Common Femoral Artery Anatomy and Relations to Bony Landmarks: A Computed Tomography Angiogram Study

Mahmoud Khalil, MD[1]; Mohamed Abouelasaad, MD[1]; Ahmed El Sharkawy, MD, PhD[2]; Ahmed Shahin, MD[1]; Amr Elsheikh, MD[1]; Ahmed EL Shall, MD;[1] Mohamed Sennara, MD[1]; Ahmed Mashaly, MD[1]; Alaa Mohamed Mohamed Reda, MD[2]; Suzan Bayoumy, MD, PhD[1]; Osama Shoeib, MD, PhD[1]

[1]Cardiology Department, Faculty of Medicine, Tanta University, Tanta, Gharbia, Egypt; [2]Radiology Department, Faculty of Medicine, Tanta University, Tanta, Gharbia, Egypt

Abstract: Background. The aim of this study is to provide a descriptive anatomy of the common femoral artery (CFA) among an Egyptian population through computed tomography (CT) angiography, looking for fixed landmarks that are visible by fluoroscopy to help perfect CFA puncture. Despite the advantages of radial artery access over a femoral approach, femoral access remains the main access in interventions that require large sheaths. **Methods.** We retrospectively collected CT peripheral angiograms performed July 2019 to July 2020. Dimension and length of the CFA were measured, and the origin and bifurcation site of the CFA was described and recorded according to 5 imaginary zones in relation to the femoral head (FH): zone 1, above; zone 2, upper third; zone 3, middle third; zone 4, lower third; and zone 5, below the FH. The bifurcation site of the CFA was described and recorded according to 3 imaginary zones in relation to the pubic tubercle (PT): zone 1, above; zone 2, at; and zone 3, below the PT. **Results.** We reviewed 380 femoral arteries for this study. The origin of the CFA was noted as almost always above zone 4. While zone 3 seems to be a safer option than zone 4 in terms of avoiding a low puncture, adding the PT—in consideration with a puncture in zone 4 or 5 above the PT—can increase the probability of avoiding a low puncture. **Conclusion.** Fluoroscopic guidance for femoral artery puncture is readily available, and combining both the FH and PT as fluoroscopic landmarks can be valuable in avoiding a low puncture.

VASCULAR DISEASE MANAGEMENT 2021;18(11):E198-E203.

Key words: femoral access, fluoroscopy, large bore access, safe puncture

Introduction

Despite the advantages of radial artery access over a femoral approach, especially in coronary artery catherization,[1,2] femoral access remains the main access in interventions that require large sheaths, such as transaortic valve replacement (TAVR). Vascular complications occur often during percutaneous interventions, particularly with femoral access, and range from minor hematomas to arterial thrombosis, pseudoaneurysm, arteriovenous fistula, distal embolization, and life-threatening retroperitoneal bleeding.[3,4] With the wide adoption of radial access over femoral access, complications may increase due to a lack of expertise and fewer interventions being done through a femoral access in daily practice.

The location of the entry point of the femoral artery (FA) strongly predicts the outcome of the procedure; therefore, exact knowledge of the anatomical features of the femoral region is important for interventionalists. The common femoral artery (CFA) is in the femoral triangle between the femoral vein (medial) and the femoral nerve (lateral). It starts at the midpoint of the inguinal ligament as a continuation of the external iliac artery after the latter branches off into the inferior epigastric artery (IEA). Usually, it terminates by bifurcating into the superficial FA and profunda femoris (deep FA) as it enters the adductor canal in the middle of the thigh.[5]

It is recommended to puncture the CFA 1 cm to 2 cm below the inguinal ligament, where the arterial pulse is palpable and compressible against the head of the femur, which allows for good hemostasis.[6] This study aims to provide a descriptive anatomy of the CFA among an Egyptian population through computed tomography (CT) angiography of the lower limb, looking for fixed bony landmarks visible by fluoroscopy that can refine perfect FA puncture during interventional procedures.

Methods

At our centers, patients are referred for lower limb CT angiogram for different indications. We retrospectively collected all CT peripheral angiograms done at our center for different indications from July 2019 to July 2020 that included the CFA.

