Angiographic Evaluation of Radial Artery Diameter Pre- and Post- Coronary Angiography

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ABSTRACT

Background: The femoral, radial, or ulnar arteries can be used for coronary angiography, which has emerged as the gold standard for diagnosing and treating coronary artery disease.

Objectives: The aim of the current study is to compare radial artery diameter pre and post-radial coronary angiography by duplex ultrasound to evaluate the effect of pre-medication at the diameter of the radial artery and analyze the predictors that can cause radial artery spam (RAS) to avoid it.

Patients and Methods: A one-arm clinical trial was carried out on 92 patients eligible for trans-radial procedures. All patients were subjected to medical history (demographic data, comorbidities, current medications especially cardiac drugs, and history of ischemic heart disease and its course), clinical examination, echocardiographic data, ECG, laboratory investigations, duplex on radial artery pre and post-trans-radial angiography.

Results: There was a significant statistical difference between radial artery diameter change and the number of radial puncture attempts (P value 0.001). The relation between data of percutaneous coronary intervention (PCI) and radial artery diameter change shows a significant statistical difference in the number of stents used at PCI (P value 0.039). While the guiding catheter used, wires used, the number of balloons used, and the types of stents used showed non-significant statistical differences (P values 0.195, 0.352, 0.995, and 0.434, respectively).

Conclusion: RAS is still an important problem in trans-radial access. During this study, we found the predictors which decrease radial artery diameter change and induced radial artery spasm in patients who underwent trans-radial coronary angiography.

Keywords: Angiographic evaluation, Radial artery diameter, Coronary angiography, Duplex ultrasound.

INTRODUCTION

Although coronary artery disease (CAD) has long been regarded as one of the leading causes of illness and mortality in affluent nations, coronary angiography has helped to reduce mortality rates [1].

The femoral, radial, or ulnar arteries can be used to conduct coronary angiography, which has emerged as the gold standard for the diagnosis and management of coronary artery disease [2].

Due to its safety, cost-effectiveness, short hospital stay, patient comfort in early ambulation, and lower risk of complications, the radial artery has emerged as the preferred conduit for coronary angiography and procedures [3]. However, the radial artery has a thick wall and is mostly made of layers of smooth muscle cells. Patients need appropriate anesthesia since the significant muscular component of the artery and the high density of alpha-1 receptors make this conduit particularly prone to spasms [4].

The biggest issue we still encounter during transradial coronary angiography is this spasm, which is uncomfortable for the patient and lowers the success percentage of the operation [5]. Numerous variables, including gender (female), the radial artery's angiographic features (small radial artery diameter), clinical diseases (DM), and procedure-related variables, were discovered to be connected to radial artery spasms [6]. Therefore, patients undergoing percutaneous coronary intervention (PCI) or coronary angiography should be assessed for primary trans-radial access; the palpation of an appropriate radial pulse volume in the right wrist is a sign of the simplicity of the Trans radial angiogram. The main factor affecting accessibility and the prevention of spasms is radial artery size [7].

The incidence of RAS is greatly decreased and patient comfort is maximized during catheter manipulation when introducer sheaths and catheters with hydrophilic coating are used [8].

The aim of the current study is to compare radial artery diameter pre and post-radial coronary angiography by duplex ultrasound to evaluate the effect of pre-medication at the diameter of the radial artery and analyze the predictors that can cause RAS to avoid it.

PATIENTS AND METHODS

A one-arm clinical trial was carried out on 92 patients eligible for trans-radial procedures, who attended to the Catheter Lab of Menoufia University Hospital (Menoufia, Egypt) during the period from September 2021 to August 2022.

Patients with absent radial pulsation, abnormal Allen's test, and Patient refusal were excluded from the study.

All patients were subjected to medical history (demographic data, comorbidities, current medications especially cardiac drugs, and history of ischemic heart disease and its course), clinical examination, echocardiographic data, ECG, laboratory investigations, duplex on radial artery pre and post-trans-radial angiography.

