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Research Article

Usefulness of TR Pneumatic Compression Band in Transradial Cardiac Catheterization

Muhammad Waqas Mazhar Qureshi[1]*, Zahid Iqbal[1] and Han Naung Tun[2]

[1]CPE Institute of Cardiology, Cardiology, Multan, Pakistan

[2]Pun Hlaing Siloam Hospital, Cardiology, Yangon, Myanmar

***Corresponding Author:** Muhammad Waqas Mazhar Qureshi, CPE Institute of Cardiology, Cardiology, Multan, Pakistan.

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Abstract

Introduction: Radial artery occlusion is a usually silent complication of transradial approach that may prevent future transradial procedures.TR Band provides quick, effective, comfortable hemostasis and reduces arterial occlusion. The purposive significance of this study was to evaluate the usefulness of TR band after coronary angiogram in decreasing the frequency of radial artery occlusion.

Materials and Methods: A total of 180 patients with undergoing coronary angiogram through transradial access of any gender between age 18 - 70 years were included. Patients with history of previous coronary angiogram through transradial access, undergoing PCI and h/o peripheral arterial disease were excluded. Full demographic informations including age, gender were included in the study. The radial artery occlusion (RAO) was assessed by Barbeau test after 24 hours of coronary angiography.

Results: Mean age was 54.19 ± 12.30 years. Out of the 180 patients, 123 (68.33%) were male and 57 (31.67%) were females with male to female ratio of 2.16:1. Radial artery occlusion was found in 14 (7.78%) patients. It was also found that presence of confounding variables i.e. diabetes mellitus, hypertension and smoking, increased the risk of radial artery occlusion though this difference was found to be only statistically significant for diabetes mellitus.

Conclusion: This study concluded that TR pneumatic compression band is a very useful and safe method with frequency of radial artery occlusion is only 7.78% after transradial cardiac catheterization.

Keywords: *Cardiac Catheterization; Radial Artery; Thrombosis; Compression*

Introduction

Cronary angiography is the mainstay of diagnosis of ischemic heart disease (IHD). It is the traditional benchmark investigation for establishing the nature, anatomy and severity of CHD. This invasive technique for imaging the coronary artery lumen remains the most accurate for the diagnosis of clinically important obstructive coronary atherosclerosis and less common non-atherosclerotic causes of possible chronic stable angina pectoris [1]. The technique of angiography itself was first developed in 1927 by the Portuguese physician Egas Moniz at the University of Lisbon for cerebral angiography, the viewing of brain vasculature by X-ray radiation with the aid of a contrast medium introduced by catheter [2].

Heart catheterization was first performed in 1929 when the German physician Werner Forssmann inserted a plastic tube in his cubital vein and guided it to the right chamber of the heart. He took an x-ray to prove his success and published it on November 5, 1929 with the title "Über die Sondierung des rechten Herzens" (About probing of the right heart) [3]. A coronary catheterization is a minimally invasive procedure to access the coronary circulation and blood-filled chambers of the heart using a catheter. It is performed for both diagnostic and interventional (treatment) purposes. Coronary catheterization is one of the several cardiology diagnostic tests and procedures [4]. Specifically, coronary catheterization is a visually interpreted test performed to recognize occlusion, stenosis, restenosis, thrombosis or aneurysmal enlargement of the coronary artery lumens; heart chamber size; heart muscle contraction performance; and some aspects

of heart valve function. Important internal heart and lung blood pressures, not measurable from outside the body, can be accurately measured during the test. The relevant problems that the test deals with most commonly occur as a result of advanced atherosclerosis - atheroma activity within the wall of the coronary arteries. Less frequently, valvular, heart muscle, or arrhythmia issues are the primary focus of the test [5].

It is performed either through femoral or radial access. Recent studies have shown that radial access have been proven to be safe and effective than the femoral access. However, the lower rate of local vascular complications may be a reason to use the radial approach [6]. Transradial catheterization has a unique set of complications and risks that each operator must appreciate. Radial artery spasm and radial artery occlusion are the most common complications, while bleeding complications such as hematomas and perforations are much less frequent [7].

