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Incidence and Predictors of Radial Artery Spasm in Transradial Coronary Angiography

Dr Sonu Sharma[1], Dr Avadhesh Narayan Khare[2]

[1]Consultant Cardiologist DHI Bhatinda, Punjab

[2]Consultant cardiologist J.K. hospital and L.N. Medical College, Bhopal

Abstract: ***Introduction: The occurrence of radial artery spasm (RAS) during angiography offsets the advantages of this route of access, increasing the degree of patient discomfort and reducing the chances of a successful catheterization. Aims and Objectives: To estimate the incidence of Radial artery spasm in patients undergoing transradial coronary angiography and to assess the predictors of Radial artery spasm in coronary angiography. Study Design: Prospective observational study. Observations and Results: During study 26.3% patients develop radial artery spasm. 15.3% develop radial artery occlusion. Female sex in an independent predictor of RAS with significant p-value (<0.001) Radial artery spasm was smokers/non smokers was statistically significant (p=0.002), more common in diabetics and difference was statistically significant. Difference in alcoholics was not significant. Patients in whom >1 catheter / single catheter, was statistically significant (p=<0.001). Left radial / Right radial approach was not statistically significant (p=0.318).Mean pain score of patients which develop /which not RAS develop was statistically significant (p=<0.001). The mean duration and length of procedure to complete a transradial angiography in patients who develop RAS and who do not develop RAS was statistically significant (p=<0.001). Conclusion: Radial artery spasm undergoing transradial coronary angiography, but it usually doesn't lead to any serious complication and angiography could be completed successfully even in patients with radial artery spasm. Female sex, short height, small body surface area, diabetes, increase length of procedure, >1 attempt to cannulate radial artery, increase pain during cannulation and >1 catheter use during angiography are important predictors of RAS.***

Keywords: Radial artery spasm, Transradial coronary angiography, Predictors of RAS

1. Introduction

The history of radial artery intervention appears to date back to 1989 when Campeau et al[1]first performed 100 catheterizations viatransradial approach. He was successful in 88 patients and this marked the beginning of a new era.

The first transradial PTCA was done by Ferdinand Kiemeneij in 1992[2, 3].

More than 20 years after the introduction, now radial access for cardiac catheterization is being adopted by a growing number of interventional cardiologists[4, 5].

Worldwide, an estimated 20% of procedures are performed by this route. Although, there is considerable variation across Europe and Asia/Australia, these regions have the highest uptake of radial access at 30% and 40% of procedures, respectively. The countries with the highest rates of radial access (70–80%) are Norway, Malaysia, and Bulgaria. in U.S. 16.1% procedures are done transradially[6, 7].In India 32% procedures done by transradial route. radial approach to angiography and intervention has emerged internationally as the preferred alternative to the traditional femoral approach[8]. Multiple observational and randomized trials performed to date have shown an association between radial access and reduced risk for bleeding and vascular complications[9]. Other studies have shown an association between radial approach and reduced costs[10], increased patient satisfaction[11, 12], and reduced mortality in high-risk patient subgroups like those with ST-segment elevation myocardial infarction (STEMI)for patients who have experienced both radial and femoral access, there is a strong preference for the radial approach due to increased functioning and less discomfort [13, 14].

In comparison with femoral access, the radial route is safer, reduces patient discomfort, fewer local complications, major bleedings, ischemic events, and major adverse events with similar rates of procedural success[15, 16, 17].

The radial artery is a thick- walled vessel composed mainly of smooth muscle cells arranged in concentric layers, type 111 artery. This marked muscular component of the artery, together with the high density of alpha-1 receptors, makes this vessel especially susceptible to spasms[18].

The occurrence of radial artery spasm offsets the advantages of this route of access, increasing the degree of patient discomfort and reducing the chances of a successful catheterization. Even in centers where there is extensive experience with the radial route, radial spasm occurs in 15% to 30% of the procedures[19].

The incidence of radial artery spasm varies greatly among different centers due to the inconsistency in prophylactic therapy and criteria for diagnosis. The SPASM study shows that young and female are the independent predictors of radial artery spasm. Other studies show that the diameter of radial artery and diabetes mellitus are the predictors of radial artery spasm. So far, there is no large scale study on the predictors of radial artery spasm.

The aim of this study is to estimate the incidence radial artery spasm and possible factors that could influence radial artery spasm.

Other important problem with radial access is Radial artery occlusion (RAO). It has been reported at rates ranging from 5% to 38% in several studies. Anticoagulant dose, gender, the patient's body weight, the diameter of the radial artery,

sheath size, the number of catheters, procedure duration, hemostatic compression method, and compression time after the procedure are some of the factors associated with RAO[20].