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ECG: For detecting the rhythm of heartbeats.
Echocardiographic data: Global contractility status, ejection fraction, segmental wall motion abnormalities, diastolic dysfunction, and valvular lesions.

Duplex on radial artery: pre-trans-radial angiography to determine the diameter of the radial artery.

Procedure details:
a) Allen's tests.
b) Pre-medication.
c) Number of radial puncture attempts.
d) Right or left access.
e) Sheath Size.
f) Size of a catheter.
g) Diagnostic coronary angiography only or coronary intervention.
h) Diagnostic catheters.
i) Guiding catheters.
j) Wires used.
k) Numbers of balloons used.
l) Numbers and types of stents used.
m) Procedure time.
n) Volume of contrast.
o) Procedural success: primary or secondary.

Repeat radial artery duplex: For detecting a change in radial artery diameter.

Study Endpoints: The study endpoint of the procedure is the occurrence of RAS and the detection of predictors of RAS during trans-radial coronary angiography and coronary intervention.

Ethical Considerations:
This study was ethically approved by the Research Ethics Committee of the Faculty of Medicine, Menoufia University. Written informed consent was obtained from all participants. This study was executed according to the code of ethics of the World Medical Association (Declaration of Helsinki) for studies on humans.

Statistical Analysis:
The collected data were introduced and statistically analyzed by utilizing the Statistical Package for Social Sciences (SPSS) version 23 for windows. Qualitative data were defined as numbers and percentages. Chi-Square test and Fisher's exact test were used for comparison between categorical variables as appropriate. Quantitative data were tested for normality by Kolmogorov-Smirnov test. Normal distribution of variables was described as means and standard deviation (SD) or median and ranges, and independent sample t-test/Mann-Whitney U test was used for comparison between groups. For the purpose of predicting the risk of RAS, a logistic regression analysis was performed. P value ≤0.05 was considered to be statistically significant.

RESULTS
Table 1 shows demographic data, socio-demographic data, risk factors, laboratory data and sonographic data.

Table (1): Demographic data, socio-demographic data, risk factors, laboratory data, and sonographic data.

Variable		Patients (n=92)
Age (years)		51.58 ± 8.81
Height (cm)		171.52 ± 9.23
Weight (kg)		83.71 ± 10.25
BMI		28.61 ± 4.15
Socio-demographic data and risk factors		
Sex	**Male**	33 (35.9%)
	Female	59 (64.1%)
HTN		46 (50%)
DM		31 (33.7%)
Smoker		32 (34.8%)
Hyperlipidemia		55 (59.8%)
IHD		49 (53.3%)
PVD		3 (3.3%)
CKD		0 (0.0%)
CHF		20 (21.7%)
Prior CABG		0 (0.0%)
Prior PCI		19 (20.7%)
Prior MI		7 (7.6%)
RWMA	Lateral	41 (44.6%)
	Anterior, Anterolateral	51 (55.4%)
Valvular lesion		62 (67.4%)
ECG	Sinus rhythm	77 (83.7%)
	AF	15 (16.3%)
Laboratory data and sonographic data		
LVEF%		56.61 ± 8.64
Hb g/dl		12.76 ± 1.28
TLCs 10X3		7.49 ± 1.30
PLT		253.2 ± 63.09
Serum Creatinine		0.91 ± 0.19
Radial diameter pre. (mm)		2.3 ± 0.14
Radial diameter post. (mm)		2.47 ± 0.37
Diameter change. (mm)		0.17 ± 0.04

Data are represented by mean ± SD or frequency (%), HTN: Hypertension, DM: Diabetes Mellitus, IHD: Ischemic Heart Disease, PVD: Peripheral vascular disease, CKD: Chronic Kidney Disease, CHF: Congestive Heart Failure, CABG: Coronary Artery Bypass Graft, PCI: Percutaneous Coronary Intervention, MI: Myocardial infarction, RWMA: Regional Wall Motion Abnormality, ECG: Electrocardiogram, AF: Atrial Fibrillation, LVEF: left ventricle Ejection fraction, Hb: Hemoglobin, TLCs: Total Leucocytic Count, PLT: Platelets.