All DICOM files were collected, and postprocessing was done using RadiAnt DICOM viewer software (Medxant, Version 2020.1). Examination of the FA is done concentrating on one side at a time; the multi-planer reconstruction (MPR) mode is used to determine the start of the CFA by the returning

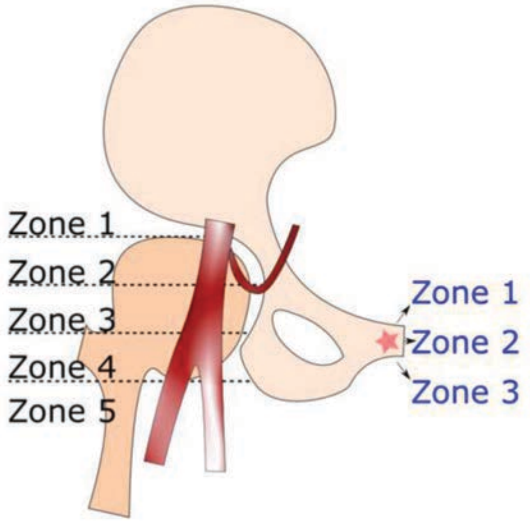

Figure 1. An illustration of the imaginary lines we used to identify the anatomy of the common femoral artery: 5 zones in relation to the femoral head and 3 zones in relation to the pubic tubercle.

point of the IEA (nadir). The end is defined by the point of distal bifurcation. Dimensions and length of the CFA were measured in the MPR mode on both sides and stored in a dedicated data sheet.

The relationship of the CFA origin and CFA end to the femoral head (FH) and the pubic tubercle (PT) were assessed in the 3D reconstruction mode with transverse view. Five imaginary zones were defined in relation to the FH (zone 1, above the FH; zone 2, upper third of the FH; zone 3, middle third of the FH; zone 4, lower third of the FH; and zone 5, below the FH). For each patient, the origin and the end of the FA were given a number from 1 to 5 according to where it lies above the FH according to imaginary zones (**Figure 1**). Using the same method, 3 imaginary zones related to the PT were identified: zone 1, above the PT; zone 2, at the PT; and zone 3, below the PT. The relation of the CFA bifurcation to the PT was described and recorded according to these imaginary zones (**Figure 1**). The study conformed to the Declaration of Helsinki on research involving human subjects.

Study aim

The aim of this CT analysis was to find fluoroscopic landmarks that could accurately help during FA puncture to get a safe stick at the CFA, combining both FH and PT as fluoroscopic landmarks.

Statistical analysis

Continuous variables were reported as mean ± standard deviation and compared with analysis of variance (paired Student's t-test). Categorical variables were expressed as frequencies and compared with chi-squared test. Normality of data was determined using the D'Agostino-Pearson test and verified using histogram plots. A two-sided *P*-value of .05 was considered significant in Student's t-test. A one-sided *P*-value of .05 was considered significant in chi-squared test. Statistical analyses were conducted using RStudio (RStudio Team, 2020).

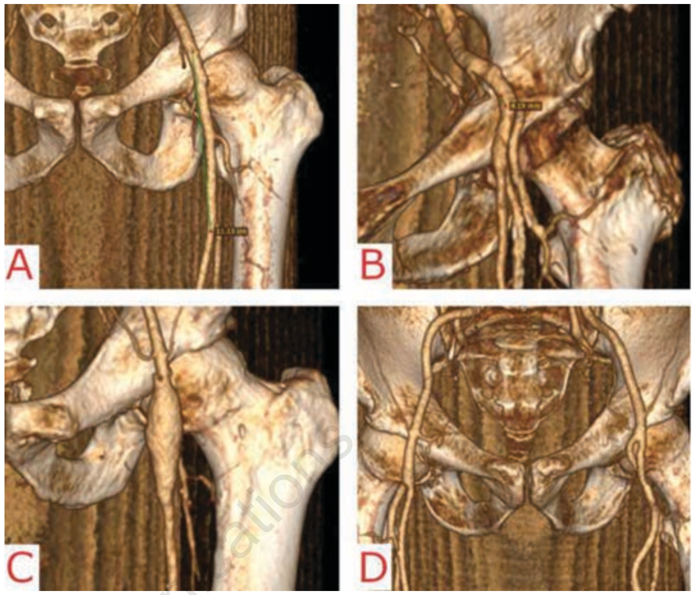

Figure 2. Examples of our population cases: **(A)** The longest common femoral artery (CFA) among our population. **(B)** The shortest CFA among our population. **(C)** A patient with a CFA aneurysm. **(D)** A patient with an evident discrepancy in length between the left and right CFAs (long left CFA and short right CFA).

