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Risk factors related to the size and volume of femoral artery pseudoaneurysm after catheter angiography: a single-center study

Özgür ÇAKIR[1,*], Zeki TALAS[2], Duygu TEMİZ KARADAĞ[3], Ayşegül DURMAZ[2], İsa ÇAM[1], Ercüment ÇİFTÇİ[1], Mühip KANKO[2]

[1]Department of Radiology, School Of Medicine, Kocaeli University, Kocaeli, Turkey
[2]Department of Cardiovascular Surgery, School Of Medicine, Kocaeli University, Kocaeli, Turkey
[3]Division of Rheumatology, Department of Internal Medicine, School Of Medicine, Kocaeli University, Kocaeli, Turkey

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Background/aim: Evaluate the risk factors associated with pseudoaneurysms' development after the percutaneous interventional procedures performed by cardiology, interventional radiology (IR), and the other clinics.

Materials and methods: We retrospectively analyzed the ultrasound scans in the hospital database and picture archiving system (PACS) and enrolled a total of 132 patients during the period from October 2015 and December 2019. We evaluated the maximum diameter and volume of the pseudoaneurysm with the patient and procedure-related factors with univariate analysis.

Results: We found that the patients with hypertension and without peripheric artery disease (PAD) had greater sac diameter ($p = 0.010$ and $p = 0.016$) and increased sac volume ($p = 0.029$ and $p = 0.007$). However, the sac volume increased in patients with diabetes than those without ($p = 0.003$). Both the increased maximum diameter and the volume of the pseudoaneurysm sac were in the patients in whom the procedure was applied in the common femoral artery (CFA) and with the venous intervention ($p < 0.010$ and $p < 0.016$; $p = 0.004$ and $p = 0.001$, respectively). We found that platelet count correlated negatively with the sac's maximum diameter and the volume ($r = -0.383$, $p < 0.001$ and $r = -0.486$, $p < 0.001$, respectively) duration of intervention correlated positively with the sac's maximum diameter and the volume ($r = 0.205$, $p = 0.019$ and $r = 0.320$, $p < 0.001$).

Conclusion: Our study reveals that prolonged procedure duration, simultaneous arterial and venous accesses, peripheral artery disease, thrombocytopenia, and puncture site are the aggressive risk factors of pseudoaneurysms size after angiographic procedures.

Key words: Pseudoaneurysm, hematoma, vascular complication, angiography

1. Introduction

Pseudoaneurysms are one of the most common complications resulting from percutaneous vascular interventions. Pseudoaneurysms develop in 2% of diagnostic procedures and 6% of those performed for therapeutic purposes [1–3]. With pseudoaneurysms, other local complications, including arteriovenous fistula, hematoma, and dissection, have been reported to occur in 1%–6% of percutaneous vascular interventions [4]. The femoral artery is a widely preferred approach among the endovascular diagnostic and interventional procedures, although the radial artery route has been increasingly used due to lower complication rates [5,6].

Several patient or procedure-related factors have been identified as leading causes of complications of pseudoaneurysms. Patient-related factors include mainly high body mass index, female sex, low pre-procedural platelet counts, and procedure-related factors with the urgency of intervention, site of the procedure, and size of the sheath [7].

Several treatment options have been identified for the management of vascular intervention-related complications. US-guided compression is a standard post-interventional procedure used throughout the last three decades, and noticeably reduced the need for surgical treatments of pseudoaneurysms. The technique is performed by placement and compression of the US probe to eliminate the flow on the pseudoaneurysm's neck with an average compression time of nearly thirty minutes [7]. US-guided percutaneous thrombin injection is one of the techniques to manage the pseudoaneurysm successfully [8–10]. For the large hematomas, which cause impending skin necrosis, infection, or in the case of a concomitant arteriovenous fistula, surgery is a treatment option [11,12].

This study's objective was to evaluate the risk factors arising from the method, the practitioner, the application reasons, or the patient-related pre-application situations.

2. Materials and methods

2.1. Patients

Using a retrospective hospital database and picture archiving system (PACS), we identified 132 patients, for whom a lower extremity arterial doppler ultrasound examination was performed between October 2015 and December 2019 to rule out extremity vascular access after an arterial puncture. We identified the search items as "pseudoaneurysm,"

*Correspondence: cakirozgur@hotmail.com

"hematoma," "loculated fluid collection." We excluded the pseudoaneurysms and interventions of viscera, carotid artery, and branches and identified the patient with diagnosed-treated with US-guided compression, US-guided thrombin injection, endovascular stent, or surgical repair. We excluded the patients with the infected pseudoaneurysm, distal ischemia due to femoral pseudoaneurysm compression, or impending compartment syndrome, spontaneous thrombosed aneurysms from the study.

