Section: Cardiology

Original Research Article

A STUDY ON THE EFFECTIVENESS OF RADIAL REHABILITATION METHODS IN POST CORONARY ANGIOGRAM PATIENTS TO PREVENT EARLY RADIAL ARTERY OCCLUSION

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ABSTRACT

Background: Radial access is the most common approach to coronary angiogram worldwide now (1). The safety of radial access is thus well proven. The complication rate following Trans radial Access (TRA) ranges from 1-10%. So, we test whether radial rehabilitation strategies improve patency and reduce radial occlusion rates in patient undergoing radial approach angiogram in CAD. **Materials and Methods:** The subjects presenting to a tertiary care hospital with Acute Coronary Syndrome (Unstable angina, NSTEMI and STEMI) are taken during the period of July 2024 and August 2024.The exclusion criteria were subjects with prior radial access, Atrial fibrillation, Bundle branch blocks, severe valvular heart disease and peripheral vascular disease on anticoagulants. The subjects were divided into two groups, radial rehabilitation group and non-rehabilitation group. The radial artery ultrasound was done prior and after 24 hrs in both groups and radial occlusion, radial diameter and velocity, ulnar diameter and velocity were computed and analysed using SPSS Version 29 software. **Result:** The distribution of age, co-morbidities were equal in both rehabilitation and non-rehabilitation group. There was no significant difference between the various groups in terms of distribution of Radial artery Thrombus (Post Treatment) ($\chi 2 = 4.068$, $p = 0.122$). The overall change in Radial Diameter (cm) over time was compared in the two groups using the Generalized Estimating Equations method. There was a significant difference in the trend of Radial Diameter (cm) over time between the two groups ($p = <0.001$). There was a significant difference between the 2 groups in terms of Radial Velocity (cm/s) ($W = 9944.500$, $p = <0.001$), with the median Radial Velocity (cm/s) (Before) being highest in the Radial Rehabilitation Done group. **Conclusion:** This study highlights the need of radial rehabilitation in high-risk individual like amputee, Chronic Kidney Disease, Peripheral Vascular disease patients in whom maintaining the diameter and velocity after radial angiogram prevents its closure. Though the Radial Artery Occlusion rate in the rehabilitation group was not statistically significant, there is improvement in the velocity which protects against early and late RAO.

INTRODUCTION

Radial access is the most common approach to angiogram worldwide now.[1] The safety of radial access is thus well proven. The complication rate following Trans radial Access (TRA) ranges from 1-10%.[1,2-7] The RAO (Radial Artery Occlusion) is influenced by modifiable and non-modifiable factors. The non modifiable factors include age, female gender, body weight, statin use, Serum creatinine, Peripheral artery disease. The modifiable factors include repeated cannulation, increased puncture attempts, size of the introducer sheath, adequate anticoagulation, time of procedure, vasodilator use, length of compression and compression pressure.[3]

The radial artery occlusion paralyses future attempts at cannulation, especially in chronic kidney disease patients in whom contra lateral radial artery must be preserved. Further the ulnar artery also is unusable in view of hand ischemia.[2] Hence the prevention of radial artery occlusion despite its relatively asymptomatic course presents a challenge to interventional Cardiology.

Female gender, smoking, younger age and hypertension are established risk factors for the incidence of radial artery occlusion. The early

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detection of RAO entitles the cardiologist to treat better and achieve radial artery patency. The patients are divided into two cohorts, which are matched according to age distribution, gender, Diabetes, Hypertension and Kidney disease and the rates of radial artery occlusion is calculated. The first cohort receives radial rehabilitation strategies like keeping the limb with gravity, ball exercises and occlusive haemostasis for 6 hrs.

The rehabilitation exercises are as follows,

1. After 6 hrs, sponge ball compressions 10 times every hour for at least 8 hours a day.
2. Ulnar compression with left hand after procedure while doing exercises.
3. All exercises to be carried out with right arm directed toward the ground.

