Ultrasound–guided evaluation of the bifurcation of the femoral artery and vein in pediatric patients

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Background: The femoral arteries (FA) and femoral veins (FV) are useful access sites for diagnostic and interventional procedures. In adults, the usual puncture sites are 1−3 cm distal from the inguinal crease. In children, however, the optimal puncture site vessels are not known. The aim of our study was to assess the number of branches and bifurcation sites of the femoral vessels in children by using ultrasonography.

Methods: Color Doppler ultrasonography was used to determine bifurcation sites of the FA and FV, relative to the inguinal crease, in 48 children (median age, 4 yr; median weight, 18.7 kg) with American Society of Anesthesiologists (ASA) Physical Status (PS) score 1−2 and who were scheduled for general anesthesia.

Results: The numbers of FAs and FVs at the inguinal crease were 1.83 ± 0.39 and 1.08 ± 0.29, respectively, in infants, and 1.83 ± 0.58 and 1.0 ± 0.0, respectively, in 10-year-old children. The bifurcation site of the FA in infants and those aged 10 years was 0.78 ± 0.30 cm and 1.47 ± 0.27 cm proximal to the inguinal crease, respectively (P < 0.05), whereas the bifurcation site of the FV in these two age groups was −0.96 ± 0.27 cm and −2.29 ± 1.09 cm distal to the inguinal crease, respectively (P < 0.05).

Conclusions: In children, the FA frequently bifurcates proximal to the inguinal crease, whereas the FV bifurcates distal to the inguinal crease. However, there are anatomical differences among age groups, so care should be taken to avoid complications during femoral vessel cannulation. (Korean J Anesthesiol 2009; 56: 290−4)

Key Words: Bifurcation, Femoral vessel, Ultrasound.

INTRODUCTION

Femoral vessels are useful access and catheterization sites for diagnostic and interventional procedures. The femoral artery (FA) is used to monitor cardiopulmonary function and analyze arterial blood gas composition, whereas the femoral vein (FV) is utilized for fluid infusion, drug administration, and blood transfusion. In pediatric patients, these vessels are more easily accessed than other vessels, there is no risk of pneumothorax, hemothorax, or thoracic duct injury, and the risk of arrhythmia is minimal [1,2]. When managing anesthetized pediatric patients, it is important for anesthesiologists to achieve consistent and secure vascular cannulation.

The usual puncture site of the femoral vessels is 1−3 cm distal from the inguinal crease [3]. However, in 75% of adults, the femoral artery bifurcates just proximal to the inguinal crease [4]. As common FA bifurcates into superficial and deep FA and common FV into deep femoral and great saphenous V, it is likely to make complications such as arterio-venous fistula. The success rate of repeated punctures becomes progressively lower, while the risk of vessel injury steadily increases. Moreover, it is easier to insert guide wire through the common femoral vessel rather than branch vessels.

Thus, to minimize complications of cannulation in children, a priori knowledge of the approximate bifurcation sites of the femoral vessels is important before attempting catheterization. The bifurcation sites, however, have not been adequately determined in children, whose anatomic relationships shift as they grow. Therefore, using ultrasound, we determined the number
of femoral vessels and their physical bifurcation sites, in relation to the inguinal crease, in children under general anesthesia.

**MATERIALS AND METHODS**

Our patient population consisted of 48 children (26 boys, 22 girls), with American Society of Anesthesiologists (ASA) Physical Status (PS) score 1–2 scheduled to undergo elective surgery under general anesthesia. The children ranged in age from 3 months to 10 years (median age, 4 yr) and in weight from 4.1 to 44.1 kg (median, 18.7 kg). The subjects were divided into four subgroups according to age, 12 subjects in each: 3 to 11 months, 12 to 35 months, 36 to 95 months, and 96 to 120 months. All subjects were scheduled to undergo elective procedures among age groups. Univariate and multivariate analyses were performed to identify factors independently associated with FA and FV bifurcation. P values less than 0.05 were considered significant.

**RESULTS**

The patient demographic characteristics are shown in Table 1. The ultrasound images of FA and FV are shown in Fig. 1.