Study limitations

Our study had two main limitations: the absence of other clinical data regarding the subjects other than age and gender. Using only CT data, our study lacks a clinical and real-life application.

Results

In total, 207 CT femoral scans were reviewed, and 17 cases were excluded due to occluded femoral arteries, extensive atherosclerosis, or poor opacification; 190 were included in the study. For each patient, the FA on both sides was examined according to the steps described in the Methods section. The mean age of our study population was 59.62 ± 11.21 years; 144 were male (75.76%) and 46 were female (24.24%).

Regarding CFA anatomy, on the right side the length was 4.41 ± 1.25 cm with an average diameter of 8.4 ± 1.78 mm. The origin was found above zone 4 in 99.5% of cases, except for 1 patient where the origin was found at zone 4 (lower third of the FH). Regarding the level of CFA bifurcation, it was found above the PT in only 14 (7.4%) cases, while all the other cases (92.6%) were found either at or below the PT. In relation to the FH, all the cases' bifurcation were either over or below the FH; 71% were below the FH. **Figure 2** includes examples from the cases showing the variability of CFA anatomy.

On the left side, CFA length was 4.41 ± 1.49 cm and average diameter was 8.46 ± 1.72 mm; the origin was found to be above zone 4 in all cases. This makes zone 4 the safest zone to avoid high punctures on both left and right sides. For the

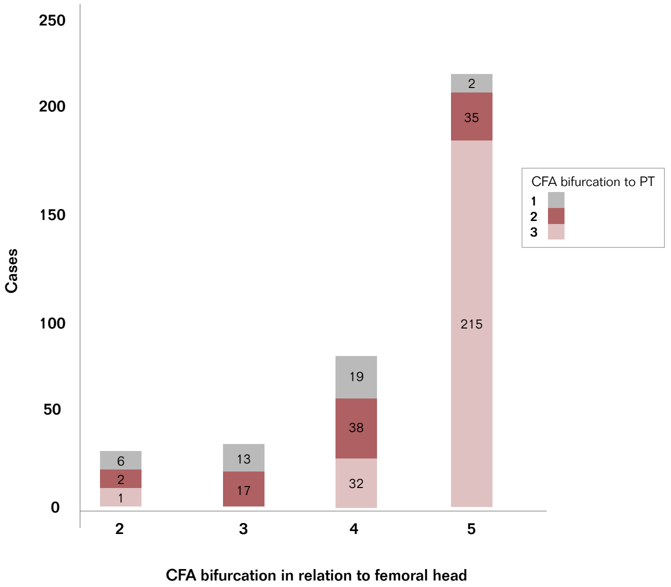

Figure 3. Graphical representation of the site of the common femoral artery (CFA) bifurcation to different imaginary zones in relation to the pubic tubercle (PT) and the femoral head.

Table 1. Different measurements of the CFA among the study population.

	Minimum	Maximum	Mean	SD	Sex Variation
Length (cm)	0.4	11.26	4.43	1.37	0.0197
Minimum diameter (cm)	1.1	14.4	7.81	1.88	0.241
Maximum diameter (cm)	2.2	15.8	9.047	1.8	0.11
Average diameter (cm)	2.35	14.50	8.44	1.75	0.146

CFA = common femoral artery; SD = standard deviation.

bifurcation level, it was found above the PT in 26 (13.6%) cases, while all others were either at or below the PT. In relation to the FH, all the cases were found on the right side either over or below the FH; 61% of cases were below the FH.

Regarding sex differences, we compared dimensions between both males (n = 144) and females (n = 46) (**Table 1**). The common FA length was found to be longer in males compared with females (4.5 ± 1.38 cm and 4.1 ± 1.31 cm, respectively; *P*=.0197). No other parameters were found to be significantly different regarding sex variation.

