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Ultrasound-guided Femoral Artery Access for Minimally Invasive Neuro-intervention and Risk Factors for Access Site Hematoma

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Abstract

Although ultrasound (US) guidance for venous access is becoming the "standard of care" for preventing access site complications, its feasibility for arterial access has not been fully investigated, especially in the neuro-interventional population. We conducted the first prospective cohort study on US-guided femoral artery access during neuro-interventional procedure. This study included 64 consecutive patients who underwent US-guided femoral artery access through 66 arterial access sites for diagnostic and/or neuro-interventional purposes. The number of attempts required for both the sheath insertion and the success of anterior wall puncture were recorded. In addition, the occurrence of major complications and hematoma formation on the arterial access site examined by US were statistically analyzed. The median number of attempts was 1 (1–2) and first-pass success rate was 63.6%. Anterior wall puncture was achieved in 98.5%. In one case (1.5%), a pseudoaneurysm was observed. In all cases, US clearly depicted a common femoral artery (CFA) and its bifurcation. Post-procedural hematoma was detected in 13 cases (19.7%), most of which were "tiny" or "moderate" in size. Low body mass index and antiplatelet therapy were the independent risk factors for access site hematoma. The US-guided CFA access was feasible even in neuro-interventional procedure. The method was particularly helpful in the patients with un-palpable pulsation of femoral arteries. To prevent arterial access site hematoma, special care should be taken in patients with low body mass index and who are on antiplatelet therapy.

Key words: ultrasound, femoral artery, neuro-intervention, complication, hematoma

Introduction

Owing to the development of newer devices and more sophisticated techniques, interventional procedures are exponentially becoming widespread for neurovascular diseases. The great advantages of these new evolving techniques are the safety profile and less invasiveness. It is very important to accomplish procedures without any complications and with minimal invasiveness.

The most common complications of diagnostic and interventional procedures involve vascular access sites,[1,2] and the common femoral artery (CFA) is the most frequently used vessel during both procedures for neurovascular diseases.[3,4] The complications of femoral artery access include hemorrhage, thrombosis, peripheral embolization, dissection, aneurysm, pseudoaneurysm, arteriovenous fistula, infection, and injury of other local structures.[2] Some of these complications are infrequent but lethal, like retroperitoneal hemorrhage or pseudoaneurysm.[5,6] In contrast, some complications, like small hematoma, occur more frequently but develop only minor symptoms which do not require additional treatment. In order to achieve a therapeutic goal with adequate patient satisfaction, all these complications should be completely avoided.

In terms of venous access, ultrasound (US) guidance has been clearly shown to not only reduce complications but also to improve procedural techniques.[7,8] Thus, the routine use of US guidance for central venous access is now becoming "standard of care."[9] Despite this, the studies on US guidance for CFA access are very sparse.[10–13] There are no reports of US guidance for CFA access performed in the specific neuro-interventional population. In the

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present study, we aimed to investigate whether the additional use of US guidance during CFA access could reduce the occurrence of access site-related complications and improve procedural techniques, as demonstrated for venous access.[7,8] This would be the first study on US-guided arterial access conducted in the neuro-interventional field to clarify its utility and safety in carrying out minimally invasive procedures.

In addition, for the purpose of providing minimally invasive procedure for patients, we focused not only on lethal and severe complications but also on minor complications that may have been neglected in the previous reports.[10,11] In the present study, in order to detect both large and small hematomas, particularly the latter which are difficult to detect by inspection or palpation, we employed post-procedural US surveillance.

Materials and Methods

This was a prospective observational cohort study performed at Hokkaido University Hospital, and it enrolled 64 consecutive patients who required CFA access through 66 puncture sites for diagnostic and/or interventional neurovascular procedures between April 2014 and December 2014. The study was conducted in accordance with the declaration of Helsinki 1964, and its later amendments. And for all patients, informed consent was obtained before participation in this study. For this cohort study, all the CFA access were done by the neurosurgeons who had over 2 years of experience in diagnostic or interventional neurovascular procedures. Most of these operators had the experience of US-guided central venous access.

