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Original Article

The Importance of Ultrasound-Guided Manual Compression in Iatrogenic Pseudoaneurysm Treatment: The Sooner the Better

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ABSTRACT
Objective: Although ultrasound-guided manual compression is a safe and cost-effective method in the treatment of pseudoaneurysm, there are many factors affecting the success of the procedure. This study aimed to determine the factors affecting the success of ultrasound-guided manual compression.
Methods: The records of patients who developed iatrogenic femoral artery pseudoaneurysm in the cardiology department between 2017 and 2020 were retrospectively analyzed. Data regarding patients, procedural and aneurysm-related factors were evaluated by univariate and multivariate logistic regression analysis.
Results: Seventy-five patients who underwent ultrasound-guided manual compression were included in our study. In study population, the rate of successful ultrasound-guided manual compression is 72%. As a result of the univariate analysis, hypertension, diabetes mellitus, sheath size, the length of aneurysm sac, the width of aneurysm sac, compression duration, aneurysm detection time> 24 hours parameters were found to be significant predictors for failed ultrasound-guided manual compression. In the multivariate analysis, it was found that the independent predictors associated with failed ultrasound-guided manual compression were the aneurysm detection time longer than 24 hours and the length of aneurysm sac (odds ratio: 5.908; 95% CI 1.136-30.720; $P = .035$ and odds ratio: 1.042; 95% CI 1.008-1.100; $P = .045$). In receiver operating characteristic (ROC) curve analysis, the length of the pseudoaneurysm sac of 34 mm and above had 90% sensitivity and 57% specificity for failed ultrasound-guided manual compression.
Conclusions: Ultrasound-guided manual compression is an effective method in the treatment of pseudoaneurysm. However, early detection and size of pseudoaneurysm are important for the success of this treatment. Checking the operation site within the first 24 hours after catheterization is important for early diagnosis and treatment of possible complications. In addition, it should be considered that treatment success is low in length of pseudoaneurysm sacs longer than 34 mm.
Keywords: Compression, pseudoaneurysm, ultrasound

INTRODUCTION

Pseudoaneurysms are structures in which the integrity of the artery wall is impaired, where the outer wall of the aneurysmal sac is limited by perivascular tissue, blood clot, or a reactive fibrous tissue. They usually occur due to vascular trauma, infection, and iatrogenic reasons. Iatrogenic pseudoaneurysm is an important complication seen after percutaneous endovascular interventions performed for diagnostic or therapeutic purposes.[1,2]

Historically, surgical treatment was suggested for the first time for the treatment of pseudoaneurysms.[3] However, after surgical procedures, prolongation of hospital stay, increase in cost, and increase in morbidity and mortality have led to the search for less invasive methods.[4-6] Since 1991, the ultrasound-guided manual compression (UGMC) method has been used in the treatment of pseudoaneurysm.[7-11] Although the success rate of UGMC has been reported to be high in the literature, failure rates of 5%-30% have been reported in several case series.[7,12,13,14] Failed UGMC has been attributed to factors such as emergency procedure, interventional procedure, use of anticoagulants, aneurysm diameter, neck diameter, and track length.[12,15,16]

In the present study, we aimed to determine the factors affecting the efficiency and the success of the UGMC method in the treatment of iatrogenic femoral artery pseudoaneurysm (IFAP).

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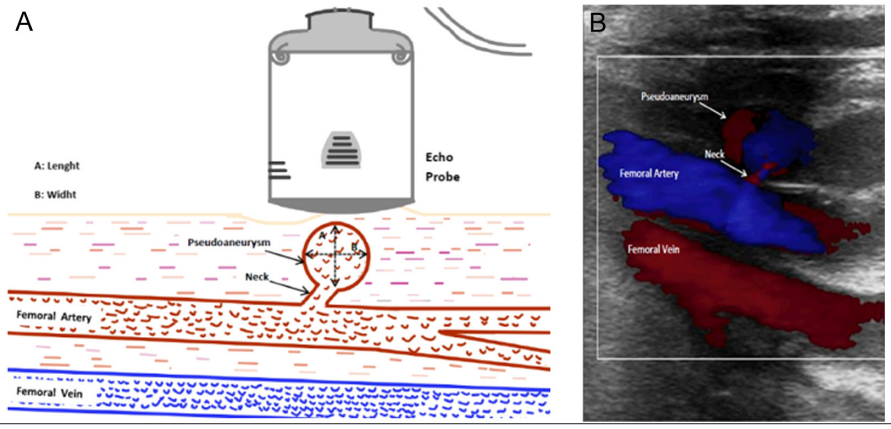
Figure 1. (A) Schematic image of PSA. (B) Ultrasound image of a PSA directly adjacent to the common femoral artery via a definable neck. Duplex scan demonstrates flow within the PSA and the femoral artery. PSA, pseudoaneurysm.



