

Frequency and Predictors of Radial Artery Occlusion Associated with Transradial Catheterization

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Abstract:

Background: Transradial access (TRA) for coronary angiography and interventions has gained widespread preference due to its lower bleeding risk, early ambulation, and improved patient comfort compared to the transfemoral approach. However, radial artery occlusion (RAO) remains its most common complication, potentially limiting future access. **Objectives:** To evaluate the frequency and predictors of radial artery occlusion (RAO) following transradial catheterization. **Methods:** This prospective observational analysis was conducted on 100 patients undergoing elective coronary angiography via TRA were enrolled. Doppler ultrasonography was performed 24 hours post-procedure to assess radial artery patency. Demographic, clinical, and procedural variables were analyzed to identify predictors of RAO. A p value <0.05 was considered statistically significant. **Results:** RAO was detected in 16% of patients. Female gender (p=0.02), shorter height (p=0.003), diabetes mellitus (p=0.001), smaller radial artery diameter (p=0.02), multiple puncture attempts (p=0.00014), multiple catheter use (p=0.02), prolonged procedure duration (p=0.0123), radial artery spasm (p=0.0009), hematoma formation (p=0.002), and compression time >30 minutes (p=0.03) were significantly associated with RAO. No major bleeding or vascular complications were noted, and all cases of RAO were asymptomatic due to adequate ulnar collateral flow. **Conclusion:** The incidence of RAO after transradial catheterization was 16%. Significant predictors included female gender, smaller radial artery diameter, diabetes, multiple punctures, and prolonged compression time. Maintaining radial artery patency during hemostasis, using optimal sheath size, and minimizing procedural trauma may reduce RAO incidence.

Keywords: Transradial catheterization, radial artery occlusion, predictors, coronary angiography, hemostasis, vascular complications.

INTRODUCTION

Coronary angiography continues to be the definitive diagnostic tool and therapeutic guide for patients with atherosclerotic coronary artery disease. The procedure can be performed through several arterial routes, including the femoral, radial, brachial, ulnar, or axillary arteries.

In recent years, the use of the radial artery for catheterization and PCI has grown rapidly. The transradial approach (TRA) is now widely favored due to its multiple advantages—earlier mobilization, fewer vascular and bleeding complications, and improved clinical outcomes in patients with acute coronary syndrome (ACS) (1).

Vascular access complications such as bleeding, hematoma formation, pseudoaneurysm, or arteriovenous fistula are significantly more frequent with the transfemoral approach (TFA) compared to TRA. Since vascular access and bleeding complications have been linked to increased morbidity and mortality, their prevention has become a crucial aspect of percutaneous coronary interventions.

Regarding procedural safety and effectiveness, TRA has proven comparable to TFA in both primary and

rescue PCI, while showing a lower rate of access-site complications, even following thrombolytic therapy [2]. Moreover, TRA is often chosen by both operators and patients because it enhances patient comfort, shortens hospital stay, and reduces overall treatment costs [3,4]. In recognition of these benefits, the European Society of Cardiology (ESC) guidelines for the management of ST-elevation myocardial infarction (STEMI) now recommend TRA as the preferred access route over TFA [5].

Despite these advantages, radial artery occlusion (RAO) remains an important complication of the transradial technique, with reported incidences ranging between 2% and 18% in prior studies [6]. Factors contributing to RAO include the administered anticoagulant dose, gender, body weight, radial artery diameter, sheath-to-artery size ratio, number of catheters used, procedure duration, as well as the technique and duration of post-procedural compression [7].

The present study was therefore conducted to determine the frequency and identify predictors of RAO among patients undergoing coronary angiography through the transradial route.

REVIEW OF LITERATURE

Earlier investigations have established that the transradial approach (TRA) provides excellent procedural success with fewer complications and is economically favorable when performed by skilled operators in the evaluation and management of coronary artery disease. Large randomized trials — notably the RIVAL (Radial versus Femoral Access for Coronary Angiography and Intervention in Acute Coronary Syndromes) and RIFLE-STEACS (Radial versus Femoral Randomized Investigation in ST-Elevation Acute Coronary Syndrome) — have shown that TRA significantly lowers morbidity and cardiac mortality in patients presenting with ST-segment elevation myocardial infarction [7,8,9].

Despite these advantages, certain technical challenges can lead to unsuccessful procedures. The main causes of failure include inability to puncture the radial artery, arterial spasm, or structural variations such as radial loops, as well as difficulty in engaging the coronary arteries [10]. According to Dehghani et al., additional factors such as subclavian tortuosity, inadequate catheter support, dissection of the radial artery, and looping of the vessel can also contribute to procedural failure [11].