I. US-guided CFA access

The US equipment used in this study was Venue 40 Ultrasound system (GE Healthcare, Wauwatosa, Wisconsin, USA) with a 12-MHz linear array transducer. This device is commonly used in the operating room or in the patient's room to perform central venous access. To use it in our angiography suite, the US equipment was placed at the left side of the operator, so that we could watch both fluoroscopic monitor and US monitor at the same time (Fig. 1a). Because of the small and flexible profile, the device is portable and also suitable for use in the angiography suite. When used for CFA access, the probe was wrapped with a clear disposable sterile cover equipped with US transmission gel.

The right groin was the preferred site for puncture. However, for patients whose right groin was unsuitable for puncture because of previous puncture and/or the use of vascular closure device, the left groin was used. For patients who required puncture on both sides of the CFA, bilateral groins were punctured (two cases).

After being draped, all patients underwent manual palpation of the following anatomic landmarks: anterior superior iliac spine, pubic symphysis,

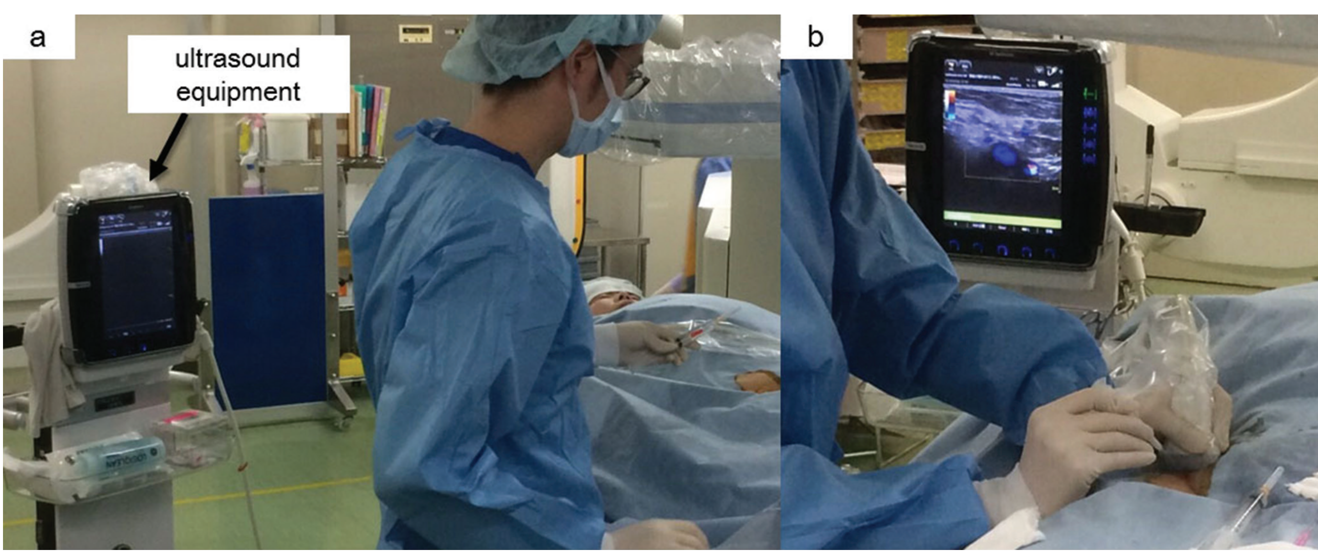

Fig. 1 Photographs of ultrasound (US) equipment and angiography suite. a: In order to use an US equipment in our angiography suite, the equipment was placed on the left side of the operator, so that we could watch both fluoroscopic monitor and US monitor at the same time. b: During puncture, US probe was held by the operator's left hand and the 18-gauge needle was handled by his right hand, so that operator could manipulate both the US probe and needle tip in real-time by himself.

and femoral arterial pulse. The intensity of arterial pulse was examined and subjectively graded as "non-palpable" or "palpable." Subsequently, the femoral head was marked with fluoroscopy for each puncture. Based on the information from fluoroscopy, we simulated the level of CFA bifurcation to be in the area under the inferior border of the femoral head in approximately 65% of patients.[10,14] Then, the level of needle entrance into the CFA was determined to be below the inguinal ligament and above the inferior border of femoral head.