METHODS

The records of patients who developed IFAP after cardiac catheterization and who underwent UGMC in the cardiology clinic of our hospital between 2017 and 2020 were retrospectively analyzed. Procedures other than the femoral artery entry site were excluded. Patients were divided into 2 groups according to whether UGMC was successful or not. Demographic characteristics and comorbidities of the patients were analyzed. The intervened artery, sheath size, diagnostic/interventional procedure, emergency/elective procedure, catheterization procedure duration, pre- and post-catheterization anticoagulant and antiaggregant treatment use, and time from catheterization to the detection of pseudoaneurysm (pseudoaneurysm age) were recorded from the catheter laboratory reports. Approval was obtained from the local ethics committee for the study.

Cardiac catheterization was performed using a 6f or 7f sheath through the common femoral artery. While antiaggregant or anticoagulant therapy was not used in diagnostic procedures, dual antiplatelet therapy and intravenous (iv) heparin (70-100 u/kg) were used in emergency interventional procedures. After the diagnostic catheterization procedures, sheath was removed immediately after the procedure, and direct manual compression was applied for 15 minutes. Sheath was withdrawn approximately 4 hours after the interventional procedures and direct manual compression was applied for 15 minutes.

Main Points

- Latrogenic pseudoaneurysm is an important complication seen after percutaneous endovascular interventions performed for diagnostic or therapeutic purposes
- Since 1991, ultrasound-guided manual compression (UGMC), which is an effective and safe treatment method, has been used in the treatment of pseudoaneurysm that develops following interventional procedures.
- The aneurysm detection time longer than 24 hours and the length of the aneurysm sac were found as independent predictors associated with failed UGMC.
- Checking the intervention site within the first 24 hours is very important for the early diagnosis of a possible pseudoaneurysm and for the success of the UGMC treatment.

The diagnosis of pseudoaneurysm was confirmed by color Doppler ultrasound test performed in patients with pain, swelling in the groin after catheterization, and systolic murmur and pulsatile mass on physical examination. The identification of a pseudoaneurysm was confirmed by the classical triad of ultrasound findings including a hypoechoic sac in the vicinity of the parent vessel, a swirling high resistance flow on Doppler ultrasound within this mass, and a to and fro type waveform in the neck or in the sac close to the neck (Figure 1A and B). In all patients, aneurysm size, number of aneurysmal sacs, presence of arteriovenous fistula, and presence of partial thrombosis were recorded before the UGMC procedure.

Compression procedure under ultrasonographic guidance was performed by a cardiologist by determining the neck of the aneurysm with superficial ultrasound and applying pressure to this area. Three cycles of compression were applied to patients with aneurysm neck length over 8 mm with a US transducer (3.5-7 Mhz) for 15-20 minutes. Analgesic treatment (iv 1-2 mg midazolam hydrochloride) was administered to patients who felt pain during the procedure. The compression procedure was continued until the blood flow to the aneurysm sac was stopped while the blood flow continued in the main femoral artery. The blood flow to the sac was evaluated after a 10-minute break between each cycle. Compression tape was applied to the patients for 12 hours after the procedure. Successful treatment after the procedure was defined as the cessation of blood flow in the false lumen and the continuation of blood flow in the common femoral artery. Each patient who underwent successful compression underwent ultrasonography (USG) control 24 hours after the procedure. Patients whose aneurysm pouch filling could not be completely prevented were accepted as failed compression. Results were expressed using mean values and standard deviation.

Ethical committee approval was received from Antalya Education and Research Hospital Ethics Committee (Date: March 24, 2021, Decision no: 1/29, Protocol no: 2021/15).