2. Materials and Methods

Study Design
This was a hospital based prospective observational study conducted in the Department of Cardiology, Vardhman Mahavir Medical College & Safdarjung Hospital, New Delhi.

Angiography was done as per the department protocol under full aseptic condition.

A modified Allen's test was used as the standard radial ischemic test to verify a patent superficial ulnar arterial system, patients with negative test on both side were excluded from study. Right wrist was prepared and draped using standard sterile technique. Inj. Lignocaine 2 % 1-2 ml was used as local anesthetic. The radial artery was cannulated using a modified Seldinger technique with a 20-gauge arterial needle and a 0.021-inch guide wire was advanced. The needle was removed, a small skin incision was made at the point of entry, and then a 6 French introducer hydrophilic sheath with a tapered dilator was advanced over the guide wire into position.6F Hydophilic coated sheaths11 cm long (Lepu Medical) were used.

An initial intra-arterial vasodilator cocktail of nitroglycerin (100-200mcg) andDiltiazem2.5mg, (depending on systemic blood pressure) was administered, along with 2500 units of intraarterial heparin.5F TIG (Terumo Corporation) catheter 100cm long was used for angiography. All introducer sheaths, guide catheters, and wires were removed immediately following the procedure, and hemostasis was directly obtained with pressure bandage.

Patients in whom sheath was successfully inserted and lytic cocktail given were taken in this study.

Radial spasm is assessed on the basis of a questionnaire addressing the following five signs:
- Persistent forearm pain,
- Pain response on catheter manipulation,
- Pain response to introducer withdrawal,
- Difficult catheter manipulation after being "trapped" by the radial artery,
- Considerable resistance on withdrawal of the introducer.

Patients pain on puncture and insertion of the sheath was rated on NRS-6 scale (Numerical Rating Scale) as 0 to 5, with 0 representing no pain at al and 5 representing worst imaginable pain.
- 0 = no pain.
- 1= mild pain.
- 2 = moderate pain.
- 3 = severe but tolerable pain.
- 4 = severe, intolerable pain and needed medication.
- 5 = severe pain needing to abandon the procedure.

Radial spasm was considered to be present if

1) At least 2 of these 5 features are present
2) Or by the presence of just 1 when it necessary to administer a second dose of the spasmolytic agent.

Various predictors of radial artery spasm that are evaluated in this study were:

1) Female sex.
2) Younger age.
3) Lower BMI.
4) Diabetes.
5) Unsuccessful first attempt of cannulation.
6) Painful cannulation of radial artery.
7) Duration of procedure.
8) Number of catheters exchanged.

Study Period
The study was conducted over a period of one and a half year, from December 2013 to May 2015.

Study Population
501patients (n=501) who coronary angiography was done through radial route were included in this study.

Inclusion Criteria
- Patients with positive modified Allen's test who are candidates for coronary angiography
- Patients of 18 to 80 years of age who underwent transradial coronary angiography.

Exclusion Criteria
- Patients in whom Modified Allen's test was negative on both sides.
- Patients in whom femoral angiography was done.
- Patients in whom radial artery cannulation failed on both sides.

Follow Up
Patency of radial artery was assessed 1-3months after the procedure via the following measures by an independent operator:
1) Reverse Allen's test.
2) Radial artery doppler.

Statistical Analysis
501 patients who fulfill the inclusion criteria were included in the study. Incidence rate of radial artery spasm was calculated by taking the ratio of new diagnosed radial artery spasm cases divided by total number of cases in study and multiplying by 100, along with there 95 % confidence interval.

The significant predictors of radial artery spasm were detected by comparing radial artery spasm cases with subsample of non radial artery spasm cases included in this study.

The statistical significance of quantitative variables was determined by unpaired t test/ non parametric Mannwhitney test. Body surface area was calculated using Mosteller formula An optimum combination of significant predictors of radial artery spasm was determined by multivariant logistic regression analysis.

The level of statistical significance was taken as P <0.05.

Data analyzed by using SPSS version 18.0 statistical software.

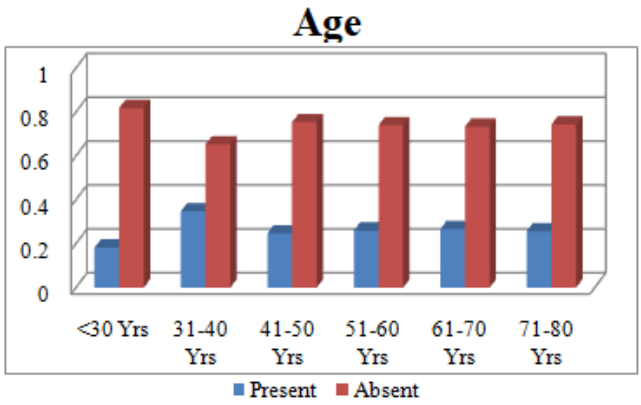
3. Observations and Results

This study recruited a total of 501 patients

Spasm
During study 132 (26.3%) patients develop radial artery spasm.