Among the recognized complications of TRA, radial artery occlusion (RAO) is the most frequent, with its incidence varying from 2% to 18% in different reports [12–15]. Risk factors associated with RAO include inadequate anticoagulation, prolonged or excessive compression after sheath removal, small artery-to-sheath ratio, tobacco use, and repeated transradial access [12–15]. The pathogenesis of early RAO primarily involves thrombus formation [6]. Administration of heparin during the procedure plays a key role in its prevention [12–15], and outcomes appear similar whether the drug is given intra-arterially or intravenously [16].

In a classic study by Spaulding et al., the rate of RAO was observed to be 70% without heparin, 24% with 2000–3000 IU, and 4.3% with 5000 IU, indicating a strong protective effect of adequate anticoagulation [17]. Another comparison of 50 IU/kg versus a fixed **5000 IU** heparin dose demonstrated no statistically significant difference in RAO occurrence [18].

Several studies have also highlighted female sex and lower body weight as contributing factors to RAO [12–15,19]. The research by Sylvain Plante et al. reported a markedly lower incidence of RAO in patients weighing more than **84 kg** [19]. Additionally, **bivalirudin** and **enoxaparin** were found to be as effective as heparin in minimizing RAO risk [19]. Prolonged, tight compression of the puncture site further increases the

likelihood of RAO, whereas patent hemostasis techniques—which maintain limited distal blood flow—substantially reduce its occurrence [20]

Aims & Objectives

- The frequency of RAO in patients undergoing transradial catheterization was evaluated.
- The predictors of RAO in patients undergoing transradial catheterization was evaluated.

MATERIAL AND METHODS

Study population

A prospective observational analysis was conducted on patients undergoing elective diagnostic coronary angiography through the transradial approach. Participants were recruited consecutively over several months in a tertiary cardiac center. Exclusion criteria included active infection at the access site, severe sepsis, prior radial intervention, pathological Allen tests, Cardiogenic shock, Decompensated HF Severe valvular heart disease AKI or a known allergy to contrast agents. All patients provided written informed consent, and the institutional ethics committee approved the study protocol.

Procedure details

- Prior to the procedure, the Allen's test was performed in all participants to assess the adequacy of blood flow to the hand and confirm the patency of both the radial and ulnar arteries [21]. In this test, pressure was applied simultaneously over the radial and ulnar arteries to temporarily occlude them. Upon releasing the pressure over the ulnar artery, normal skin color was expected to return within seven seconds. A delayed return of color beyond 7–10 seconds was considered **abnormal**, indicating insufficient collateral circulation from the ulnar artery.
- During coronary angiography, unfractionated heparin was administered through the side port of the introducer sheath. The heparin dose was calculated individually according to the patient's body weight.
- Following completion of the procedure, the radial sheath was immediately withdrawn, and hemostasis was achieved by compression **of the puncture site. The** duration of fluoroscopy, **the** occurrence of radial artery spasm, **and their** impact on procedural success were systematically recorded for each patient.
- To assess vascular integrity, **Doppler ultrasonography** of the radial artery was performed **24 hours post-procedure** to evaluate arterial patency and detect any evidence of radial artery occlusion

RESULTS AND OBSERVATIONS:

- The studied population included 100 patients with a mean age of 59.77 ± 13.63 years.
- Number of female patient -43
- The Doppler examination revealed RAO in 16 patients out of 100 . (The frequency of radial artery occlusion was 16%)

Table 1 summarizes the demographic and clinical characteristics of the studied population.

TABLE 1	
Age (years)	59.77 ± 13.63
Gender	
Male	57
Female	43
Weight (kgs)	68.94 ± 12.61
Height (cms)	161.87 ± 10.90
BMI (kg/m^2)	26.48 ± 5.27
DM	20
Hypertension	38
Smoking	62
Dyslipidemia	21
RAO	16
RA Diameter	2.7 ± 0.2 mm

According to RA Doppler ultrasonography, patients were divided into 2 groups: patients with occluded RA (RAO group) and patients with patent RA (non- RAO group).

Table 2 summarizes the demographic, clinical characteristics data of both groups.

