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Incidence and risk factors of radial artery spasm during distal radial angiography

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ABSTRACT

Objective: Radial artery spasm (RAS) is a common complication of radial coronary angiography. Our aim was to assess how different risk factors influence the occurrence of RAS during distal radial coronary angiography.

Patients and Methods: A total of 183 consecutive patients undergoing distal radial angiography at 2 centers were included in our study. RAS was defined clinically. The relationship between the demographic and clinical characteristics of the patients and the development of RAS was evaluated.

Results: Radial artery spasm developed in 23 (12.5%) of the patients. While the female sex ratio was higher in those who developed RAS, the mean age was lower ($p<0.001$). In addition, procedure time, number of punctures, access time and percutaneous coronary intervention (PCI) rate were found to be higher in patients who developed RAS ($p<0.001$). Multivariate logistic regression analysis showed that gender, age, access time and number of punctures were independent predictors. In the ROC analysis, procedure and access times were found to predict RAS.

Conclusion: Among patients who underwent distal radial angiography, RAS was found to be more common in women and younger individuals. In addition, prolonged procedure and access times and a high number of punctures increase the possibility of RAS.

Keywords: Distal radial angiography, Radial artery spasm, Number of punctures, Access time, Procedure time

1. INTRODUCTION

Percutaneous coronary angiography is a procedure for the diagnosis and treatment of coronary artery disease. In the past, the femoral artery was the primary access point for angiography [1]. However, as technology has advanced, alternative access sites such as the radial, distal radial and ulnar arteries have become viable options [2].

In 2017, Kiemeneij documented that cannulation of the radial artery in the anatomical snuffbox (AS) is safe and practical [3]. The AS is a recessed area on the radial side of the wrist that protrudes when the thumb is extended. The distal portion of the radial artery runs deep through the AS [4]. As it extends further distally, it transforms into the deep palmar branch of the radial artery and connects with the lower part of the ulnar artery, creating the deep palmar arch of the hand. In the event of obstruction at the AS site, tissue ischemia is prevented by sustained forward flow in the superficial palmar arch and interconnected collateral vessels [5]. This novel approach has the potential to alleviate some of the disadvantages of traditional radial artery cannulation from multiple perspectives.

Radial artery spasm (RAS) is a complication observed during radial angiography that can cause significant pain to the patient and in some cases lead to an unsuccessful angiography procedure [6]. Previous studies have found the incidence of RAS to be between 6.8-30% [7]. RAS results from the abrupt narrowing of the radial artery, which makes it difficult to advance the catheter and can lead to failure of the procedure [8]. In case of procedure failure, alternative access routes are used, resulting in prolonged angiography time and an increased risk of complications associated with the new access route [9]. Several studies have documented that the risk of RAS may be increased by various factors, including patient demographics, the presence of cardiovascular risk factors, radial artery anatomy, and factors related to the procedure [7,10-12]. To reduce the risk of RAS, the use of vasodilators, calcium channel blockers, sedation and analgesic medications is recommended prior to the procedure [13]. It is also recommended to use hydrophilic wires and smaller diameter catheters and to avoid cold intra-arterial injections [14].

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The aim of our study is to determine the incidence and predictors of radial artery spasm development in patients who underwent coronary angiography via the distal radial artery. We also compared the characteristics of patients who developed RAS and who did not develop RAS.

2. PATIENTS and METHODS

A total of 183 patients from 2 centers who underwent distal radial angiography were included in our study. Patients were consecutively selected between April 2021 and May 2022. Patients were divided into 2 groups according to whether they had radial artery spasm or not. The study excluded patients who met the following criteria: acute ST elevation myocardial infarction, hemodynamic instability, cardiogenic shock, use of catheters other than 6 French, patient refusal, and those aged 75 years and older. Due to the unreliability of the assessment of RAS in elderly patients, we decided not to include people over 75 years of age in the study. The procedures were performed by the same interventional cardiologists in each center. Demographic characteristics such as age, gender, body mass index (BM), hypertension, diabetes, chronic obstructive pulmonary disease, chronic renal failure, heart rate and blood parameters, and a brief medical history were obtained from each patient.