Table 2 shows medications used before the procedure, data of coronary angiography, procedure details, and data of PCI.

Table (2): Medications used before the procedure, data of coronary angiography, data of PCI, and procedure details.

Medications used before the procedure		**Patients (n=92)**
Antiplatelets		64 (69.6%)
Anticoagulant		15 (16.3)
Antiangina		27 (29.3%)
ACEI/ARB		41 (44.6%)
BB		50 (54.3%)
CCB		0 (0.0%)
Cholesterol-lowering agents		49 (53.3%)
Hypoglycaemic agents		31 (33.7%)
Data of coronary angiography		
Previous use of radial approach		9 (9.8%)
Allen's test intact or not		92 (100%)
Local ana. Xylocaine only oGr add tridill		0 (0.0%)
Needle (cm)	4	92 (100%)
Direct insertion of the needle		0 (0.0%)
Right or left access	Right	92 (100%)
Sheath size (F)	6	92 (100%)
Anti-Spasm medications (NTG)		92 (100%)
Size of the catheter (F)	6	92 (100%)
Number of radial punctures attempts	1	52 (56.5%)
	2	31 (33.7%)
	3	6 (6.5%)
	4	3 (3.3%)
Diagnostic catheter type	JR 3.5	18 (20%)
	JR3.5 and JL 3.5	42 (46.7%)
	JR 3.5 and JL 4	30 (33.3%)
Procedure Detail		
Procedure time		31.03 ± 20.73
Volume of contrast		175.82 ± 112.87
Data of PCI		
GC	No	47 (51.1%)
	Judkin	23 (25%)
	EBU	8 (8.7%)
	XB	14 (15.2%)
Wire used	No	47 (51.1%)
	Asahi	16 (17.4%)
	BMW	22 (23.9%)
	pt2 ms	7 (7.6%)
Balloon	0	59 (65.6%)
	1	14 (15.2%)
	2	15 (16.7%)
	3	2 (2.2%)
Number of stents	0	47 (52.2%)
	1	25 (27.8%)
	2	16 (17.8%)
	3	2 (2.2%)
Type of stent	No	47 (52.2%)
	Promus	16 (17.8%)
	Resolute	2 (2.2%)
	Ultimaster	9 (10%)
	Xience	16 (17.8%)
Radial artery spasm		34 (37%)
Procedural success		89 (96.7%)
Note	PCI	43 (47.8%)
	C.A	47 (52.2%)

Data are represented by mean ± SD or frequency (%), ACEI: Angiotensin Converting Enzyme inhibitor, ARB: Angiotensin Receptor Blocker, BB: Beta Blocker, CCB: Calcium Channel Blocker, JR: Judkin Right, JL: Judkin Left, PCI: Percutaneous Coronary Intervention, AF: Atrial Fibrillation, GC: Guiding Catheter.

The relation between socio-demographic data with diameter change there was a significant statistical difference with age and BMI (P values <0.001 and 0.020, respectively).

The relation between Socio-demographic data, risk factors, and diameter change there was a non-significant statistical difference except at gender especially females and smokers (P values 0.049 and 0.027, respectively). Relation between medication used and diameter change, the significant statistical difference in patients who used beta-blockers (P-value <0.001), while no significant statistical difference at other values such as antiplatelets, anticoagulant, antianginal, ACEI and ARB, cholesterol-lowering agents, and hypoglycemic agents (P-values 0.772, 0.441, 0.165, 0.093, 0.612 and 0.914, respectively) **(Table 3).**

Table (3): Relation between socio-demographic data, risk factors, and diameter change, and relation between medication used and diameter change