The bifurcation site was reviewed in relation to both the FH and the PT. While zone 3 seems to be a safer option than zone 4 in terms of avoiding a low puncture (a puncture below the CFA bifurcation), adding the PT in consideration with a puncture in zone 4 at or above the superior border of the PT can increase the probability of avoiding a low puncture (on the left side: X-squared = 43.191, df = 1, *P*-value=4.965; on the right side: X-squared = 30.645, df = 1, *P*-value=3.099) (**Figure 3**).

We combined the right and left FAs to include 380 arteries as there was no statistically significant difference between dominant and non-dominant sides and to increase the study sample.

The nadir point of the internal iliac artery was found 122 (32.1%) times in zone 1 of the FH; 198 times (52.1%) in zone 2 of the FH; 59 times (15.5%) in zone 3 of the FH; and 1 time (0.26%) in zone 4 of the FH.

CFA bifurcation was detected according to the 5 femoral zones: 252 (66.3%) times in zone 5 of the FA; 89 times in zone 4 of the FA; 30 times in zone 3 of the FA; and 9 times in zone 2 of the FA. The bifurcation according to the PT was found in 248, 92, and 40 cases below, at, and above the PT, respectively (**Table 2, Figure 4**).

Assuming a puncture site at zone 4 could avoid a low puncture (below the common femoral bifurcation) in 252 cases (66.3%) where the bifurcation occurred in zone 5. Adding the PT for a puncture in zone 4 above the PT could avoid a low puncture in 322 cases (84.7%; X-squared = 79.859, df = 1, *P*-value<2.2).

Discussion

To our knowledge, this may be the largest CT study for the CFA anatomy. In our study, we divided the area over the FH to 5 zones (zone 1 above the FH; zones 2, 3, and 4 over the FH; and zone 5, below the FH). We studied 380 femoral arteries and found that the nadir of the IEA (which corresponds to the CFA origin) opposite to zone 1 in 31%, zone 2 in 52%, zone 3 in 15%, and almost never occurred below zone 3. CFA bifurcation never occurred above the head of the femur; it occurred at zone 2 in 2.7%, while opposite zone 3 in 7.6% and zone 4 in 22.5%; most bifurcations occurred in zone 5 (66.7%). Our data show that fluoroscopic guidance during femoral puncture aiming at the lower two-thirds of the FA provides a 67.2% chance of CFA puncture. So, we included the PT (CFA bifurcation occurred above in 10.4%, at the same level in 23.6%, and 65.7% below the PT). While zone 3 in relation to the FH seems to be a safer option than zone 4 in terms of avoiding low puncture, adding the PT in consideration with a puncture in zone 4 or 5 at or above the PT can increase the probability of avoiding a low puncture, as the CFA bifurcation occurs below the PT in 70% of the FAs and 60.5% in left-side arteries.

The anatomy of the CFA is considered of significant importance for interventionalists. It is considered ideal to puncture the CFA above the level of the bifurcation, as higher puncture above the nadir of the IEA (accessing the external iliac artery) is associated with at least a 15-fold increase in the incidence of retroperitoneal hematomas,[7] while a lower puncture increases the risk of pseudoaneurysms, arteriovenous fistulas, hematomas, and perforations.[8]

Vascular complications are considered the leading cause of morbidity after percutaneous interventions.[9] The Valve Academic Research Consortium-2 (VARC-2)[10] studied clinical

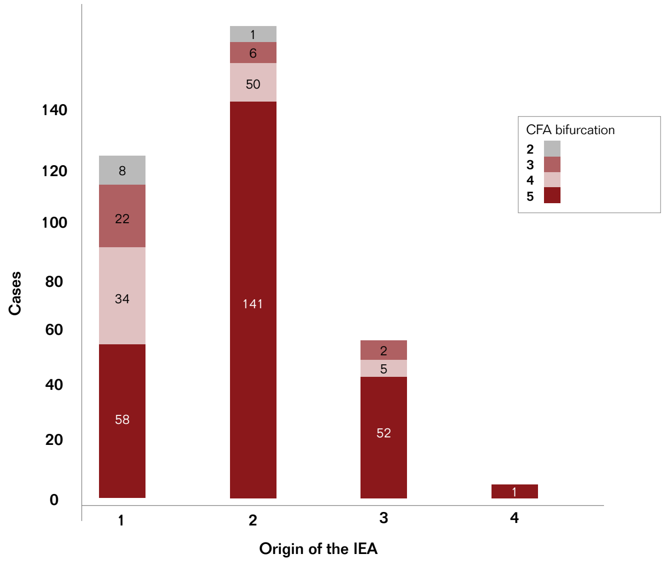

Figure 4. Graphical representation of the site of the common femoral artery (CFA) origin at the nadir of the inferior epigastric artery (IEA) in relation to the femoral head.