In addition to the traditional method of using fluoroscopy guidance,[14] US guidance was employed during CFA access in all the patients (Fig. 2a). After the US equipment was set-up and the patient was draped, US imaging was performed around the planned puncture point. The CFA, superficial femoral artery (SFA), profunda femoral artery (PFA), and femoral vein (FV) were detected. Then we tried to identify the exact location of the CFA bifurcation. In some cases, the CFA bifurcation was located more proximal than our assumption; therefore, for such patients (approximately one-third of the total), we had to change the planned puncture site in order to attain optimal sheath insertion into the CFA.

After the infiltration of local anesthesia around the determined puncture point, US-guided CFA access was performed. The modified Seldinger technique was applied in all cases.[10] During CFA puncture, US probe was held by the operator's left hand and the 18-gauge needle was handled by his right hand, so that operator could manipulate both the US probe and needle tip in real-time by himself (Fig. 1b). Using this method, needle tip was continuously depicted. Then, the needle tip was slowly advanced toward the CFA until it penetrated the anterior wall and reached the lumen of the CFA (Fig. 2b). We tried not to penetrate the posterior wall to avoid the risk for vascular wall injury and hemorrhage. The success of anterior wall puncture without posterior wall penetration and the number of attempts required for sheath insertion were recorded by the operator. Subsequently, the sheath was inserted by the usual method. Vascular sheath size ranged from 4 Fr to 9 Fr, depending on the requirement for angiography or interventional procedure. Femoral angiogram through the inserted sheath was performed to visualize and confirm the proper site and adequate sheath insertion into the CFA (Fig. 2c).

After the procedure, hemostasis was achieved by manual compression for cases that used 4 Fr or 5 Fr

