High Deep Femoral Artery Bifurcation Can Disturb Safe Femoral Venous Access: CT Assessment in Patients Who Underwent Femoral Venous Access Under Doppler Ultrasound Guidance

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Abstract

Purpose: To retrospectively evaluate the variations of deep femoral artery (DFA) bifurcation on computed tomography (CT) and technical success in femoral venous access.

Materials and Methods: CT images of 353 patients who underwent adrenal venous sampling were evaluated. Height with relation to the inferior border of the femoral head and direction of DFA bifurcations were classified as follows: type L, low bifurcation; type H1, high lateral bifurcation; type H2, high posterior to posterolateral bifurcation; type H3, high posteromedial bifurcation; and type H4, high medial bifurcation crossing in front of the femoral vein. Technical success and complications during femoral venous access were also evaluated.

Results: The frequencies of types L, H1, H2, H3, and H4 were 82.7%, 9.1%, 6.9%, 0.4%, and 0.9%, respectively. In 92.2% of type H1 and 69.4% of type H2, the superior femoral artery displaced medially by the high DFA partially overlapped the femoral vein. Upon the inclusions of H3 and H4, in 14.4% of cases, the high DFAs could obstruct the access route to the femoral vein. Using Doppler ultrasound guidance, no significant differences were observed in the rates of success for puncture in the first attempt (84.5% vs. 75.4%, $p = 0.122$) and accidental arterial puncture (1.0% vs. 0%, $p = 1.00$) between low and high DFA bifurcations, respectively.

Conclusions: High DFA bifurcation is observed in 17.3% of patients and could obstruct the access route to the femoral vein. This can be evaluated using Doppler ultrasound guidance to avoid accidental arterial puncture during femoral venous access.

Key words: Deep femoral artery, femoral vein, puncture, interventional radiology, computed tomography

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Introduction

The femoral vein is commonly used as an access site for various venous interventional radiology procedures. It is often selected for central venous line placement, particularly during urgent circumstances [1]. However, the rate of infectious or thrombotic complications is higher than that observed in the jugular or subclavian veins [2]. Presently, femoral venous access is still often performed without ultrasound guidance, unlike jugular venous access. Nonetheless, serious complications due to accidental arterial puncture,

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such as retroperitoneal hemorrhage or arteriovenous fistula (AVF), have been reported [3-6].

During femoral venous access using Doppler ultrasound guidance, cases with deep femoral artery (DFA) variations that obstruct venous access are often encountered. Some reports evaluated variations in the DFA using angiography or cadavers to determine the impact of arterial puncture or surgery [7-13]. Others have assessed the variations in the medial and lateral circumflex femoral arteries (MCFA and LCFA, respectively), branches of the DFA, for orthopedic surgery [14-17]. Some case reports and case series have reported DFA variations that cross in front of the femoral vein [3, 5, 14, 18]. However, there is no systematic report evaluating the variations in DFA bifurcation and obstruction of the femoral venous access. Moreover, the rate of complications associated with these variations during femoral venous access has not been reported.

Thus, the current study was designed to retrospectively evaluate the frequencies of variations in DFA bifurcation on CT and accidental arterial puncture during femoral venous access in patients who underwent adrenal venous sampling (AVS).

Materials and Methods

Patients

This retrospective single-institution study was approved by the institutional review board of our facility. The requirement for written informed consent for the inclusion of individual patient data in the analysis was waived because of the investigation's retrospective nature. However, consent for the AVS procedure was obtained. A total of 360 patients who met the criteria for suspected primary aldosteronism [19] underwent AVS between November 2015 and June 2019. Of these, seven patients were excluded as contrast-enhanced CT of their pelvis was not available. No other patients were excluded from the study. The final study group consisted of 353 patients (144 men and 209 women; median age, 53 years; range, 25-79 years) with a mean body mass index of 24.9 ± 4.6 kg/m^2.

CT Examinations

Contrast-enhanced CT images were obtained before AVS using a 64-row detector scanner (Aquilion 64; Canon Medical Systems, Otawara, Japan) or a 320-row detector scanner (Aquilion One or Aquilion One GENESIS Edition; Canon Medical Systems). The screening of adrenal tumors was conducted at the following settings: a 1:1 table pitch; collimation, 0.5-1 mm; reconstruction thickness/interval, 1.0 mm/1.0 mm; 100-120 kVp with automatic exposure control; and adaptive iterative dose reduction (AIDR) [20]. After injecting the contrast medium for 30 s, three-phase images were obtained after 45 s, 55 s, and 180 s. The first and second phases' scan ranges were the upper abdomen, while the third phase covered the abdomen and pelvis. The total iodine dose was 600 mg/kg (maximum amount, 45 g). The median interval between CT and AVS was 62 days (range, 1-1281 days).