Variable		**Diameter change**	
			P value
Sex	Male	0.40 (-0.70-1.00)	0.049
	Female	0.30 (-0.80-0.80)	
HTN	Yes	0.25 (-0.80-1.00)	0.937
	No	0.30 (-0.70-0.80)	
DM	Yes	0.30 (-0.60-1.00)	0.914
	No	0.30 (-0.80-0.90)	
Smoker	Yes	-0.10 (-0.60-0.80)	0.027
	No	0.30 (-0.80-1.00)	
Hyperlipidaemia	Yes	0.30 (-0.80-1.00)	0.908
	No	0.30 (-0.40-0.70)	
IHD	Yes	0.30 (-0.60-1.00)	0.469
	No	0.30 (-0.80-0.90)	
PVD	Yes	-0.20 (-0.30-0.50)	0.572
	No	0.30 (-0.80-1.00)	
CKD	No	0.30 (-0.80-1.00)	----
CHF	Yes	0.40 (-0.70-1.00)	0.051
	No	0.30 (-0.80-0.90)	
Prior CABG	No	0.30 (-0.80-1.00)	-----
Prior PCI	Yes	0.30 (-0.40-1.00)	0.662
	No	0.30 (-0.80-0.90)	
Prior MI	Yes	-0.10 (-0.40-0.50)	0.276
	No	0.30 (-0.80-1.00)	
RWMA	Lateral	0.30 (-0.80-0.90)	0.479
	Ant, Anterolat.	0.30 (-0.70-1.00)	
Valvular lesion	Yes	0.30 (-0.80-1.00)	0.880
	No	0.30 (-0.40-0.70)	

Variable		Diameter change	P value
ECG	Sinus rhythm	0.30 (-0.80-1.00)	0.361
	AF	0.40 (-0.70-0.50)	
Medication used			
Antiplatelets	Yes	0.30 (-0.60-1.00)	0.772
	No	0.30 (-0.80-0.60)	
Anticoagulants	Yes	0.30 (-0.70-0.50)	0.441
	No	0.30 (-0.80-1.00)	
ANTIANGINAL	Yes	0.10 (-0.60-1.00)	0.165
	No	0.30 (-0.80-0.90)	
ACEI/ARB	Yes	-0.10 (-0.80-1.00)	0.093
	No	0.30 (-0.70-0.90)	
BB	Yes	0.40 (-0.40-1.00)	<0.001
	No	-0.20 (-0.80-0.80)	
CCB	No	0.30 (-0.80-1.00)	----
Cholesterol-lowering agents	Yes	0.30 (-0.60-1.00)	0.612
	No	0.30 (-0.80-0.90)	
Hypoglycemic agents	Yes	0.30 (-0.60-1.00)	0.914

Data are represented by median (range), HTN: Hypertension, DM: Diabetes Mellitus, IHD: Ischemic Heart Disease, PVD: Peripheral vascular disease, CKD: Chronic Kidney Disease, CHF: Congestive Heart Failure, CABG: Coronary Artery Bypass Graft, PCI: Percutaneous Coronary Intervention, MI: Myocardial infarction, RWMA: Regional Wall Motion Abnormality, ECG: Electrocardiogram, ACEI: Angiotensin Converting Enzyme inhibitor, ARB: Angiotensin Receptor Blocker, BB: Beta Blocker, CCB: Calcium Channel Blocker.

The relation between data of coronary angiography and diameter change, this table shows that significant statistical difference in the Number of radial puncture attempts (P-value 0.001).

The relation between data of PCI and diameter change shows a significant statistical difference in the number of stents used at PCI (P-value 0.039).

But the guiding catheter used, wires used, the number of balloons used, and the types of stents used show a non-significant statistical differences with P values 0.195, 0.352, 0.995, and 0.434, respectively **(Table 4)**.

Table (4): Relation between data of coronary angiography and diameter change and relation between data of PCI and diameter change.