Demographic and clinical characteristic of study group (Table 2)

Parameter	RAO group (n=16)	Non RAO group (n=84)	p-value	
Age	58.19 ± 15.40	60.07 ± 13.34	0.61	Not Significant
Gender				
Male	5	52	0.02	Significant
Female	11	32		
Body weight (kg)	75.87 ± 10.23	67.25 ± 11.65	0.06	Not Significant
Height (cm)	154.7 ± 13.7	163.2 ± 9.88	0.003	Significant
BMI (kg/m^2)	27.43 ± 6.95	26.3 ± 4.92	0.43	Not Significant
Heparin dose 40 unit / kg	$3034.8 \pm$	$2690 \pm$	0.06	Not Significant
DM	8	12	0.001	Significant
HTN	10	28	0.37	Not Significant
Smoking	12	50	0.59	Not Significant
Dyslipidemia	5	16	0.31	Not Significant
RA Diameter (mm)	2.58 ± 0.24	2.73 ± 0.19	0.02	Significant

Parameter	RAO group (n=16)	Non RAO group (n=84)	p-value	
Puncture attempt				
Single	7	75	0.00014	Significant
Multiple	9	9		
Number of catheters used				
Single	13	82	0.02	Significant
Multiple	3	2		
Duration	13.68±3.04	10.61±4.62	0.0123	Significant
Puncture Site				
Proximal	16	81	1	Not significant
Snuff Box	0	3		
Haematoma	4	1	0.002	Significant
Spasm	5	2	0.0009	Significant
Pressure >30 min	8	19	0.03	Significant

Transradial coronary catheterization was successfully completed in all 100 patients. There were **no major vascular complications**, such as significant bleeding, pseudoaneurysm, or arteriovenous fistula formation.

Radial artery spasm **occurred in** seven patients, **but these episodes were transient and did not interfere with procedural success**. Minor hematoma **was observed in** five patients, all of which resolved spontaneously. Only three patients reported post-procedural discomfort, which was effectively managed using local heat application and mild nonsteroidal anti-inflammatory drugs.

All patients in the RAO group **remained** asymptomatic, and no impairment of hand function was observed owing to adequate collateral flow through the ulnar artery.

Predictors of RAO:

Female sex was associated with a higher rate of radial artery occlusion. On statistical analysis, the following factors showed a **significant correlation** with RAO: female gender, shorter height, diabetes mellitus, smaller radial artery diameter, multiple puncture attempts, use of multiple catheters, prolonged procedural duration, development of hematoma or arterial spasm, and compression time exceeding 30 minutes.

No significant association was found between RAO and body mass index, hypertension, smoking, dyslipidemia, or puncture site.

DISCUSSION

In this study, the incidence of radial artery occlusion (16%) was slightly higher than that reported in previous literature. This variation may be attributed to the use of Doppler ultrasonography for post-procedure assessment, which is more sensitive than the palpation method employed in many earlier studies. Even with proximal occlusion, palpable pulsations can persist because of collateral supply via the palmar arch, potentially leading to underestimation of RAO in prior research.

Among the significant predictors, female sex was associated with a higher likelihood of RAO, most likely due to the smaller radial artery caliber commonly seen in women. Similar observations have been made in earlier studies.

Pancholy and Patel [7] demonstrated that shorter hemostatic compression times significantly reduce the risk of both early and late RAO without increasing bleeding events. Further studies confirmed that maintaining patent hemostasis—allowing partial radial

flow during compression—is more crucial than compression duration itself in preventing occlusion.

In our cohort, all procedures were performed using 6-French sheaths. Given a fixed sheath diameter (~2 mm), the radial artery diameter emerged as an independent predictor of RAO. A smaller vessel diameter increases the sheath-to-artery ratio, resulting in greater luminal compromise, mechanical stretching, and potential endothelial injury, predisposing the vessel to spasm, intimal trauma, and subsequent thrombosis.

Dahm et al. [22] found in a randomized trial that the incidence of RAO was 5.9% with 6-French and 1.1% with 5-French guiding catheters (p=0.05), reinforcing the importance of maintaining a sheath-to-artery ratio below 1 to preserve patency.

The number of catheters used was also significantly higher in the RAO group. Repeated catheter or guidewire manipulation can provoke arterial spasm and lead to endothelial disruption, increasing the risk of thrombosis and eventual occlusion.

LIMITATIONS

This study has certain limitations.

1. It was a single-center, prospective observational study, which limits generalizability.
2. The sample size (n=100) was relatively small to establish strong statistical power.
3. The operator's experience, an important determinant of procedural success and complication rate, was not accounted for.
4. Future randomized multicentric studies are warranted to validate these findings.

CONCLUSION

The transradial approach (TRA) for coronary angiography and interventions offers several advantages over the transfemoral route, including greater patient comfort, fewer bleeding complications, and shorter recovery times. However, radial artery occlusion remains the most common complication, potentially limiting future radial access.

Routine adoption of patent hemostasis techniques, adequate anticoagulation, and shorter compression durations can significantly reduce the incidence of RAO. All patients undergoing TRA should be screened for radial artery patency before discharge.

Further research and technological innovations are needed to refine procedural techniques and minimize this important complication of radial access.

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