Venous Access Methods

Unilateral double femoral venous access was performed by one of the radiology residents, fellows, radiologists, or interventional radiologists, using a previously suggested protocol [21]. The presence or absence of arteries in front of the femoral vein, such as the low inferior epigastric artery loop and high DFA bifurcation on contrast-enhanced CT, was evaluated before the procedure [7, 22]. Furthermore, immediately before venous access, Doppler ultrasound examination was performed to check the arteries. A sequential insertion of two 18-gauge needles was conducted in tandem into a single femoral vein using Doppler ultrasound guidance after local anesthesia. When both punctures failed, the two needles were inserted again. In cases where one of the two punctures was successful, double sheath insertion via a single hole method (two-in-one method) was used as described in a previous report [21]. This protocol was repeated until venous access was achieved. Subsequently, AVS was performed according to the method described in previous reports [21, 23, 24]. The access site was checked after 2 h of bed rest and the next day to evaluate hematoma. The presence or absence of AVF was also assessed using a stethoscope.

CT Evaluation

Images were independently evaluated by an interventional radiologist (with more than 18 years of experience in AVS-S.M) and an interventional radiology fellow (with more than 2 years of experience in AVS-T.Y) using a viewer (ShadeQuest/ViewR; Yokogawa Medical Solutions, Tokyo, Japan). In case of discrepancies, a final judgment was obtained by consensus. Transaxial CT images with 3.0-mm thickness and interval and a scout view, which indicated the bifurcation height, were used. The cases were randomized, and the reviewers were blinded to the details about the variations and femoral venous access. The reviewers classified DFA bifurcation types concerning the femoral head and femoral vein, as shown in **Figure 1**. The height of the DFA bifurcation was evaluated according to a previous report [9] as follows: zones 1-4, divided equally in a craniocaudal direction on the femoral head, and zone 5, below the inferior border of the femoral head. Zones 0-4 were defined as high bifurcation, and zone 5 as low bifurcation (type L). Bifurcation on or around the femoral head's inferior border or the one that was difficult to designate as zone 4 or 5 was classified as zone 5 with low bifurcation. The direction of the DFA origin in patients with high DFA bifurcation was also evaluated as follows: lateral (type H1), posterior to posterolateral (type H2), posteromedial in which the DFA ran under the superior femoral artery (SFA) (type H3), or medial, in which the DFA crossed in front of the femoral vein (type H4). In case of variations, whether the arteries overlapped with the femo-