Radial artery occlusion (RAO) is a usually silent complication of transradial approach that may prevent future transradial procedures. Since simple pulse check at the level of radial cannulation is not reliable, plethysmography and duplex ultrasound are required to assure diagnosis [8]. A randomized comparison of TR band and radistop hemostatic compression devices after transradial coronary intervention illustrated that radial artery occlusion at the time of discharge was seen in 9.2% of the patients though only 6.8% showed persistent occlusion at the time of follow-up [9]. Radial access allows for earlier patient ambulation and same-day hospital discharge in PCI patients and is associated with decreased cost [10,11]. This approach has a higher rate (5 - 10%) of asymptomatic radial artery occlusion [12].

TR Band provides quick, effective, and comfortable hemostasis. It consists of a transparent support plate and 2 inflatable balloons; one to provide pressure over the puncture site and one to keep the first balloon in proper position. Patent hemostasis is highly effective in reducing radial artery occlusion (RAO) after radial access and guided compression should be performed to maintain radial artery patency at the time of hemostasis, to prevent future radial artery occlusion (RAO) [13].

Compression method, guided by the patient's mean arterial pressure value at the end of catheterization of the radial artery, is safe and effective and reduces arterial occlusion compared with the standard compression method using a pneumatic device (TR band) [14]. Pancholy SB evaluated the effect of two different hemostatic devices (HemoBand and Inflatable TR Band) on radial artery outcomes after transradial catheterization. In group I, 11.2% patients developed early occlusion (at 24 hours), compared to 4.4% in Group II ($p < 0.005$). In Group I, 7.2% patients developed evidence of chronic occlusion (at 30 days), compared to 3.2% patients in Group II ($p < 0.05$). A significant reduction in radial artery occlusion was noted with hemostasis using the TR Band compared to the Hemo Band, without compromising hemostatic efficacy [15].

Ch. Pervaiz Elahi Institute of Cardiology Multan is a post graduate teaching institute of cardiology where cardiac catheterization is frequently performed for diagnostic and therapeutic purposes. The purposive significance of this study was to evaluate the usefulness of TR band after coronary angiogram in decreasing the frequency of radial artery occlusion (RAO). TR Band usefulness and safety has been determined internationally [13-15] and yet to be evaluated in local population.

Objectives

The objective of the study was to determine the frequency of radial artery occlusion (RAO) with application of TR pneumatic compression band after transradial cardiac catheterization.

Operational definitions

Radial Artery Occlusion: Radial artery occlusion was diagnosed by the Barbeau test by the use of plethysmography and pulse oximeter. A pulse oximeter was placed on the ipsilateral thumb and the morphology of the plethysmography tracing was noted. If pulse waveform was not noted it was labeled as radial artery occlusion (Barbeau test response-D).

Materials and Methods

Study Design: Descriptive, Cross Sectional study.

Setting: Department of angiography at Ch. Pervaiz Elahi Institute of Cardiology Multan.

Sample size: Sample size was calculated by formula

$$n = \frac{z^2pq}{d^2}$$

Where z =1.96, p=4.49, q =100-p and d (margin of error) = 3%. Thus sample size was 180 patients.

Sample technique: Non-probability, Consecutive sampling.

Sample selection

Inclusion Criteria: Patients undergoing coronary angiogram through transradial access of any gender between age 18 - 70 years.

Exclusion Criteria:

- Patients with history of previous coronary angiogram through transradial access.
- Patients undergoing PCI.
- Patients having history of peripheral arterial disease.
- Age > 70 yrs.
- Patients having history of carotid or renal artery stenosis.

Data collection procedure

After taking permission from hospital ethical committee, all patients fulfilling the inclusion criteria were included in the study. An informed consent was taken from patients for using their data in research. Full demographic informations including age, gender were included in the study and also the effect of hypertension (HTN), diabetes (DM) and smoking on the outcome of my study was observed. Hypertension (HTN) was assessed on history or patient having blood pressure > 140/90 mmHg. Diabetes Mellitus (DM) was assessed on history or patient having fasting blood sugar > 126 mg/dl or random blood sugar > 200 mg/dl while smoking was assessed only on history. The radial artery occlusion (RAO) was assessed by Barbeau test after 24 hours of coronary angiography. Barbeau test was performed by the consultant cardiologist having F.C.P.S in cardiology with 5 years experience.

Data analysis procedure

Data was entered into SPSS version 10.0 and analyzed through it. Quantitative variables like age were presented as mean and standard deviation. Qualitative variables of the study were gender and presence of RAO. Frequency and percentages were calculated for qualitative variables. Stratification with respect to age and gender was done on these variables and also the other confounding variables (DM, HTN and smoking) to see the effect of these variables on outcome of the study. Post stratification chi-square test was applied to see their effect on outcome. P value was considered significant at < 0.05.