The two cohorts are subjected to ultrasound before angiogram and 1 day after angiogram. This early point of time was chosen since the majority of patients were discharged on this day and early detection of occlusion is better.[4] Some case definitions are:

1. RAO (Radial Artery Occlusion) was defined as the absence of radial pulsations on palpation and ante grade flow signal on Doppler studies. Procedural time was defined as the time between local anaesthesia and the removal of the last catheter.
2. Post-procedural pain was defined as the puncture site or forearm pain following homeostasis with or without swelling during the hospital stay or at out-hospital follow-up.
3. Major hematoma was defined as hematoma more than 5 cm in diameter, while minor one was defined as less than 5 cm in diameter.
4. Procedure success was defined as coronary angiography or angioplasty completed via the trans radial route without changing to another vascular access.
5. The ultrasonic findings were classified into 4 types; (A) no stenosis, (B) segmental stenosis, (C) diffuse stenosis, and (D) no flow. Type B was defined as segmentally stenotic at, 10 mm and 10% stenotic compared with the average diameter of proximal and distal areas of the puncture site. Type C was defined as (1) stenosis .50mm, (2) 15% of the diameter stenosis before the procedure, and (3) the intimal thickening of the radial arterial wall 0.4 mm. Type D was determined by a colour Doppler ultrasonic study.[8]

The study aims to find the effectiveness of radial rehabilitation methods on the radial artery occlusion post radial access in two cohorts and thus devise regular strategies to reduce RAO.

MATERIALS AND METHODS

Patients admitted with chest pain either unstable angina or myocardial infarction who are posted for radial angiogram are divided into two groups after randomization and matching.

Prior to angiography, demographic and anthropometric measurements will be recorded along with a detailed cardiovascular and systemic examination. Laboratory parameters like serum creatinine, liver function test, serum electrolyte levels, and complete blood count will be recorded.

A 12-lead surface ECG in supine position and Echocardiogram, before performing coronary angiography is done. The radial artery diameter, velocity, flow and thrombus is determined prior to angiogram. The subject is again assessed after 24 hours by Doppler (MINDRAY)ultrasound for detection of RAO. The suspected cases of RAO are further evaluated by a radiologist and treated. The data is collected in proforma and computed in MS EXCEL. The analysis is done with SPSS Version 29 software.

Studytools

- Detailed history
- Clinical examination
- Complete blood count - SYSMEX 3-part auto analyser
- Liver function test, renal function test (ERBA XL500 auto analyser)
- CK-MB, Troponin I
- 12 lead ECG (BPL Cardiart 9108)
- ECHO MIND RAY M6
- DOPPLER MIND RAY M6

Study Design Population and duration

The subjects presenting to a tertiary care hospital with Acute Coronary Syndrome (Unstable angina, NSTEMI and STEMI) are taken during the period of July 2024 and August 2024.

Inclusion Criteria

- Patients admitted with chest pain who subsequently undergo coronary angiography through radial access in tertiary care centre.

Exclusion Criteria

- Previously undergone radial access coronary angiography
- Severe valvular heart disease
- Atrial fibrillation
- Bundle branch block, or evidence of any other intraventricular conduction defect
- Previous peripheral vascular disease and subjects on anticoagulants

Endpoint: The primary endpoint was the occurrence of Radial Artery Occlusion (RAO) in the two groups. The secondary end points include radial artery velocity diameter and velocity in the rehabilitation and non-rehabilitation group.

Statistical Analysis: Data were analysed using SPSS Software 15. Continuous variables were expressed as mean ± standard deviation (SD) and compared using the independent t-test. Categorical variables were expressed as proportions (%) and analysed using the Chi-square test. Non-Parametric tests were used to make statistical inference as data were not normally distributed. Wilcoxon-Mann-Whitney Test test was used to compare the two groups at each of the

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timepoints (right-most column in the table above). Wilcoxon signed-rank test was used to explore the difference in Radial Velocity (cm/s) between the time points within each group. Generalized Estimating Equations method was used to explore the difference in change in Radial Velocity (cm/s) between the two groups over time (last row in the table above).