All patients had a palpable arterial pulse on the distal radial pulse. After disinfection with povidone-iodine, the forearm was placed on a soft surface while the wrist was placed in ulnar deviation and partial flexion to facilitate palpation and puncture of the artery. The operator stood on the patient's right side to prepare for puncture of the distal radial artery. The access point was the deep palmar artery between the first and second metacarpal bones. After injecting 2 mL of procaine Hcl under the skin at the entry point, the needle was guided to the site with the strongest pulse. After the arterial puncture, a straight 0.018-inch guidewire was carefully passed through the patient's wrist. A hydrophilic radial 6-French sheath was then inserted into the distal radial artery. All patients received 2500 units of unfractionated heparin (50 IU/kg) and 200 µg nitrate via the sheath. Right and left 6-F Judkins catheters were used for diagnostic angiography. In cases where interventional procedures were required, the choice between 6-F Judkins, EBU or Amplatz guide catheters was made based on the nature of the lesion and the individual characteristics of the patient. Once the procedure was completed, the radial sheath was withdrawn and immediate hemostasis was achieved by compression. Patients were closely monitored and observed for the development of radial artery spasm.

Radial artery spasm was determined clinically, and a clinical diagnosis of RAS was made based on the presence of two or more of the following criteria, or one if the operator had administered a second dose of the antispasmodic [15]:

a. Persistent pain in the forearm, b. Pain response to catheter manipulation, c. Pain reaction to sheath withdrawal, d. Difficult catheter manipulation after compression by the radial artery, e. Resistance when pulling out the sheath.

The study was approved by the Diyarbakır Gazi Yaşargil Training and Research Hospital Ethics Committee (date and number: 10/05/2024 and 59).

Statistical Analysis

The data were analyzed using the statistical program SPSS 25.0 (Armonk, NY: IBM Corp.). The Kolmogorov-Smirnov test was used to determine whether each variable was normally distributed. Continuous variables with normal distribution were defined as mean ± standard deviation. Continuous variables with abnormal distribution were defined as median (interquartile range). The Student's t-test was used for variables with normal distribution and the Mann-Whitney U-test for variables with abnormal distribution. The Chi-square test was used for the comparison of categorical variables. Receiver operating characteristic (ROC) analysis was used to test the ability of procedure time and access time to predict RAS and to determine a cutoff value based on the sum of the highest sensitivity and specificity. Univariate and multivariate analyzes with logistic regression models were performed to identify predictors of RAS. A P value < 0.05 was considered significant.

3. RESULTS

A total of 183 patients, including 155 patients with stable angina pectoris and 28 non-ST elevation acute coronary syndrome patients, were included in our study. The patients were 54 women and 129 men, and their mean age was 58.6 years. Percutaneous coronary intervention (PCI) was performed in 52 patients. RAS developed in 23 (12.5%) of the patients. The female sex ratio was significantly higher in patients who developed RAS (60.9% vs. 25.0%, p<0.001). The mean age was lower in patients who developed RAS (51.2±7.9 vs. 59.8±10.8, p<0.001). In addition, procedure time, access time and number of punctures were higher in patients with RAS (52.7±15.2 vs. 38.9±10.9, p<0.001, 75.4±22.6 vs. 50.1±12.4, p<0.001, 2.69±0.87 vs. 1.63±0.64, p<0.001, respectively) (Figure 1). In addition, the PCI rate was found to be higher in patients who developed RAS (65.2% vs. 23.1%, p<0.001). There was no difference between patient groups in terms of characteristics such as hypertension, diabetes mellitus, chronic renal failure, heart rate, laboratory parameters and BMI. The basic demographic characteristics of the patients are shown in Table I.

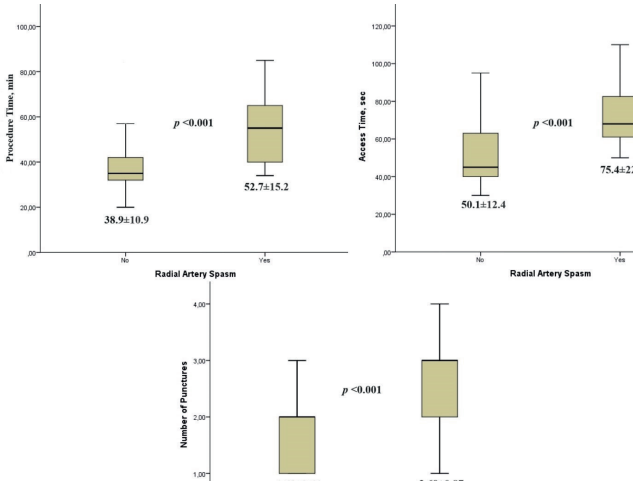

Figure 1. *Comparison of procedure time, access time and number of punctures with box plot in patients with and without radial artery spasm*