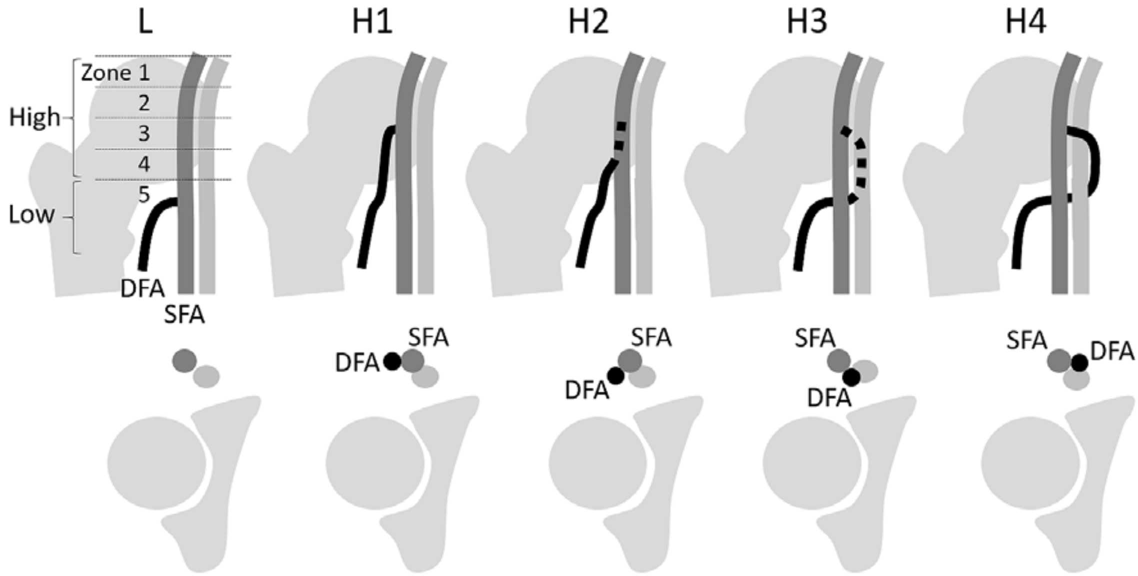

Figure 1. Schemas of deep femoral artery (DFA) bifurcation types: type L, low bifurcation; type H1, high lateral bifurcation; type H2, high posterior to posterolateral bifurcation; type H3, high posteromedial bifurcation; and type H4, high medial bifurcation crossing in front of the femoral vein. The femoral head's inferior border was used as the border between the high and low DFA bifurcations. The zone of the DFA bifurcation level was defined in relation to the femoral head. Schemas in the lower column are the transaxial images in zone 3 as an example. SFA, superior femoral artery

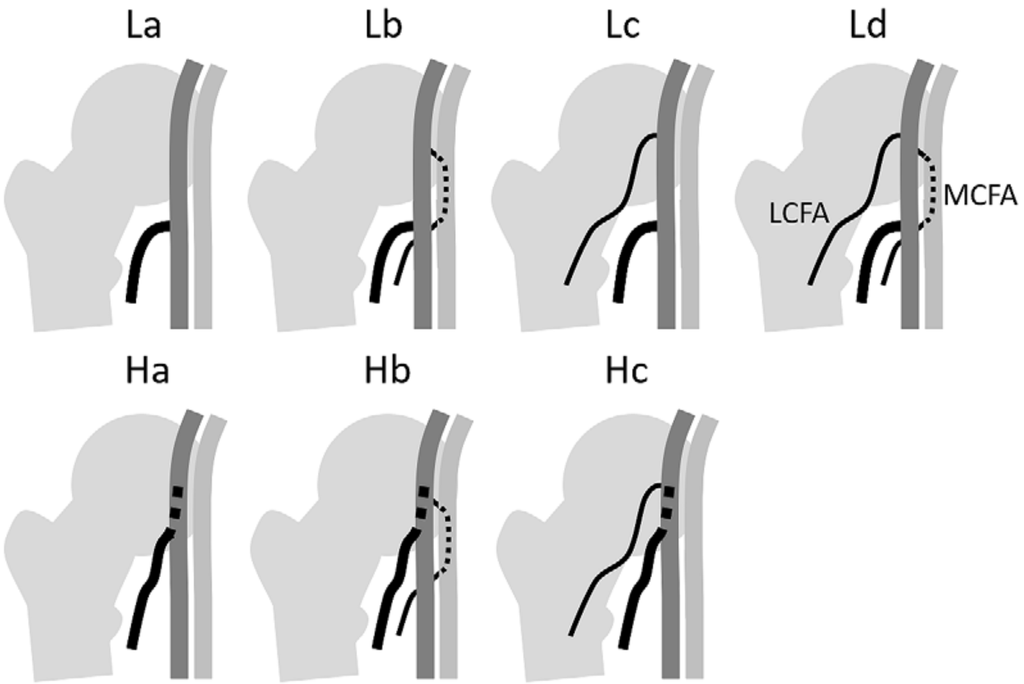

Figure 2. Schemas of the high medial circumflex femoral artery (MCFA) and lateral circumflex femoral artery (LCFA) origin with low and high deep femoral artery (DFA) bifurcations: subtype La, low DFA bifurcation without high MCFA and LCFA; subtype Lb, with a high MCFA; subtype Lc, with a high LCFA; subtype Ld, with high MCFA and LCFA; subtype Ha, high DFA bifurcation without high MCFA and LCFA; subtype Hb, with a high MCFA; and subtype Hc, with a high LCFA. Images of the high DFA bifurcation are examples of type H2.

ral vein was assessed. As a subclassification, MCFA and LCFA origin's height with low and high DFA bifurcations were also evaluated in a similar way, as shown in **Figure 2**.

