Original Article

Association of Radial Artery Diameter with Radial Artery Spasm in Patients Undergoing Transradial Cardiac Catheterization

Ismail Ahmed Khan, Umer Shafiq, Sohail Aziz, Zohair Aziz, Wajahat Lodhi, Waleed Hassan, Asif Manzoor

ABSTRACT

Objective: To assess the association of radial artery spasm (RAS) with radial artery diameter and other factors in patients undergoing transradial cardiac catheterization.

Methodology: This descriptive, cross-sectional study was conducted at the Fauji Foundation Hospital, Rawalpindi from June to September 2025 after ethical approval. After taking informed written consent, 150 patients who underwent coronary angiography or percutaneous coronary intervention using transradial approach were included. Prior to the procedure, radial artery diameter was assessed by the linear probe of Xario 100g Ultrasound machine. Radial artery spasm was assessed clinically by the operator and radial artery angiograms. Patients were divided into two groups: group I with no RAS and group II with RAS. The association of RAS with the radial artery diameter and other variables were determined. Statistical Package for the Social Sciences (SPSS) version 26 was used for data analysis.

Results: Radial artery spasm occurred in 35(23.3%) patients. The time to vascular access was significantly higher (150.60±49.77 seconds) in patients with RAS as compared to those without spasm (43.69±29.61 seconds) (p=0.001). The number of procedure attempts, episodes of vasovagal syncope (3.3% versus 0%) and access site crossover (6% versus 0%) were also significantly higher in patients with RAS. The radial artery spasm had a significant positive association with radial artery diameter, ejection fraction, angiographic findings, and treatment plan. The ROC curve showed an area under the curve of 0.876, showing the excellent ability of radial artery diameter to predict RAS.

Conclusion: Radial artery spasm affects a significant proportion of patients (23.3%) undergoing transradial cardiac catheterization. The radial artery diameter, vascular access time, need for ultrasound assistance to secure vascular assistance, additional vasodilator & glide wire, vasovagal syncope, and access site crossover were significantly higher in patients with RAS.

Keywords: *Radial Artery. Cardiac catheterization. Percutaneous coronary intervention. Coronary angiography.*

INTRODUCTION

Cardiac catheterization is an important and potentially lifesaving diagnostic and therapeutic modality, with the purpose to diagnose and treat conditions like coronary artery disease (CAD). It includes procedures such as diagnostic coronary angiography and percutaneous coronary intervention (PCI).[1] Various access sites can be used for left heart catheterization, such as the radial artery, ulnar artery, and femoral artery. In the current times, the radial artery is used as the access site of preference in diagnostic and therapeutic left heart catheterization procedures including diagnostic coronary angiography and percutaneous coronary intervention. This is because of ease of access, patient comfort, lower risk of vascular complications, shorter hospital stay, and early patient mobilization proven by various clinical trials.[2] However, intraprocedural and postprocedural complications can still occur via transradial access. Intraprocedural complications are radial artery spasm, kinking of the catheter, arterial dissection & perforation and vasovagal syncope. On the other hand, postprocedural complications include occlusion of the radial artery, pseudoaneurysm, hematoma formation, arteriovenous fistula, and nerve damage. These complications can potentially contribute to morbidity and mortality. They can lead to patient discomfort, limb dysfunction, long procedure duration, high chances of access site crossover, and life-threatening complications such as compartment syndrome.[3]

Radial artery spasm is generally identified when the operator feels resistance while advancing the sheath or catheter through the radial artery, causing pain in the forearm or arm. This complication is very common and is one of the leading causes of access site crossover. The spasm of the radial artery occurs frequently owing to the vasoreactivity of the vessel. Most of the cases are mild that can be prevented and treated. Pain relief and sedation can markedly decrease the incidence of RAS. Proper selection of equipment also reduces the chances of RAS.[4]

The risk factors of RAS include female gender, young or old age, diabetes mellitus, hypertension, deranged lipid profile, smoking, anxiety, and tachycardia. Radial artery spasm has been associated with both radial artery characteristics and procedural

Sharif Medical & Dental College, Sharif Medical City. Sharif Medical City Road, Off Raiwind Road, Jati Umra, Lahore 54000, Pakistan.