Table 2. Relation of the origin and end of the CFA to bony landmarks.

Relation of the Nadir of the Inferior Epigastric Artery to the Femoral Head	n = 380
1	122 (32.1%)
2	198 (52.1%)
3	59 (15.6%)
4	1 (0.26%)
5	0
Relation of the CFA Bifurcation Level to the Femoral Head	**n = 380**
1	0
2	9 (2.4%)
3	30 (7.9%)
4	89 (23.4%)
5	252 (66.3%)
Relation of the CFA Bifurcation Level to the Pubic Tubercle	**n = 380**
1	40 (10.5%)
2	92 (24.2%)
3	248 (65.2%)

CFA = common femoral artery.

endpoints for TAVR procedures and considers bleeding complications, especially those resulting from vascular access, to be subclassified to life-threatening, major or minor.[10] The Bleeding Academic Research Consortium (BARC)[11] demonstrated that bleeding is associated with nonfatal myocardial infarction,[12] stroke,[13] and stent thrombosis.[14] The exact mechanisms underlying this relationship are not fully understood but may indicate that in such clinical scenarios, physicians stop evidence-based therapies, including antiplatelets, beta-blockers, and statins[15] to avoid the direct effects of blood transfusion used to treat bleeding,[16,17] or a greater prevalence of comorbidities in patients who bleed,[18] as well as the deleterious role of anemia.[19]

The CFA normally passes over the head of the femur,[20,21] so using bony landmarks to determine the site of the CFA provides help in obtaining successful access.[5,22] Many trials have studied the best method and site to access the CFA to reduce morbidities; it was found that fluoroscopic guidance significantly reduced the incidence of vascular complications.[23,24] Chinikar et al[25] compared fluoroscopic (305 cases) and anatomical (304 cases) of guided puncture and found that fluoroscopy significantly increased the puncture over the FH (96.7% vs 82.3%, *P*-value=.001) and the fluoroscopic method increased CFA puncture significantly (93.8% vs 87.5 %, *P*-value=.012). Also, fluoroscopy significantly increased the successful puncture in high-risk groups (female patients and those with a body mass index [BMI] > 30 kg/m^2).[25] Abu-Fadel et al[26] compared 474 cases with fluoroscopic-assisted CFA access and 498 cases with anatomical-assisted access. They found that fluoroscopy decreased the number of low puncture sites. However, the time to sheath insertion, the number of arterial punctures needed to obtain access, and the incidence of complications were similar.[26]

CT angiography of the lower extremities has been proven to be an accurate method for assessment of aortoiliac and lower limb vessels.[27] Ota et al, who compared CT angiography with intraarterial digital subtraction angiography for assessment of peripheral arterial disease (PAD), concluded that CT is a sensitive and accurate method for studying lower-extremity vasculature.[28] It has been established as a method for diagnosis and follow-up of PAD with superiority over magnetic resonance imaging angiography.[29]

In a study by Yaganti et al,[30] their first intention was to explain the limitations of the current recommendation regarding fluoroscopic guidance for FA puncture due to either anatomical considerations or different patients' characteristics such as BMI. They have no specific recommendation regarding fluoroscopic guidance except for looking to the PT, which may help the operator imagine the position of the inguinal ligament.

Seto et al[31] looked only for the relation to the FH and investigated the effect of different patients' characteristics. They found no specific criteria related to the femoral bifurcation but found that male sex and body surface area may predict a low-seated IEA, and they recommend using ultrasound guidance for FA puncture.

Gopalakrishnan et al[32] studied the relation between the FA and the CFA and concluded that the lower third of the FH is a better option to avoid a high puncture, but this may lead to an increased incidence of a lower puncture below the femoral bifurcation. Our data show that combining both the FH and the PT during a CFA puncture may help avoid a low puncture.