Table I. *Basic demographic characteristics of patients*

	RAS(+) n:23	RAS(-) n:160	P Value
Gender (Female), n(%)	14(60.9)	40(25.0)	**<0.001**
Age, (years)	51.2±7.9	59.8±10.8	**<0.001**
Body mass index, (kg/m2)	28.5±4.3	27.4±3.9	0.184
HT, n(%)	11(47.8)	55(34.4)	0.209
DM, n(%)	8(34.8)	47(29.4)	0.597
COPD n(%)	4(17.4)	24(15.0)	0.766
PCI, n(%)	15(65.2)	37(23.1)	**<0.001**
CRF, n(%)	8(34.8)	47(29.4)	0.597
EF, (%)	50.2±10.3	48.8±10.8	0.567
Heart Rate (minute)	87.0±17.9	85.6±17.2	0.718
Systolic Blood Pressure (mmHg)	134.7±16.6	128.4±17.3	0.104
Diastolic Blood Pressure(mmHg)	80.8±12.3	77.8±11.9	0.256
Procedure time, min	52.7±15.2	38.9±10.9	**<0.001**
Access time, sec	75.4±22.6	50.1±12.4	**<0.001**
Number of punctures	2.69±0.87	1.63±0.64	**<0.001**
Hgb(gr/dl)	13.5±1.8	13.8±1.7	0.450
Hct(%)	41.0±5.1	41.7±5.0	0.524
Plt(10e3/uL)	252±69	250±77	0.932
BUN, (mg/dL)	34(26-44)	37(28-45)	0.712
Creatinine, (mg/dL)	0.87(0.74-1.07)	0.87(0.77-1.02)	0.867

RAS: Radial Artery Spasm, HT: Hypertension, DM: Diabetes Mellitus, COPD: Chronic Obstructive Pulmonary Disease, PCI: Percutaneous Coronary Intervention, CRF: Chronic Renal Failure, EF: Ejection Fraction, Hgb: Hemoglobin, Hct: Hematocrit, Plt: platelet, BUN: Blood Urea Nitrogen

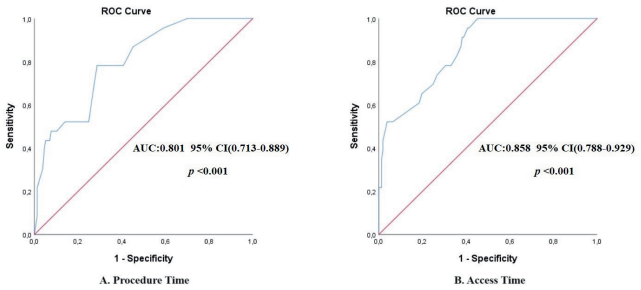

Figure 2. *ROC curve analysis for radial artery spasm prediction using procedure time and access time*

Table II. *Independent determinants of radial artery spasm in univariate and multivariate logistic regression analysis model*

	Univariate analysis			Multivariate analysis		
Radial artery spasm(+)						
	OR	**95%CI**	**p**	**OR**	**95%CI**	**p**
Gender	4.667	1.877-11.601	**0.001**	12.451	1.974-78.527	**0.007**
Age	0.904	0.852-0.959	**0.001**	0.685	0.551-0.852	**0.001**
PCI	6.233	2.451-15.853	**<0.001**	1.469	0.061-35.253	0.813
Procedure time	1.078	1.042-1.114	**<0.001**	1.067	0.952-1.195	0.266
Access time	1.102	1.056-1.150	**<0.001**	1.141	1.036-1.257	**0.007**
Number of punctures	6.514	3.154-13.452	**<0.001**	18.479	2.097-162.842	**0.009**

OR: Odds Ratio, CI: Confident Interval, PCI: Percutaneous Coronary Intervention

Independent predictors of radial artery spasm were determined in univariate and multivariate logistic regression analysis model (Table II). In the univariate analysis, gender (OR:4.667, 95%CI:1.877-11.601, p=0.001), age (OR:0.904, 95%CI:0.852-0.959, p=0.001), PCI (OR:6.233, 95%CI:2.451-15.853, p<0.001), procedure time (OR:1.078, 95%CI:1.042-1.114, p<0.001), access time (OR:1.102, 95%CI:1.056-1.150, p<0.001) and number of punctures (OR:6.514, 95%CI:3.154-13.452, p<0.001) were found to be independent determinants. In the multivariate analysis, gender (OR:12.451, 95%CI:1.974-78.527, p=0.007), age (OR:0.685, 95%CI:0.551-0.852, p=0.001), access time (OR:1.141, 95%CI:1.036-1.257, p=0.007) and number of punctures (OR:18.479, 95%CI:2.097-162.842, p=0.009) were found to be independent determinants. In the ROC analysis, the cutoff value for procedure time of 39.5 predicted radial artery spasm with a sensitivity of 78% and a specificity of 72% [(area under the curve (AUC): 0.801, 95% CI: 0.713-0.889, p<0.001)] (Figure 2A). The cutoff value for access time of 59.0 predicted radial artery spasm with 78% sensitivity and 70% specificity [(area under the curve (AUC): 0.858, 95% CI: 0.788-0.929, p<0.001)] (Figure 2B).