Statistical Analysis

All statistical analyses (sensitivity, specificity, negative predictive value, and positive predictive value) were performed using MedCalc Statistical Software version v19.4.1 (MedCalc Software, Ostend, Belgium) and Statistical Package for the Social Sciences 25.0 (Armonk, NY: IBM SPSS Corp.). The data of the patients are expressed as median (quartiles) for distributed data and percentage for categorical variables. Shapiro Wilk test was used if the continuous variables were normally distributed. Student's *t*-test was used for parameters with normal distribution and Mann–Whitney U-test was used for parameters with non-normal distribution. Chi square test or Fisher's exact test was used in the analysis of categorical variables. Whether the width and length of the pseudoaneurysm sac measurements were effective in distinguishing successful compression patients from failed compression patients was evaluated by calculating the area under the ROC curve, and significant predictors were determined by binary logistic regression. $P < .05$ was considered statistically significant.

RESULTS

Seventy-five patients who received UGMC treatment for IFAP were divided into 2 groups, 54 (72%) as successful compression and 21 (28%) as failed compression. Some demographic characteristics of the patients such as age (65.5 ± 13.5 and 63.1 ± 10.0), male gender (50% and 42.9%), smoking, hyperlipidemia, chronic renal failure, and peripheral artery disease were found to be similar in both groups, whereas diabetes mellitus and hypertension differed significantly in the failed UGMC group (Table 1).

Comparing blood parameters such as international normalized ratio, hemoglobin, and platelets between the groups, no significant difference was found. In addition, there was no statistically significant difference between the use of antiaggregant and anticoagulant drugs in both groups.

Procedure- and aneurysm-related risk characteristics of the groups are presented in Table 2. There was no significant difference in both groups in terms of diagnostic/therapeutic procedure, emergency/elective procedure, type of procedure, and duration of the procedure that led to IFAP development. However, the use of large-scale sheath was found to be higher in the failed UGMC group (*P*:.048).

While the diameter of the pseudoaneurysm sac length (30.0 mm (20.0-45.2) and 47.0 mm (38.5-69.0) $P < .001$) and the width of the pseudoaneurysm sac (18.0 mm (12.0-30.0) and 30.0 mm (17.5-49.0) *P* .007) were found to be significantly larger; the pseudoaneurysm sac's being unilobuled/multilobuled or the presence of partial thrombosis in the sac were found to be similar in both groups.

The time until the detection of pseudoaneurysm was longer in the failed UGMC group (24.0 hours (21.0-48.7) and 35.0 hours (27.0-69.0) *P*: 0.011); especially pseudoaneurysms detected after the first 24 hours were found to be statistically significant for failed UGMC ($P < .001$). However, the UGMC duration (37.5 minutes (34.5-48.0) and 50.0 minutes (40.0-57.5)) was also found to be longer in the failed UGMC group.

Comparing the groups, the length and width of the pseudoaneurysm sac (30.0 mm (20.0-45.2) and 47.0 mm (38.5-69.0) $P < .001$; 18.0 mm (12.0-30.0) 30.0 mm (17.5-49.0) *P*: .007) in the failed UGMC group were found to be statistically significantly large.

As a result of the univariate regression analysis, parameters such as hypertension, diabetes mellitus, sheath size, the length of the aneurysm sac, the width of the aneurysm sac, compression duration, aneurysm detection time >24 hours were found to be significant predictors for failed UGMC ($P = .036$, $P = .014$,

Table 1. Demographic Characteristics, Clinical Features, and Laboratory Findings of Patients

Variables	Successful UGMC Group (n = 54)	Failed UGMC Group (n = 21)	*P*
Age, years	65.5 ± 13.5	63.1 ± 10.0	.345
Male, % (n)	50.0 (27)	42.9 (9)	.578
HT, % (n)	53.7 (29)	81.0 (17)	.030
DM, % (n)	22.2 (12)	52.4 (11)	.011
Smoking, % (n)	22.2 (12)	38.1 (8)	.163
Hyperlipidemia, % (n)	61.1 (33)	71.4 (15)	.403
CAD, % (n)	68.5 (37)	90.5 (19)	.050
PAD*, % (n)	9.3 (5)	14.3 (3)	.396
CRF*, % (n)	9.3 (5)	4.8 (1)	1.000
Antiaggregant therapy*, % (n)			
–None	5.6 (3)	9.5 (2)	0.507
–Single therapy	20.4 (11)	9.5 (2)	
–Dual therapy	74.1 (40)	81.0 (17)	
Anticoagulant therapy*, % (n)			
–None	77.8 (42)	81.0 (17)	0.440
–LMWH therapy	14.8 (8)	9.5 (2)	
–VKA therapy	5.6 (3)	0.0 (0)	
–NOAC therapy	1.9 (1)	9.5 (2)	
INR	1.06 (1.00–1.18)	1.09 (1.06–1.13)	0.200
Hemoglobin, g/dL	11.8 (10.6–14.1)	11.9 (9.8–12.8)	0.265
Platelet count, ($\times 10^3$ per µL)	209.0 (179.0–268.0)	204.5 (190.0–229.2)	0.166