Conclusions

Vascular complications in interventional cardiology are debilitating, so blind FA puncture, even with an experienced operator, is not advised. Using imaging guidance can decrease such complications and improve a patient's outcome. Ultrasound may not be available in all cath labs, especially in countries with low budgets. As the fluoroscope is available, we examined the combination of fixed bony landmarks to guide FA puncture with an easy and readily available tool. Combining both the FH and PT as fluoroscopic landmarks can be valuable in avoiding a low puncture. ■

Disclosure: *The authors have completed and returned the ICMJE Form for Disclosure of Potential Conflicts of Interest. The authors report no conflicts of interest regarding the content herein.*

Manuscript accepted September 28, 2021.

Address for correspondence: Osama Shoeib, MD, PhD, Tanta University, Cardiology Department, 1st El Geish Street, Tanta, Gharbia, Egypt 31512. Email: Oshouip@gmail.com

REFERENCES

1. Valgimigli M, Gagnor A, Calabró P, et al. Radial versus femoral access in patients with acute coronary syndromes undergoing invasive management: a randomised multicentre trial. *Lancet.* 2015;385:2465-2476.
2. Jolly SS, Amlani S, Hamon M, Yusuf S, Mehta SR. Radial versus femoral access for coronary angiography or intervention and the impact on major bleeding and ischemic events: a systematic review and meta-analysis of randomized trials. *Am Heart J.* 2009;157:132-140.
3. Kim D, Orron DE, Skillman JJ, et al. Role of superficial femoral artery puncture in the development of pseudoaneurysm and arteriovenous fistula complicating percutaneous transfemoral cardiac catheterization. *Cathet Cardiovasc Diagn.* 1992;25:91-97.
4. Ellis SG, Bhatt D, Kapadia S, Lee D, Yen M, Whitlow PL. Correlates and outcomes of retroperitoneal hemorrhage complicating percutaneous coronary intervention. *Catheter Cardiovasc Interv.* 2006;67:541-545.
5. Schnyder G, Sawhney N, Whisenant B, Tsimikas S, Turi ZG. Common femoral artery anatomy is influenced by demographics and comorbidity: implications for cardiac and peripheral invasive studies. *Catheter Cardiovasc Interv.* 2001;53:289-295.
6. Fitts J, Ver Lee P, Hofmaster P, Malenka D, for the Northern New England Cardiovascular Study Group. Fluoroscopy-guided femoral artery puncture reduces the risk of PCI-related vascular complications. *J Interv Cardiol.* 2008;21:273-278.
7. Cilingiroglu M, Feldman T, Salinger MH, Levisay J, Turi ZG. Fluoroscopically-guided micropuncture femoral artery access for large-caliber sheath insertion. *J Invasive Cardiol* 2011;23:157-161.
8. Stone PA, Campbell JE. Complications related to femoral artery access for transcatheter procedures. *Vasc Endovascular Surg.* 2012;46:617-623.
9. Lee MS, Applegate B, Rao SV, Kirtane AJ, Seto A, Stone GW. Minimizing femoral artery access complications during percutaneous coronary intervention: a comprehensive review. *Catheter Cardiovasc Interv.* 2014;84:62-69.
10. Kappetein AP, Head SJ, Généreux P, et al. Updated standardized endpoint definitions for transcatheter aortic valve implantation: the Valve Academic Research Consortium-2 consensus document. *J Am Coll Cardiol.* 2012;60:1438-1454.
11. Mehran R, Rao SV, Bhatt DL, et al. Standardized bleeding definitions for cardiovascular clinical trials: A consensus report from the Bleeding Academic Research Consortium. *Circulation.* 2011;123:2736-2747.
12. Rao SV, O'Grady K, Pieper KS, et al. Impact of bleeding severity on clinical outcomes among patients with acute coronary syndromes. *Am J Cardiol.* 2005;96:1200-1206.
13. Kinnaird TD, Stabile E, Mintz GS, et al. Incidence, predictors, and prognostic implications of bleeding and blood transfusion following percutaneous coronary interventions. *Am J Cardiol.* 2003;92:930-935.