Correspondence: Dr. Ismail Ahmed Khan
Fellow Interventional Cardiology, Department of Cardiology
Fauji Foundation Hospital, Rawalpindi
E-mail: xperiasp17@gmail.com

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factors. The radial artery parameters associated with RAS are small caliber of the radial artery and low intensity of the radial pulse. Emergency procedures, multiple attempts, use of multiple catheters, and large sheaths can lead to RAS.[5]

The association of radial artery spasm with clinical parameters such as co-morbids have been studied in detail, there is paucity of local data regarding the association of radial artery diameter with radial artery spasm, and while logic dictates that smaller radial artery diameter should be a significant contributor to this rather common complication. This study aimed to bridge this gap in knowledge that can potentially serve to identify patients at risk of radial artery spasm and its subsequent vascular complications, and hence reduce morbidity and mortality in patients undergoing transradial cardiac catheterization.

METHODOLOGY

This descriptive, cross-sectional study was conducted at the Fauji Foundation Hospital, Rawalpindi from June to September 2025. After ethical approval (Letter No. 977/RC/FFH/RWP, 23-06-2025), the sample size of 150 was estimated using 11% frequency of radial artery spasm, 95% confidence interval, and 5% margin of error.[6] The patients were included using non-probability convenience sampling.

All the patients who underwent coronary angiography or percutaneous coronary intervention using transradial approach were included in the study. Exclusion criteria were patients with absent radial pulse, prior abnormal modified Allen's test, history of radial artery occlusion, known radial artery abnormalities, arteriovenous fistulas involving the radial artery, peripheral artery disease involving upper limbs, history of vascular complications in prior transradial cardiac catheterization, hemodynamic instability, and patients undergoing procedure from an alternative access site. Informed written consent was taken from the patients and their demographics, co-morbidities, electrocardiographic changes, and ejection fraction were noted.

Modified Allen's test was performed to check the patency of the radial artery and the adequacy of collateral supply from the ulnar artery. After occluding both arteries and then releasing the ulnar artery, return of hand color within ≤5 seconds indicated adequate collateral flow and a normal result.[7] Patients with abnormal test results were excluded from the study as per the defined exclusion criteria.

Prior to the procedure, radial artery diameters were assessed by the linear probe of Xario 100g Ultrasound machine, set on vascular mode at a frequency of 10 MHz. Measurements were taken in cross-sectional plane in 2D mode at optimal gain settings, at a depth of 2-3 centimeters, keeping the arterial lumen in the middle third of the screen, with the calipers positioned in a manner to measure the anterior-posterior diameter from inner wall to inner wall. All measurements were taken 1cm proximal to the styloid process. As per the hospital's cardiac catheterization lab protocols, 5000 IU of I/V unfractionated heparin along with 200 mcg of I/V nitrates mixed in 10 ml of normal saline was injected via the sheath after securing the vascular access.

Radial artery spasm was assessed clinically by the operator performing the procedure on the basis of pain or resistance encountered during manipulation of sheath, catheters or guidewires. In such instances, radial artery angiograms were performed to document radial artery spasm and differentiate it from other possible causes of pain and resistance, such as radial artery loops or tortuosity.[5] The total number of attempts, time, and need of ultrasonographic (USG) assistance in securing vascular access, flouroscopy time and coronary angiographic findings were recorded. Similarly, in the event of radial artery spasm, the need of additional vasodilators, the use of hydrophilic guidewires, or the need and location of access site crossover were also recorded. Any procedural complication, such as vasovagal syncope was also noted.

To eliminate interobserver bias, modified Allen's test, assessment of radial artery diameter on ultrasound and assessment of radial artery spasm were done by the consensus of 2 interventional cardiologists with experience of more than 200 transradial cardiac catheterizations per year.

STATISTICAL ANALYSIS

The data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 26. Categorical and numerical variables were presented as frequency (percentage) and mean (standard deviation), respectively. Independent t-test was used for the association of numerical variables. Chi-square and Fisher's exact test was used to analyze categorical variables. The receiver operating characteristic (ROC) curve was drawn for radial artery diameter to evaluate its ability to predict radial artery spasm. The area under the curve (AUC) of greater than 0.6 is considered meaningful,

graded as poor if >0.6 but <0.7, fair if >0.7 but <0.8, good if >0.8 but <0.9, and excellent if >0.9.[8] The cut-off value of radial artery diameter was estimated using the Youden Index. The Youden index (J) is used to calculate the threshold value of a parameter with maximum sensitivity and specificity using the formula: sensitivity + specificity – 1.[8] The results were considered significant at the p-value of <0.05.