Table 1: Spasm during transradial coronary angiography

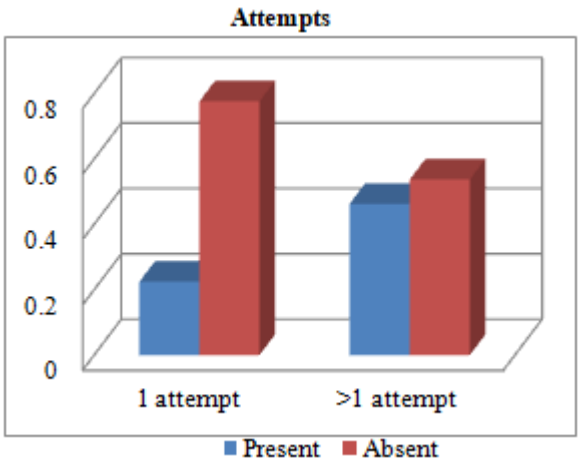
Spasm	Number (n=501)	Percent (%)
Present	132	26.3
Absent	369	73.7
Total	501	100



Radial artery occlusion
Out of 501 patients in study, 30 patients were lost to follow up and out of remaining 471 patients 72 (15.3%) develop radial artery occlusion on follow up while in 399 (84.7%) patients radial artery was patent

Table 2: Radial artery occlusion

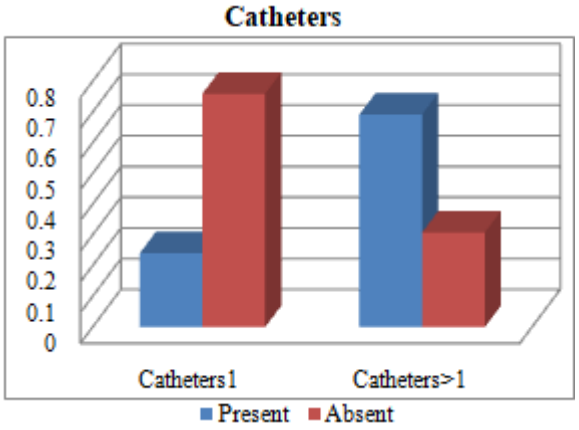
Radial artery	Number (n=471)	Percent (%)
Occlusion	72	15.3
Patent	399	84.7
Total	471	94
Lost to follow up	30	6
	501	100



Age distribution of patients with /without spasm
There was no significant relationship between any particular age group with development of radial artery spasm

Table 3: Age distribution of patients with /without spasm

Age	Spasm Present Number (%)	Total	p-value
<30 Yrs	2 (18.2%)	11 (100.00%)	0.81
31-40 Yrs	16 (34.78%)	46 (100.00%)	
41-50 Yrs	37 (24.67%)	150 (100.00%)	
51-60 Yrs	40 (25.97%)	154 (100.00%)	
61-70 Yrs	28 (26.67%)	105 (100.00%)	
71-80 Yrs	9 (25.71%)	35 (100.00%)	
Total	132 (26.35%)	501 (100.00%)	



Sex distribution of patients with /without spasm
44.96% (58) female patients develop radial artery spasm, while only 19.89 % (74) male patients develop spasm, female sex in an independent predictor of radial artery spasm with significant p-value (<0.001)

Table 4: Sex distribution of patients with /without spasm

Sex	Spasm		Total	p-value
	Present	**Absent**		
Male	74 (19.89%)	298 (80.11%)	372 (100%)	**<0.001**
Female	58 (44.96%)	71 (55.04%)	129 (100%)	
Total	132 (26.35%)	369 (73.65%)	501 (100%)	

Demographic Factors
In this study mean age of patients who develop radial artery spasm was 54.01±11.28, while it was 53.88±11.14 in those who does not develop spasm p-value was non significant (p=0.909).Mean weight of patient who develop spasm was 64.05±11.99 while it was 65.51±10.96 slightly more in patients who does not develop spasm but this difference was non significant (p=0.2). BMI in patients with spasm was 25.43±4.43 and patients without spasm were 24.96±3.81. Mean height of patients who develop spasm was 158.74±9.12 and mean height of patients who do not develop spasm was 162.02±8.82 & this difference was statistically significant (**p=<0.001).**Mean BSA of patients who develop RAS was 1.67±0.19 and mean BSA of patients without spasm was 1.71±0.17 and this difference was statistically significant **(p=0.035)**