Clinical Evaluation

Radiological procedure reports were reviewed to evaluate

Table 1. Frequencies of DFA bifurcation types and zone of DFA bifurcation level against the femoral head

Type	Total	Right	Left	DFA bifurcation level			
	(n = 706)	(n = 353)	(n = 353)	Zone 1	Zone 2	Zone 3	Zone 4
L	584 (82.7%)	294 (83.3%)	290 (82.2%)	-	-	-	-
H1	64 (9.1%)	23 (6.5%)	41 (11.6%)	2 (3.1%)	15 (23.4%)	36 (56.3%)	11 (17.2%)
H2	49 (6.9%)	31 (8.8%)	18 (5.1%)	0 (0%)	3 (6.1%)	21 (42.9%)	25 (51.0%)
H3	3 (0.4%)	0 (0%)	3 (0.8%)	0 (0%)	1 (33.3%)	2 (66.7%)	0 (0%)
H4	6 (0.9%)	5 (1.4%)	1 (0.3%)	1 (16.7%)	0 (0%)	5 (83.3%)	0 (0%)

DFA = deep femoral artery.

the number of attempts for successful puncture and investigate the presence or absence of accidental arterial puncture. The information about the DFA bifurcation variations described in radiological procedure reports and ultrasound images stored as proof were also checked to assess whether the operators had noticed these variations prior to the procedure. Medical records were reviewed to investigate the presence or absence of an inguinal hematoma and AVF post-procedure.

Statistical analysis

Statistical analyses were performed using JMP 15 software (SAS Institute Inc., Cary, North Carolina, United States). Statistical significance was set at $p < .05$. Fisher's exact test was used to compare the relationship between the right and left sides' variations. It was also used to compare the frequencies of accidental arterial puncture and inguinal hematoma between the low and high DFA bifurcations. Reader agreements for recording the DFA bifurcation types and subtypes were assessed using kappa statistics. The degree of observer agreement, as indicated by kappa values, was interpreted as follows: 0-0.20, slight agreement; 0.21-0.40, fair agreement; 0.41-0.60, moderate agreement; 0.61-0.80, substantial agreement; and 0.81-1.00, almost perfect agreement [25].

Results

The frequencies of the DFA bifurcation types and bifurcation levels are summarized in **Table 1**. There was an almost perfect interobserver agreement for the DFA bifurcation types with kappa statistics (k = 0.843). The frequency of type H1 was marginally higher in the left DFA group (p = 0.03). The frequency of type H2 was slightly higher in the right DFA group (p = 0.056). Otherwise, there were no significant differences in the frequencies' types between the right and left DFAs (p = 0.22-1.00). High DFA bifurcations were observed in the bilateral DFAs in 34 (9.6%) patients; however, it was not observed bilaterally in 265 (75.1%) patients. If one of the DFAs had high bifurcation, the odds ratio of having a contralateral high DFA bifurcation was 12.4 (6.5-23.6). The frequencies of high MCFA and LCFA origin with low and high DFAs are summarized in **Table 2**. No significant differences in the frequencies of the types were observed between the right and left DFAs (p = 0.62-1.00). Substantial interobserver agreement was observed for the subtypes with kappa statistics (k = 0.784).

In 59 of 64 (92.2%) and 34 of 49 (69.4%) DFAs with type H1 and H2, the SFA displaced medially by the DFA partially overlapped the femoral vein (**Figure 3**). In 9 of 9 (100%) DFAs with type H3 and H4, the DFA partially overlapped or crossed in front of the femoral vein (**Figure 4** and **5**). Thus, these 102 (14.4%) high DFAs obstructed the access route to the femoral vein. Moreover, in three patients with subtype Lc, the SFA displaced medially by the LCFA partially overlapped the femoral vein. In one patient with subtype Lb, the MCFA crossed medially in front of the femoral vein. Thus, a total of 106 (15.0%) variations related to DFA obstructed safe femoral venous access.

During AVS, in 19 of 39 (48.7%) patients who had high DFA bifurcation and obstructed the right femoral vein, operators recorded the variations in the procedure reports or ultrasound images were stored as proof. The left femoral vein was selected for venous access in two of these patients with type H1 and H4 on the right side, as safe venous access in the right femoral vein seemed difficult on preprocedural CT and Doppler ultrasound evaluation (**Figure 3** and **5**). The frequencies of the number of attempts for a successful puncture, arterial puncture, and hematoma during or after femoral venous access in low and high DFA bifurcations are summarized in **Table 3**. The success rate of puncture in the first attempt in high DFA bifurcations was slightly lower

Table 2. Frequencies of high MCFA and LCFA origin with low and high DFA bifurcations