RESULTS

The mean age of the patients was 59.21±10.52 years with a range of 26 to 89 years. There were 115(76.7%) females and 35(23.3%) males. Most of the patients (42.6%) had stable angina, 26.7% had non-ST-elevation myocardial infarction (NSTEMI), 24% had ST-elevation myocardial infarction (STEMI), and 6.7% had unstable angina. Seventy seven (51.3%) patients were diabetic, 115(76.7%) were hypertensive, 9(6%) were smokers, and 22(14.7%) had a history of prior PCI. Most of the patients had triple vessel coronary artery disease (TVCAD) (26%) and double vessel coronary artery disease (DVCAD) (26%), followed by single vessel coronary artery disease (SVCAD) (18.7%). The majority of the patients were managed with medical treatment (38%), followed by PCI (36.7%).

The mean radial artery diameter of all patients was 2.25±0.35 mm. The mean angiographic fluoroscopic time was 3.05±3.45 minutes. In patients who underwent PCI, the mean PCI fluoroscopic time was 9.89±6.63 minutes, and in these patients, the total fluoroscopic time was 12±6.7 minutes.

Radial artery spasm occurred in 35(23.3%) patients. The mean time to vascular access was significantly higher (150.60±49.77 seconds) in patients with radial artery spasm as compared to those without spasm (43.69±29.61 seconds). Whereas the angiographic, PCI, and total fluoroscopic time were not statistically different (p >0.05). A significantly higher proportion of patients with RAS required ultrasound assistance for vascular access (10.6%), use of additional vasodilators (18%), guidewire insertion (14.7%) and crossover to other site (6%) compared to those without RAS. The frequency of RAS also increased with increasing number of procedure attempts. Moreover, episodes of vasovagal syncope (3.3%) were also significantly higher in patients with RAS (p=0.001) (Table 1).

The radial artery spasm had a significant positive association with radial artery diameter. The mean radial artery diameter was much lower in patients with radial artery spasm. The ejection fraction was significantly lower in patients with spasm than with no spasm. Triple vessel disease was significantly associated with RAS (30.8%), followed by DVCAD (25.6%) and SVCAD (21.4%). The patients who underwent PCI had the highest proportion of RAS (29.1%) as compared to coronary artery bypass grafting (CABG) and medical treatment. The radial artery spasm had no significant link with age, gender, diabetes mellitus, hypertension, smoking, and prior PCI (p >0.05). (Table 2).

The ROC curve drawn for radial artery diameter to predict radial artery spasm showed an area under the curve of 0.876. This shows that the radial artery diameter has an excellent ability to predict radial artery spasm. The cut-off value of radial artery diameter for predicting radial artery spasm was estimated to be 2.05 mm. At this cut-off value, the sensitivity of radial artery diameter was 77% and the specificity was 88% (Figure 1).