Variable		**Diameter change**	P value
Previous use of radial approach	Yes	0.50 (-0.40-0.80)	0.070
	No	0.30 (-0.80-1.00)	
Allen's test intact or not	Yes	0.30 (-0.80-1.00)	-----
Local ana. Xylocaine only or add tridill	No	0.30 (-0.80-1.00)	-----
Needle (cm)	4	0.30 (-0.80-1.00)	-----
Direct insertion of the needle	Yes	0.30 (-0.80-1.00)	-----
Number of radial punctures attempts	1	0.40 (-0.60-1.00)	0.001
	2	-0.10 (-0.70-0.70)	
	3	-0.25 (-0.40-)0.40	
	4	-0.20 (-0.80--0.10)	
Right or left access	Rt	0.30 (-0.80-1.00)	-----
Sheath size (F)	6	0.30 (-0.80-1.00)	-----
Anti-spasm medications (NTG)	Yes	0.30 (-0.80-1.00)	-----
Size of the catheter (F)	6	0.30 (-0.80-1.00)	-----
Diagnostic catheter type	JR 3.5	0.35 (-0.60-0.70)	0.474
	JR 3.5 & JL 3.5	0.20 (-0.40-1.00)	
	JR 3.5 & JL 4	0.30 (-0.40-0.80)	
GC	No	0.30 (-0.70-1.00)	0.195
	judkin	-0.10 (-0.40-0.70)	
	EBU	0.45 (0.20-0.60)	
	XB	0.20 (-0.80-0.80)	
Wire used	No	0.30 (-0.70-1.00)	0.352
	Asahi	-0.10 (-0.40-0.50)	
	BMW	0.30 (-0.80-0.80)	
	pt2 ms	0.40 (-0.40-0.70)	
Number of Balloons	0	0.30 (-0.80-1.00)	0.995
	1	0.30 (-0.40-0.80)	
	2	0.30 (-0.40-0.70)	
	3	0.30 (0.20-0.40)	
Number of stents	0	0.30 (-0.70-1.00)	0.039
	1	0.10 (-0.40-0.70)	
	2	0.50 (-0.80-0.80)	
	3	-0.25 (-0.30--0.20)	
Types of stents	No	0.30 (-0.70-1.00)	0.434
	Promus	0.40 (-0.80-0.80)	
	Resolute	0.40 (0.30-0.50)	
	Ultimaster	-0.20 (-0.40-0.70)	
	Xience	0.30 (-0.30-0.70)	