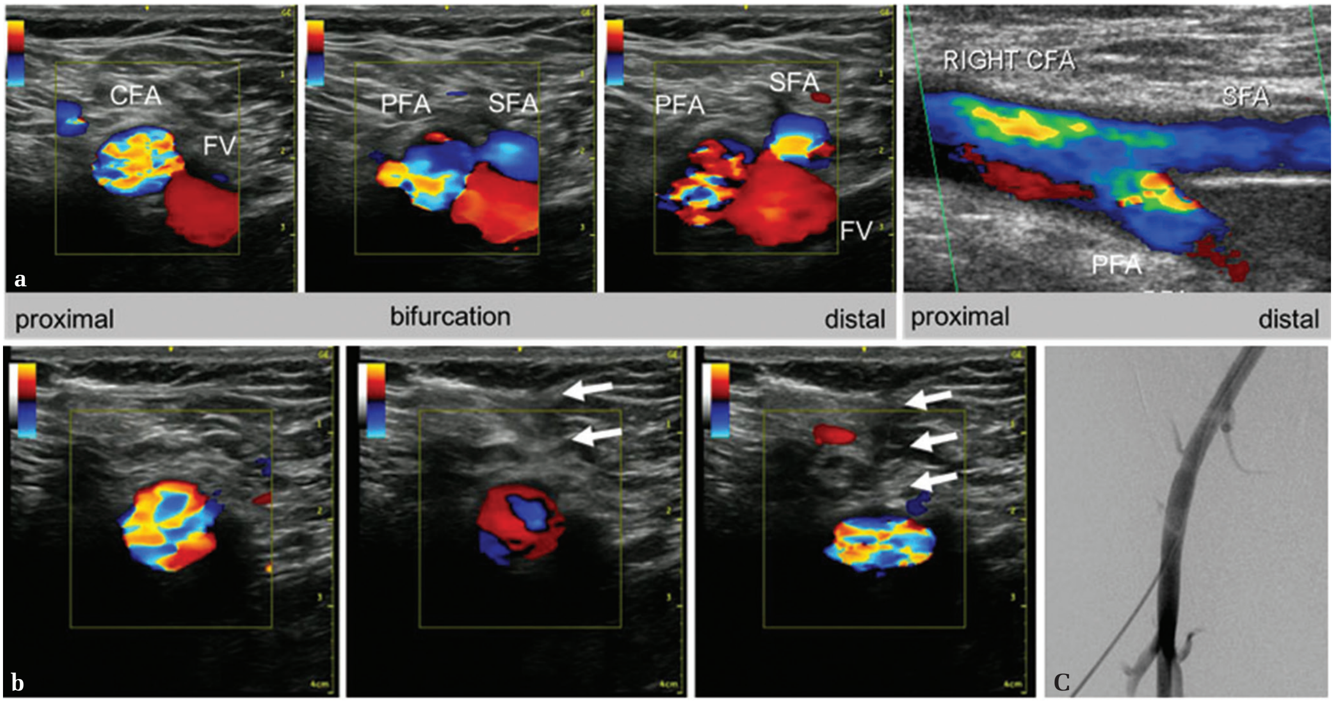

Fig. 2 Intra-procedural photographs of ultrasound (US)-guided common femoral artery (CFA) access. a: Observation of puncture site by the US clearly depicted the CFA, profunda femoral artery (PFA), and superficial femoral artery (SFA). The bifurcation level was easily identified. b: During the puncture, needle tip was gradually proceeding toward the CFA. Both needle tip (*arrows*) and lumen of CFA were visualized in real-time. c: Sheath cannulation at the proper site was confirmed by femoral artery angiogram through the inserted sheath.

sheath and by vascular closure system for cases that employed sheaths larger than 6 Fr. To obtain robust hemostasis, additional compression for several hours and subsequent immobilization were continued in the patient's room.

The occurrence of major complications, including pseudoaneurysm formation, retroperitoneal hemorrhage, arteriovenous fistula, infection of access site, and arterial dissection, was assessed at the time of discharge. To thoroughly investigate local hematoma formation, US examination was conducted 24 h after the procedure in all the patients. The technicians who performed the US examination were blinded. The maximum length of any detected hematoma was measured and quantitatively assessed in each patient. Hematoma was graded according to maximum length as follows: less than 20 mm as "tiny," 20–50 mm as "moderate," and more than 50 mm as "large."

II. Statistical analysis

The data were expressed as mean ± standard deviation (SD) or median [interquartile range (IQR)] for continuous variables. For categorical variables, the number of patients and percentages were expressed. Stepwise logistic regression was applied to analyze the relevant factors for the occurrence of post-procedural access site hematoma formation. The variables with a p-value of < 0.1 on univariate analyses were further used for multivariate analyses. The level of significance was set at $p < 0.05$.

Results

The baseline demographic and clinical characteristics of the study population are shown in Table 1. In two patients, approach from the bilateral femoral arteries was required for simultaneous interventional procedure and intra-procedural angiography. The number of obese patients, defined as body mass index (BMI) > 27, was 11 (17.2%). Cerebral angiogram, spinal angiogram, and neuro-interventional procedures were performed in 41 (62.1%), 7 (10.6%), and 18 (27.3%) patients, respectively. Among all femoral artery access sites, seven sites (10.6%) were "non-palpable." A summary of these cases is shown in Table 2.

I. The advantage of US-guided femoral artery access

The US-guided femoral arterial access was performed in all patients and procedures. In all cases, a clear depiction of CFA and branched SFA and PFA was attained (Fig. 2a). Thus, the level of bifurcation was easily identified in all cases. US guidance was particularly helpful in enabling the visualization of femoral arteries that were difficult to recognize by usual palpation (non-palpable cases, Table 2).

