Abstract—Background: Femoral venous access is an essential part of patient care in the emergency department (ED). However, current medical literature and texts have not dealt with it much using actual patient anatomy. Objectives: This study aimed to show that manipulation of the lower extremities may alter the anatomy to a more favorable position for cannulation. Methods: Ultrasound examination was conducted on a prospective sample of ED patients to evaluate anatomical variance of the femoral artery and vein overlap as well as the change in femoral vein diameter with leg position. Bilateral measurements of the diameter of the vein were taken at three different leg positions (straight, abduction, and abduction with external rotation). Results: This study enrolled a total of 132 ED patients. Of these, 122 (92%) patients showed some degree of overlap on the right and 126 (95%) patients showed some degree of overlap on the left. There was a statistically significant decrease in the percentage of overlap when moving the leg from a straightened position to an abducted position, and an additional decrease when moving the leg into an abducted and externally rotated position. There was also a statistically significant increase in the size of the femoral vein with each of these positions. Conclusions: Up to 95% of people have some degree of overlap of the femoral vein by the femoral artery. By positioning the leg in an abducted and externally rotated position, the amount of overlap is reduced and the diameter of the vein is increased, maximizing the percentage of the vein available for cannulation. © 2014 Elsevier Inc.

Keywords—ultrasound; central venous access; femoral vein position

INTRODUCTION

It is common practice in the emergency department (ED) to access the femoral vein for blood draws and insertion of central venous catheters. This is done when peripheral sites are unable to be accessed. Many practicing emergency physicians have been taught that the femoral vein lies directly medial to the femoral artery. In clinical practice, the standard procedure for locating and cannulating the femoral vein is to first locate the femoral artery by palpating the arterial pulse at the inguinal ligament and then move 1 cm medially and 1–2 cm inferior. If no venous blood is aspirated, clinicians typically redirect the needle laterally until venous blood return is noted (1).

Using this method, the femoral artery may be punctured multiple times without ever gaining access to the vein. It is the experience of these researchers, through imaging with ultrasound (US), that there is often anatomical variance in femoral vasculature where the femoral vein is located in a posterior sagittal plane in relation to the femoral artery, thus obscuring the vein. This overlap, whether partial or complete, makes access to the vein difficult. Although it is well known that US guidance can reduce the incidence of complications with central line insertion, it is not universally used on a routine basis. Use of US guidance prior to every central line insertion to assess for anatomical variance may decrease the number of attempts needed for successful cannulation (2–4).
There is statistically significant variance in the femoral vasculature, with the femoral vein being overlapped at least partially up to 72% of the time (5). Multiple studies have shown that certain medical conditions or body positions can affect the size of the femoral vein and therefore the success rate of cannulation (6–8).

The opinion of these authors was that anatomical positioning did play a role in the amount of femoral vein availability for cannulation. The hypothesis of this study was that when a patient’s leg is placed in the abducted and externally rotated position, there will be less overlap of the femoral artery and vein.

**MATERIALS AND METHODS**

Approval for this study was obtained from our local Institutional Review Board to be carried out in the ED at a community hospital in the Midwestern United States. The study group included individuals older than 18 years of age who were judged by an emergency physician to be competent to make medical decisions. Exclusion criteria included patients with any previous regional surgery or major trauma to the femoral vein or artery, and patients who were in need of emergent care. Patients were screened and selected by investigators using convenience sampling from September 2010 to January 2011. Informed consent was obtained, as well as demographic information about age, sex, and weight. Patients’ chief complaint was not obtained, as these investigators wanted to get a true “general population” sample. Participants were assured that neither participation nor nonparticipation would affect their medical care while in the ED.

For an a priori power of at least 80%, setting alpha at 5% to detect moderate differences (differences in the magnitude of 10% in overlap) as significant, we needed at least 40 subjects. This sample size was based on a multivariate analysis of variance (MANOVA). To account for dropouts and those who would like to discontinue after the initial measurements, 132 patients were examined supine, with each leg individually measured in three positions: straight, abduction, and external rotation, using a portable US machine with a 5-MHz, 38-mm broadband linear probe (Titan, SonoSite Inc., Bothell, WA).

Four investigators, all of which were US trained, collected data and followed the same protocol for probe positions relative to the inguinal ligament and leg placement. Standard leg placement devices were developed to assist with standardizing of leg position. For ease of data collection, the right groin was examined first in all three positions, followed by the left groin in all three positions. The straight leg position was achieved by placing the patient supine, with both legs extended and the medial malleoli aligned 6 inches apart from each other. For the abduction position, the contralateral leg was left in the straight position while the leg being examined was abducted to a distance of 18 inches from the straight leg between the medial malleoli. This distance was chosen due to limitation presented by the width of the examination table. It was felt that if the test leg were allowed to be abducted off the edge of the table, an additional rotational...
component would be introduced. For the externally rotated position, the contralateral leg was left in straight position while the test leg was abducted to 18 inches as before and externally rotated.