Table 5: Demographic Factors

	Spasm	N	Mean	Std. Deviation	t-value	p-value
Age	Present	132	54.01	11.28	0.114	0.909
	Absent	369	53.88	11.14		
Weight	Present	132	64.05	11.99	1.283	0.2
	Absent	369	65.51	10.96		
Height	Present	132	158.74	9.12	3.678	**<0.001**
	Absent	369	162.06	8.82		
BMI	Present	132	25.43	4.43	1.172	0.242
	Absent	369	24.96	3.81		
BSA	Present	132	1.67	0.19	2.12	**0.035**
	Absent	369	1.71	0.17		

Table 6: Multivariate analysis of demographic factors

	B	S.E.	Wald	df	Sig.	Exp (B)	95.0% C.I.for EXP (B)	
							Lower	**Upper**
AGE	0.006	0.01	0.37	1	0.543	1.006	0.987	1.025
SEX	1.165	0.293	15.803	1	<0.001	3.205	1.805	5.691
Weight	-0.002	0.01	0.047	1	0.828	0.998	0.978	1.018
Height	0.005	0.016	0.083	1	0.774	1.005	0.973	1.037
Constant	-0.693	2.392	0.084	1	0.772	0.5		

Risk For CAD relationship with Spasm

34.6% (45) of diabetic patients develop radial artery spasm during coronary angiography, while only 23.5% (87) of non diabetic develop radial artery spasm and this was statistically significant (**p=0.013)**. 27.1% (55) of hypertensive develop spasm during procedure while 25.8% (77) of non hypertensive develop spasm which was statistically non significant (p=0754).Surprisingly radial artery spasm was found in 31.1% (95) non smokers and only 18.9% (37) smokers this was statistically significant (**p=0.002)**. Radial artery spasm develop in27.9% (111) non alcoholics and 20.4% (21) alcoholics which was statistically non significant (p=0.123)

Table 7: Risk factors For CAD relationship with Spasm

		Spasm			
Risk factors for CAD		Present	Absent	Total	P- value
Diabetes	Yes	45 (34.6%)	85 (65.4%)	130 (100%)	**0.013**
	No	87 (23.5%)	284 (76.5%)	371 (100%)	
Hypertension	Yes	55 (27.1%)	148 (72.9%)	203 (100%)	0.754
	No	77 (25.8%)	221 (74.2%)	298 (100%)	
H/o CVA	Yes	1 (25%)	3 (75%)	4 (100%)	0.95
	No	`131 (26.4%)	366 (73.6%)	497 (100%)	
Smoking	Yes	37 (18.9%)	159 (81.1%)	196 (100%)	**0.002**
	No	95 (31.1%)	210 (68.9%)	305 (100%)	
Alcoholism	Yes	21 (20.4%)	82 (79.6%)	103 (100%)	0.123
	No	111 (27.9%)	287 (72.1%)	398 (100%)	

Table 8: Multivariate analysis Risk factors For CAD

	B	S.E.	Wald	df	Sig.	Exp (B)	95.0% C.I.for EXP (B)	
							Lower	Upper
Diabetes	-0.485	0.234	4.278	1	0.039	0.616	0.389	0.975
Hypertension	0.094	0.218	0.187	1	0.665	1.099	0.717	1.684
Smoking	0.586	0.244	5.767	1	0.016	1.797	1.114	2.899
Alcoholism	0.063	0.299	0.044	1	0.834	1.065	0.593	1.912
Constant	0.908	0.165	30.287	1	0	2.479		

Procedural Characteristics

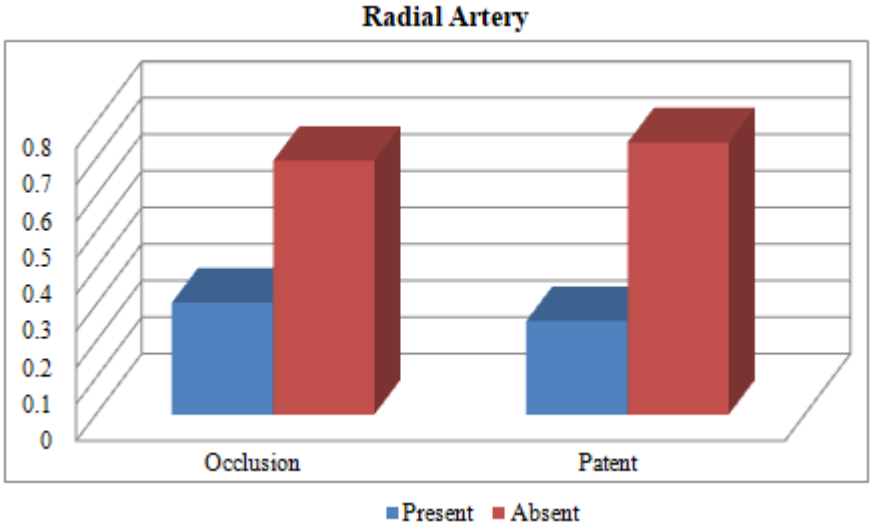
Angiography Duration

The mean duration to complete a transradial coronary angiography in patients who develop radial artery spasm during this study was 12.47±7.10 min while it was only 6.96 ± 3.16 min in patients who do not develop radial artery spasm which was statistically significant **(p=<0.001).**