Type	Frequency			MCFA and LCFA origin level			
	Total	Right	Left	Zone 1	Zone 2	Zone 3	Zone 4
La	501 (71.0%)	253 (71.7%)	248 (70.3%)	-	-	-	-
Lb	27 (3.8%)	15 (4.2%)	12 (3.4%)	0 (0%)	5 (18.5%)	11 (40.7%)	11 (40.7%)
Lc	52 (7.4%)	25 (7.1%)	27 (7.6%)	1 (1.9%)	11 (21.2%)	23 (44.2%)	17 (32.7%)
Ld	4 (0.6%)	1 (0.3%)	3 (0.8%)	0 (0%)	1 (25.0%)	2 (50.0%)	1 (25.0%)
Ha	102 (14.4%)	49 (13.9%)	53 (15.0%)	-	-	-	-
Hb	7 (1.0%)	4 (1aa.1%)	3 (0.8%)	0 (0%)	0 (0%)	7 (100%)	0 (0%)
Hc	13 (1.8%)	6 (1.7%)	7 (2.0%)	2 (15.4%)	3 (23.1%)	5 (38.5%)	3 (23.1%)

DFA = deep femoral artery, MCFA = medial circumflex femoral artery, LCFA = lateral circumflex femoral artery.

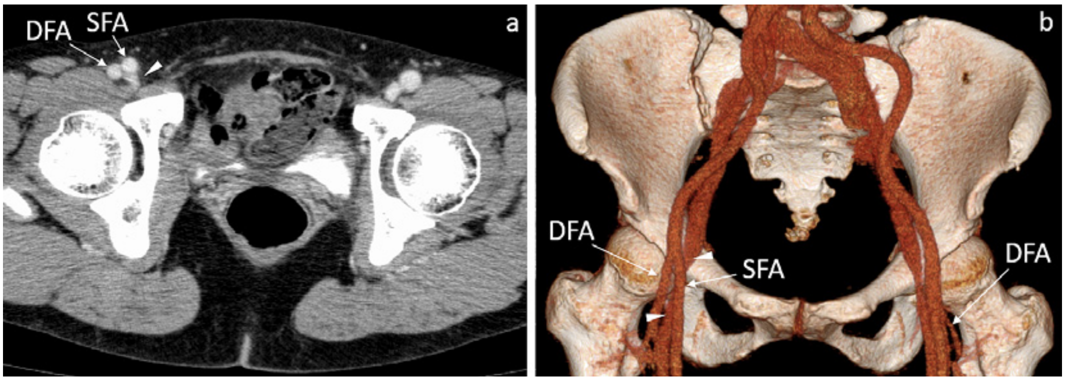

Figure 3. Representative CT images of high deep femoral artery (DFA) bifurcation in type H1 (subtype Ha) in a 60-year-old woman (a, b). The right DFA bifurcates high running laterally to the superficial femoral artery (SFA), which lies on the femoral vein (arrowheads). The left DFA has no variations. The left femoral approach was selected.

than that in low DFA bifurcation, although a significant difference was not observed (75.4% vs. 84.5%, $p = 0.122$). This might be due to the higher frequency of residents who performed venous access in patients with high DFA bifurcation compared with those with low DFA bifurcation ($p = 0.036$). No significant differences were observed in arterial puncture and hematoma ($p = 1.00$, $p = 0.69$).

Discussion

Our results showed that high DFA bifurcation is relatively common, and many of the DFA variations could obstruct safe femoral venous access. Notably, in 0.9% of the cases, high DFA crossed medially in front of the femoral vein. However, these data have not been evaluated and well recognized, while femoral venous access continues to be a commonly performed procedure. This lack of information could be due to severe complications that have not been appreciably noticed in femoral venous access as in the cases of jugular and subclavian venous access. Retroperitoneal hemorrhage caused by accidental puncture of these arteries might be prevented by manual compression, as these variations lie lower than the inguinal ligament. However, if a catheter or sheath is inserted into a vein through an artery, AVF can occur [3, 5]. AVF might disappear with manual compression or may remain unnoticed without any symptoms. At any rate, the risk of arterial puncture or AVF should be avoided.

A meta-analysis of 20 articles classified the direction of the DFA origin into six types and reported the frequency for each of them as follows: lateral, 21.7%; anterolateral, 0.4%; posterolateral, 34.0%; posterior, 38.8%; postero-medial, 2.6%; and medial, 2.5% [13]. We classified the lateral and anterolateral types into type H1 and posterolateral and posterior types into type H2 for simplicity. The rates of 52.4% in type H1 and 40.2% in type H2 differ from the previous meta-analysis, which might be because we classified the direction of the DFA origin only in patients with high DFA

Figure 4. A representative CT image of high deep femoral artery (DFA) bifurcation in type H2 (subtype Ha) on the right side and type 3 (subtype Hc) on the left side in a 59-year-old woman. The right DFA bifurcates high running posterior to the superficial femoral artery (SFA) without overlapping the femoral vein (arrowhead). The left DFA bifurcates high running posteromedial to the femoral vein (arrowhead). The left lateral circumflex femoral artery (LCFA) also bifurcates high. The right femoral approach was selected.

bifurcations. Differences in the variations within MCFA and LCFA were also observed. In three cases with high LCFA displacing SFA medially in subtype Lc and one case with high MCFA that crossed in front of the femoral vein in subtype Lb, femoral venous access was obstructed.