*Fisher's exact test.
HT, hypertension; DM, diabetes mellitus; CAD, coronary artery disease; PAD, peripheral artery disease; CRF, chronic renal failure; LMWH, low–molecular–weight heparin; VKA, vitamin K antagonist; NOAC, non–vitamin K antagonist oral anticoagulant; INR, International normalized ratio.

Table 2. Procedural and Aneurysmal Risk Characteristics of Patients

Variables	Successful UGMC Group	Failed UGMC Group	*P*
Procedure, % (n)			
Emergency procedure	22.2 (12)	28.6 (6)	.563
Elective procedure	77.8 (42)	71.4 (15)	
Intervention, % (n)			
Diagnostic	37.0 (20)	38.1 (8)	.932
Therapeutic	63.0 (34)	61.9 (13)	
Type of procedure*, % (n)			
CAG	90.7 (49)	90.5 (19)	.712
EPS	3.7 (2)	9.5 (2)	
TAVI	1.9 (1)	0.0 (0)	
PAG	3,7 (2)	0.0 (0)	
Duration of procedure (minutes)	17.5 (10.0–23.2)	19.0 (14.0–28.5)	
Sheat size*, % (F)			
6f	96.3 (52)	81. (17)	.048
7f	3.7 (2)	19.0 (4)	
Aneurysm sac diameter (length) (mm)	30.0 (20.0–45.2)	47.0 (38.5–69.0)	<.001
Aneurysm sac diameter (width) (mm)	18.0 (12.0–30.0)	30.0 (17.5–49.0)	.007
Unilobule/multilobule sac*, % (n)			
Unilobule	83.3 (45)	85.7 (18)	1.000
Multilobule	16.7 (9)	14.3 (3)	
Partial thrombosis of pseudoaneurysm, % (n)			
No	64.8 (35)	57.1 (12)	.600
Yes	35.2 (19)	42.9 (9)	
Duration of compression (minute)	37.5 (34.5–48.0)	50.0 (40.0–57.5)	.002
Time lag before diagnosis (hour)	24.0 (21.0–48.7)	35.0 (27.0–69.0)	.011
Time lag before diagnosis of aneurysm			
≤ 24 hours (n = 34)	57.4 (31)	14.3 (3)	<.001
>24 hours (n = 41)	42.6 (23)	85.7 (18)	

* Fisher's exact test.
CAG, coronary angiography; EPS, electrophysiological study; TAVI, transcatheter aortic valve implantation; PAG, peripheral angiography.

P = .047, *P* = .001, *P* = .029, *P* = .012, *P* = .002, respectively). In the multivariate logistic regression analysis performed with these parameters, it was found that the independent predictors associated with failed UGMC were the aneurysm detection time longer than 24 hours and the length of the aneurysm sac (OR: 5.908; 95% CI 1.136-30.720; *P* = .035, and OR: 1.042; 95% CI 1.008-1.100; *P* = .045) (Table 3).

In ROC curve analysis, the length diameter of the pseudoaneurysm sac of 34 mm and above had 90% sensitivity and 57% specificity for failed UGMC (Figure 2).

Major complications associated with UGMC such as rupture, distal embolization, skin necrosis, or neuropathy were not detected in our patients. However, transient hypotension developed during compression in 2 patients, and vagal reaction developed in 1 patient as a result compression was interrupted in these patients. Compression was continued after the patients were stabilized.