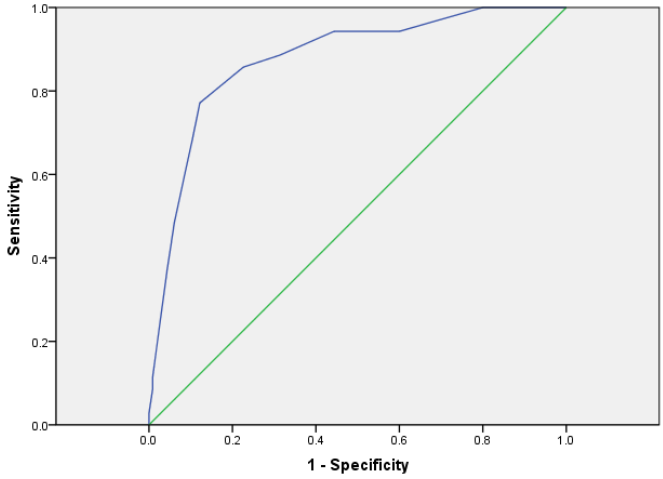

Figure 1: ROC Curve for Radial Artery Diameter to Predict Radial Artery Spasm

Table 1: Procedural Outcomes in Patients with or without Radial Artery Spasm

Parameters		Radial Artery Spasm (Frequency & Percentage)		Total	p-value
		No	Yes		
Number of Attempts	1	102(68%)	11(7.3%)	113(75.3%)	0.001*
	2	11(7.3%)	14(9.4%)	25(16.7%)	
	3	2(1.3%)	8(5.4%)	10(6.7%)	
	4	0(0%)	2(1.3%)	2(1.3%)	
	Total	115(76.7%)	35(23.3%)	150(100%)	
Need for USG Assistance to Secure Vascular Access	No	111(74%)	19(12.7%)	130(86.7%)	0.001*
	Yes	4(2.7%)	16(10.6%)	20(13.3%)	
	Total	115(76.7%)	35(23.3%)	150(100%)	
Need of Additional Vasodilator	No	115(76.7%)	8(5.3%)	123(82%)	0.001*
	Yes	0(0%)	27(18%)	27(18%)	
	Total	115(76.7%)	35(23.3%)	150(100%)	
Need of Guide wire	No	112(74.7%)	13(8.6%)	125(83.3%)	0.001*
	Yes	3(2%)	22(14.7%)	25(16.7%)	
	Total	115(76.7%)	35(23.3%)	150(100%)	
Vasovagal Syncope	No	115(76.7%)	30(20%)	145(96.7%)	0.001*
	Yes	0(0%)	5(3.3%)	5(3.3%)	
	Total	115(76.7%)	35(23.3%)	150(100%)	
Crossover	No	115(76.7%)	26(17.3%)	141(94%)	0.001*
	Yes	0(0%)	9(6%)	9(6%)	
	Total	115(76.7%)	35(23.3%)	150(100%)	
Time to Vascular Access (Seconds)	Mean±SD	43.69±29.61	150.60±49.77	-	0.001*

**Significant p-value*

Table 2: Association of Radial Artery Spasm with Radial Artery Diameter and Clinical Parameters

Parameters		Radial Artery Spasm		Total	p-value
		No	Yes		
Radial Artery Diameter (mm)	Mean±SD	2.36±0.29	1.88±0.26	-	0.001*
Ejection Fraction	Mean±SD	50.96±9.93	45.86±10.87	-	0.01*
Angiographic Findings (Frequency & Percentage)	Normal Coronaries	19(12.7%)	4(2.6%)	23(15.3%)	0.001*
	Minor CAD	9(6%)	2(1.3%)	11(7.3%)	
	Subcritical CAD	9(6%)	1(0.7%)	10(6.7%)	
	SVCAD	22(14.7%)	6(4%)	28(18.7%)	
	DVCAD	29(19.3%)	10(6.7%)	39(26%)	
	TVCAD	27(18%)	12(8%)	39(26%)	
	Total	115(76.7%)	35(23.3%)	150(100%)	
Treatment Plan (Frequency & Percentage)	Medical Rx	46(30.7%)	11(7.3%)	57(38%)	0.001*
	PCI	39(26%)	16(10.7%)	55(36.7%)	
	CABG	30(20%)	8(5.3%)	38(25.3%)	
	Total	115(76.7%)	35(23.3%)	150(100%)	

**Significant p-value*

DISCUSSION

The frequency of RAS in our study was 23.3%. Roczniak et al. also reported symptomatic angiographic RAS in 24.3% of patients.[9] This was higher than 11% reported in a previous study.[6] The reported incidence of radial artery spasm ranges from 1% to 34%, while radial artery occlusion occurred in up to 19.7% of cases. This wide variation may be attributed to differences in arterial size, operator experience, and the equipment used during the procedure.[10] Patel et al. observed the RAS rate of 5.5% and emphasized that the type of vasodilator used in transradial access can also contribute to a wide difference in the occurrence of radial artery spasm.[11]

The mean radial artery diameter of patients was 2.25±0.35 mm in our study. Similarly, Hasan et al. observed that the mean radial artery diameter was 2.35±0.41 mm. Moreover, literature showed that the diameter of the radial artery was smaller in Asians (2.63±0.35mm) as compared to the western population (3.6±0.8 mm). The smaller caliber of the radial artery and its resultant tendency to develop spasms may lead to higher procedural failure in the transradial approach.[12]

In the current study, patients with RAS had a significantly smaller mean radial artery diameter (1.88±0.26 mm vs. 2.36±0.29 mm) (p=0.001). Sanketh et al. found that the frequency of radial artery occlusion was 24% in patients with small radial artery diameter (<2.5 mm) as compared to 6.7% in patients with larger diameter (p=0.03).[13] Radial artery dimension was smaller among RAS patients as compared to those without RAS but the results were not significant in another study.[9]

