Ultrasound imaging findings of femoral veins in patients with renal failure and its impact on vascular access

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Abstract

Background. Patients requiring dialysis due to acute or chronic renal failure frequently require temporary vascular access. Femoral vein catheterization is the easiest method for obtaining temporary vascular access in haemodialysis patients. The aim of this study was to utilize ultrasound imaging to describe femoral vein structures and to examine anatomical variations in uraemic patients.

Methods. We evaluated 114 (70 males, 44 females) renal failure patients. Femoral arteries were localized manually inferior to the femoral ligament, and ultrasonographic examination was performed from this location. Images of the vessels and demographic data of patients were recorded and analysed. Femoral veins were classified according to their diameter, patency and palpation status of the neighbouring femoral artery.

Results. Three patients had a history of prior femoral catheterization. In one of these, who had a history of bilateral catheterization, we detected bilateral femoral vein thrombosis. Overall, non-palpable femoral arteries or unsuitable femoral veins were found unilaterally in 16 patients (14.0%) and bilaterally in six patients (5.2%). The depth of femoral arteries ($r=0.54$, $P<0.001$) and femoral veins ($r=0.59$, $P<0.001$) was correlated with body mass index (BMI). Femoral arteries and femoral veins were located significantly deeper in overweight (BMI >25) patients compared with normal weight patients (20.7±6.5 mm vs 14.6±5.1 mm, $P<0.001$ and 26.1±6.7 mm vs 18.9±5.5 mm, $P<0.001$).

Conclusions. Bilateral anatomical variations of femoral veins were relatively rare. However, ultrasound surveys should be performed in obese patients or when the femoral artery is not palpable.

Keywords: femoral artery; femoral vein; haemodialysis; vascular access

Introduction

Reliable and safe venous access is mandatory for the management of patients with acute or chronic renal failure that require haemodialysis. Internal jugular, femoral or subclavian vein catheterization are essential methods that provide temporary access in these patients. Cannulation of the femoral vein is easier than central thoracic veins, and the incidence of cannulation-related complications is also much less compared with other sites [1–3]. The femoral vein can also be used for maintenance haemodialysis by repeated puncturing or by placement of a cuffed catheter [4,5]. In general, a mostly external landmark-based technique is used to locate the femoral vein.

Anatomical variations of the internal jugular vein have been well documented [6]. However, to the best of our knowledge, anatomical variations of the femoral vein in patients with renal failure have not been studied systematically. In the present study, we investigated the anatomical structure of the femoral vein in uraemic patients. We also evaluated the reliability of external landmark-based techniques in locating femoral vein.

Subjects and methods

We evaluated 114 (70 males, 44 females) renal failure patients, aged 52.5±17.1 years. Renal failure was acute in seven patients and chronic in the remaining 107. Causes of chronic renal failure were hypertensive nephrosclerosis in 17 (14.9%), diabetes in 16 (14.0%), chronic glomerulonephritis in 12 (10.5%), polycystic kidney disease in nine (7.9%), obstructive nephropathy in nine (7.9%), amyloidosis in four (3.5%), miscellaneous in six (5.2%) and unknown in 34 (29.8%) patients. Sixty-four patients were evaluated before...
the initiation of haemodialysis therapy, their mean calculated creatinine clearance (Cockcroft–Gault formula) was 12.6 ± 4.9 ml/min/1.73 m². The remaining 50 patients were already on haemodialysis therapy. Body height and weight were measured at the day of ultrasound examination, and previous femoral catheterization history was recorded. Body mass index (BMI) was calculated from height and weight.

The same observer performed all ultrasonographic measurements. Patients who were on haemodialysis were evaluated before a mid-week dialysis session. Before ultrasonographic study, patients were positioned in the supine position, and the femoral artery was localized manually in the femoral triangle inferior to the inguinal ligament; the palpation status (palpable or not palpable) of the femoral artery was recorded. Ultrasonographic examination was performed in this location using a 5–10 MHz linear array transducer (Ultramark 9 HDI, Advanced Technology Laboratories, Bothell, WA). The femoral vein was identified by lack of pulsatility, by compressibility with minimal pressure and by an increase in vein lumen size induced by the Valsalva manoeuvre. In suspected cases, Doppler examination was performed to identify the femoral vein. The following measurements were performed at end-expiration: the distances between the vessels, the luminal diameter of the vessels and the depth of the vessels below the skin measured from the vessel wall (Figure 1). Femoral veins were defined as adequate sized (≥5 mm) or small sized (<5 mm) according to their diameter.

Data are expressed as means ± SD. Continuous variables were compared using Student’s t-tests or Mann–Whitney U-tests when appropriate. Associations between ultrasonographic measurements and anthropometric data were evaluated with Pearson’s correlation. All tests were performed using SPSS for Windows, version 10.0 software (SPSS Inc, Chicago, IL). P < 0.05 was considered statistically significant.