Table 9: Procedural Duration

Procedure Duration	Spasm		Total
	Present	Absent	
0-5 Min	16 (11.19%)	127 (88.81%)	143 (100.00%)
6-10 Min	54 (20.30%)	212 (79.70%)	266 (100.00%)
11-15 Min	19 (51.35%)	18 (48.65%)	37 (100.00%)
16-20 Min	19 (63.33%)	11 (36.67%)	30 (100.00%)
>20 Min	24 (96.00%)	1 (4.00%)	25 (100.00%)
Total	132 (26.35%)	369 (73.65%)	501 (100.00%)

	Spasm	Number	Mean	Std. Deviation	t-value	p-value
Length of procedure	Present	132	12.47	7.10	11.964	**<0.001**
	Absent	369	6.96	3.16		



Attempts to cannulate radial artery

46.34% (38) of patients in whom radial artery cannulation was done in >1 attempt develop radial artery spasm while only 22.43% (94) of patients in whow radial artery cannulation was done in 1 attempt develop radial artery spasm, this was statistically significant (**p=<0.001)**

Table 10: Attempts to cannulate radial artery

Attempts	Spasm		Total	P- value
	Present	Absent		
1 attempt	94 (22.43%)	325 (77.57%)	419 (100.00%)	**<0.001**
>1 attempt	38 (46.34%)	44 (53.66%)	82 (100.00%)	
Total	132 (26.35%)	369 (73.65%)	501 (100.00%)	

Pain during cannulation

Mean pain score of patients which develop radial artery spasm was 2.67±1.47 and those which not develop this complication was 1.25±0.86 and this was statistically significant (**p=<0.001).**100% (2) of patients with pain score 5 develop radial artery spasm, 78.48% (62)of patients with pain score 4 develop radial artery spasm, 40.74% (11) of patients with pain score 3 develop radial artery spasm.

Table 11: Pain during cannulation

	Spasm			
Pain during cannulation	Present	Absent	Total	P- value
0	8 (18.18%)	36 (81.82%)	44 (100.00%)	<0.001
1	36 (12.37%)	255 (87.63%)	291 (100.00%)	
2	13 (22.41%)	45 (77.59%)	58 (100.00%)	
3	11 (40.74%)	16 (59.26%)	27 (100.00%)	
4	62 (78.48%)	17 (21.52%)	79 (100.00%)	
5	2 (100.00%)	0 (0.00%)	2 (100.00%)	
Total	132 (26.35%)	369 (73.65%)	501 (100.00%)	

	Spasm	Number	Mean	Std. Deviation	t-value	p-value
Pain during cannulation	Present	132	2.67	1.47	13.262	<0.001
	Absent	369	1.25	0.86		

Total number of catheters used in coronary angiography

69.23% (18) Patients in whom >1 catheter was used to complete transradial coronary angiography develop radial artery spasm during angiography and spasm occur only in 24% (114) of patients in whom angiography was done with single catheter, which was statistically significant (p=<0.001).

Table 12: Total number of catheters used in coronary angiography

Catheters	Spasm		Total	p-value
	Present	Absent		
1	114 (24.00%)	361 (76.00%)	475 (100.00%)	
>1	18 (69.23%)	8 (30.77%)	26 (100.00%)	
Total	132 (26.35%)	369 (73.65%)	501 (100.00%)	<0.001

Relationship of CAD severity with spasm

21 (32.81%) of TVD patient develop spasm, 26 (27.08%) of DVD patients develop spasm, 45 (26.01%) of SVD patient had spasm and 39 (24.07%) non critical CAD patients develop RAS.

Table 13: Relationship of CAD severity with spasm

CAG Finding	Spasm		Total	p-value
	Present	Absent		
Non critical	39 (24.07%)	123 (75.93%)	162 (100.00%)	0.71
DVD	26 (27.08%)	70 (72.92%)	96 (100.00%)	
SVD	45 (26.01%)	128 (73.99%)	173 (100.00%)	
TVD	21 (32.81%)	43 (67.19%)	64 (100.00%)	
Others	1 (16.67%)	5 (83.33%)	6 (100.00%)	
Total	132 (26.35%)	369 (73.65%)	501 (100.00%)	

Route of CAG

3 (42.86%) patients in whom coronary angiography was via left radial approach develop RAS, and 4 (57.14%) patients doesn't had spasm while 129 (26.11%) patients in whom angiography was done via Right radial approach develop RAS and 365 (73.89%) doesn't develop RAS during study and this was not statistically significant (p=0.318).