The average patient age was 59.21±10.52 years in our study and most of the patients were females (76.7%). The age and gender distribution had no significant association with RAS incidence. In another study, the average age was 62.5±11.2 years with 62.3% males. The patients with smaller radial artery diameters were generally older and had a lower proportion of males. However, multivariate analysis revealed that age and gender were not significant predictors of radial artery occlusion.[13] In a study by Mazhar et al., age was not significantly associated with RAS however, RAS showed a significant association with the female gender.[6] Another study reported that the frequency of RAS was significantly higher among females (66.6%; p=0.003) and those aged ≤65 years (62.5%; p=0.001).[14] Roczniak et al. also found that women were significantly more likely to experience radial artery spasm as compared to men (OR = 2.94, p=0.02).[9]

In our study, 76.7% of the patients were hypertensive and 51.3% were diabetic. Only 6% were smokers. The association of RAS with hypertension, diabetes mellitus, smoking, and prior PCI was insignificant. Previous studies didn't find any significant association of RAS with diabetes and hypertension.[6,15] Hasan et al. also reported that radial artery diameter wasn't significantly linked to diabetes and hypertension.[12] In addition to diabetes and hypertension, smoking was also not considered a predictor of RAS.[14]

Our results showed that the fluoroscopic time was not significantly different in patients with RAS as compared to patients without RAS. Procedural factors like puncture attempts, longer vascular access time, more frequent use of ultrasound, guide wire, additional vasodilators, as well as higher rates of vasovagal episodes and access site crossover were strongly linked to RAS in our participants (p ≤0.001). Another study reported that first-attempt failure significantly predicted spasm.[9] Roy et al. reported increased procedural time and access site crossover in patients who developed radial artery spasm while undergoing transradial access.[16] More than one procedural attempts were linked with RAS in a study conducted in 2023.[15] Another study was conducted to compare radial artery diameter pre and post-radial coronary angiography and a change in radial artery diameter was significantly associated with the number of puncture attempts.[17] Our data reinforce that minimizing puncture attempts can reduce spasm risk.

A majority of RAS patients needed additional vasodilators in our study. Vasodilators such as nitric oxide donors and calcium channel blockers can be administered individually or in combination with other agents to create an anti-spasmolytic radial "cocktail" aimed at preventing or reducing radial artery spasm.[10] Roczniak et al. used nitroglycerine and lidocaine cocktail but administration of the radial cocktail did not result in a statistically significant reduction in the odds of spasm (p=0.48).[9]

CONCLUSION

Radial artery spasm affects a significant proportion of patients (23.3%) undergoing transradial cardiac catheterization. The vascular access time, need for ultrasound assistance to secure vascular access, additional vasodilator & guide wire, vasovagal syncope, and access site crossover were significantly higher in patients with RAS. It had a significant association with small radial artery diameter, ejection fraction, angiographic findings, and treatment plan.

LIMITATIONS & RECOMMEDATIONS

The small sample size and conduction of the study at a single center affect the generalizability of the results. Future multicenter studies should be conducted on a large scale in Pakistan.

Small radial artery diameter is an associated factor of radial artery spasm. These patients must be considered at high-risk and managed optimally to reduce the chances of RAS.

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Authors' Contributions:
I.A.K: Conceived and designed the study, supervised data collection, and critically reviewed the manuscript.
U.S: Contributed to study design, performed data analysis and interpretation, and drafted the manuscript.
S.A: Assisted in data collection, clinical evaluation, and literature review.
Z.A: Participated in patient selection, data acquisition, and manuscript formatting.
W.L: Contributed to data analysis and interpretation of results.
W.H: Assisted in statistical analysis and preparation of tables and figures.
A.M: Supervised the overall research process, reviewed the final manuscript for intellectual content, and approved it for publication.

REFERENCES

1. Holzer RJ, Bergersen L, Thomson J, Aboulhosn J, Aggarwal V, Akagi T, et al. PICS/AEPC/APPCS/CSANZ/ SCAI/SOLACI: expert consensus statement on cardiac catheterization for pediatric patients and adults with congenital heart disease. JACC Cardiovasc Interv. 2024; 17(2):115-216. doi:10.1016/j.jcin.2023.11.001.