Ethical Considerations: The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the institutional ethics committee. Written informed consent was obtained from all participants before enrolment.

RESULTS

The descriptive variables are compiled in Table 1. Among the clinical characteristics, 120 underwent radial rehabilitation and 120 did not (non -radial rehabilitation group). The age varied from 32-77 years. Most of the subjects were 51–60-year-old. Male were 134(55.8%) and women were 106(44.20%). Most of the subjects undergoing angiogram were subjects with Unstable Angina. Among them 118 were diabetic and 107 were hypertensive. The Ejection Fraction by ECHO was < 45% in 96(40%) and was >45% in 144(32.5%) subjects. Most of the subjects (47.5 %) are diagnosed with Unstable angina, 26.7% were diagnosed with AWMI, the mean (SD) of Sheath In/ Sheath Out Time (Minutes) was 8.44 (1.59). The median (IQR) of Sheath In/ Sheath Out Time (Minutes) was 7.00 (7-10). The Sheath In/ Sheath Out Time (Minutes) ranged from 7 - 15.

There was no significant difference between the various groups in terms of distribution of Thrombus on ultrasound (Post Treatment) ($\chi 2$ = 4.068, p = 0.122).

The radial artery occlusion (thrombus) was noted in 4 subjects who were in the non -radial rehabilitation group, but it was not statistically significant.

In Radial Rehabilitation: Done, the mean Radial Diameter (cm) decreased from a maximum of 2.72 at the Before timepoint to a minimum of 2.60 at the After timepoint. This change was statistically significant (Wilcoxon Test: V = 5223.0, p = <0.001).

In Radial Rehabilitation: Not Done, the mean Radial Diameter (cm) decreased from a maximum of 2.63 at the Before timepoint to a minimum of 2.33 at the After timepoint. This change was statistically significant (Wilcoxon Test: V = 7021.0, p = <0.001).

The overall change in Radial Diameter (cm) over time was compared in the two groups using the Generalized Estimating Equations method. There was a significant difference in the trend of Radial Diameter (cm) over time between the two groups (p = <0.001) as demonstrated in Figure 1.

The overall change in Radial Velocity (cm/s) over time was compared in the two groups using the Generalized Estimating Equations method. There was a significant difference in the trend of Radial Velocity (cm/s) over time between the two groups (p = <0.001) as given in Figure 2.

In Radial Rehabilitation: Done, the mean Ulnar Diameter (cm) decreased from a maximum of 2.36 at the Before timepoint to a minimum of 2.35 at the After timepoint.

In Radial Rehabilitation: Not Done, the mean Ulnar Diameter (cm) increased from a minimum of 2.25 at the Before timepoint to a maximum of 2.35 at the After timepoint.

The overall change in Ulnar Diameter (cm) over time was compared in the two groups using the Generalized Estimating Equations method. There was a significant difference in the trend of Ulnar Diameter (cm) over time between the two groups (p = <0.001).

The two groups differed significantly in terms of Ulnar Velocity (cm/s) at the following timepoints: Before, After.

In Radial Rehabilitation: Done, the mean Ulnar Velocity (cm/s) increased from a minimum of 26.68 at the Before timepoint to a maximum of 27.40 at the After timepoint. This change was statistically significant (Wilcoxon Test: V = 2210.0, p = 0.022).

In Radial Rehabilitation: Not Done, the mean Ulnar Velocity (cm/s) increased from a minimum of 22.76 at the Before timepoint to a maximum of 25.47 at the After timepoint. This change was statistically significant (Wilcoxon Test: V = 525.5, p = <0.001).

The overall change in Ulnar Velocity (cm/s) over time was compared in the two groups using the Generalized Estimating Equations method. There was a significant difference in the trend of Ulnar Velocity (cm/s) over time between the two groups (p = <0.001).

The Number Needed to Treat(NNT) is 30 angiogram patients to prevent one radial occlusion.