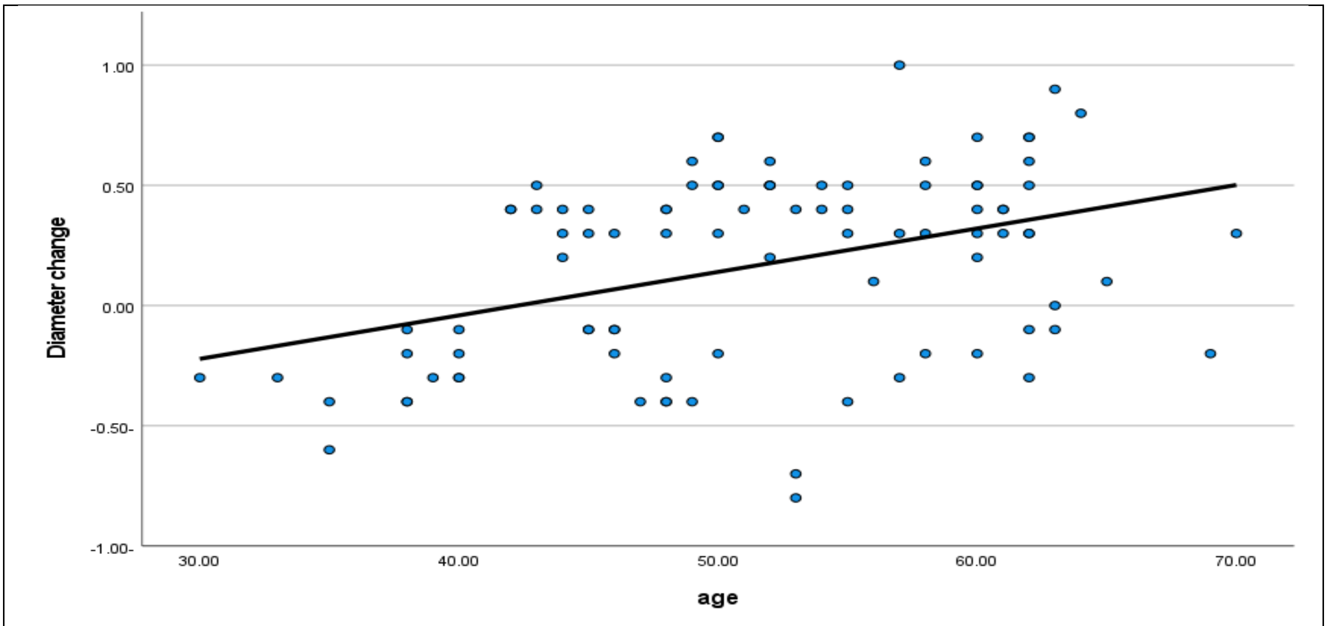
Data are represented by median (range), PCI: Percutaneous Coronary Intervention, GC: Guiding Catheter.

Table 5 shows the relation between procedure time, the volume of contrast, and diameter change. There was a non-significant statistical difference, as the P value of procedure time was 0.167, and the P value of the volume of contrast was 0.722.

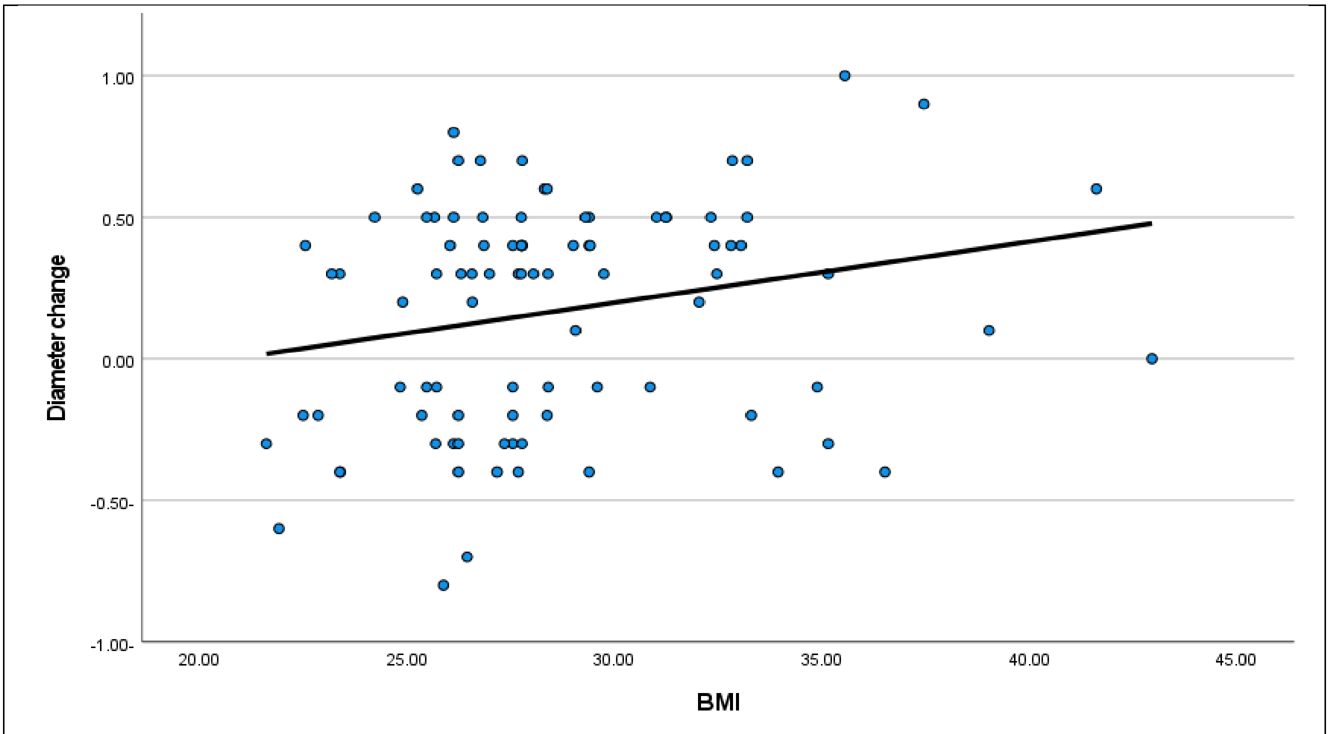
The relation between socio-demographic data with diameter change there was a significant statistical difference with age and BMI (P values <0.001 and 0.020, respectively) **(Figure 1).**