DISCUSSION

Ultrasound-guided manual compression, first described by Fellmeth et al.[7] in 1991, is a safe and cost-effective method; however, its success rate varies between 57% and 99% in various case series.[9,12,17] In our clinic, our success rate after UGMC was 72%, which was consistent with the studies in the literature. In studies where the success rate was higher, the presence of partial thrombosis after compression was considered successful compression, whereas pseudoaneurysms with large hematoma were considered not suitable for compression and were excluded from the study.[7,18] Partial thrombosis was not used as a criterion for success in our study, while the presence of a large hematoma was not considered a contraindication for UGMC.

Other studies in the literature report that anticoagulant and antiplatelet therapy cause higher failure and recurrence rates.[15-19] Although IFAP was detected more in those receiving single or dual antiplatelet therapy in our study (93%), taking antiplatelet or anticoagulant therapy was not found to be a predictor of failed UGMC. This may be related to the discontinuation of anticoagulant treatment before the procedure or the low number of patients in our study group.

The need for long compression times may also be associated with failed UGMC. While the average compression time in the literature is approximately 44 minutes, in some situations, there are cases with compression time up to 300 minutes.[18] There are also studies reporting that long compression times do not correlate with the success of UGMC. Eisenberg et al[15] explained this by the failure to perform effective compression for more than 1 hour due to patient comfort and operator fatigue. Although compression time was found to be longer in the failed UGMC group in our study, it was not found to be an independent predictor for failed UGMC in multivariate analysis. In our study, a statistically significant difference may not have been found between the compression time and failed UGMC due to the inability to continue compression for a long time due to patient and operator comfort.

Different results were obtained in studies investigating the relationship between pseudoaneurysm age and UGMC success. Shatnawi et al.[20] reported an association between aneurysm age >48 hours after catheterization and the rate of failed UGMC. Similarly, the aneurysm detection time was found to be longer

Table 3. Univariate and Multivariate Analysis of Factors Associated with Ultrasound-Guided Manual Compression Failure

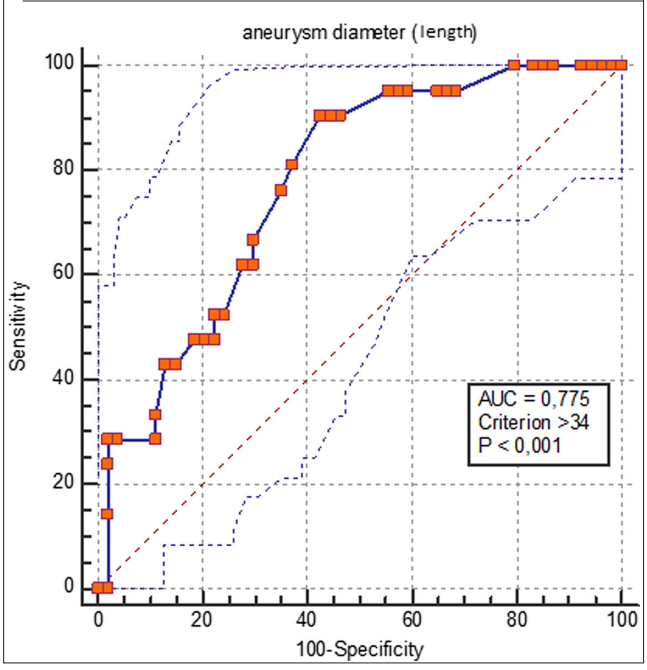
	Univariate		Multivariate	
Variables	**OR (95% CI)**	***P***	**Adjusted OR (95% CI)**	***P***
Age (years)	0.985 (0.946-1.026)	.464		
HT	3.664 (1.089-12.329)	.036	2.858 (0.529-15.445)	.223
DM	3.850 (1.321-11.224)	.014	2.188 (0.527-9.094)	.281
CAD	4.365 (0.912-20.899)	.065	6.344 (0.849-47.389)	.072
Sheath size (6f, 7f)	6.118 (1.028-36.405)	.047	5.204 (0.187-144.772)	.331
Aneurysm sac diameter (length)(mm)	1.058 (1.024-1.094)	.001	1.042 (1.008-1.100)	.045
Aneurysm sac diameter (width) (mm)	1.029 (1.003-1.056)	.029	1.029 (0.982-1.078)	.227
Compression time (minutes)	1.043 (1.009-1.078)	.012	1.032 (0.981-1.086)	.226
Time lag before diagnosis of aneurysm >24 hour	8.087 (2.126-30.760)	.002	5.908 (1.136-30.720)	.035

HT, hypertension; DM, diabetes mellitus; CAD, coronary artery disease; OR, odds ratio.

in the failed UGMC group in our study, and aneurysm detection time of >24 hours was determined as an independent predictor of failed UGMC in the multivariate analysis. This situation may be explained by the fact that the pseudointima layer that develops in the aneurysm sac over time and endothelialization prevents thrombosis, which is necessary for successful compression.[15] Therefore, checking the intervention site within the first 24 hours is very important for the early diagnosis of a possible pseudoaneurysm and for the success of the UGMC treatment to be applied.