Ultrasound guidance has been reported to be successful in providing access to the internal jugular veins and is the recommended practice to improve placement success and reduce complications [26]. Methods for accessing femoral veins are still controversial. A Cochrane review showed that the rate of accidental arterial puncture for femoral vein cannulation using ultrasound guidance was lower than that of the landmark method (9 of 150 [6.0%] vs. 27 of 161 [16.8%] and the risk ratio with 95% CI was 0.4 [0.14,1.16]) [27]. However, it was concluded that there was no evidence of a difference in inadvertent arterial puncture, possibly due to the small sample size. A report showed that the rates of mechanical complications with femoral venous central line placement without ultrasound guidance in critically ill patients were reportedly not as low (17.3% including 9.0% of arterial puncture and 1.4% of major hematoma) [1]. The rate of accidental arterial puncture in our study was quite low (0.9%) when compared to these results. Although our retrospective study has no comparison with cases not using Doppler ultrasound guidance, our results suggest femoral venous

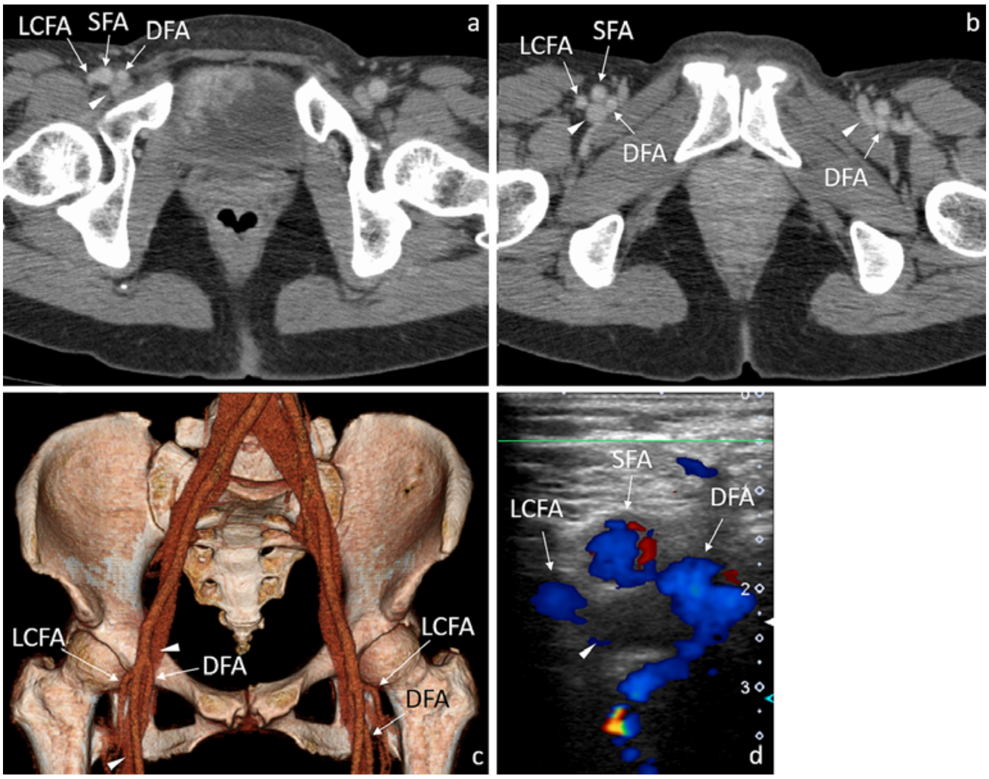

Figure 5. CT (a, b, c) and Doppler ultrasound (d) images of high deep femoral artery (DFA) bifurcation in type 4 (subtype Hc) in a 49-year-old woman. The right DFA bifurcates high running anteromedial to the femoral vein (arrowheads). The right lateral circumflex femoral artery (LCFA) also bifurcates high. The femoral vein (arrowheads) is surrounded by these arteries, including the superficial femoral artery (SFA). The left femoral approach was selected.

