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Comparison of ultrasound-guided and manual palpation methods in retrograde femoral artery catheterization: A retrospective study

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ABSTRACT

Background: The purpose of this study is to assess the success and complication rates of two different techniques used for retrograde femoral artery access.

Methods: This retrospective study included angiographies performed by retrograde femoral artery access. Arterial punctures were performed with either ultrasound guided (group 1) or manual palpation (group 2) methods. Patients' pulses were examined by a nurse practitioner and graded subjectively before preparing the puncture side (grade 0–3). Arterial puncture performed through a strong(3) or medium pulsed(2) artery was included in this study. The puncture side (right or left femoral), complications, average catheterization time calculated from patients' notes, first-pass success rate, and the number of puncture attempts were analyzed. Sheath sizes, body mass index (BMI), and, vascular closure device usage after the angiographic procedure were also recorded and analyzed.

Results: A total of 256 angiographies were found to be eligible; age, pulse grading, and puncture side distributions were similar ($p > 0.05$). Mean puncture attempts to catheterize femoral arteries were 1.09 ± 0.09 and 1.25 ± 0.24 times, which took 1.49 ± 0.19 and 1.75 ± 0.25 minutes for group 1 and group 2, respectively, which were statistically significant ($p < 0.001$). Complication rates were similar for both groups ($p = 0.561$) and increased with BMI > 35 ($p = 0.003$).

Conclusion: Ultrasound guidance is comparable with the manual palpation method and is somewhat better in certain conditions. Thus, it should be considered as an option during routine retrograde femoral artery access. According to our results, even in arteries with strong pulses, first-pass success rate, average catheterization time, and puncture attempts were better with ultrasound guidance.

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Introduction

Radial-first strategy has emerged and is recommended for patients with acute coronary syndromes, although this technique has lagged in interventional radiology practice [1]. Femoral artery is still one of the most preferred access site for angiographic procedures and access site-related complications are the utmost important complications occurring after angiographic procedures [2,3]. The most important, although rare, local complications of retrograde femoral access are arterial dissection, vessel rupture, pseudoaneurysm formation, and retroperitoneal hemorrhage [3,4]. Despite new trends on using small-caliber sheaths and catheter systems from the radial artery catheterizations, about 7% of the radial arterial catheterization attempts need to be converted to femoral artery access [5]. Puncturing the femoral artery with a palpable pulse is rarely problematic, and there are several landmarks for successful femoral artery catheterization [6,7]. Maximal arterial pulse is the most reliable

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marker for the common femoral artery puncture, with 92.7% reliability [6]. Ultrasound is the new stethoscope of 21st-century physicians, although physical examination with palpation should still be an important step at the patient examination, especially for the angiographer [8]. Ultrasound-guided access has demonstrated its superiority in a couple of interventional procedures like venous access, antegrade femoral access, and distal retrograde access [9,10]. Previous studies have concluded that ultrasound guidance is beneficial when there is a weak or absent pulse in the femoral arteries [11,12]. However, these studies concluded that success and complication rates were similar for patients with strong pulses, which could hamper having definite conclusions [12]. The time needed for ultrasound preparation, cost of an ultrasound device, and cost-effectiveness was not included in these studies [12,13]. The time required to catheterize the initial access artery is critical in emergent procedures, especially for unstable patients under medication.

This retrospective study aimed to assess the success and complication rates of two different methods performed by retrograde femoral artery access in patients with either strong or medium arterial pulses.

Materials and Methods

Study participants

The institutional review board approved this retrospective study (I2-116-21). All patients gave informed consent and were aged between 18 and 91 years. The indications for the retrograde femoral artery access were as follows: liver-directed transarterial interventions, lower limb diagnostic angiographies, and peripheral transarterial embolizations. The inclusion criteria were as follows: 1. Patients who had details in their hospital notes regarding their arterial pulse grades, number of puncture attempts, and femoral artery puncture sides (right/left), 2. Retrograde femoral artery access. The exclusion criteria were as follows: 1. Patients with no pulse or low pulsed femoral arteries. 2. Patients who need more than three puncture attempts during catheterization of the femoral artery.

Angiographies performed between 01.01.2019 and 31.12.2019 were analyzed from our archive system and 256 angiographies were found suitable for this study. Group 1 consisted of angiographies performed with ultrasound-guided retrograde femoral artery access (USGFA) and group 2 consisted of angiographies performed with the standard femoral palpation technique (ST). Since the USGFA has demonstrated its superiority over the manual palpation method in no pulse or low-pulsed arteries, this study focused primarily on medium- and strong-pulsed femoral arteries.

Patient information, such as age, gender, body mass index (BMI), pulse grade, number of puncture attempts, side of limb preferred for the puncture, average catheterization time (CT), hemostasis technique (compression/closure device), sheath size, and puncture site complications, were recorded and analyzed. There are >1,000 angiographic procedures performed in our <AQ>IR clinic annually. All procedures were performed by a single operator (first author) with >5 years of experience in angiographic procedures and there were no patients with acute coronary syndromes in this cohort.