Table (5): Relation between procedure time, the volume of contrast, and diameter change.

Variable	Diameter change		
	Correlation Coefficient	**P value**	**N**
Procedure time	-0.145-	0.167	92
volume of contrast	-0.038-	0.722	92



(A)



(B)

Figure (1): Relation between diameter change, and (A) age, (B) BMI.

DISCUSSION

For the diagnosis of atherosclerotic coronary artery disease and the development of treatment plans, coronary angiography has emerged as the gold standard. It is possible to do coronary angiography through the femoral, radial, or ulnar arteries. For coronary angiography and angioplasty procedures, the common femoral artery has traditionally been the preferred entry location. However, because to radial access' lower risk of complications, the European Society of Cardiology Guidelines on Myocardial Revascularization suggested using this method as the norm for coronary angiography and angioplasty [2].

In our study, regarding the relationship between age and the change in radial artery diameter, there was a highly significant positive relationship between age and the change in radial artery diameter; as in the younger patients, radial artery diameter decreased and spasms occurred more frequently and vice versa (P-value <0.001). This can be explained by the higher sympathetic tone and concentration of circulating catecholamines in younger patients, leading to increased vascular tone.

This finding agreed with the **Jia *et al.*** [9] study which recorded the incidence of RAS in 1427 patients arranged to receive trans-radial coronary angiography and intervention, which reported a statistically significant relationship between young age and radial artery spasm (P-value 0.038).

Regarding the relation between BMI and change in radial artery diameter, there was a significant positive relationship between BMI and the change in radial artery diameter (P-value 0.020). This can be explained by the smaller radial artery diameter with a low BMI.

Our finding agreed with **Aykan *et al.*** [10] study which recorded the incidence of RAS in 222 patients arranged to receive trans-radial coronary angiography and intervention, which reported a statistically significant relationship between BMI and radial artery spasm (P-value 0.013).

Regarding the relation between other Socio-demographic data and change in radial artery diameter, there was a significant relationship between gender (specially females) and change in radial artery diameter (P-value 0.049), and this can be explained by females having small radial artery diameter, which increase the rate of radial artery spasm during trans-radial coronary angiography and females were more anxious with more stimulation of catecholaminergic receptors.

Our finding was in agreement with **Khan *et al.*** [11] study which recorded RAS in 136 patients who underwent trans-radial coronary angiography, which reported a statistically significant relationship between female gender and radial artery spasm (P-value <0.05).

Also, our finding agreed with **Kanazawa *et al.*** [12] study, which found that 140 patients (25%) out of the 558 patients who had follow-up radial artery angiography (RAG) showed radial artery damage. Radial artery stenosis (RAS) in its localized form affected seven patients (1%), RAS in its diffuse form affected 78 patients (14%), and RAO affected 55 individuals (10%). In comparison to patients without RAS/RAO, individuals with RAS/RAO were more likely to be female and had lower body mass indices.