Table 3. Frequencies of number of attempts for successful venous puncture, accidental arterial puncture, and hematoma during or after femoral venous access in low and high DFA bifurcations

DFA bifurcation	Operator of venous access			No. of attempts for successful puncture			Arterial puncture	Hematoma
	Interventional radiologist	Fellow or radiologist	Resident	1st	2nd	3rd or more		
Total (n=353)	29 (8.2%)	195 (55.2%)	129 (36.5%)	293 (83.0%)	36 (10.2%)	24 (6.8%)	3 (0.9%)	11 (3.1%)
Low (n=296)	27 (9.1%)	168 (56.8%)	101§ (34.1%)	250* (84.5%)	28 (9.5%)	18 (6.1%)	3† (1.0%)	9‡ (3.0%)
High (n=57)	2 (3.5%)	27 (47.4%)	28§ (49.1%)	43* (75.4%)	8 (14.0%)	6 (10.5%)	0† (0%)	2‡ (3.5%)

DFA = deep femoral artery. No significant differences are observed between patients with low and high bifurcations (*p = 0.122, †p = 1.00, and ‡p = 0.69). The frequencies of residents who performed venous access in patients with high DFA bifurcation is significantly higher than that with low DFA bifurcation (§p = 0.036).

access using Doppler ultrasound guidance avoiding accidental arterial puncture even in high DFA bifurcation cases. Avoiding accidental arterial puncture without Doppler ultrasound guidance in a case such as that shown in **Figure 5** is impossible where arteries surrounded the femoral vein.

The present retrospective study had several limitations owing to its retrospective nature. First, we did not evaluate arterial phase CT images because of their availability in these patients. Although the evaluation of significant variations such as DFA bifurcation types by late-phase images is possible, small variations may be overlooked. Another limitation is that we did not evaluate CT or Doppler ultrasound examinations to check for AVF after AVS. Long-term follow-up might be required for detecting AVF as time may be required for its growth and detection [5]. Additionally, we did not compare technical success and complications with cases without Doppler ultrasound guidance, as described.

Conclusion

In conclusion, high DFA bifurcation is observed in 17.3%, and in 14.4% of cases, femoral venous access could be obstructed by arteries related to high DFA bifurcations. Notably, in 0.9% of cases, the high DFA crossed medially in front of the femoral vein. High DFA bifurcation can be evaluated during femoral venous access using Doppler ultrasound guidance to avoid accidental arterial puncture.

Conflict of interest: The authors declare that they have no conflicts of interest to report.

Disclaimer: Satoru Morita is one of the Editorial Board members of Interventional Radiology. This author was not involved in the peer-review or decision-making process for this paper.

References

1. Merrer J, De Jonghe B, Golliot F, Lefrant JY, Raffy B, Barre E, et al.; French Catheter Study Group in Intensive Care. Complications of femoral and subclavian venous catheterization in critically ill patients: a randomized controlled trial. JAMA 2001; 286: 700-707.
2. Frykholm P, Pikwer A, Hammarskjöld F, Larsson AT, Lindgren S, Lindwall R, et al. Clinical guidelines on central venous catheterisation. Swedish Society of Anaesthesiology and Intensive Care Medicine. Acta Anaesthesiol Scand 2014; 58: 508-524.
3. Sahashi Y, Takasugi N, Yanagimoto TS, Endo S, Nakashima T, Okura H. Arteriovenous femoral fistula after insertion of leadless pacemaker-A case with an anomaly of the deep femoral artery. J Arrhythm 2019; 35: 770-772.
4. Matsui K, Machida S, Shirai S. Retroperitoneal hemorrhage caused by inferior epigastric artery injury. Clin Exp Nephrol 2016; 20: 143-144.
5. Jin L, Wang J, Wu C, Shao C, Yu X, Lei W. Femoral arteriovenous fistula associated with leg swelling 6 months after removal of a hemodialysis catheter: A Case Report. Case Rep Med (Baltimore) 2015; 94: e1738.
6. Bodhey NK, Gupta AK, Sreedhar R, Manohar SR. Retroperitoneal hematoma: an unusual complication after femoral vein cannulation. J Cardiothorac Vasc Anesth 2006; 20: 859-861.
7. Mengal MN, Ashraf T, Hassan Rizvi SN, Badini A, Karim M. Assessment of femoral artery bifurcation level with conventional angiography. Cureus 2018; 10: e3479.
8. Ahn HY, Lee HJ, Lee HJ, Yang JH, Yi JS, Lee IW. Assessment of the optimal site of femoral artery puncture and angiographic anatomical study of the common femoral artery. J Korean Neurosurg Soc 2014; 56: 91-97.
9. Yaganti V, Mejevoi N, Hasan O, Cohen M, Wasty N. Pitfalls associated with the use of current recommendations for fluoroscopy-guided common femoral artery access. Catheter Cardiovasc Interv 2013; 81: 674-679.
10. Seto AH, Tyler J, Suh WM, Harrison AT, Vera JA, Zacharias SJ, et

al. Defining the common femoral artery: insights from the femoral arterial access with ultrasound trial. Catheter Cardiovasc Interv 2017; 89: 1185-1192.