We retracted the data related to the sac size and volume from imaging reports and related to the procedure (puncture side, sheath size, synchronic vein cannulation), duration and types of the processes [coronary stent, transcutaneous aortic valve implantation (TAVI), diagnostic], practitioner [cardiologist, interventional radiologist (IR) and others] or treatment methods of the pseudoaneurysm (compression, thrombin injection, surgery) from the radiology records. The treatment of lower extremity pseudoaneurysms was spontaneous thrombosis of the aneurysm, ultrasound-guided compression therapy, ultrasound-guided thrombin injection, or surgery. We obtained patient's chronic diseases [hypertension (HT), diabetes mellitus (DM), peripheric artery disease], pre-procedure medications (anticoagulants, antiaggregants), smoking, laboratory results before pseudoaneurysm treatment (hemoglobin, platelet count, INR, puncture side, sheath size, synchronic vein cannulation) from the hospital digital recording system.

We documented the maximum diameter of pseudoaneurysm on three dimensions as length, height, and width. We calculated the pseudoaneurysm volume by multiplying these three measures with a coefficient (length × height × width × 0.52) as shown in Figures 1 and 2.

This retrospective study was approved by the local Institutional Review Board approval with the approval number of KU GOKAEK 2019/229 and did not require written informed consent.

2.2. Statistical analysis

The descriptive statistics for clinical and demographic characteristics of the patients were presented as frequency and percentage (%) for categorical variables and median with interquartile range (median [Q3–Q1]) or mean with standard deviation according to the distribution of the continuous variables. The normality was assessed both visually and through the Shapiro–Wilk test. Mann–Whitney U test (Wilcoxon rank-sum test) was used for parameters that were not normally distributed to evaluate the intergroup differences between two independent groups and Kruskal–Wallis test for more groups. Dunn's pairwise tests were carried out with post hoc analysis using the Mann–Whitney U test. The p value was adjusted using the Bonferroni correction. We used Spearman's rank correlation coefficients to examine the degree of associations between the maximum diameter and the volume of the pseudoaneurysm sac and patient and procedure-related risk variables.

We performed statistical analyses by using the "SPSS v: 20.0 software package" (IBM Inc., Chicago, IL, USA) and RStudio (v: 1.2.1335 2009-2019 RStudio, Inc). Two-sided p values less than 0.05 were considered statistically significant ($p < 0.05$).

3. Results

All patients were aged 58 years or older, and sex distribution was approximately equal. Nearly two-thirds of patients had diabetes, whereas only around 40% had hypertension or PAD, and fewer than a third had a history of smoking. More than half had not had any form of pre-intervention treatment, and the remainder was divided among and range of antiplatelet

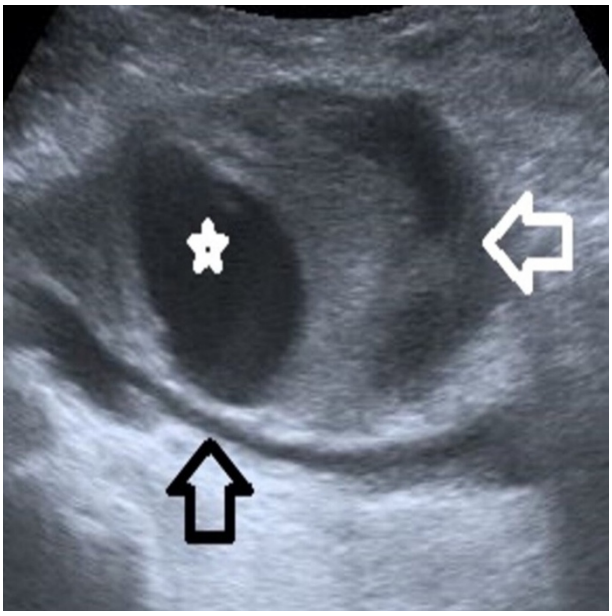

Figure 1. B-mode ultrasound image showing partially thrombosed pseudoaneurysm (white arrow) of the right common femoral artery (black arrow).

