compared with descriptive statistics.

Data Analysis

The study subjects were divided into four age categories: 1–<2, 2–4, 5–7, and 8–12 years. Fisher exact test was used to determine significance of association between
age and compatibility rates for each i.v. catheter size. In addition, the Fisher exact test was used to assess the association between i.v. catheter size and compatibility to fit into the SV within each age category. Each calculated SV area was compared to the areas of the respective different i.v. catheter sizes (24G, 22G, 20G, and 18G), and if the SV area was larger than the i.v. catheter area, it was considered compatible. Calculated vein area was then reduced by 20% and compared to catheter size in a separate analysis.

Demographic characteristics are presented descriptively as medians with interquartile range (IQR) and numbers, when appropriate. A *p*-value of < 0.05 was considered significant. SAS version 9.1 (SAS Institute Inc., Cary, NC) was used for analysis.

**RESULTS**

Sixty patients were enrolled during the study, with a total of 120 extremities available for US visualization and measurement of the SV. The distribution of subjects and identified SV were as follows: 1–<2 years: 12 subjects with 23 SV measured; 2–4 years: 20 subjects with 37 SV measured; 5–7 years: 14 subjects with 27 SV measured; 8–12 years: 14 patients and 28 SV measured. Overall, the SV was not measured or identified in five extremities involving a total of 4 patients.

For the remaining 115 (96%) SVs available for further analysis, the median age was 4 years (IQR 2) and median weight 22.7 kg (IQR 14.5). Twenty-six (40%) of the enrolled patients were female. For our study group the

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**Table 1. Body and Saphenous Vein (SV) Characteristics of the Study Population per Age Group**

<table>
<thead>
<tr>
<th>Age, Years</th>
<th>1–&lt;2</th>
<th>2–4</th>
<th>5–7</th>
<th>8–12</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 12</td>
<td>n = 20</td>
<td>n = 14</td>
<td>n = 14</td>
<td>n = 14</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>Median</td>
<td>IQR (25%–75%)</td>
<td>Median</td>
<td>IQR (25%–75%)</td>
</tr>
<tr>
<td>12.1</td>
<td>(10.8–12.8)</td>
<td>16.6</td>
<td>(15–21.6)</td>
<td>27.5</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>77</td>
<td>(75–81)</td>
<td>98</td>
<td>(94–107)</td>
</tr>
<tr>
<td>Right SV area (mm²)</td>
<td>2.96</td>
<td>(1.88–3.06)</td>
<td>2.15</td>
<td>(1.53–2.71)</td>
</tr>
<tr>
<td>Left SV area (mm²)</td>
<td>1.98</td>
<td>(1.43–2.83)</td>
<td>1.88</td>
<td>(1.32–3.39)</td>
</tr>
</tbody>
</table>

IQR = interquartile range.
 compatibility rate of different size IV catheters to fit the measured SV areas was as follows: 24G = 100%, 22G = 100%, 20G = 97.3%, 18G = 86.1%. Table 1 describes body and saphenous vein characteristics per age category. Table 2 describes the high compatibility rates of the different catheter gauges in regards to the US-measured area of SV per age group. In Table 3, using a 20% reduction in vein area for each age group and catheter size, there continued to be high compatibility rates up to the 18G catheter size.

Age did not have a significant effect on the compatibility rate of different size i.v. catheters to fit the US-measured SV (24G, p = 1.00; 22G, p = 1.00; 20G, p = 0.697; 18G, p = 0.504). Intravenous catheter size did not significantly affect the compatibility rate of fitting into the measured SV within each age group (1–<2, p = 0.057; 5–7, p = 0.058; and 8–12, p = 0.615) except in the 2–4 years of age group (p = 0.004).

**DISCUSSION**

SV cutdown is well described in the pediatric literature, although it is becoming an obsolete procedure due to advances in central line placement and intraosseous access (10–14). However, there are potential disadvantages to these techniques. Complications can occur in central line placement, including pneumothorax, arterial puncture, and central venous thrombosis, as well as bloodstream infection (15,16). In addition, central line placement can be time-consuming and technically difficult in critically ill pediatric patients. Intraosseous needle placement can also lead to potential complications, including subcutaneous infiltration, needle clogging, infection (cellulitis or osteomyelitis), and compartment syndrome (17).

Intravenous access with peripheral i.v. access being the preferred route is still one of the most critical components in ED pediatric care. One retrospective study revealed that lack of peripheral venous access (64%) was the most common indicated reason for placement of central venous catheters (18). When traditional techniques for peripheral i.v. access fail, we need alternative methods such as ultrasound guidance that will provide rapid access. We chose the SV as a site for potential US-guidance i.v. placement for several reasons. The SV anatomy and path is predictable and has a superficial location at the ankle. In addition, during resuscitation, the ankle site is distant from the primary resuscitative efforts usually centered on the head and torso region, allowing for possible unhindered access to the SV at the ankle for i.v. placement.