11. Massoud TF, Fletcher EW. Anatomical variants of the profunda femoris artery: an angiographic study. Surg Radiol Anat 1997; 19: 99-103.

12. Gupta V, Feng K, Cheruvu P, Boyer N, Yeghiazarians Y, Ports TA, et al. High femoral artery bifurcation predicts contralateral high bifurcation: implications for complex percutaneous cardiovascular procedures requiring large caliber and/or dual access. J Invasive Cardiol 2014; 26: 409-412.

13. Tomaszewski KA, Henry BM, Vikse J, Pękala P, Roy J, Svensen M, et al. Variations in the origin of the deep femoral artery: A meta-analysis. Clin Anat 2017; 30: 106-113.

14. Rusu MC, Ilie AC, Brezean I. Human anatomic variations: common, external iliac, origin of the obturator, inferior epigastric and medial circumflex femoral arteries, and deep femoral artery course on the medial side of the femoral vessels. Surg Radiol Anat 2017; 39: 1285-1288.

15. Tanyeli E, Yildirim M, Uzel M, Vural F. Deep femoral artery with four variations: a case report. Surg Radiol Anat 2006; 28: 211-213.

16. Tomaszewski KA, Henry BM, Vikse J, Roy J, Pękala PA, Svensen M, et al. The origin of the medial circumflex femoral artery: a meta-analysis and proposal of a new classification system. PeerJ 2016; 4: e1726.

17. Łabętowicz P, Olewnik Ł, Podgórski M, Majos M, Stefańczyk L, Topol M, et al. A morphological study of the medial and lateral femoral circumflex arteries: a proposal for a new classification. Folia Morphol (Warsz) 2019; 78: 738-745.

18. Rajani SJ, Ravat MK, Rajani JK, Bhedi AN. Cadaveric study of profunda femoris artery with some unique variations. J Clin Diagn Res 2015; 9: AC01-AC03.

19. Nishikawa T, Omura M, Satoh F, Shibata H, Takahashi K, Tamura N, Tanabe A, Task Force Committee on Primary Aldosteronism, The Japan Endocrine Society, The Japan Endocrine Society, et al. Guidelines for the diagnosis and treatment of primary aldosteronism—the Japan Endocrine Society 2009. Endocr J 2011; 58: 711-721.

20. Morita S, Nishina Y, Yamazaki H, Sonoyama Y, Ichihara A, Sakai S. Dual adrenal venous phase contrast-enhanced MDCT for visualization of right adrenal veins in patients with primary aldosteronism. Eur Radiol 2016; 26: 2073-2077.

21. Morita S, Yamamoto T, Kamoshida K, Yamazaki H, Suzuki K, Yatabe M, et al. Safety and feasibility of unilateral double femoral venous access including double sheath insertion via a single-hole method for adrenal venous sampling. Jpn J Radiol 2020 Apr 13. Online ahead of print;38: 800-806.

22. Perandini S, Perandini A, Puntel G, Puppini G, Montemezzi S. Corona mortis variant of the obturator artery: a systematic study of 300 hemipelvises by means of computed tomography angiography. Pol J Radiol 2018; 83: e519-e523.

23. Morita S, Yamazaki H, Endo K, Suzaki S, Mitsuhashi A, Shiohara T, et al. Image fusion guidance with pre-procedural CT with real-time fluoroscopy for adrenal venous sampling. Cardiovasc Intervent Radiol 2018; 41: 1214-1222.

24. Morita S, Yamazaki H, Sonoyama Y, Nishina Y, Ichihara A, Sakai S. Successful adrenal venous sampling by non-experts with reference to CT images. Cardiovasc Intervent Radiol 2016; 39: 1001-1006.

25. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977; 33: 159-174.

26. Saugel B, Scheeren TWL, Teboul JL. Ultrasound-guided central venous catheter placement: a structured review and recommendations for clinical practice. Crit Care 2017; 21: 225.

27. Brass P, Hellmich M, Kolodziej L, Schick G, Smith AF. Ultrasound guidance versus anatomical landmarks for subclavian or femoral vein catheterization. Cochrane Database Syst Rev 2015; 1: CD011447.