Results

Age range in this study was from 18 to 70 years with mean age of 54.19 ± 12.30 years. Majority of the patients 67 (37.22%) were between 61 to 70 years of age as shown in table 1. Out of the 180 patients, 123 (68.33%) were male and 57 (31.67%) were females with male to female ratio of 2.16:1 (Figure 1). Frequency of patients with status of diabetes mellitus, hypertension and smoking has shown in table 2.

Age (in years)	No. of Patients	% age
18 - 30	12	6.67
31 - 40	18	10.0
41 - 50	33	18.33
51 - 60	51	28.33
61 - 70	67	37.22

Table 1: *% age of patients according to Age distribution (n = 180).*

Mean ± SD = 54.19 ± 12.30 years.

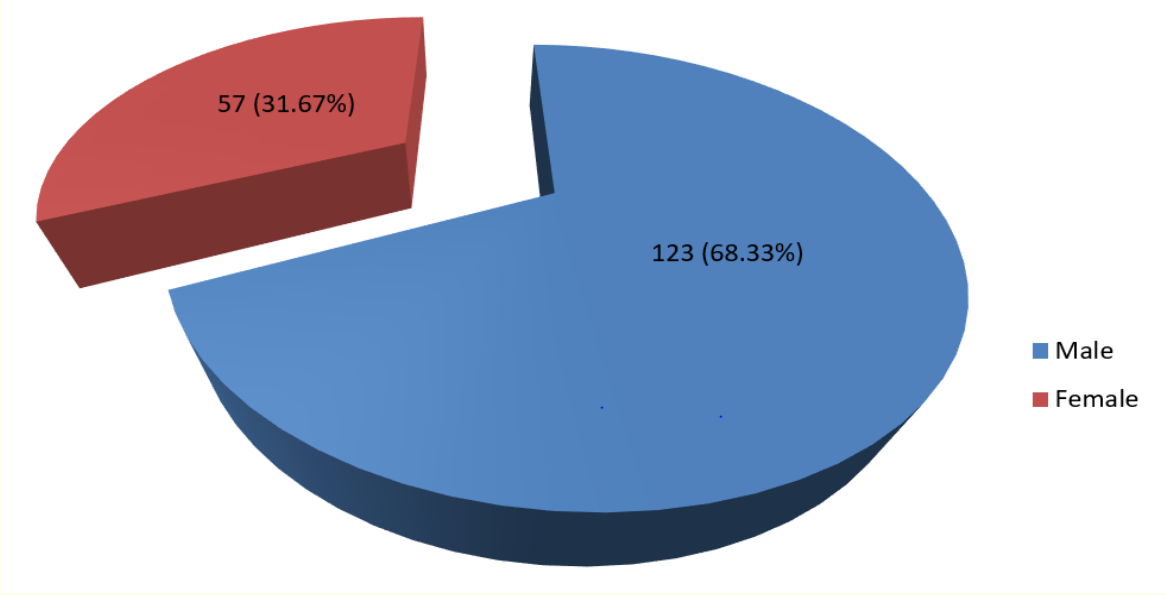

Figure 1: *% age of patients according to gender (n = 180).*

Confounding variables		Frequency	% age
Diabetes Mellitus	Yes	83	46.11
	No	97	53.89
Hypertension	Yes	91	50.51
	No	89	49.44
Smoking	Yes	102	56.67
	No	78	43.33

Table 2: *% age of patients with status of other confounding variables (n = 94).*

Radial artery occlusion (RAO) was found in 14 (7.78%) patients, whereas there was no radial artery occlusion (RAO) in 166 (92.22%) patients as shown in figure 2. When Stratification was done on age groups and gender, it was found that there was no significant difference of radial artery occlusion (RAO) between different age groups and genders as shown in table 3 and 4 respectively. Stratification of confounding variables i.e. diabetes mellitus, hypertension and smoking have shown in table 5-7 respectively and it was found that presence of these factors increased the risk of radial artery occlusion (RAO) though this difference was found to be only statistically significant for diabetes mellitus.