2. Kis M, Soydan E. Preservation of radial vasomotor functions through the anatomic snuffbox: a prospective comparison with other radial accesses during coronary angiography. J Coll Physicians Surg Pak. 2020; 30(11):1121-5. doi:10.29271/jcpsp.2020.11.1121.

3. Safitri H, Alkatiri AA, Firman D, Mangkuanom AS. Managing transradial artery access complications during coronary intervention: three case reports. JAPSC. 2023; 2:e28. doi:10.15420/japsc.2022.29.

4. Riangwiwat T, Blankenship JC. Vascular complications of transradial access for cardiac catheterization. US Cardiol. 2021; 15:e04. doi:10.15420/usc.2020.23.

5. Zus AS, Crisan S, Luca S, Nisulescu D, Valcovici M, Patru O, et al. Radial artery spasm-a review on incidence, prevention and treatment. Diagnostics (Basel). 2024; 14(17):1897. doi:10.3390/diagnostics14171897.

6. Mazhar MW, Tuyyab F, Samin A, Khan KA, Khan S, Ullah A, et al. Incidence and predictors of radial artery spasm during left heart catherization. Pak Armed Forces Med J. 2020; 71(Suppl 2):S288-92. Available from: https://www.pafmj.org/PAFMJ/article/view/7763.

7. Moon J, Lee GH, Park TJ, Ki SH. Is the modified Allen's test a useful tool for evaluating the vascular dominance of the forearm? J Korean Med Sci. 2025; 40(36):e230. doi:10. 3346/jkms.2025.40.e230.

8. Corbacıoglu SK, Aksel G. Receiver operating characteristic curve analysis in diagnostic accuracy studies: a guide to interpreting the area under the curve value. Turk J Emerg Med. 2023; 23(4):195-8. doi:10.4103/tjem.tjem_182_23.

9. Roczniak J, Tarnawski A, Dziewierz A, Glanowski S, Pawlik A, Sabatowski K, et al. Radial artery spasms - angiographic morphology, risk factors and management. Postepy Kardiol Interwencyjnej. 2024; 20(1):53-61. doi:10. 5114/aic.2024.136936.

10. Coghill EM, Johnson T, Morris RE, Megson IL, Leslie SJ. Radial artery access site complications during cardiac procedures, clinical implications and potential solutions: the role of nitric oxide. World J Cardiol. 2020; 12(1):26-34. doi:10.4330/wjc.v12.i1.26.

11. Patel K, Duckett M, Vidovich MI, Ibrahim K. Intra-arterial nicardipine versus verapamil during transradial access coronary catheterization. Cardiovasc Revasc Med. 2025; 74:40-4. doi:10.1016/j.carrev.2024.08.008.

12. Hasan MM, Dutta AK, Al Mahmood MR, Kanungo S, Rahman A, Hassan MR. Quantitative angiographic radial artery diameter measurement and its relationship with common variables: A cross-sectional study. Medicine (Baltimore). 2025; 104(32):e43797. doi:10.1097/MD.0000 000000043797.

13. Sanketh SJ, Charantimath NV, Kumar S. Relationship between radial artery diameters with incidence of radial artery occlusion after transradial coronary catheterization: an observational cohort study. Sch J App Med Sci. 2024; 12(11):1652-6. doi:10.36347/sjams.2024.v12i11.035.

14. Khan M, Daud MY, Awan MS, Khan MI, Khan H, Yousuf MA. Frequency and predictors of radial artery spasm during coronary angiography/percutaneous coronary intervention. J Ayub Med Coll Abbottabad. 2020; 32(3):357-9. Available from: https://jamc.ayubmed.edu.pk/ index.php/jamc/article/view/7643/2936.

15. Curtis E, Fernandez R, Khoo J, Weaver J, Lee A, Halcomb L. Clinical predictors and management for radial artery spasm: an Australian cross-sectional study. BMC Cardiovasc Disord. 2023; 23(1):33. doi:10.1186/s12872-023-03119-9.

16. Roy S, Kabach M, Patel DB, Guzman LA, Jovin IS. Radial artery access complications: prevention, diagnosis and management. Cardiovasc Revasc Med. 2022; 40:163-71. doi:10.1016/j.carrev.2021.12.007.

17. Abdelrahman AO, Soliman MA, Elkersh AM, Mina MB. Angiographic evaluation of radial artery diameter pre-and post-coronary angiography. EJHM. 2023; 90(1):1365-71. doi:10.21608/ejhm.2023.282151.