The mean numbers of FAs at the inguinal crease in these four subgroups were 1.83 ± 0.39, 2.08 ± 0.52, 2.33 ± 0.49, and 1.83 ± 0.58, respectively (P = 0.06); and the mean numbers of FVs at the inguinal crease were 1.08 ± 0.29, 1.0 ± 0.0, 1.0 ± 0.0, and 1.0 ± 0.0, respectively (P = 0.32).

<table>
<thead>
<tr>
<th>Age group</th>
<th>Gender</th>
<th>Age (months)</th>
<th>Weight (kg)</th>
<th>Height (cm)</th>
<th>BSA (m²)</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3–11 months</td>
<td>M/F 7/5</td>
<td>5.6 ± 3.2</td>
<td>7.0 ± 2.6</td>
<td>65.4 ± 9.5</td>
<td>0.36 ± 0.09</td>
<td>15.8 ± 1.9</td>
</tr>
<tr>
<td>12–35 months</td>
<td>M/F 8/4</td>
<td>25.1 ± 6.6</td>
<td>13.2 ± 2.6</td>
<td>89.8 ± 6.8</td>
<td>0.58 ± 0.08</td>
<td>16.3 ± 1.5</td>
</tr>
<tr>
<td>36–95 months</td>
<td>M/F 5/7</td>
<td>72.8 ± 8.1</td>
<td>24.2 ± 2.9</td>
<td>120.2 ± 3.8</td>
<td>0.9 ± 0.06</td>
<td>16.8 ± 1.8</td>
</tr>
<tr>
<td>96–120 months</td>
<td>M/F 6/6</td>
<td>108.5 ± 12.0</td>
<td>31.1 ± 6.4</td>
<td>135.3 ± 8.3</td>
<td>1.08 ± 0.14</td>
<td>16.9 ± 2.0</td>
</tr>
</tbody>
</table>

All values are expressed as mean ± SD. BSA: body surface area, BMI: body mass index, M: male, F: female.
of the femoral artery differed significantly between children aged 96–120 months and those aged 3–11 or those aged 12–35 months, and between children aged 36–95 months and those aged 3–11 months (P < 0.001). In addition, the bifurcation sites of the femoral vein differed significantly between children aged 3–11 months and those aged 36–95 months, or those aged 96–120 months (P = 0.003) (Fig. 2).

We found that FA bifurcation was significantly correlated with height (r = 0.647, P < 0.001), weight (r = 0.619, P < 0.001), age (r = 0.609, P < 0.001), and body surface area (BSA; r = 0.619, P < 0.001) (Table 2). Moreover, FV bifurcation was inversely correlated with height (r = −0.607, P < 0.001), weight (r = −0.541, P < 0.001), age (r = −0.552, P < 0.001), and BSA (r = −0.576, P < 0.001) (Table 2). Multivariate stepwise linear regression analysis showed that height was the only independent predictor of the bifurcation of both FA and FV (Table 2).

**DISCUSSION**

In the inguinal region in adults, the FA and FV closely approximate each other, although both have numerous well-described anatomic variations in bifurcation sites proximal or dis-

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**Fig. 1.** Ultrasound images of femoral artery (white arrow) and femoral vein (black arrow).

**Fig. 2.** Relationship between patient age and distance from the bifurcation sites of femoral vessels to the inguinal crease. The bifurcation sites of the femoral artery differed significantly between children aged 96–120 months (IV) and those aged 3–11 (I) or those aged 12–35 months (II), and between children aged 36–95 months (III) and those aged 3–11 months (P < 0.001). In addition, the bifurcation sites of the femoral vein differed significantly between children aged 3–11 months and those aged 36–95 months, or those aged 96–120 months (P = 0.003).