Table 14

	Spasm			
Route	Present	Absent	Total	p-value
LT Radial	3 (42.86%)	4 (57.14%)	7 (100.00%)	0.318
RT Radial	129 (26.11%)	365 (73.89%)	494 (100.00%)	
Total	132 (26.35%)	369 (73.65%)	501 (100.00%)	

Table 15: Multivariate analysis of Procedural Characteristics

	B	S.E.	Wald	df	Sig.	Exp (B)	95.0% C.I.for EXP (B)	
							Lower	Upper
Length procedure	-0.273	0.062	19.534	1	<0.001	0.761	0.674	0.859
Attempts	0.713	0.647	1.214	1	0.271	2.04	0.574	7.255
Pain during cannulation	-1.051	0.223	22.23	1	<0.001	0.35	0.226	0.541
Catheters	1.505	1.174	1.643	1	0.2	4.506	0.451	45.007
Route	2.243	4.44	0.255	1	0.614	9.418	0.002	5.67E+04
Constant	4.311	1.742	6.123	1	0.013	74.482		

Follow Up

Demographic factors and Radial artery occlusion

Mean age of patients who develop radial artery occlusion on follow up was 55.72 ± 11.23 yrs and in patients with patent radial artery mean age was 53.36 ± 11.21 yrs which was not significant difference (p=0.101). Mean weight of patients with occluded radial artery on follow up was 62.56 ± 9.70 kg and this was significantly less as compared to patients with patient radial artery (**p=0.025)**. mean height of patients with radial artery occlusion was 159.17 ± 8.52cm and those with patent radial artery artery was 161.56 ± 9.13 cm which was significantly less in radial artery occlusion group (**p= 0.039)**. BMI of patients with radial artery occlusion was 24.71±3.48 kg/m^2 and patients without occlusion was slightly more 25.21±4.06 kg/m^2, this difference was statistically non- significant (p= 0.323)

Table 16: Demographic factors and Radial artery occlusion

	Radial Artery on follow up	N	Mean	Std. Deviation	p-value
AGE (yrs)	Occlusion	72	55.72	11.23	0.101
	Patent	399	53.36	11.21	
Weight (kg)	Occlusion	72	62.56	9.70	0.025
	Patent	399	65.76	11.41	
Height (cm)	Occlusion	72	159.17	8.52	0.039
	Patent	399	161.56	9.13	
BMI (kg/m^2)	Occlusion	72	24.71	3.48	0.323
	Patent	399	25.21	4.06	

Sex difference in Radial artery occlusion

23 (19.17%) of females and 49 (13.96%) of males develop Radial artery occlusion on follow up which was statistically non- significant (p=0.171)

Table 17: Sex difference in Radial artery occlusion

Sex	Radial Artery		Total	p-value
	Occlusion	Patent		
Male	49 (13.96%)	302 (86.04%)	351 (100.00%)	0.171
Female	23 (19.17%)	97 (80.83%)	120 (100.00%)	
Total	72 (15.29%)	399 (84.71%)	471 (100.00%)	

Radial artery occlusion in patients with risk factors for CAD

25.81% (32) of diabetic patients develop radial artery occlusion during follow up, while 11.53% (40) of non diabetic develop radial artery occlusion and this was statistically significant (**p=<0.001)**. 15.98% (31) of hypertensive develop radial artery occlusion on follow up while 14.80% (41) of non hypertensive develop occlusion which was statistically non significant (p=0.727).radial artery occlusion was found in 14.44% (27) smokers and 15.85% (45) non-smokers this was statistically non significant (p=0.384). radial artery occlusion develop in 15.86% (59) non alcoholics and 13.13% (13) alcoholics which was statistically non significant (p=0.503).