14. Manoukian S, Feit F, Mehran R, et al. Impact of major bleeding on 30-day mortality and clinical outcomes in patients with acute coronary syndromes: an analysis from the ACUITY Trial. *J Am Coll Cardiol.* 2007;49:1362-1368.
15. Wang TY, Xiao L, Alexander KP, et al. Antiplatelet therapy use after discharge among acute myocardial infarction patients with in-hospital bleeding. *Circulation.* 2008;118:2139-2145.
16. Doyle BJ, Rihal CS, Gastineau DA, Holmes Jr DR. Bleeding, blood transfusion, and increased mortality after percutaneous coronary intervention: implications for contemporary practice. *J Am Coll Cardiol.* 2009;53:2019-2027.
17. Rao SV, Jollis JG, Harrington RA, et al. Relationship of blood transfusion and clinical outcomes in patients with acute coronary syndromes. *JAMA.* 2004;292:1555-1562.
18. Spencer FA, Moscucci M, Granger CB, et al. Does comorbidity account for the excess mortality in patients with major bleeding in acute myocardial infarction? *Circulation* 2007;116:2793-2801.
19. Sabatine MS, Morrow DA, Giugliano RP, et al. Association of hemoglobin levels with clinical outcomes in acute coronary syndromes. *Circulation* 2005;111:2042-2049.
20. Kawashima T, Okamoto K, Wada T, Shuto T, Umeno T, Miyamoto S. Femoral artery anatomy is a risk factor for limb ischemia in minimally invasive cardiac surgery. *Gen Thorac Cardiovasc Surg.* 2021;69:246-253.
21. Schnyder G, Sawhney N, Whisenant B, Tsimikas S, Turi ZG. Common femoral artery anatomy is influenced by demographics and comorbidity: implications for cardiac and peripheral invasive studies. *Catheter Cardiovasc Interv.* 2001;53:289-295.
22. Pitta SR, Prasad A, Kumar G, Lennon R, Rihal CS, Holmes DR. Location of femoral artery access and correlation with vascular complications. *Catheter Cardiovasc Interv.* 2011;78:294-299.
23. Jacobi JA, Schussler JM, Johnson KB. Routine femoral head fluoroscopy to reduce complications in coronary catheterization. *Proc (Bayl Univ Med Cent).* 2009;22:7-8.
24. Garrett PD, Eckart RE, Bauch TD, Thompson CM, Stajduhar KC. Fluoroscopic localization of the femoral head as a landmark for common femoral artery cannulation. *Catheter Cardiovasc Interv.* 2005;65:205-207.
25. Chinikar M, Ahmadi A, Heidarzadeh A, Sadeghipour P. Imaging or trusting on surface anatomy? A comparison between fluoroscopic guidance and anatomic landmarks for femoral artery access in diagnostic cardiac catheterization. A randomized control trial. *Cardiovasc Interv Ther.* 2014;29:18-23.
26. Abu-Fadel MS, Sparling JM, Zacharias SJ, et al. Fluoroscopy vs. traditional guided femoral arterial access and the use of closure devices: a randomized controlled trial. *Catheter Cardiovasc Interv.* 2009;74:533-539.

27. Catalano C, Fraioli F, Laghi A, et al. Infrarenal aortic and lower-extremity arterial disease: diagnostic performance of multi-detector row CT angiography. *Radiology.* 2004;231:555-563.
28. Ota H, Takase K, Igarashi K, et al. MDCT compared with digital subtraction angiography for assessment of lower extremity arterial occlusive disease: importance of reviewing cross-sectional images. *AJR Am J Roentgenal.* 2004;182:201-209.
29. Ouwendijk R, de Vries M, Pattynama PMT, et al. Imaging peripheral arterial disease: a randomized controlled trial comparing contrast-enhanced MR angiography and multi-detector row CT angiography. *Radiology.* 2005;236:1094-1103.
30. 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.
31. Seto AH, Tyler J, Suh WM, et al. Defining the common femoral artery: insights from the femoral arterial access with ultrasound trial. *Catheter Cardiovasc Interv.* 2017;89:1185-1192.
32. Gopalakrishnan PP, Manoharan P, Shekhar C, et al. Redefining the fluoroscopic landmarks for common femoral arterial puncture during cardiac catheterization: femoral angiogram and computed tomography angiogram (FACT) study of common femoral artery anatomy. *Catheter Cardiovasc Interv.* 2019;94:367-375.