Our hypothesis was that the SV would be compatible in terms of size with standard i.v. catheters (24G, 22G, 20G, 18G). Although our study focus was comparing SV areas to i.v. catheter areas, having a peripheral vessel compatible in size to the i.v. catheter may not translate to successful US-guided peripheral i.v. placement. Therefore, the next logical step will be to attempt to cannulate the SV using US guidance in further research.

The scope of future studies can be broad and not just limited to identification and cannulation of the SV. Panebianco et al. concluded that successful US-guided peripheral i.v. placement in adult patients was solely related to vessel characteristics detected with US and not to patient characteristics (19). It is not clear whether the same will be true in pediatric patients; it will be important to assess if there are associations between vessel diameter and vessel depth from the skin surface as well as patient’s age, weight, height, body mass index, and hydration status to successful US-guided SV i.v. placement in pediatric patients.

**Limitations**

Lack of cannulation is a significant limitation in our study, although we have demonstrated that the SV size can allow for potential cannulation by various size catheters. Actual cannulation and placement of a functioning i.v. will be the ideal clinical endpoint.

Study was limited to a single site. The study had only two sonographers, which allowed for consistency and ensured a level of quality in performing the objectives of the study. But this may have provided several limitations. First, it could limit the applicability to other EDs because other providers may not have attained the skill level of the study sonographers, especially as they could have refined and improved their skill level as the study progressed. Second, patients were enrolled only when

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**Table 2. Compatibility Rate (%) of Ultrasound-measured Saphenous Vein in Different Pediatric Age Groups with Regard to Different i.v. Catheter Size (Area)**

<table>
<thead>
<tr>
<th>Catheter Size</th>
<th>1–2 Years</th>
<th>2–4 Years</th>
<th>5–7 Years</th>
<th>8–12 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 Gauge</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>22 Gauge</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>20 Gauge</td>
<td>100</td>
<td>95</td>
<td>100</td>
<td>96</td>
</tr>
<tr>
<td>18 Gauge</td>
<td>87</td>
<td>78</td>
<td>89</td>
<td>93</td>
</tr>
</tbody>
</table>

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**Table 3. Compatibility Rate (%) of Ultrasound-measured Saphenous Vein in Different Pediatric Age Groups with Regard to Different i.v. Catheter Size (Area) Using a 20% “Wiggle Room” Difference between Vein Size and Catheter**

<table>
<thead>
<tr>
<th>Catheter Size</th>
<th>1–2 Years</th>
<th>2–4 Years</th>
<th>5–7 Years</th>
<th>8–12 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 Gauge</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>22 Gauge</td>
<td>100</td>
<td>97.3</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>20 Gauge</td>
<td>95.7</td>
<td>86.5</td>
<td>88.9</td>
<td>92.9</td>
</tr>
<tr>
<td>18 Gauge</td>
<td>74</td>
<td>59.5</td>
<td>66.7</td>
<td>85.7</td>
</tr>
</tbody>
</table>
these sonographers were available, which was mostly during daytime and hence were a convenience sample. The sonographers were not blinded to the study objectives, which potentially exposes the results to several biases, including selection bias.

Although this was an observational study, the exclusion of unstable patients could have positively affected our outcome data. In addition, it excludes a group that would eventually be a target for US-guided i.v. placement. We did not account for the effect of hydration status on the SV size.

CONCLUSIONS

US can localize the SV in pediatric ED patients. US size of the SV in various pediatric age ranges suggests that the SV may be a potential US venous access site with multiple-size i.v. catheters, with only 18G catheters having potential size limitations. Future US-guided SV studies in pediatric patients are justified.

REFERENCES

ARTICLE SUMMARY

1. Why is this topic important?
Saphenous vein access is performed by cutdown. Many emergency physicians have limited experience with cutdown. Ultrasound has been found to assist with vascular access, including central and peripheral venous access.

2. What does this study attempt to show?
We attempt to show that we could find the distal saphenous vein near the ankle in different pediatric ranges. Secondly, we measured the dimensions of the veins to determine whether various different size intravenous catheters would fit within such veins.

3. What are the key findings?
Saphenous veins were able to be seen near the ankle in children, and their size may fit typical intravenous catheters up to 18 gauge.

4. How is patient care impacted?
Ultrasound-guided saphenous vein cannulation should be considered as a potential site for an intravenous catheter in children.