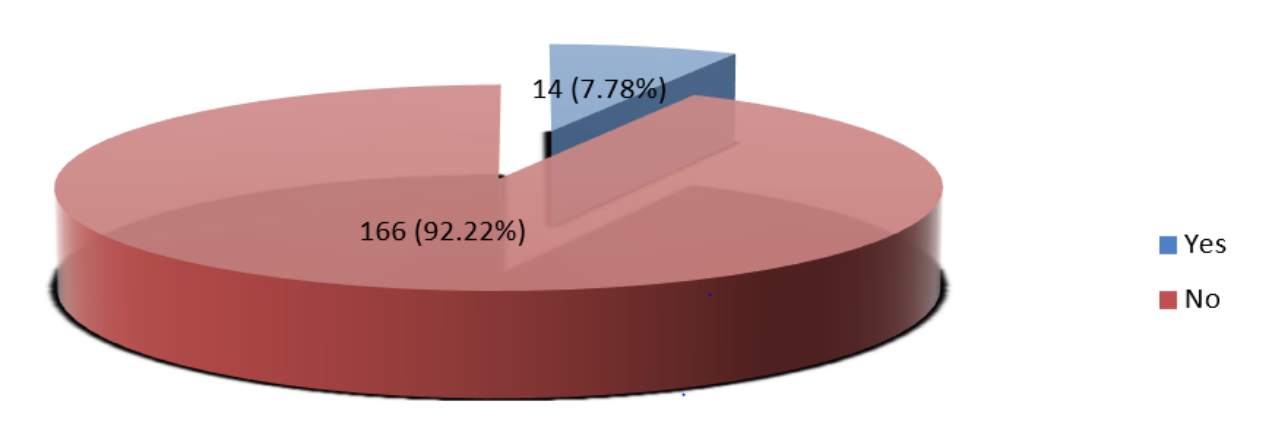

Figure 2: *% age of patients with Radial artery occlusion (RAO).*

Age (years)	Radial artery occlusion		p-value
	Yes	No	
18 - 30	00 (0.0%)	12 (100.0%)	0.745
31 - 40	01 (5.55%)	17 (94.44%)	
41 - 50	02 (6.06%)	31 (93.94%)	
51 - 60	04 (7.84%)	47 (92.16%)	
61 - 70	07 (10.45%)	60 (89.55%)	

Table 3: *Stratification of age groups with respect to Radial artery occlusion.*

Gender	Radial artery occlusion		p-value
	Yes	No	
Male	09 (7.32%)	114 (92.68%)	0.735
Female	05 (8.77%)	52 (91.23%)	

Table 4: *Stratification of Gender with respect to Radial artery occlusion.*

Diabetes Mellitus	Radial artery occlusion		p-value
	Yes	No	
Yes	10 (12.05%)	73 (87.95%)	0.048
No	04 (4.12%)	93 (95.88%)	

Table 5: *Stratification of Diabetes Mellitus with respect to Radial artery occlusion.*

Hypertension	Radial artery occlusion		p-value
	Yes	No	
Yes	08 (8.79%)	83 (91.21%)	0.608
No	06 (6.74%)	83 (93.26%)	

Table 6: *Stratification of BMI with respect to Radial artery occlusion.*

Smoker	Radial artery occlusion		p-value
	Yes	No	
Yes	11 (10.78%)	91 (89.22%)	0.085
No	03 (3.85%)	75 (96.15%)	

Table 7: *Stratification of Smoking with respect to Radial artery occlusion.*

Discussion

Although the transfemoral approach to cardiac catheterization has dominated the explosive growth of invasive cardiology in past decades, transradial access appeared early in the development of cardiac catheterization techniques. In 1948, Radner published one of the first descriptions of transradial central arterial catheterization and attempts at coronary artery imaging using radial artery cut-down and 8- to 10-F catheters.

The ease of achieving hemostasis after radial artery access and the significant decrease in access site complications are probably the main reasons that make the transradial approach attractive. Radial artery compression is well tolerated and easy to perform in view of the absence of large neurovascular structures in the vicinity of radial artery, extensive collateralization at the level of the hand, and the hard surface of radius bone upon which the radial artery lies. These attributes allow for the application of liberal compression and frequently excessive compression at the radial access site. The small lumen and thicker wall of the radial artery lead to obliteration of the radial artery lumen and a resultant cessation of radial artery flow when liberal compression is applied [1]. Although hemostatic compression at the radial access site is very effective in providing hemostasis, in this study we have determined the frequency of radial artery occlusion (RAO) with application of TR pneumatic compression band after transradial cardiac catheterization.