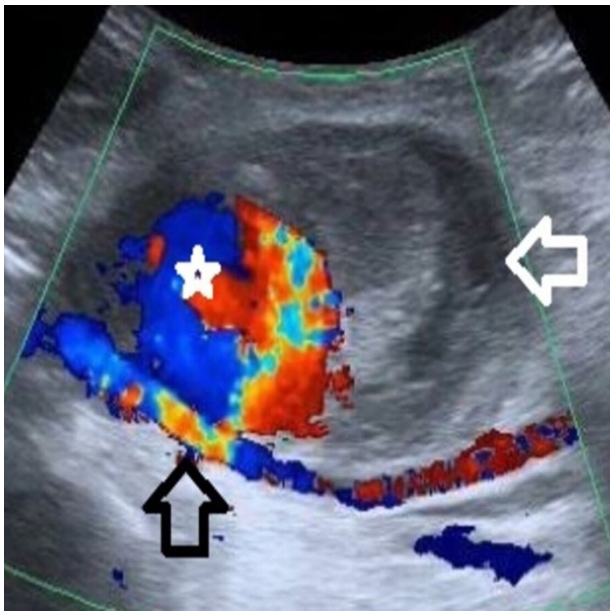

Figure 2. Color-coded duplex ultrasound image showing partially thrombosed pseudoaneurysm (white arrow) of the right common femoral artery (black arrow). The characteristic swirling blood flow sign ("yin-yang" sign) is marked with a white star.

and anticoagulant therapies, as shown in Table 1. More than two-thirds of procedures were carried out in the cardiology specialty, with the remainder taking place in interventional radiology. The data related to the characteristics of pseudoaneurysm, and the process applied for pseudoaneurysm in Table 2. The maximum diameter and volume of the pseudoaneurysm's sac were about 50 mm and 35 mm^3, respectively. Nearly half of (47.7%) of the procedures were performed using a sheath with a size of 6 Fr (6.28 mm). Most of the pseudoaneurysm developed after the angiographic procedures for any reason (46.4%). In 38.6% of the patients, the pseudoaneurysm was treated with only ultrasound-guided thrombin injection, and 9.1% required open surgical repair.

We analyzed the change in the maximum diameter and the volume of the pseudoaneurysm sac due to patient and procedure-related risk factors. We found that the patients with hypertension and without peripheric artery disease (PAD) had greater sac diameter ($p = 0.010$ and $p = 0.016$, respectively) and increased sac volume ($p = 0.029$ and $p = 0.007$, respectively). However, the sac volume was increased in patients with diabetes than those without ($p = 0.003$).

The pseudoaneurysm maximum diameter and volume were higher in patients who underwent treatment with the synchronous common femoral artery (CFA) and common femoral vein (CFV) catheterization ($p < 0.010$ and $p < 0.016$; $p = 0.004$ and $p = 0.001$ respectively) (Table 3).

Table 1. Patient characteristics and drug regimens before pseudoaneurysm intervention.

	N = 132	
Age (years), median [Q1–Q3]	67	(58–74)
Female, n (%)	69	(51.9)
Diabetes mellitus, n (%)	82	(61.7)
Hypertension, n (%)	56	(42.1)
Peripheric artery disease (PAD), n (%)	50	(37.6)
Smoking, n (%)	42	(31.6)
Hemoglobin (g/L), median [Q1-Q3]	11.2	(10.4–12.7)
Platelet count (x10^9/L), median [Q1–Q3]	204	(121–480)
INR, median (Q1–Q3)	1.13	(1.01–1.55)
Pre-intervention treatment		
None, n (%)	75	(55.6)
Acetylsalicylic acid, n (%)	39	(29.5)
Clopidogrel, n (%)	34	(25.8)
Warfarin, n (%)	21	(15.9)
Antiplatelet mono-therapy, n (%)	10	(7.6)
Antiplatelet dual-therapy, n (%)	28	(21.2)
Anticoagulant mono-therapy, n (%)	16	(12.1)
Anticoagulant + mono-antiplatelet, n (%)	5	(3.8)
Specialty performing procedure		
Cardiology, n (%)	92	(69.6)
IR, n (%)	40	(30.4)

We evaluated the correlation between the maximum diameter and the volume of the pseudoaneurysm sac and patient-related and procedure risk variables. We found that platelet count correlated negatively with the sac's maximum diameter and the volume ($r = -0.383$, $p < 0.001$ and $r = -0.486$, $p < 0.001$, respectively); duration of intervention correlated negatively with the sac's maximum diameter and the volume ($r = 0.205$, $p = 0.019$ and $r = 0.320$, $p < 0.001$, respectively) (Table 4). When the sac's maximum diameter and the volume were compared across the pre-intervention treatment and sheath size, there was a significant difference between the treatment groups. The pairwise comparison revealed that the difference resulted from the dual antiplatelet and mono-antiplatelet treatment groups ($p = 0.002$). The sac's maximum

Table 2. Characteristics of pseudoaneurysm and procedure characteristics for pseudoaneurysm intervention.