Measurements were taken in the straight leg position (Figure 1; the distance of overlap was calculated to be 1.17 cm, and this was divided by the diameter of the vein, which was 1.85 cm; this resulted in a calculated percentage of overlap of 63%), abduction, and abduction with external rotation (Figure 2; the distance of overlap was calculated to be .63 cm, and this was divided by the diameter of the vein, which was 1.66 cm, resulting in a calculated percentage of overlap of 38%), immediately distal to the inguinal ligament with the probe oriented in a transverse fashion. The traditional method of palpating the femoral artery, then moving 1 cm medial and 1 cm inferior to the inguinal ligament was used for placement of the US probe. This method of probe placement was used to determine the vascular anatomy at the site where a clinician would traditionally attempt to cannulate the femoral vein. If unable to palpate the arterial pulse, no additional pressure was applied, and the femoral vasculature was located by using US alone by increasing the depth. An image was taken in each position on both legs. The vein and artery were distinguished from each other by the relative anatomical position, compressibility of the vein, and size. Using the US calipers in each leg position, a 90° tangential line was created from the medial border of the femoral artery intersecting the vein. A second line was drawn horizontally from the edge of the vein to the tangential line for a measurement of distance of overlap. Then, extending the horizontal line to the opposite edge of the vein, a total diameter was measured (Figure 1). Taking these two measurements, the percentage of the vein obscured by the artery was calculated. These data were used to evaluate changes in percentage of vein obscured in the three test positions for each of the left and right sides, yielding six distinct leg positions. All investigators reviewed all images after the completion of data collection to assure accuracy of data collection. Two patients were excluded due to incomplete data. Patient demographic information was also collected (e.g., age, sex, weight) and was used to see if there were any trends among groups.

As previously stated, MANOVA was the statistical method used with post hoc pairwise comparisons. Correction for sphericity, where appropriate, was done using the Greenhouse-Geisser procedure. The anatomical variance, measured by the percent overlap, for each of the six leg positions constituted the dependent variables, whereas gender, age, and weight were the independent variables. Statistical significance was set at \( p \leq 0.05 \).

<table>
<thead>
<tr>
<th>Table 1. Study Participant’s Characteristics</th>
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<tbody>
<tr>
<td>Male, n (%)</td>
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<tr>
<td>Female, n (%)</td>
</tr>
<tr>
<td>Age, y, mean, (SD)</td>
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<tr>
<td>Weight, lbs, mean, (SD)</td>
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</table>

SD = standard deviation.
Table 2. Femoral Vein Measurement Results

<table>
<thead>
<tr>
<th>Position (#)</th>
<th>Vein Diameter, cm (SD)</th>
<th>Mean Percentage of Overlap (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left leg straight (1)</td>
<td>1.26 (0.32)</td>
<td>34.15 (23.32)</td>
</tr>
<tr>
<td>Left leg abduced (2)</td>
<td>1.29 (0.30)</td>
<td>29.10 (20.19)</td>
</tr>
<tr>
<td>Left leg abd/ext rot (3)</td>
<td>1.33 (0.30)</td>
<td>21.91 (17.91)</td>
</tr>
<tr>
<td>Right leg straight (4)</td>
<td>1.25 (0.37)</td>
<td>35.43 (25.48)</td>
</tr>
<tr>
<td>Right leg abducted (5)</td>
<td>1.29 (0.35)</td>
<td>30.38 (22.73)</td>
</tr>
<tr>
<td>Right leg abd/ext rot (6)</td>
<td>1.33 (0.32)</td>
<td>24.21 (20.75)</td>
</tr>
</tbody>
</table>

SD = standard deviation; abd = abducted; ext rot = externally rotated.

Using the ultrasound calipers in each leg position, a 90° tangential line was created from the medial border of the femoral artery intersecting the vein. A second line was drawn horizontally from the edge of the vein to the tangential line for a measurement of distance of overlap. Then, extending the horizontal line to the opposite edge of the vein, a total diameter was measured. Taking these two measurements, the percentage of the vein obscured by the artery was calculated.

RESULTS

During the 8-month study period, 132 patients consented to participate in this study. Of these patients, 70 were female, 62 were male, and the average age was 59 years (Table 1). Out of the 132, 122 (92%, with 95% confidence interval [CI] 87.367–96.629%) patients showed some degree of overlap on the right side and 126 (95%, with 95% CI 91.277–98.718%) patients showed some degree of overlap on the left.

There was a statistically significant decrease in the mean percentage of overlap, with each change in leg position on both the right and left side. On the left there was a 5.05% (p = 0.028, 95% CI 0.292–9.808) decrease in overlap from position 1 to position 2, and a 7.19% (p < 0.0001, 95% CI 3.076–11.304) decrease from position 2 to position 3, with an overall decrease of 12.24% (p < 0.0001, 95% CI 5.212–16.993) from position 1 to position 3. On the right there was a 5.05% (p = 0.025, 95% CI 6.336–18.145) decrease in overlap from position 4 to position 5, and a 6.17% (p = 0.001, 95% CI 1.848–10.496) decrease in overlap from position 5 to position 6, with an overall decrease of 11.22% (p < 0.0001, 95% CI 5.359–17.079) from position 4 to position 6 (Table 2).