The adverse event classification of the Society of Interventional Radiology was used to estimate and understand the importance of complications related to the techniques performed [14] (Table 1).

Femoral puncture technique

Conforming to our institutional protocol, the femoral puncture sites were examined by one of the senior nurse practitioners before puncture site cleaning and preparation. According to the palpation findings, femoral pulses were examined and graded subjectively using a 4-grade scale (grades 0–3) as described in the literature [15]. A strong pulse at the palpation site represented grade 3; medium pulse represented grade 2; weak pulse represented grade 1; and if no arterial pulse could be palpated, then grade 0 was assigned. All patients in this study were in a supine position, and femoral artery access was performed in a retrograde fashion with a bevel-tipped hollow 18-gauge (G) needle. ST was done at a point where the best arterial pulse was palpated. Anatomic landmarks like the imaginary line between the superior iliac spine and pubic symphysis, inguinal fold, and the femoral head localization using fluoroscopic images were used in combination when needed. For the USGFA, a 7.5 Hz linear ultrasound probe (Sonosite, USA) was used. The common femoral artery segment without atherosclerotic plaques was preferred for femoral access under ultrasound guidance. No matter which method was initially selected, 3–5 minutes of manual compression was performed

to the puncture site after three unsuccessful puncture attempts to prevent excessive hematoma. Afterward, either practitioner performing catheterization or puncture technique was changed. All results were recorded in the patient notes by the nurse practitioner.

CT was calculated using the patients' notes as follows: documented intervention starting time, which begins after completion of sterile draping, was subtracted from the time recorded on the first angiographic images. CT also included the time local anesthetic injection duration and the physical examination of the puncture site for both techniques. A vascular closure device (AngioSeal, St. Jude Medical, Austin, TX) or the standard manual compression technique was used to maintain hemostasis at the puncture site.

Statistical analyses

IBM-SPSS 20.0 (IBM Corp., Armonk, NY) was used to conduct the statistical analyses. Descriptive data for age are presented as average standard deviation (±), whereas categorical data representing the number of participants (angiographies) are indicated as a percentage (%). Independent *t*-test was used to compare ages in different gender groups. For the descriptive statistics average, standard deviation (±), median, minimum, and maximum values were used, while numbers and percentages were used for discrete data. The relationships among the categorical variables were analyzed using Pearson's' chi-squared test. In the comparison of continuous data for patients undergoing two different catheterization techniques for femoral artery catheterization, the compliance of the data with normal distribution was tested. Independent *t*-test was used for the data that showed a normal distribution and Mann–Whitney U test was used for those that did not. For results with $p < 0.05$, we assessed the statistical significance of the findings.

Results

A total of 125 angiographies (female: 55, male: 70) were in group 1 (right femoral: 82, left femoral: 43) and 131 (female: 35, male: 96) were in group 2 (right femoral: 96, left femoral: 35); mean patient ages were 58.58 ± 13.02 years and 59.97 ± 14.68 years, respectively. While there was a significant increase in female predominance in group 1 ($p = 0.004$), no other differences in terms of age ($p = 0.426$), pulse grading ($p = 0.232$), and femoral artery puncture side distributions ($p = 0.182$) were observed ($p > 0.05$) (Table 2).

Mean puncture attempts were 1.09 ± 0.09 times in group 1 (1–2 times) and 1.25 ± 0.24 times in group 2 (1–3 times), which were significantly lower for group 1 ($p = 0.004$). First-pass success rates were 91.2% and 77.1% for group 1 and group 2, respectively ($p = 0.017$).

Mean catheterization time was significantly lower for group 1, with a duration of 1.49 ± 0.19 minutes for group 1 compared to 1.75 ± 0.25 minutes for group 2 ($p < 0.001$).

We identified the differences between the distributions of sheath sizes used for femoral artery access. Sheath sizes ≥6 Fr were used more frequently in group 1 (52.8% *vs*. 26.7%) ($p < 0.001$).

Vascular closure devices were used for 26.4% ($n = 33$) of the angiographies in group 1 and for 24.4% ($n = 32$) of the angiographies in group 2, and this difference was not statistically significant ($p = 0.717$). 34.4% of the patients in group 1 and 26.7% of the patients in group 2 were catheterized from the left femoral artery ($p = 0.182$).