Regarding the relation between smoking and change in radial artery diameter, there was a significant relationship between smoking and change in radial artery diameter (P-value 0.027), and this is explained by increasing circulating catecholamines with smokers, which stimulate α-1-adrenoreceptors that induce vasospasm.

Our finding was in agreement with **Jia *et al.*** [9] study, which reported a statistically significant relationship between smoking and radial artery spasm (P-value 0.019).

Regarding the relation between medication used and change in radial artery diameter, there was a highly significant positive relationship between the usage of Beta-blockers and change in radial artery diameter (P-value <0.001), as in patients who used oral Beta Blockers, radial artery diameter change increase and rate of spasm decrease. This can be explained by the $Ca2+$-activated $K+$ channels and the relaxation induced by Beta blockers was related to nitric oxide release.

Our finding agreed with **Gohar Eslami's** [13] study which enrolled 64 patients who underwent diagnostic radial angiography, which reported a statistically significant relationship between the usage of Beta-blockers and increasing in radial artery diameter (P-value <0.001).

Regarding the relation between data of coronary angiography and change in radial artery diameter, there was a significant negative relationship between the number of radial punctures attempts and change in radial artery diameter (P-value 0.001), where multiple radial punctures attempts induced decreasing in radial artery diameter which induce spasm. This can be explained by injury or hematoma stimulating α-1 receptors that are activated through catecholamines causing vasospasm.

Our finding was in agreement with **Jia *et al.*** [9] study which investigated the incidence of RAS during trans radial procedures and reported a statistically significant relationship between unsuccessful access at the first attempt and radial artery spasm (P-value 0.032).

Regarding the relation between data of PCI and change in radial artery diameter, there was a significant negative relationship between the number of stents inserted and change in radial artery diameter (P-value 0.039), where excessive catheter manipulation, excessive stents insertion, and sheath mobilization induced radial artery spasm.

Our finding agreed with **Backman *et al.*** [14] study which recorded RAS and its association with trans-radial cardiac catheterization and percutaneous coronary intervention.

Also, our finding agreed with **Ho *et al.*** [15] study recorded incidence, predisposing factors, prevention, and management of Radial artery spasm during trans-radial cardiac catheterization and percutaneous coronary intervention, which reported that an increasing number of catheters used during trans-radial cardiac catheterization one of the risk factors induced radial artery spasm.

In our study, regarding the relationship between risk factors and change in radial artery diameter, there was no statistically significant difference between hypertensive and non-hypertensive patients, also between diabetic and non-diabetic patients with a change in radial artery diameter, with P values 0.937 and 0.914, respectively.

Our finding agreed with **Okuyan *et al.*** [16] study, which aim to determine the radial artery diameter through angiography of 97 patients arranged for radial interventions, which reported that the diameters were similar in hypertensive and normotensive patients and diabetic and non-diabetic patients.

In addition, **Kanazawa et al** [12] demonstrated that the proportion of patients with a history of PCI, hypertension, dyslipidaemia, diabetes, and the acute coronary syndrome was not significantly different between patients with and without RAS.

However, our finding disagreed with the **Kristić and Lukenda** [17] study, which aim to estimate the prevalence and possible risk factors of RAS in patients undergoing the trans-radial coronary procedure at 7197 patients, which reported that diabetes was one of the predictors of radial artery spasm. This difference may be due to the small sample size of our study.

CONCLUSION

RAS is still an important problem in trans-radial access, during this study we found the predictors which decrease radial artery diameter change and induced radial artery spasm in patients who underwent trans-radial coronary angiography. The main predictors were young age, low BMI, females, smoking, patients who had not used beta-blockers, an increase in the number of radial puncture attempts, and finally increase in the number of stents inserted.

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