	N = 132	
Diameter of pseudoaneurysm, mm, [Q1–Q3]	50	[40–59]
Volume of the pseudoaneurysm, mm^3, [Q1–Q3]	35	[13–77]
Sheath size		
5 Fr (5.24 mm), n (%)	56	(42.4%)
6 Fr (6.28 mm), n (%)	63	(47.7%)
7 Fr (7.33 mm), n (%)	6	(4.5%)
8 Fr (8.34 mm), n (%)	6	(4.5%)
Unknown, n (%)	1	(0.8%)
Duration of intervention, min, [Q1–Q3]	25	[11–45]
Site of pseudoaneurysm (CFA), n (%)	76	(57.6%)
Causative procedure		
Cardiology		
Coronary angioplasty with stent insertion, n (%)	21	(15.9%)
Endocardial ablation, n (%)	10	(7.6%)
Transcutaneous aortic valve implantation, n (%)	9	(6.8%)
Pacemaker insertion, n (%)	3	(2.3%)
Vascular interventional radiology		
Angioplasty (any vessel), n (%)	3	(2.3%)
Aneurism repair, n (%)	9	(6.8%)
Stent insertion (any vessel), n (%)	18	(13.6%)
Other		
Angiography (any vessel), n (%)	56	(42.4%)
Treatment of pseudoaneurysm		
Compression only, n (%)	42	(31.8%)
Thrombin injection only, n (%)	51	(38.6%)
Compression + Tissel, n (%)	39	(29.5%)
Thrombin injection number		
None, n (%)	51	(38.6%)
Once, n (%)	70	(53%)
Twice, n (%)	11	(8.3%)
Compression duration (for successful), min, [Q1-Q3]	20	[15–25]
Open surgical repair, n (%)	12	(9.1%)

Table 3. The change in maximum diameter and the volume of the pseudoaneurysm sac between patient-related risk variables, procedure, and aneurysm related risk characteristics.

		Maximum diameter (Mm)	P	Volume (mm^3)	P
Female		51[34–66]	0.571	34 [11.3–84.8]	0.823
Male		49 [41–59]		39 [14–71]	
Hypertension	(yes)	51 [41–66]	0.010*	39 [13–83]	0.029*
	(no)	40 [33–59]		18 [13–66.5]	
Diabetes	(yes)	50 [47–66]	0.056	50 [13–92]	0.003*
	(no)	48 [34–59]		22 [13–62]	
PAD	(yes)	46 [34–56]	0.016*	22 [12–50]	0.007*
	(no)	55 [40–66]		45 [18-83]	
Smoking	(yes)	50 [47–59.5]	0.342	43 [18–67]	0.279
	(no)	49 [34–59]		22 [12.8–79]	
Hematoma	(yes)	50 [50–62.5]	0.179	22 [12–86.5]	0.529
	(no)	49 [34–59]		37 [13–71]	
Cardiology		49 [40–59]	0.804	41 [14–74.8]	0.193
IR		50 [34–57]		34.5 [12–82]	
CFA		40 [33–53.5]	<0.001*	41 [14–74.8]	<0.001*
SFA		59 [50–70]		34.5 [12–82]	
Venous intervention	(yes)	59 [49–66]	0.004*	71 [41–83]	0.001*
	(no)	48.5 [33.8–59]		22 [12–67]	
Operation	(yes)	44.5 [22.5–68]	0.475	23.5 [9.25–61.8]	0.154
	(no)	50 [40–59]		38 [13–78.8]	

Table 4. Correlation between the in maximum diameter and the volume of the pseudoaneurysm sac and patient-related and procedure risk variables.