Table 18: Radial artery occlusion in patients with risk factors for CAD

		Radial Artery		Total	p-value
		Occlusion	Patent		
Diabetes	Yes	32 (25.81%)	92 (74.19%)	124 (100.00%)	**<0.001**
	No	40 (11.53%)	307 (88.47%)	347 (100.00%)	
Hypertension	Yes	31 (15.98%)	163 (84.02%)	194 (100.00%)	0.727
	No	41 (14.80%)	236 (85.20%)	277 (100.00%)	
H/O CVA	Yes	1 (33.33%)	2 (66.67%)	3 (100.00%)	0.384
	No	71 (15.17%)	397 (84.83%)	468 (100.00%)	
Smoking	Yes	27 (14.44%)	160 (85.56%)	187 (100.00%)	0.384
	No	45 (15.85%)	239 (84.15%)	284 (100.00%)	
Alcoholism	Yes	13 (13.13%)	86 (86.87%)	99 (100.00%)	0.503
	No	59 (15.86%)	313 (84.14%)	372 (100.00%)	
Total		72 (15.29%)	399 (84.71%)	471 (100.00%)	

Procedural characteristics and radial artery occlusion

Mean length of procedure in patients with radial artery occlusion was 11.11 ± 6.97 min while it was only 7.89 ± 4.58 min in patients with patent radial artery and this difference was statistically significant (**p<0.001)**.mean pain score during radial artery cannulation was 1.64±1.18 in patients with radial artery occlusion while it was 1.62±1.25 in patients with patent radial artery on follow up. Mean pain score during radial sheath removal was 2.04±1.27 in patients with radial artery occlusion while it was 1.82±1.26 in patients with patent radial artery on follow up and this was Statistically non- significant (p=0.178)

Table 19

	Radial Artery on follow up	N	Mean	Std. Deviation	p-value
Length procedure (min)	Occlusion	72	11.11	6.97	<0.001
	Patent	399	7.89	4.58	
Pain during cannulation	Occlusion	72	1.64	1.18	0.913
	Patent	399	1.62	1.25	
Pain sheath removal	Occlusion	72	2.04	1.27	0.178
	Patent	399	1.82	1.26	

Radial artery patency in patients with radial artery spasm

In this study 30.56% (22) of patients who develop radial artery occlusion on follow up had radial artery spasm during angiography while in 69.44% (50) of patient with radial artery occlusion doesn't had radial artery spasm during angiography.25.56% (102) of patients with patent radial artery on follow up had radial artery spasm during angiography and 74.44% (297) of patient with patent radial artery doesn't had radial artery spasm during angiography.

Table 19: Radial artery patency in patients with radial artery spasm

Radial Artery	Spasm		Total	p-value
	Present	Absent		
Occlusion	22 (30.56%)	50 (69.44%)	72 (100.00%)	0.376
Patent	102 (25.56%)	297 (74.44%)	399 (100.00%)	
Total	124 (26.33%)	347 (73.67%)	471 (100.00%)	

4. Discussion

501 patients who underwent transradial coronary angiography were included in this study, incidence of radial artery spasm was calculated and various predictors of radial artery spasm in earlier studies were studied for their significant relationship with development of radial artery spasm.

Most of the patients in this study were males 74.3%. Mean age of the patients was 53.945±11.21 years. 72% of patients were ≤ 60 years of age, 69.5% patients had weight ≤ 70 kg. 88% patients had height ≤ 170 cm, % of patients had BSA and 49.9 % of patients had BMI ≤ 24.9.

In this study 25.9 % of patients were diabetic, 40.5% were hypertensive, 39.1% were smokers, 0.8% had past history of CVA and 20.6% drink alcohol.

Time taken to complete transradial coronary angiography was <10 min in 81.6% patients and in only 5% patients > 20 min are required to do transradial angiography. In 83.6% patient's radial artery cannulation was done in first attempt and majority (58.1%) patients had only mild pain during cannulation.

In 94.8% patients angiography was completed by single catheter and in majority (98.6%) patients angiography was done via right radial artery.

During our study 26.3% patients develop radial artery spasm, various studies had shown spasm rate between 6.8 % to 30 %, study by Rathore et al had shown radial artery spasm rate around 29%, while Ruiz – Salmeron et al had shown 18.2% spasm rate.

During our study there was no relationship between any age group and development of radial artery spasm (p=0.81). 44.96% female patients develop radial artery spasm, while only 19.89% male patients develop spasm thus female sex in an independent predictor of radial artery spasm with significant p-value (<0.001), study by Rathore S et al also showed female sex (OR 2.01, p=0.001) as an independent predictor of radial artery spasm.

Mean weight of patient who develop spasm was 64.05±11.99 while it was 65.51±10.96 in patients who does not develop spasm & this difference was non significant (p=0.2). BMI in patients with spasm was 25.43±4.43 and in patients without spasm was 24.96±3.81 & this difference was also non significant (p=0.242). Patients who develop spasm were shorter mean height 158.74±9.12 compared to patients without spasm 162.02±8.82 & this difference was statistically significant (**p=<0.001)**.study by Rathore S et al also showed that short height is associated with increase incidence of radial artery spasm.

Multivariate analysis of demographic factors in our study showed that female sex in the only independent factor associated with increased incidence of radial artery spasm.

In this study 34.6% of diabetic patients develop radial artery spasm while only 23.5% of non diabetic develop radial artery spasm and this was statistically significant (**p=0.013)**.