Table 1 Characteristics and outcomes of ultrasound-guided femoral artery access in 64 patients (66 arterial access site)

Patient background characteristic		
Clinical characteristics		
Age, years	(mean ± SD)	47.5 ± 21.6
Gender, male	(number, %)	23, 35.9%
BMI (kg/m^2)	(mean ± SD)	22.9 ± 4.5
Obesity (BMI > 27)	(number, %)	11, 17.2%
Hypertension	(number, %)	27, 42.2%
Hypercholesterolemia	(number, %)	11, 17.2%
Diabetes mellitus	(number, %)	4, 6.3%
Renal disease	(number, %)	5, 7.8%
Cardiac disease	(number, %)	7, 10.9%
Procedural characteristic		
Cerebral angiogram	(number, %)	41, 62.1%
Spinal angiogram	(number, %)	7, 10.6%
Neuro-interventional procedure	(number, %)	18, 27.3%
Un-palpable pulse	(number, %)	7, 10.6%
Sheath size		
4, 5 Fr	(number, %)	52, 78.8%
> 6 Fr	(number, %)	14, 21.2%
Closure device used	(number, %)	14, 21.2%
Drugs used		
heparin	(number, %)	43, 67.2%
warfarin	(number, %)	1, 1.5%
aspirin	(number, %)	12, 18.2%
clopidogrel	(number, %)	4, 6.1%
cilostazol	(number, %)	7, 10.6%
Outcomes of US-guided femoral artery access		
Intra-procedural outcomes		
Number of attempts	(median, IQR)	1, 1–2
First-pass success	(number, %)	42, 63.6%
Success of anterior wall puncture	(number, %)	65, 98.5%
Post-procedural outcomes		
Major complications		
pseudo aneurysm	(number, %)	1, 1.5%
Local hematoma formation	(number, %)	13, 19.7%
median size of hematoma, mm	(median, IQR)	20.1, 9.6–31.6
tiny (< 20 mm)	(number, %)	6, 9.1%
moderate (20–50 mm)	(number, %)	5, 7.6%
large (> 50 mm)	(number, %)	2, 3.0%

BMI: body mass index, IQR: interquartile range, SD: standard deviation.

The major reason for "non-palpable" artery was remarkable obesity. For these patients, although the number of attempts tended to increase, anterior wall puncture was attained. Furthermore, there were no complications and access site hematoma formation.

II. Intra- and post-procedural outcomes of US-guided femoral arterial access

Under US-guided femoral artery access, the median number of attempts was 1 (IQR 1–2) and the first pass success rate was 63.6%. Furthermore, it was noteworthy that anterior wall puncture rate reached up to 98.5%; this high success rate may be attributed to the visualization of both the CFA lumen and tip of the needle during puncture.

As for major complications, a pseudoaneurysm formation occurred in one case (1.5%). This patient, who underwent neuro-interventional procedure for cerebral aneurysm, required emergent vascular surgery to repair the pseudoaneurysm and was eventually discharged without any deficits. Post-procedural US examination detected access site hematoma in 13 (19.7%) cases. The median size of hematoma was 20.1 mm (IQR: 9.6–31.6 mm). Hematoma was "tiny" in 6 (9.1%), "moderate" in 5 (7.6%), and "large" in 2 (3.0%) cases. Majority of the detected hematoma were relatively small in size.

III. Predictors of local hematoma formation

The results of univariate and multivariate logistic regression analyses are shown in Table 3. Univariate analysis showed that the use of antiplatelet therapy and the interventional procedure were the significant factors for access site hematoma formation. In multivariate logistic regression, the independent significant predictors of access site hematoma formation were low BMI (kg/m^2) [odds ratio (OR), 0.8; 95% confidence interval (CI), 0.65–0.98; p = 0.033] and antiplatelet therapy (OR, 15.45; 95% CI, 1.24–192.53; p = 0.033).