Table 1: Descriptive statistics of the study population

All Parameters	Mean ± SD || Median (IQR) || Min-Max OR N (%)
Radial Rehabilitation	
Done	120 (50.0%)
Not Done	120 (50.0%)
Age (Years)	52.37 ± 9.14 || 52.00 (45.00-60.00) || 32.00 - 77.00
Age	
31-40 Years	29 (12.1%)
41-50 Years	79 (32.9%)
51-60 Years	87 (36.2%)
61-70 Years	38 (15.8%)
71-80 Years	7 (2.9%)
Gender	

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Male	134 (55.8%)
Female	106 (44.2%)
Diagnosis. 0	
Unstable Angina	113 (47.1%)
AWMI	59 (24.6%)
NSTEMI	29 (12.1%)
IPWMI	38 (15.8%)
HLWMI	1 (0.4%)
Comorbidities: Diabetes Mellitus (Yes)	118 (49.2%)
Comorbidities: Hypertension (Yes)	107 (44.6%)
Comorbidities: None (Yes)	78 (32.5%)
Ejection Fraction (%)	55.39 ± 12.24 || 60.00 (45.00-68.00) || 30.00 - 69.00
Ejection Fraction	
≤45	96 (40.0%)
>45	144 (60.0%)
Thrombus on Radial Artery	4 (1.7%)
Radial Artery Spasm (Present)	8 (3.3%)
Sheath In/ Sheath Out Time (Minutes)	8.44 ± 1.59 || 7.00 (7.00-10.00) || 7.00 - 15.00
Radial Diameter (cm) (Before)	2.68 ± 0.48 || 2.60 (2.38-3.00) || 1.40 - 4.00
Radial Velocity (cm/s) (Before)	29.12 ± 7.57 || 28.00 (24.00-36.00) || 11.00 - 46.00
Radial Character (Before)	After rehabilitation
None	0 (0.0) 4(1.7%)
Monophasic	0 (0.0%) 13(5.4%)
Biphasic	20 (8.3%) 118(49.2%)
Triphasic	220 (91.7%) 105(43.8%)
Ulnar Diameter (cm) (Before)	2.31 ± 0.40 || 2.20 (2.00-2.60) || 1.40 - 3.40
Ulnar Velocity (cm/s) (Before)	24.72 ± 6.05 || 24.00 (20.00-30.00) || 11.00 - 42.00
Radial Diameter (cm) (After)	2.46 ± 0.51 || 2.45 (2.10-2.80) || 0.80 - 3.80
Radial Velocity (cm/s) (After)	25.62 ± 8.37 || 26.00 (20.00-32.00) || 0.00 - 48.00
Ulnar Diameter (cm) (After)	2.35 ± 0.38 || 2.20 (2.10-2.60) || 1.40 - 3.40
Ulnar Velocity (cm/s) (After)	26.43 ± 5.69 || 26.00 (22.00-30.00) || 14.00 - 45.00
Change in Radial Diameter (cm) (After)	-0.21 ± 0.22 || -0.20 (-0.30--0.10) || -2.20 - 0.20
Change in Radial Velocity (cm/s) (After)	-3.49 ± 5.09 || -4.00 (-6.00--2.00) || -32.00 - 6.00
Change in Ulnar Diameter (cm) (After)	0.04 ± 0.16 || 0.00 (0.00-0.20) || -1.00 - 0.60
Change in Ulnar Velocity (cm/s) (After)	1.71 ± 3.46 || 2.00 (0.00-4.00) || -12.00 - 14.00

Table 2: distribution between the radial rehabilitation and non-radial rehabilitation group