Rathore S et al also showed that diabetes (OR 1.84, p=0.003) was associated with increase incidence of radial artery spasm. Jia et al also found diabetes (p=0.026) as an independent predictor of radial artery spasm.

There was no statistically significant (p=0.754) difference between hypertensives and non hypertensives. Surprisingly radial artery spasm was found in 31.1% non smokers and only 18.9% smokers this is statistically significant (p=0.002).

Multivariate analysis of CAD risk factors in our study showed that diabetes in the only independent CAD risk factor associated with increased incidence of radial artery spasm.

The mean duration to complete a transradial coronary angiography in patients who develop radial artery spasm during this study was 12.47±7.10 min while it was only 6.96 ± 3.16 min in patients who do not develop radial artery spasm which was statistically significant (**p=<0.001)**.

Patients in whom >1 attempt are required to cannulate radial artery had increase chance (46.34%) of developing RAS as compared to patients in whom radial artery cannulation was done in 1 attempt (22.43%) this was statistically significant (p=<0.001).

Jia et al also concluded that unsuccessful 1st attempt to cannulation is an important predictor of RAS (p=0.002)

Mean pain score during radial artery cannulation of patients which develop radial artery spasm was 2.67±1.47 and those which not develop this complication was 1.25±0.86 and this is statistically significant **(p=<0.001).**

This finding was similar to that observed inJia et al study which also concluded that moderate to severe pain during cannulation is predictor of RAS (p=<0.001). Ruiz – Salmeron et al also found painful cannulation as a good predictor of RAS.

In our study 69.23% Patients in whom >1 catheter was used to complete transradial coronary angiography develop radial artery spasm while spasm occur only in 24% of patients in whom angiography was done with single catheter, which was statistically significant (p=<0.001).

Ruiz- Salmeron et al in their study concluded ≥ 3 catheters use as an predictor of RAS. Study by Jia et al also concluded that > 3 catheters use is predictor of RAS (p=0.048).

On multivariate analysis only length of procedure and moderate to severe pain during cannulation were found as predictors of RAS in our study.

During our study 15.29% patients develop radial artery occlusion, various studies had shown occlusion rate between 5% to 38 %, study by Spaulding *et al.*, which included 415 patients and radial angiography was done via left radial artery, RAO rates were 70%, 24%, and 4.3% in groups without heparin, 2000-3000 IU heparin and 5000 IU of heparin, respectively.

During our study there was no relationship between any age group, gender and development of radial artery occlusion. Mean weight of patients with occluded radial artery on follow up was 62.56 ± 9.70 kg and this was significantly less as compared to patients with patient radial artery **(p=0.025)**. mean height of patients with radial artery occlusion was 159.17 ± 8.52cm and those with patent radial artery artery was 161.56 ± 9.13 cm which was significantly less in radial artery occlusion group (**p= 0.039)**. BMI of patients with radial artery occlusion was 24.71±3.48 kg/m^2 and patients without occlusion was slightly more 25.21±4.06 kg/m^2, this difference was statistically non- significant (p= 0.323) study by Pancholy et al also showed that low body weight was associated with increased risk of radial artery occlusion.

During our study 25.81% of diabetic patients develop radial artery occlusion during follow up, while 11.53% of non diabetic develop radial artery occlusion and this was statistically significant **(p=<0.001)** while there was no relationship between hypertension, h/o CVA, smoking, alcohol intake and development of radial artery occlusion.

Mean length of procedure in patients with radial artery occlusion was 11.11 ± 6.97 min while it was only 7.89 ± 4.58 min in patients with patent radial artery and this difference was statistically significant (**p<0.001)**. while during our study there was no significant difference in mean pain score during radial artery cannulation, no. of catherers used, pain during sheath removal between patients who develop radial artery occlusion and those with patent radial artery on follow up.

Study by Pancholy et al also showed that increase procedure duration was associated with increase chances of radial artery occlusion.

5. Conclusion

This study concluded that radial artery spasm is quite common in Indian population undergoing transradial coronary angiography even after use of spasmolytic cocktail, but it usually doesn't lead to any serious complication and angiography could be completed successfully even in patients with radial artery spasm. Female sex, short height, small body surface area, diabetes, increase length of procedure, >1 attempt to cannulate radial artery, increase pain during cannulation and >1 catheter use during angiography are important predictors of RAS.

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Author Profile

Dr Avadhesh Narayan Khare had done my MBBS from T.N.M.C. Mumbai, MD Medicine from GMC Bhopal and DM Cardiology from PGIMER Dr RML hospital New Delhi. Currently working as Consultant Interventinal Cardiologist at J.K. Hospital and L.N. Medical College, Bhopal.