Discussion

Traditionally, fluoroscopic guidance with the palpation of the femoral arterial pulse had been widely recommended to determine the proper site of puncture during CFA access, which is below the inguinal ligament but proximal to its bifurcation.[2,14] It is known that the puncture of the femoral artery that is too high increases the risk for retroperitoneal hematoma, whereas a puncture that is too low results in a higher rate of pseudoaneurysm or lethal hematoma formation.[2,15,16] Thus, the determination of a proper site for CFA access is very important. It has been proven that approximately 65% of CFAs bifurcate into the SFA and PFA below the inferior border of the femoral head.[10,14] Based on these facts, the puncture site was used to be determined by this fluoroscopic landmark.[14] However, in the remaining 35% of patients, the level of bifurcation is much higher than the fluoroscopic landmark, and the actual bifurcation level is not routinely assessed before the procedure. In such cases, the planned level of puncture may be incorrect and this could lead to inadequate femoral artery access and unexpected lethal complications. In order to avoid this risk, the use of US guidance during femoral artery access was very useful in real-time clear visualization of the CFA bifurcation level

Table 2 Summary of un-palpable patients and outcomes of ultrasound-guided femoral artery access

Age	Sex	BMI (kg/m^2)	Backgrounds: Disease	Backgrounds: Procedure	Reason for un-palpable	Outcomes: Number of attempts	Outcomes: Anterior wall puncture	Outcomes: Complication/ hematoma formation
59	F	35.3	brain tumor	cerebral angiogram	obesity	2	yes	none
50	F	29.2	Moyamoya disease	cerebral angiogram	obesity	3	yes	none
53	M	29.2	Moyamoya disease	cerebral angiogram	obesity	1	yes	none
42	F	29.9	cerebral aneurysm	intervention	obesity	1	yes	none
39	F	33.9	cerebral aneurysm	cerebral angiogram	previous history of multiple puncture	3	yes	none
20	F	20.5	cerebral infarction	intervention	ventricular assist device	1	yes	none
39	F	33.9	cerebral aneurysm	intervention	obesity previous history of multiple puncture	3	yes	none

BMI: body mass index, F: female, M: male.

Table 3 Risk factors for access site hematoma formation

	Univariate analysis			Multivariate analysis		
	p value	OR	95% CI	p value	OR	95% CI
Clinical factors						
Sex (male)	0.731	0.8	0.22–2.93	NA	NA	NA
Age (> 60 years)	0.116	2.7	0.78–9.31	NA	NA	NA
BMI (kg/m^2)	**0.083***	**0.86**	**0.73–1.02**	**0.033***	**0.8**	**0.65–0.98**
Hypertension	**0.099***	**2.86**	**0.82–10.00**	0.601	1.52	0.32–7.24
Hypercholesterolemia	0.492	1.69	0.38–7.51	NA	NA	NA
Diabetes mellitus	0.904	NA	NA	NA	NA	NA
Renal disease	0.986	1.02	0.10–9.98	NA	NA	NA
Cardiac disease	0.764	0.71	0.08–6.53	NA	NA	NA
Antiplatelet therapy	**0.007***	**6.71**	**1.69–26.75**	**0.033***	**15.45**	**1.24–192.53**
Anticoagulant therapy	0.117	3.61	0.73–17.95	NA	NA	NA
Procedural factors						
Interventional procedure	**0.022***	**4.45**	**1.24–15.97**	0.085	8.5	0.75–96.64
Sheath size (> 6 Fr)	**0.099***	**3.06**	**0.81–11.53**	0.175	0.1	0.00–2.78
Number of attempts	0.788	1.1	0.54–2.27	NA	NA	NA
First pass success	0.861	0.89	0.26–3.12	NA	NA	NA
Anterior wall puncture	0.952	NA	NA	NA	NA	NA

*$p < 0.05$. BMI: body mass index, CI: confidence interval, OR: odds ratio.

in all cases. This was the great advantage of US in performing an optimal CFA access. In the past reports in the field of radiology,[11] cardiology,[10] or peripheral arterial disease,[12,13] all of these authors emphasized that real-time visualization of bifurcation level was a strong advantage. Based on the results of the present study, US-guided CFA access was considered to be safe during interventional procedures as well for neuro-interventional procedures.