6.2% of right-sided angiographies ($n = 11$) and 3.8% of left-sided angiographies ($n = 3$) developed complications, which was not statistically significant ($p = 0.561$). One patient in group 1 developed a group D complication (retroperitoneal hematoma), which needed blood transfusions and intensive care unit follow-up, and another patient in group 2 with a BMI >35 experienced a group C complication (pseudoaneurysm formation). There were no other major complications recorded in both groups; only small hematomas (<3 cm) occurred for the rest of the procedures ($n = 12$). All major complications occurred after ≥6 Fr sheath insertions. After angiography, complications occurred in 4.8% of the patients in group 1 and 6.1% of the patients in group 2 with no statistically significant differences ($p = 0.646$). Seven small hematomas (17.1%) occurred in patients with a BMI >35, which was significantly higher in contrast to the patients with a BMI < 35 ($p = 0.003$).

Discussion

This study focused on patients with strong or medium femoral pulses to further understand the importance of ultrasound-guided access. The success of two different retrograde femoral artery puncture techniques was investigated. We identified that the first-pass success rates, puncture attempts, and average catheterization time were

better in those who underwent ultrasound-guided retrograde femoral artery access. Interestingly, the complications that occurred were similar between groups.

Ultrasound-guided vascular access has been used in many studies and has validated its success in venous interventions [9]. Besides, USGFA has demonstrated superiority in no pulsed or weak pulsed arteries when compared to ST, and no differences were identified in patients with strong or medium pulses [4,11,12,15]. However, patient numbers with strong or medium pulses are not well represented in these studies, and therefore, further investigation should be carried out.

In a recent meta-analysis, Sorrentino et al. [5] analyzed USGFA and ST for retrograde femoral artery access and found better results concerning first-pass success, puncture attempts, and CT, and reported lower minor complication rates for USGFA. However, femoral pulse grading was overlooked by some of the studies evaluated in this meta-analysis [5]. Flawless catheterization is essential in emergent situations such as stroke interventions or embolization procedures in unstable patients. We observed significantly low puncture attempts and less CT in group 1, which is consistent with the literature. Besides, none of the patients needed more than two puncture attempts in group 1. Complication rates were also lower in group 1, but there were no significant differences between groups. These results demonstrate the importance of ultrasound guidance when placing a retrograde femoral artery catheterization, even in patients with strong or medium pulsed femoral arteries.

Complications and success rates of vascular closure devices used to maintain hemostasis after catheterization of the artery under USGFA or ST have been previously reported and, these results were similar between patients whose femoral arteries were punctured with either technique [16–18]. We observed that the vascular closure device usages were similar between groups, and the results from the current study demonstrate similar results to the literature.

Naddaf et al. [19] demonstrated that complication rates were positively correlated with the sheath sizes (>6 Fr), and closure devices could be protected from these consequences. Sheath sizes ≥ 6 Fr were used significantly more for the patients in group 1. This observation could be due to operator preference for USGFAs to be used more frequently for therapeutic interventions and ST for diagnostic angiographies. Although ≥ 6 Fr catheters were used more frequently in group 1, the complication rates were similar between groups. We believe this outcome is due to the positive effect of ultrasound guidance.

Left-sided access was higher in group 1 (34.4%) in contrast to group 2 (26.7%), but was not found to be significant. This slight discrepancy could be due to operators' preferences. A total of 14 patients (5.5%) developed complications in both groups, and complication rates in the right femoral artery were higher in the current study. This insignificant difference could be due to more frequent usage of ≥ 6 Fr sheaths during right-sided punctures. Unfortunately, the total number of complications was underpowered to draw a statistical conclusion.

Lee et al. [20] demonstrated that the risk of high femoral artery puncture rates increases with ultrasound-guided access. The common femoral artery was above the inguinal crease in about 72% of the patients, and retroperitoneal hematoma risk increased with high femoral punctures [6,21]. The efficacy of the vascular closure devices in preventing complications, such as retroperitoneal hematoma, was similar to manual compressions [16]. One patient in both groups experienced significant complications despite using a vascular closure device, but patient numbers are insufficient to make a confident conclusion. Yun et al. [2] reported that ultrasounds could be used safely to determine the inguinal ligament to prevent high punctures. The group D complication in group 1 could be due to a high femoral puncture above the inguinal ligament related to USG; thus, the inguinal ligament should always be evaluated and considered before USG.

The most important limitation of this study was its retrospective nature, and the use of a single operator performing femoral access with different techniques could create bias within the study. Randomized prospective studies with a larger patient population could be better to further investigate the benefit of using an ultrasound device routinely during femoral artery access. Some of the readers will consider lack of baseline comorbidities of the patients and absence of the number of patients treated with antiplatelet agents, anticoagulants, and/or inhibitors of Glycoprotein IIb/IIIa as other limitations for this study. In addition to these, comparison of the anatomical variations seen in femoral artery ultrasound and fluoroscopic localization based on palpation methods can be investigated in further studies.

Conclusion

An interventionist has to be aware of the potential advantages of different techniques and should always consider the potential complications. According to the current results, ultrasound-guided retrograde femoral artery access demonstrated its superiority over "standard palpation technique" among strong- and medium-pulsed arteries with a positive impact on catheterization time, first-pass success rates, and puncture attempts.

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