Radial artery occlusion (RAO) occurs in 2% to 10% of patients after transradial catheterization. Extensive macro- and micro-collateralization protects the hand from ischemic complications at rest, although occasional digital ischemia/gangrene has been reported, which is likely due to embolization of digital end arteries. Local inflammatory symptoms occur in some patients, and frequently resolve spontaneously. In the majority of patients, re-canalization of the occluded radial artery occurs during the following month with re-establishment of radial artery patency [16]. Rathore S., *et al.* [9] in his randomized comparison of TR band and radistop hemostatic compression devices after transradial coronary intervention illustrated that radial artery occlusion at the time of discharge was seen

in 9.2% of the patients though only 6.8% showed persistent occlusion at the time of follow-up. In another study, Pancholy SB., *et al.* evaluated the effect of two different hemostatic devices (HemoBand and Inflatable TR Band) on radial artery outcomes after transradial catheterization. In group I, 11.2% patients developed early occlusion (at 24 hours), compared to 4.4% in Group II ($p < 0.005$). In Group I, 7.2% patients developed evidence of chronic occlusion (at 30 days), compared to 3.2% patients in Group II ($p < 0.05$). A significant reduction in radial artery occlusion was noted with hemostasis using the TR Band compared to the Hemo Band, without compromising hemostatic efficacy [15].

Several variables influence the incidence of radial artery occlusion. Adequate anticoagulation is extremely important. This is usually not an issue in patients undergoing interventional procedures, but the incidence of radial occlusion was as high as 30% in patients receiving only 1,000 units of heparin during diagnostic catheterization [17]. Due to this risk of radial occlusion, we tend to reserve the use of the radial artery for interventional procedures and look-see diagnostic catheterization. Elective diagnostic catheterizations are performed transradially only when there is an increased risk of femoral complications.

Catheter size has been shown to be an important predictor of post-procedure radial artery occlusion. Saito has studied the ratio of the radial artery internal diameter to the external diameter of the arterial sheath [18]. The incidence of occlusion was 4% in patients with a ratio of greater than 1, as compared to 13% in those with a ratio of less than 1. Radial procedures have traditionally been performed using 6 Fr catheters, and most patients have an internal radial artery diameter larger than the 2.52 mm external 6 Fr sheath diameter [18]. The incidence of radial occlusion following 6 Fr procedures is less than 5%, but the rate increases with larger sheath sizes [18].

Zankl AR., *et al.* [13] recognized RAO by Doppler in 10.5% of 488 patients undergoing coronary angioplasty. Surprisingly high was the proportion of symptomatic patients in this group complaining of forearm pain - 58.5%. None of these individuals had symptomatic hand ischemia. The use of low molecular weight heparin (LMWH) in this group for 4 weeks resulted in artery recanalization in 86.7% of them and relief of symptoms. No bleeding complications were noted. In another study, 42.5% of patients with the diagnosis of RAO suffered pain in the puncture site immediately after the procedure, with another 7% of patients with symptoms that appeared after a few days. There were no signs of hand ischemia. Fifty-nine percent of patients with confirmed RAO received LMWH. Recanalization, assessed after 14 days, was significantly more common in the LMWH group as compared to the group treated symptomatically (55.6% vs. 13.5%, $p < 0.001$) [19].

The Prevention of Radial Artery Occlusion-Patent Hemostasis Evaluation Trial (PROPHET) tested the concept of patent hemostasis using the HemoBand (HemoBand Corporation, Portland, OR) [20]. Patients were randomly assigned to conventional pressure application versus compression guided by pulse oximetry (the ulnar artery was occluded and the HemoBand was loosened until a pulsatile plethysmography signal was observed). The intervention group had significantly less RAO than the control group, both at 24 hours (5% versus 12%, $P < 0.05$) and at 1 month (1.8% versus 7.0%, $P < 0.05$) [12]. So, on the whole it was concluded that TR pneumatic compression band is a very useful and safe method in reducing the frequency of radial artery occlusion after transradial cardiac catheterization.

Conclusion

This study concluded that frequency of radial artery occlusion (RAO) is only 7.78% with application of TR pneumatic compression band after transradial cardiac catheterization. Thus TR pneumatic compression band is a very useful and safe method in reducing the frequency of radial artery occlusion after transradial cardiac catheterization. So, we recommend that TR pneumatic compression band should be used routinely after transradial cardiac catheterization in order to reduce the radial artery occlusion (RAO) as well as the morbidity of these particular patients.

Conflict of Interest

The authors declare there is no conflict of interest in the study and no funding from any organization and company.

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