Parameters	**Radial Rehabilitation**		**p value**
	Done (n = 120)	**Not Done (n = 120)**	
Age (Years)	51.30 ± 8.48	53.44 ± 9.67	0.1101
Age***			0.0432
31-40 Years	17 (14.2%)	12 (10.0%)	
41-50 Years	44 (36.7%)	35 (29.2%)	
51-60 Years	43 (35.8%)	44 (36.7%)	
61-70 Years	16 (13.3%)	22 (18.3%)	
71-80 Years	0 (0.0%)	7 (5.8%)	
Gender			0.0692
Male	74 (61.7%)	60 (50.0%)	
Female	46 (38.3%)	60 (50.0%)	
Diagnosis			0.5332
Unstable Angina	57 (47.5%)	56 (46.7%)	
AWMI	32 (26.7%)	27 (22.5%)	
NSTEMI	15 (12.5%)	14 (11.7%)	
IPWMI	15 (12.5%)	23 (19.2%)	
HLWMI	1 (0.8%)	0 (0.0%)	
Comorbidities: Diabetes Mellitus (Yes)	57 (47.5%)	61 (50.8%)	0.6062
Comorbidities: Hypertension (Yes)	59 (49.2%)	48 (40.0%)	0.1532
Comorbidities: None (Yes)	35 (29.2%)	43 (35.8%)	0.2702
Ejection Fraction (%)	55.33 ± 12.32	55.45 ± 12.21	0.8771
Ejection Fraction			0.7922
≤45	49 (40.8%)	47 (39.2%)	
>45	71 (59.2%)	73 (60.8%)	
Thrombus in Radial Artery	0 (0.0%)	4 (3.3%)	0.1223
Radial Artery Spasm (Present)	4 (3.3%)	4 (3.3%)	1.0003
Sheath In/ Sheath Out Time (Minutes)	8.35 ± 1.50	8.53 ± 1.68	0.4931
Radial Diameter (cm) (Before)	2.72 ± 0.42	2.63 ± 0.52	0.1541
Radial Velocity (cm/s) (Before)***	31.70 ± 7.08	26.53 ± 7.17	<0.0011
Radial Character (Before)***			<0.0012
None	0 (0.0%)	0 (0.0%)	
Monophasic	0 (0.0%)	0 (0.0%)	
Biphasic	0 (0.0%)	20 (16.7%)	
Triphasic	120 (100.0%)	100 (83.3%)	

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Ulnar Diameter (cm) (Before)	2.36 ± 0.42	2.25 ± 0.37	0.1041
Ulnar Velocity (cm/s) (Before)***	26.68 ± 6.56	22.76 ± 4.77	<0.0011
Radial Diameter (cm) (After)***	2.60 ± 0.45	2.33 ± 0.52	<0.0011
Radial Velocity (cm/s) (After)***	30.19 ± 6.86	21.06 ± 7.18	<0.0011
Ulnar Diameter (cm) (After)	2.35 ± 0.41	2.35 ± 0.35	0.3601
Ulnar Velocity (cm/s) (After)***	27.40 ± 6.29	25.47 ± 4.85	0.0131
Change in Radial Diameter (cm) (After)***	-0.13 ± 0.23	-0.29 ± 0.17	<0.0011
Change in Radial Velocity (cm/s) (After)***	-1.51 ± 4.69	-5.47 ± 4.70	<0.0011
Change in Ulnar Diameter (cm) (After)***	-0.02 ± 0.17	0.10 ± 0.14	<0.0011
Change in Ulnar Velocity (cm/s) (After)***	0.72 ± 3.76	2.71 ± 2.81	<0.0011
Percent Change in Radial Diameter (cm) (After)***	-4.66 ± 7.96	-11.49 ± 7.32	<0.0011
Percent Change in Radial Velocity (cm/s) (After)***	-3.63 ± 14.69	-20.46 ± 17.84	<0.0011
Percent Change in Ulnar Diameter (cm) (After)***	-0.41 ± 6.65	5.02 ± 6.97	<0.0011
Percent Change in Ulnar Velocity (cm/s) (After)***	4.20 ± 15.14	13.19 ± 13.82	<0.0011