	Maximum diameter		Volume	
	r	p	r	p
Age	0.075	0.391	−0.057	0.519
Haemoglobin	0.159	0.068	0.231	0.008*
Platelet count	−0.383	<0.001*	−0.486	<0.001*
INR	−0.112	0.201	−0.061	0.489
Duration of intervention	0.205	0.019*	0.320	<0.001*
Duration of compression	0.127	0.148	0.063	0.472

INR, international normalized ratio.

diameter and volume were greater with larger sheath size. We analyzed the sac's maximum diameter and volume in terms of post-intervention treatment and the intervention reason. The maximum diameter of the sac did not influence the decision of the post-intervention treatment. However, ultrasound-guided compression repair (UGCR) + ultrasound-guided thrombin injection (UGTI) was preferred more compared to UGTI alone ($p = 0.007$). Cryoablation and cardiac stent caused greater sac volume and max diameter than the imaging/diagnostic group ($p = 0.001$ and $p < 0.001$, respectively).

4. Discussion

Clinical assessment of vascular access is related to identifying pseudoaneurysm and its risk factors. We obtained several modifiable factors after percutaneous vascular interventions in a large cohort of patients in our study.

Our results revealed that HT, DM, and PAD were related to increased sac diameter and volume of the pseudoaneurysm in accordance with the literature [13–15]. Our results revealed that the size and volume of pseudoaneurysm were related to synchronous arterial and venous catheterization that has not been reported previously by a study in the literature. We considered this result linked to the synchronous arterial and venous catheterization procedure performed by cardiologists for TAVI and pacemaker applications, which require devices and stents with larger-bore and longer sheaths, prolonged procedure duration, and perioperative anticoagulation [12].

The most common puncture site of peripheral pseudoaneurysms was CFA in our study, as stated in the literature's most frequent location [16–18]. Compared to SFA, our results showed that the pseudoaneurysm' size and volume were more significant in CFA. The possible explanation for this result may be that the cohort included procedures performed mainly by radiologists in our study. They were related to broader sized access and longer procedure duration than the other coronary angiography and intracardiac device implantation interventions. This result may be a point of interest to other studies because it has never been reported.

The prolonged procedure duration is a significant risk factor, and the correlation between prolonged duration and size-volume of aneurysm sac was found statistically significant in our study. In the only study of Badr et al., prolonged procedure duration was not associated with the increased aneurysm size in the literature other than ours [15]. In our study, the size and volume of the pseudoaneurysm were evaluated with prolonged procedure time, whereas in the studies of Badr et al., only the size was assessed. Prolonged procedure time may require more time for sheath removing in the artery, cause more vascular endothelium damage, and need more anticoagulants in the procedure such as stents.

Our study also demonstrated that thrombocytopenia was a significant and independent risk factor of pseudoaneurysm after arterial catheterization. Our result showed a significant correlation between the thrombocyte count and the size-volume of the pseudoaneurysm. In the literature, the correlation between the occurrence-recurrence of pseudoaneurysm after arterial catheterization and platelet count under a cut-of 200×10^9/L level is well-known [19,20]. However, our study showed a relationship between the overall platelet count and pseudoaneurysm's diameter and volume.

Anticoagulant and antiplatelet drug regimens before vascular procedures are modifiable risk factors. Medications used as a standard practice to prevent thromboembolic complication after any large-sized sheath in any artery accesses has been identified as a common risk factor for pseudoaneurysm [12]. We showed a significant change in sac volume and maximum diameter across the pre-procedure treatment groups. However, this result was due to the increased volume and diameter in patients under mono antiplatelet compared to dual mono antiplatelet therapy. This unexpected result may be explained by the high number of patients in the monotherapy group.

Our study's strengths were the large sample size, the amount, and variety of data collected for each patient. However, our study had several limitations, including the retrospective design, lack of data such as body mass index, other arterial accesses, arterial puncture with or without ultrasound guidance.

The most significant local complication after diagnostic and therapeutic angiography is pseudoaneurysm. Our study reveals that prolonged procedure duration, simultaneous arterial and venous accesses, chronic diseases (DM, HT, PAD), thrombocytopenia, the puncture site are related to the development of pseudoaneurysms after angiographic procedures.

Femoral pseudoaneurysm is one of the most common complications resulting from percutaneous vascular interventions. The prolonged procedure duration, simultaneous arterial and venous accesses, chronic diseases (DM, HT, PAD), thrombocytopenia, the puncture site are related to the development of femoral pseudoaneurysms. Prolonged procedure time may require more time for sheath removing in the artery, cause more vascular endothelium damage, and need more anticoagulants in the procedure such as stents.

Conflict of interest

No conflict of interest was declared by the authors.

Informed consent

This retrospective study was approved by the local Institutional Review Board's approval with the approval number of KU GOKAEK 2019/229 and did not require written informed consent.

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