4. DISCUSSION

In our study, 12.5% of patients who underwent coronary angiography via the distal radial artery were found to have radial artery spasm. This was similar to rates reported in the literatüre [7]. We found a higher female gender and PCI rate, lower age, longer procedure and access time, and higher number of punctures in patients who developed RAS.

The use of radial artery access in coronary angiography has come to the fore with low complication rates, high patient satisfaction and rapid recovery times and has become the standard approach in many centers. This method, whose safety and effectiveness has been proven, can provide optimal results with correct patient selection and experienced operators. Some previous studies found distal radial angiography to be superior to the traditional method in terms of patient satisfaction, preservation of radial endothelial functions and preservation of vasomotor functions [16-18]. Another advantage of distal radial angiography is that the process of achieving hemostasis is easier and shorter [19]. Since, the distal radial artery is located closer to the surface on the dorsum of the hand, it requires less pressure for hemostasis. This accelerates the mobilization of patients after the procedure and increases their comfort. Considering all these features, distal radial angiography, which is newer in the radial artery approach, seems to be more advantageous than traditional radial angiography.

The radial artery is a slender blood vessel controlled by alpha-adrenergic nerves. This characteristic makes it prone to spasm, which ultimately leads to the potential failure of medical interventions on this artery [20]. Radial artery spasm is a potential problem associated with the transradial approach and has the potential to impact the procedure at different points. If it occurs at the beginning of coronary angiography, it has the potential to impede the course of the exchange wire. If it occurs in the middle of the procedure, it can cause problems with catheter insertion

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and manipulation. If it occurs at the end of the procedure, it may cause difficulties when trying to withdraw the catheter and sheath. RAS can cause a vasovagal reaction in patients due to the severe pain it causes. It can also lead to procedural delays and, in certain cases, the inability to complete the procedure.

In our study, RAS was found to be more common in women. This situation was consistent with the literatüre [7,10,21]. Mong et al., found that women had greater sensitivity to vasoconstrictors and less sensitivity to vasodilators in their radial arteries compared to men [22]. Furthermore, the smaller size of the radial arteries in women affects the radial artery/sheath ratio, which increases the risk of RAS [7]. As a result of these considerations, some operators opt to initiate the procedure in female patients with smaller diameter catheters. In addition, one of the most important findings of this study is the relationship between patient age and the risk of RAS. Our study shows that younger patients are more prone to RAS during distal radial angiography. The lower prevalence of RAS in the elderly may be due to the physiologic changes associated with aging, including muscle denervation and endothelial dysfunction [8]. However, while some studies support our findings, others, on the contrary, have found a higher rate of RAS in elderly patients [7,8,23]. Therefore, further studies are needed to validate the nature of this association. We also identified procedure time, number of punctures and access time as potential factors contributing to RAS. Our results confirm previous studies [15,24,25]. The first unsuccessful attempt to cannulate the radial artery and subsequent multiple attempts may induce radial artery spasm, which is likely due to muscle structure [26,27]. Longer procedure and access times have the potential to increase RAS by causing more catheter manipulations and more pain.

Healthcare providers should be mindful of these factors and work to facilitate access process and ensure minimal trauma to the radial artery. In light of these findings, healthcare practitioners should consider tailoring their approach to distal radial angiography, taking into account the patient's gender and age, procedure and access times, number of punctures, and potential need for PCI. Preventive measures to reduce RAS, such as smaller diameter catheters or vasodilators, can be used in high-risk situations.

Limitation

Our study included a relatively small number of patients. Some variables that could influence the results (e.g. nutritional status, anxiety level) were not taken into account. The patients' previous experience with angiography or similar procedures was not assessed.

Conclusion

Our study shows that the development of radial artery spasm in patients undergoing distal radial angiography depends on some clinical factors. A closer examination of these factors may help to treat patients better and prevent this complication. Considering these risk factors when cannulating the radial artery may contribute to clinical practice to achieve better outcomes.

Compliance with Ethical Standards

Ethical approval: The study was approved by the Diyarbakır Gazi Yaşargil Training and Research Hospital Ethics Committee (date and number: 10/05/2024 and 59).

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Conflict of interest: The authors declare that they have no potential conflict of interest regarding the investigation, authorship, and/or publication of this article.

Authors contributions: RK: Study design, Data collection, Statistical data analysis, Literature search, Writing the first draft of the manuscript, TG and MD: Data collection, Writing the first draft of the manuscript, Supervision and quality control. All authors read and approved the final version of the article.

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