While there are publications showing that the size of the pseudoaneurysm sac is unrelated to failed UGMC,[20] many studies found that the size of the pseudoaneurysm sac was the limiting factor affecting the success of UGMC.[15,21,22] Our study has demonstrated that there is an inverse relationship between pseudoaneurysm size and compression success. This result may be explained by the fact that the flow through larger pseudoaneurysms tends to be greater than the flow in smaller pseudoaneurysms and therefore it is more difficult to stop it completely. In our study, it was also found that the diameter of the pseudoaneurysm was larger and that the success of UGMC was lower in patients with pseudoaneurysm after >24 hours. This result once again reveals the importance of early diagnosis in the treatment of pseudoaneurysm.

Figure 2. Receiver operating characteristic curves showing the AUC for aneurysm diameter (length). AUC, area under curve.



Limitations

The main limitations of our study were that it is a single-center study, that the operators performing the procedure had varying length of experience, and the body mass index of many patients were not recorded.

CONCLUSION

Ultrasound-guided manual compression is an effective and safe treatment method in the treatment of pseudoaneurysm that develops following interventional procedures. However, for this treatment to be successful, it is important to detect the pseudoaneurysm before 24 hours. Checking the intervention site within the first 24 hours after catheterization may increase the success of UGMC treatment by detecting possible pseudoaneurysm before it becomes too large. In addition, since the size of the pseudoaneurysm sac length also affects the success of UGMC, it should be considered that treatment success is low, especially in the length of pseudoaneurysm sacs longer than 34 mm.

Ethics Committee Approval: Ethical committee approval was received from the Antalya Education and Research Hospital Ethics Committee (Date: March 24, 2021, Decision no: 1/29, Protocol no: 2021/15).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

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Author Contributions: Concept – G.K, N.B. ; Design – Ş.A., G.Ç.; Supervision – Ş.S., G.Ç.; ; Materials – R.G., G.K.; Data Collection and/or Processing – E.C.O., R.G.; Analysis and/or Interpretation – R.G., E.C.O.; Literature Review – G.K., G.Ç.; Writing – G.K., N.B.; Critical Review – G.Ç., Ş.A.