**Results**

The mean body height, weight and BMI were 167.0 ± 9.5 cm, 69.2 ± 14.3 kg and 24.9 ± 5.0 kg/m², respectively. Three patients had a history of prior femoral catheterization, and one of these had experienced bilateral catheterization. In all patients, femoral veins were lying medially to femoral arteries. However, in one patient, the left femoral vein could not be visualized, and in one patient with a history of previous bilateral femoral catheterization, bilateral femoral vein thrombosis was detected. The results of ultrasonographic measurements are listed in Table 1. The depth and diameter of the femoral vessels and the distance between femoral arteries and veins were similar in the right and left sides. Femoral veins were classified according to their diameter, patency and the palpation status of the neighbouring femoral artery (Table 2).

**Adequate size, palpable**

In this group, the femoral artery was palpable and femoral vein diameter was adequate for cannulation. This was found in 88.6% of right and 86.8% of left femoral veins.

**Adequate size, not palpable**

In this group, the femoral vein diameter was adequate for cannulation. However, the femoral artery was not palpable and it was thus difficult to locate the femoral

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**Table 1. Ultrasound measurement findings**

<table>
<thead>
<tr>
<th></th>
<th>Right (mean ± SD) [range]</th>
<th>Left (mean ± SD) [range]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance between FA and skin (mm)</td>
<td>17.1 ± 6.4 [5.2–48.6]</td>
<td>17.1 ± 6.7 [5.3–47.3]</td>
</tr>
<tr>
<td>Distance between FV and skin (mm)</td>
<td>22.0 ± 6.7 [5.7–48.0]</td>
<td>21.9 ± 7.4 [7.2–54.1]a</td>
</tr>
<tr>
<td>Diameter of FA (mm)</td>
<td>8.8 ± 1.9 [4.7–15.1]</td>
<td>8.6 ± 2.1 [4.7–19.3]</td>
</tr>
<tr>
<td>Diameter of FV (mm)</td>
<td>9.3 ± 2.6 [4.0–14.7]</td>
<td>9.5 ± 2.5 [3.7–15.5]a</td>
</tr>
<tr>
<td>Distance between FA and FV (mm)</td>
<td>2.6 ± 2.0 [0–7.4]</td>
<td>2.6 ± 1.9 [0–8.7]a</td>
</tr>
</tbody>
</table>

FA = femoral artery; FV = femoral vein.

aIn one patient, the left femoral vein was not visible; therefore, 113 measurements were performed.

**Table 2. Classification of femoral veins according to size, patency and the palpation status of the neighbouring femoral artery**

<table>
<thead>
<tr>
<th>Palpable FA</th>
<th>Non-palpable FA</th>
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<tbody>
<tr>
<td>Adequate size FV (≥5 mm)</td>
<td>200 (87.7%)</td>
</tr>
<tr>
<td>Small size FV (&lt;5 mm)</td>
<td>15 (6.6%)</td>
</tr>
<tr>
<td>Not visualized or non-patent FV</td>
<td>2 (0.9%)</td>
</tr>
</tbody>
</table>

FA = femoral artery; FV = femoral vein.
vein exactly using external landmarks. This group represented 4.4% of right and 3.5% of left femoral veins.

**Small size**
The size of the femoral vein was too small for successful cannulation. This group represented 6.1% of right and 7.9% of left femoral veins.

**Not patent or not visualized**
In this group, the femoral vein was not patent or was not visualized in the area near the femoral artery. This group comprised 0.8 and 1.8% of right and left femoral veins, respectively.

Altogether, non-palpable femoral arteries or unsuitable femoral veins were found unilaterally in 16 patients (14.0%) and bilaterally in six patients (5.2%).

The depth of femoral vessels was correlated with body weight and BMI. Correlations of femoral artery ($r = 0.54, P < 0.001$) and femoral vein ($r = 0.59, P < 0.001$; Figure 2) depth with BMI were better than that with body weight. There was also a positive correlation between femoral artery diameter and body height ($r = 0.38, P = 0.001$). Femoral arteries and femoral veins were located significantly deeper in overweight (BMI >25) patients compared with normal weight patients ($20.7 \pm 6.5 \text{ vs } 14.6 \pm 5.1 \text{ mm}, P < 0.001$ and $26.1 \pm 6.7 \text{ vs } 18.9 \pm 5.5 \text{ mm}, P < 0.001$). Non-palpable femoral arteries were located deeper than palpable arteries ($23.9 \pm 10.9 \text{ vs } 16.8 \pm 6.1 \text{ mm}, P = 0.023$).

**Discussion**
To the best of our knowledge, this is the first study that evaluated anatomical variations of femoral veins in patients with renal failure. We showed that variations in the location of femoral veins are rare. In all cases, femoral veins were lying medially to femoral arteries and only one femoral vein could not be visualized by ultrasonographic examination. However, a normally located femoral vein does not guarantee the success of external landmark-based cannulation.