Analysis of intra-procedural outcome of US-guided femoral artery access (Table 1) demonstrated extremely high success rate of anterior wall puncture (98.5%) and less number of attempts [1(IQR 1–2)]. These results were similar to the past reports of US-guided femoral artery access.[10,11] However, our results showed relatively low first-pass success rate (63.6%). This fact seemed to be resulting from an immature technique in early cases. In addition, technical attempt not to injure the posterior wall might be also contributing to the failure of puncture. Actually, first-pass success rate gradually improved with the experience of US-guided femoral artery access.

We considered that US-guided CFA access also has additional advantage for patients in whom the femoral arterial pulse was difficult to detect by usual palpation. This advantage was demonstrated in this cohort study in seven patients who had “non-palpable” femoral arteries. Majority of these patients were obese (BMI > 29), except for one 20-year-old skinny female patient who had a past history of severe heart disease and had a ventricular-assisted device attached for life-support. She developed acute cerebral infarction and required emergent neuro-interventional procedure for recanalization therapy. In other cases as well, US guidance was very helpful for prompt and appropriate CFA access. Although the use of US guidance in all cases of femoral arterial access make procedure cumbersome and complicated, this novel method was absolutely helpful in “non-palpable” patients.

In this cohort study, we also analyzed post-procedural hematoma formation. In order to accomplish the procedure with minimally invasiveness, which is one of the important aspects of neuro-interventional procedures, we focused not only on “large” access site hematomas but also on “moderate” and “tiny” hematomas. Post-procedural US examination was useful to detect all these hematoma formations. Our result revealed that patients with low BMI and those with a history of antiplatelet therapy were independently at risk for access site hematoma formation. Although this might be due to the higher detection ability of US in skinny patients than obese patients, we considered that lack of connective tissue or fatty tissue around the access site may be contributing to hematoma formation. As for the technical bias of US examination, all the examinations were performed by expert technicians of US under blinded fashion. For patients with low BMI and on antiplatelet therapy, we should take particular care for avoiding this complication.

Interestingly, other considerable factors, such as anticoagulant agents, procedure type, inserted sheath size, number of attempts, and so on, were not independent risk factors for access site hematoma. Although the small sample size might be contributing to this result, US-guided femoral artery access may have greatly contributed in reducing the potential risk of hematoma formation. Indeed, US-guided femoral artery puncture showed favorable outcomes concerning techniques during the femoral artery puncture, including a remarkably high rate of anterior wall puncture success.

Conclusion

The US-guided femoral artery access was useful in determining the proper site of CFA puncture, enabling real-time identification of the bifurcation level. Although the technical cumbersome would be the problem, this technique was absolutely feasible particularly for the patients with “non-palpable” femoral artery. Skinny patients and patients with history of antiplatelet therapy were independent risk factors for access site hematoma formation.

Conflicts of Interest Disclosure

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article. In addition, all authors are the members of Japan Neurosurgical Society (JNS). And all of them have registered online Self-reported COI Disclosure Statement Forms through the website for JNS.