There was also a statistically significant increase in the size of the femoral vein with each change in leg position. In the left leg the femoral vein increased in size from a mean measurement of 1.26 cm in position 1 to 1.29 cm in position 2 (p = 0.028, 95% CI 0.028–0.042). The femoral vein further increased in size in position 3, to 1.33 cm (p < 0.0001, 95% CI 0.031–0.045). The increase in size from position 1 to position 3 was also statistically significant (p < 0.0001, 95% CI 0.059–0.072). In the right leg, the femoral vein increased in size from a mean measurement of 1.25 cm in position 4 to 1.29 cm in position 5 (p = 0.025, 95% CI 0.022–0.035). Relative to position 1, the femoral vein increased in size in position 6, to 1.33 cm (p < 0.001, 0.027–0.053). The increase in size from position 4 to position 6 was again statistically significant (p < 0.0001, 95% CI 0.059–0.073). Table 2 provides the descriptive statistics of the mean percent overlap and the mean vein diameter, with associated SDs.

The demographic variables sex, age, and weight were not statistically significant predictors of the percent overlap. The left vs. right side of the body also were not statistically significant predictors of the percent overlap.

DISCUSSION

Femoral venous cannulation is performed in EDs everyday for various reasons. One such use is for venous access when peripheral access is unobtainable or not appropriate. We sought to determine the exact nature of the anatomy of the femoral artery in relation to the femoral vein and to determine how leg position would affect this relationship. Although this had been addressed in some previous studies, those studies were done with smaller sample sizes and the images used were not obtained in uniform fashion (5,7,8). Our study was performed on a larger sample size, of patients chosen at random, with images obtained in a universal fashion. Our results showed that the majority of people have at least some overlap of the femoral vein by the femoral artery, which can contribute to the risk of puncturing the artery. Of the 132 people scanned, 122 (92%) showed some degree of overlap on the right and 126 (95%) showed some degree of overlap on the left. We also showed that by positioning the leg in an abducted and externally rotated position, the amount of overlap is reduced and the overall diameter of the vein is increased, thus maximizing the percentage of the vein available for cannulation.

It is well known that femoral artery punctures can have complications, whether doing intentional catheterization for cardiac procedures or even just a single needle puncture (9). False aneurysm, arterial occlusion, hemorrhage, arteriovenous fistula, and infection are all potential catastrophic complications (10). Also, delay in vascular access can be life threatening in an emergency situation. Inadvertent arterial puncture may result in time spent holding pressure to stop bleeding while another site is prepared for cannulation. Given the possible significant morbidity involved, practitioners should use all available resources and techniques to minimize the inadvertent puncture of the artery and increase the chance of accessing the vein successfully.
Limitations

Our study was limited in the sense that we did not involve examining whether the actual placement of femoral lines and position changes are associated with success rate. This fact is important, as our patients’ anatomy may differ from those who would require femoral line placement. We also did not look at complication rate of femoral vein cannulation to determine if position played a role in its decrease. Also, the patients that participated in our study were relatively healthy individuals who were not in need of aggressive therapy, as is the case in patients who may need central venous access from a femoral catheter in the ED. The images obtained for use in this study were obtained by four different researchers, and we did not perform interrater reliability on the acquisition of such images. We believe further studies should be done looking at actual performance of procedures with these leg positions to determine if there is a statistically significant improvement in the rate of cannulation without complications.

CONCLUSION

Up to 95% of people have some degree of overlap of the femoral vein by the femoral artery. By positioning the leg in an abducted and externally rotated position, the amount of overlap is reduced and the diameter of the vein is increased, maximizing 25% of the vein available for cannulation.

REFERENCES

ARTICLE SUMMARY

1. Why is this topic important?
   Current literature (Rosen’s, Tintinalli’s, Roberts and Hedges) teaches landmark-guided placement of femoral catheters, and this paper shows that this may lead to increased cannulations of the femoral artery, or increased attempts to cannulate the femoral vein due to overlap.

2. What does this study attempt to show?
   This study showed that anatomical variability is common in the majority of patients who were evaluated, and that lower extremity position can significantly change femoral anatomy.

3. What are the key findings?
   There are anatomical variabilities, especially overlap of the femoral artery and femoral vein, in 95% of patients studied, which is decreased with abduction and external rotation of the lower extremity.

4. How is patient care impacted?
   By simply moving the lower extremity into an abducted and externally rotated position, you can significantly decrease the femoral artery’s overlap of the femoral vein. The use of ultrasound can aid you in visualizing the femoral vasculature, which will allow you to place the patient into the proper position to successfully cannulate the femoral vein.