The external landmark-guided technique relies on the palpation of the femoral artery inferior to the inguinal ligament. The femoral vein is usually medial to this location and the puncture is done from this point [4,6,7]. The success of this approach also depends on a normal calibre target vein, on vein patency and veins being in their expected positions [7]. In our study, 4.8% of femoral arteries were not palpable and this made it difficult to localize femoral veins exactly using external landmarks [8]. Moreover, 7.0% of femoral veins were difficult to cannulate because of their small size, and this was especially true with the generally used external landmark-guided technique [9]. Finally, 1.3% of the femoral veins were not patent or were absent, making placement of a femoral catheter impossible even with ultrasound guidance.

In certain situations, such as acute pulmonary oedema and respiratory distress, the femoral approach can be the preferred route. It is also useful when anatomical variations or stenosis due to prior catheter placement prevent the use of central thoracic veins. Moreover, this approach helps to preserve the upper central veins for future vascular access sites in chronic dialysis patients, in whom an improved life expectancy depends on careful management of their venous potential [1]. Finally, the femoral route is convenient and safe [1–3].

In previous work, the success rate of the landmark-based technique was ~55% on the first attempt at cannulation [7,8]. Kwon et al. [7] evaluated landmark-based cannulation in 38 patients and reported a successful cannulation rate of 89.5% on the second attempt. While examining 16 patients, Farrell et al. [8] attained a success rate of 100% with landmark-based cannulation and multiple punctures. According to a recent review, ultrasound guidance reduced the relative risk of failed catheter placement by 71% in the femoral vein [10]. These findings are consistent with those of the present study, in which 87.7% of the inspected veins were suitable for external landmark-based cannulation. In addition, because only three femoral veins were not patent, a successful cannulation was theoretically possible in 98.7% of the inspected veins. However, it should be recalled that multiple punctures increase the rate of cannulation-related complications.

The most frequent complications related to femoral vein cannulation procedures are local haematoma formation and femoral artery puncture [1,7,8,11]. The rate of femoral artery puncture was reported to be between 6.2 and 15.8% with the landmark-guided method and 0–7.1% with the ultrasound-guided method [7,8]. The rate of local haematoma formation was reported to be 2.6% with the landmark-guided
method and 0% with the ultrasound-guided method [8]. Femoral artery puncture can lead to arteriovenous fistula or pseudoaneurysm formation, but these complications are seldom reported [1]. Data on delayed complications are limited. In our study, only three of the 114 patients had a history of prior femoral catheterization, and thrombosis was detected in one of them. Recently, Weyde et al. [3] evaluated 14 patients with previous prolonged (>2 weeks) femoral catheterization history and reported that femoral venous stenoses were detected in four of them. Because the number of patients with previous catheterization history was relatively low in our study group, we believe that our results should be interpreted with caution in relation to patients who have had previous catheterization.

The femoral vein can also serve for maintenance haemodialysis by using repeated puncturing. Kaneda et al. [4] reported findings with this method in 30 patients having a mean body weight of 48.1 ± 10.5 kg. They examined the depth of the femoral veins in 20 of their 30 patients and found that mean values were 14.5 ± 2.93 and 13.9 ± 2.6 mm for the right and left sides, respectively. When taking patient weight differences in account, these data are consistent with our findings. Indeed, we showed that the depth of femoral vessels was correlated with BMI and body weight. These data have implications for catheter placement and for repeated femoral puncturing. An operator relying on the landmark technique should attempt femoral vein catheterization in deeper locations in patients with a high BMI.

The anatomical variations of femoral veins in non-uraemic patients have been studied. Hughes et al. [12] examined the anatomical structures of femoral vessels in 50 patients who were admitted to intensive care units. They reported that the femoral artery overlaps the femoral vein in a significant number of subjects especially where the vessels pass towards the apex of the femoral triangle. However, there was no complete overlap just below the inguinal ligament. Our results are in agreement with this work because we examined vessel anatomy only at the level of the inguinal ligament.

Internal jugular catheterization is another frequently used vascular access method. Anatomical variations of the internal jugular vein have been investigated previously in uraemic patients. While evaluating 104 patients with ultrasound, Lin et al. [6] found anatomical variations in 18.3% of the right and 16.4% of the left internal jugular veins. Thus, anatomical variations of femoral veins appear to be less frequent compared with those of the internal jugular vein.

In conclusion, anatomical variations, and especially location anomalies, of the femoral vein are rare. However, it should be kept in mind that non-palpable femoral arteries can also compromise the success of external landmark-based cannulation. Moreover, femoral veins tend to be located deeper in obese patients, and previous femoral catheterization history can be associated with femoral occlusion. Ultrasound-guided cannulation should be the preferred method, especially in patients with non-palpable femoral arteries and previous catheterization history. Overweight and particularly obese patients should also be candidates for ultrasound-guided cannulation.

Conflict of interest statement. None declared.

References


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