***Significant at p<0.05, 1: Wilcoxon-Mann-Whitney U Test, 2: Chi-Squared Test, 3: Fisher's Exact Test

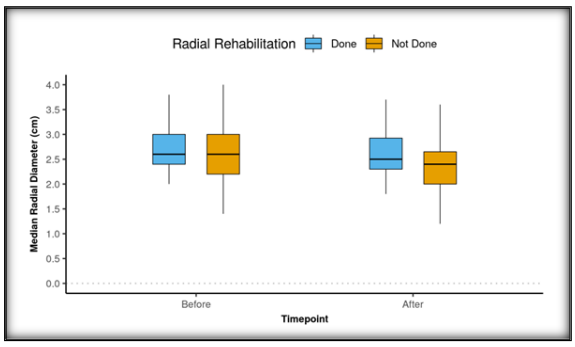

Figure 1: The Box-and-Whisker plot below depicts the distribution of Radial Diameter (cm) over different timepoints. In each box, the middle horizontal line represents the median Radial Diameter (cm), the upper and lower bounds of the box represent the 75th and the 25th centile of Radial Diameter (cm) respectively, and the upper and lower extent of the whiskers represent the Tukey limits for Radial Diameter (cm) at each of the timepoints respectively.

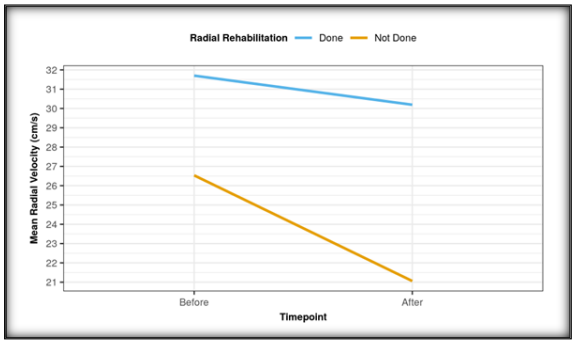

Figure 2: Change in Radial Velocity (cm/s) Over Time

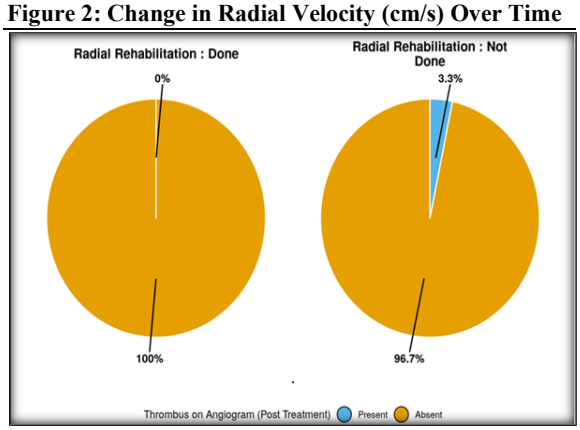

Figure 3: Percentage of subjects with thrombus in two groups.

DISCUSSION

This study derives that there is a significant improvement in the radial artery diameter and velocity after radial rehabilitation exercises, which prevent radial artery occlusion. The ulnar velocity also showed significant increase in non -radial rehabilitation group when compared to the rehabilitation group, indicating that the collateral vessel flow was needed in case of non- rehabilitation group to maintain blood flow to the hand.

The absolute thrombus was found in 4 of 240 patients, all of which did not undergo radial rehabilitation. The thrombus rate did not show significant statistical significance though. The reduced rate of RAO can be attributed to already established angiogram practices like adequate sedation and anticoagulation, cocktail to prevent radial artery spasm, reduced sheath in-sheath out time, early mobilization etc.,

The study's strengths include its precision in evaluating rehabilitation strategies like calculation of radial artery diameter, velocity etc., However, the small sample size and single-centre design limit generalizability. But it emphasizes the importance of simple bed side exercises to improve radial artery patency so that it can be accessed later for revascularization. Further studies in large multicentre are needed to see the effectiveness and application in that population.

The exercises are doable and harmless, and thus can be done even in resource limited settings.

CONCLUSION

This study throws light on the importance of rehabilitation exercises in mitigating the risk of radial artery occlusion after an angiogram. These exercises are cost effective in resource limited settings and are proven to be reducing occlusion rates and improving the radial diameter and velocity.

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