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REFERENCES

1. Asrar Ul Haq M, Tsay IM, Dinh DT, et al. Prevalence and outcomes of trans-radial access for percutaneous coronary intervention in contemporary practise. *Int J Cardiol*. 2016;221:264-268. [CrossRef]
2. Feldman DN, Swaminathan RV, Kaltenbach LA, et al. Adoption of radial access and comparison of outcomes to femoral access in percutaneous coronary intervention: an updated report from the national cardiovascular data registry (2007-2012). *Circulation*. 2013;127(23):2295-2306. [CrossRef]
3. Lewis DR, Bullbulia RA, Murphy P, et al. Vascular surgical intervention for complications of cardiovascular radiology: 13 years' experience in a single centre. *Ann R Coll Surg Engl*. 1999;81(1):23-26. Available at: https://pubmed.ncbi.nlm.nih.gov/10325680/
4. Babu SC, Piccorelli GO, Shah PM, Stein JH, Clauss RH. Incidence and results of arterial complications among 16,350 patients undergoing cardiac catheterization. *J Vasc Surg*. 1989;10(2):113-116. [CrossRef]
5. Lumsden AB, Miller JM, Kosinski AS, et al. A prospective evaluation of surgically treated groin complications following percutaneous cardiac procedures. *Am Surg*. 1994;60(2):132-137. Available at: https://pubmed.ncbi.nlm.nih.gov/8304645/
6. Omoigui NA, Califf RM, Pieper K, et al. Peripheral vascular complications in the Coronary Angioplasty Versus Excisional Atherectomy Trial (CAVEAT-I). *J Am Coll Cardiol*. 1995;26(4):922-930. [CrossRef]
7. Fellmeth BD, Roberts AC, Bookstein JJ, et al. Postangiographic femoral artery injuries: nonsurgical repair with US-guided compression. *Radiology*. 1991;178(3):671-675. [CrossRef]
8. Hertz SM, Brener BJ. Ultrasound-guided pseudoaneurysm compression: efficacy after coronary stenting and angioplasty. *J Vasc Surg*. 1997;26(6):913-916. [CrossRef]
9. Lange P, Houe T, Helgstrand UJ. The efficacy of ultrasound-guided compression of iatrogenic femoral pseudo-aneurysms. *Eur J Vasc Endovasc Surg*. 2001;21(3):248-250. [CrossRef]
10. Çakır H, Tuncel Ç, Uncu H, Ökten CC, Karaca S, Özsöyler İ. Iatrogenic femoral artery pseudoaneurysms. *Türk Göğüs Kalp Damar Cerrahisi Derg*. 2013;21(1):54-58. [CrossRef]
11. Hood DB, Mattos MA, Douglas MG, et al. Determinants of success of color-flow duplex-guided compression repair of femoral pseudoaneurysms. *Surgery*. 1996;120(4):585-588. [CrossRef]
12. Popovic B, Freysz L, Chometon F,et al. Femoral pseudoaneurysm and current cardiac catheterization: evaluation of risk factors and treatment. *Int J Cardiol*. 2010;141(1):75-80. [CrossRef]
13. Schaub F, Theiss W, Busch R, Heinz M, Paschalidis M, Schömig A. Management of 219 consecutive cases of post catheterization pseudo aneurysm. *Jacc*. 1997;30(3):670-675. [CrossRef]
14. Kontopodis N, Tsetis D, Tavlas E, Dedes A, Ioannou CV. Ultrasound guided compression versus ultrasound guided thrombin injection for the treatment of post-catheterization femoral pseudoaneurysms: systematic review and meta-analysis of comparative Studies. *Eur J Vasc Endovasc Surg*. 2016;51(6):815-823. [CrossRef]
15. Eisenberg L, Paulson EK, Kliewer MA, Hudson MP, DeLong DM, Carroll BA. Sonographically guided compression repair of pseudoaneurysms: further experience from a single institution. *AJR Am J Roentgenol*. 1999;173(6):1567-1573. [CrossRef]
16. Stone PA, Campbell JE, AbuRahma AF. Femoral pseudoaneurysm after percutaneous access. *J Vasc Surg*. 2014;60(5):1359-1366. [CrossRef]
17. Paschalidis M, Theiss W, Kölling K, Busch R, Schömig A. Randomised comparison of manual compression repair versus ultrasound guided compression repair of postcatheterisation femoral pseudoaneurysms. *Heart*. 2006;92(2):251-252. [CrossRef]
18. Coley BD, Roberts AC, Fellmeth BD, Valji K, Bookstein JJ, Hye RJ. Postangiographic femoral artery pseudoaneurysms: further experience with US-guided compression repair. *Radiology*. 1995;194(2):307-311. [CrossRef]
19. Cox GS, Young JR, Gray BR, Grubb MW, Hertzer NR. Ultrasound-guided compression repair of postcatheterization pseudoaneurysms: results of treatment in one hundred cases. *J Vasc Surg*. 1994;19(4):683-686. [CrossRef]
20. Shatnawi NJ, Al-zoubi NA , Jarrah J, Khader Y , Heis M, Mamoon H. Al-Omari Risk factors attributed to failure of ultrasound-guided compression for post-cardiac catheterization femoral artery pseudoaneurysms. *SAGE Open Med*. 2019;7:1-6. [CrossRef]
21. Dean SM, Olin JW, Piedmonte M, Grubb M, Young JR. Ultrasound-guided compression closure of postcatheterization pseudoaneurysms during concurrent anticoagulation: a review of seventy-seven patients. *J Vasc Surg*. 1996;23(1):28-35. [CrossRef]
22. Kumins NH, Landau DS, Montalvo J, et al., Expanded indications for the treatment of postcatheterization femoral pseudoaneurysms with ultrasound-guided compression. *Am J Surg*. 1998;176(2):131-136. [CrossRef]