**Table 2.** Univariate and Multivariate Stepwise Linear Regression Analysis of the Relationship between the Bifurcation Sites of Femoral Vessel and Demographic Parameters

<table>
<thead>
<tr>
<th>Variables</th>
<th>FA Univariate</th>
<th>Multivariate</th>
<th>FV Univariate</th>
<th>Multivariate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>0.647</td>
<td>&lt;0.001</td>
<td>0.607</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Weight</td>
<td>0.619</td>
<td>&lt;0.001</td>
<td>0.541</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age</td>
<td>0.609</td>
<td>&lt;0.001</td>
<td>0.552</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BSA</td>
<td>0.619</td>
<td>&lt;0.001</td>
<td>0.576</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI</td>
<td>0.197</td>
<td>0.18</td>
<td>−0.117</td>
<td>0.427</td>
</tr>
</tbody>
</table>

BSA: body surface area, BMI: body mass index, FA: femoral artery, FV: femoral vein.

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tal to the inguinal crease [5-7]. For example, angiographic examination of 200 bifurcation sites of the FA on both sides in 100 adults found that 153 (76.5%) bifurcated proximal to the inguinal crease, becoming the superficial and deep FAs; of these, 7 (3.5%) bifurcated on the inguinal crease, and 40 (20%) bifurcated distal to the inguinal crease [4]. In addition, diagnostic aortographic imaging of femoral catheterization showed that 71.9% of FAs in adults bifurcated proximal to the inguinal crease, whereas the average distance from the inguinal crease to the bifurcation site was 0.61 cm [6].

Using an ultrasound device, we found that, in children, the FAs bifurcated proximal to the inguinal crease, whereas the FVs bifurcated distally. To determine if anatomy varied with age, we divided the subjects into four age subgroups. We observed significant differences in the bifurcation sites of the FA and FV among age groups, especially between the oldest (96–120 months) and youngest (3–11 months) subgroups. We observed significant correlations between bifurcation sites and patient height, weight, age, and BSA, with a multivariate stepwise linear regression analysis showing that height is an independent predictor of the bifurcation sites of the FA and FV. Thus, by knowing a pediatric patient’s height, it may be possible to estimate the bifurcation site of the femoral vessels; if a pediatric patient’s height less than 100 cm, the bifurcation sites of the FA would be within 1 cm proximal to the inguinal crease and patient’s height more than 80 cm, the bifurcation sites of the FV possibly lies 1 cm distal to the inguinal crease.

Ultrasound devices are frequently used for vessel catheterization due to their ease of use and accuracy [8,9]. Moreover, ultrasound central vein catheterization via the FV had a higher success rate and a lower complication rate (7%) than catheterization using puncturing indices alone [10]. Since vessel diameter is smaller in children than in adults, complication rates due to repetitive punctures are higher in children, especially those aged less than 1 year [11-14]. To avoid these complications, it is important to know the exact puncture site appropriate for catheterization.

Most studies of the FA and FV, including their size, the distance between them, and their anatomical relationship, have been performed in adults [4,5,15,16], with only one performed to date in children [17]. Several factors have limited studies in children, including difficulties in patient recruitment and of obtaining informed consent and poor compliance. All of our subjects, however, were assessed while under general anesthesia, when they were unable to move or cry, enabling us to obtain accurate and consistent data. Unlike studies in adults, which typically use computed tomography (CT) or angiography to identify the bifurcation site [4-6], our study was safe and convenient as we used an ultrasound device, which is neither radioactive nor invasive.

Our study had several limitations, including the non-assessment of the anatomical relationships between the FA and FV. In adults, 78% of femoral vessels are situated in an anterior-posterior position [5], not in the lateral-medial position typically reported in textbooks [18]. In addition, the FA and FV in adults were found to overlap as they run distal from the inguinal ligament [15]. During puncture, this may lead to complications, such as the formation of arteriovenous fistulas, due to the inadvertent puncture of other vessels. In pediatric patients, the FV was overlapped completely (8%) or partially (4%) by the FA [17]. In contrast, we did not observe overlap of the FA and FV, neither at their bifurcation sites nor at the inguinal crease. Therefore, we did not investigate the anatomical relationship between the FA and FV. The evaluation was included only right femoral vessel is also limitation of our study.

In conclusion, our results demonstrate that, in children, the FA usually bifurcates proximal, and the FV bifurcates distal, to the inguinal crease as the children’s height becomes taller. This may guide anesthesiologists during femoral vessel cannulation in pediatric patients. However, there are anatomical differences among age groups, so care should be taken to avoid complications during femoral vessel cannulation.

REFERENCES