References

1) Chandrasekar B, Doucet S, Bilodeau L, Crepeau J, deGuise P, Gregoire J, Gallo R, Cote G, Bonan R, Joyal M, Gosselin G, Tanguay JF, Dyrda I, Bois M, Pasternac A: Complications of cardiac catheterization in the current era: a single-center experience. *Catheter Cardiovasc Interv* 52: 289–295, 2001
2) Sherev DA, Shaw RE, Brent BN: Angiographic predictors of femoral access site complications: implication for planned percutaneous coronary intervention. *Catheter Cardiovasc Interv* 65: 196–202, 2005
3) Corley JA, Kasliwal MK, Tan LA, Lopes DK: Delayed vascular claudication following diagnostic cerebral angiography: a rare complication of the AngioSeal arteriotomy closure device. *J Cerebrovasc Endovasc Neurosurg* 16: 275–280, 2014
4) Patel MR, Jneid H, Derdeyn CP, Klein LW, Levine GN, Lookstein RA, White CJ, Yeghiazarians Y, Rosenfield K; American Heart Association Diagnostic and Interventional Cardiac Catheterization Committee of the Council on Clinical Cardiology, Council on Cardiovascular Radiology and Intervention, Council on Peripheral Vascular Disease, Council on Cardiovascular Surgery and Anesthesia, and Stroke Council: Arteriotomy closure devices for cardiovascular procedures: a scientific statement from the American Heart Association. *Circulation* 122: 1882–1893, 2010
5) Steinhubl SR, Berger PB, Mann JT, Fry ET, DeLago A, Wilmer C, Topol EJ; CREDO Investigators. Clopidogrel for the Reduction of Events During Observation: Early and sustained dual oral antiplatelet therapy following percutaneous coronary intervention: a randomized controlled trial. *JAMA* 288: 2411–2420, 2002
6) Assessment of the Safety and Efficacy of a New Thrombolytic Regimen (ASSENT)-3 Investigators: Efficacy and safety of tenecteplase in combination with enoxaparin, abciximab, or unfractionated heparin: the ASSENT-3 randomised trial in acute myocardial infarction. *Lancet* 358: 605–613, 2001
7) Hind D, Calvert N, McWilliams R, Davidson A, Paisley S, Beverley C, Thomas S: Ultrasonic locating devices for central venous cannulation: meta-analysis. *BMJ* 327: 361, 2003
8) Randolph AG, Cook DJ, Gonzales CA, Pribble CG: Ultrasound guidance for placement of central venous catheters: a meta-analysis of the literature. *Crit Care Med* 24: 2053–2058, 1996
9) Maecken T, Grau T: Ultrasound imaging in vascular access. *Crit Care Med* 35: S178–S185, 2007
10) Seto AH, Abu-Fadel MS, Sparling JM, Zacharias SJ, Daly TS, Harrison AT, Suh WM, Vera JA, Aston CE, Winters RJ, Patel PM, Hennebry TA, Kern MJ: Real-time ultrasound guidance facilitates femoral arterial access and reduces vascular complications: FAUST (Femoral Arterial Access With Ultrasound Trial). *JACC Cardiovasc Interv* 3: 751–758, 2010
11) Gedikoglu M, Oguzkurt L, Gur S, Andic C, Sariturk C, Ozkan U: Comparison of ultrasound guidance with the traditional palpation and fluoroscopy method for the common femoral artery puncture. *Catheter Cardiovasc Interv* 82: 1187–1192, 2013
12) Kalish J, Eslami M, Gillespie D, Schermerhorn M, Rybin D, Doros G, Farber A; Vascular Study Group of New England: Routine use of ultrasound guidance in femoral arterial access for peripheral vascular intervention decreases groin hematoma rates. *J Vasc Surg* 61: 1231–1238, 2015
13) Lo RC, Fokkema MT, Curran T, Darling J, Hamdan AD, Wyers M, Martin M, Schermerhorn ML: Routine use of ultrasound-guided access reduces access site-related complications after lower extremity percutaneous revascularization. *J Vasc Surg* 61: 405–412, 2015

14) Abu-Fadel MS, Sparling JM, Zacharias SJ, Aston CE, Saucedo JF, Schechter E, Hennebry TA: Fluoroscopy vs. traditional guided femoral arterial access and the use of closure devices: a randomized controlled trial. *Catheter Cardiovasc Interv* 74: 533–539, 2009
15) Farouque HM, Tremmel JA, Raissi Shabari F, Aggarwal M, Fearon WF, Ng MK, Rezaee M, Yeung AC, Lee DP: Risk factors for the development of retroperitoneal hematoma after percutaneous coronary intervention in the era of glycoprotein IIb/IIIa inhibitors and vascular closure devices. *J Am Coll Cardiol* 45: 363–368, 2005
16) Altin RS, Flicker S, Naidech HJ: Pseudoaneurysm and arteriovenous fistula after femoral artery catheterization: association with low femoral punctures. *AJR Am J Roentgenol* 152: 629–631, 1989

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