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RADIAL ARTERY PATENCY FOLLOWING TRANSRADIAL INTERVENTION AT TERTIARY CARE HOSPITAL PESHAWAR KHYBER PAKHTUNKHWA

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Abstract

The current study was conducted to evaluate radial artery patency following percutaneous coronary intervention (PCI) performed through the transradial approach in a tertiary care hospital of Khyber Pakhtunkhwa. The transradial approach has grown in considerable acceptance in recent years because of its practical rewards over the transfemoral route. In addition to providing greater comfort to patients, it is associated with fewer access-site complications and allows earlier mobilization after the procedure. The findings of this study verified suitable radial artery patency rates after PCI, indicating that the transradial approach can be used effectively without significantly compromising vascular integrity. A low frequency of bleeding-related complications was also observed, further

supporting the safety of this access technique in routine clinical practice. Most participants included in the study were male, a finding that is consistent with the higher prevalence of coronary artery disease reported among men in many populations. Age-related differences were also noted during data analysis. Advancing age is commonly associated with structural changes in blood vessels, including increased arterial stiffness and reduced elasticity. These factors may influence the ease of arterial access and procedural outcomes. Although older patients may present additional technical challenges, the results of the present study suggest that successful transradial intervention can still be achieved across different age groups when appropriate procedural measures are followed. The findings also draw attention to anatomical variations among female patients. Smaller radial artery diameter may increase the likelihood of vasospasm and make vascular access more challenging in some cases. Careful patient assessment before the procedure and appropriate selection of equipment may help reduce these difficulties. Consideration of individual patient characteristics remains important for optimizing procedural success and minimizing complications. Overall, the results of this study support the continued use of the transradial approach for coronary interventions. Its favorable safety profile, combined with high radial artery patency rates and reduced bleeding complications, makes it a reliable option for PCI. The findings contribute to the growing body of evidence supporting transradial access as an effective alternative to the transfemoral approach in contemporary interventional cardiology practice.

INTRODUCTION

Cardiovascular diseases (CVDs) remain a leading cause of mortality worldwide, particularly in developing countries where healthcare resources are limited. Coronary artery disease is a major contributor to this burden, and coronary angiography and percutaneous coronary intervention (PCI) are routinely performed for its diagnosis and treatment. The choice of vascular access site during these procedures plays a key role in patient outcomes, particularly in terms of complications and arterial integrity [1].

Traditionally, the femoral artery was the preferred access route; however, the transradial approach has become increasingly popular due to its lower complication rates, reduced bleeding risk, and improved patient comfort. Patients undergoing radial access can mobilize earlier, making it a widely accepted standard in contemporary interventional cardiology [2]. Despite these advantages, radial artery occlusion (RAO) remains the most common

complication following transradial procedures, often occurring silently due to collateral circulation maintaining hand perfusion [3].

Although RAO is frequently asymptomatic, its clinical importance is significant because the radial artery is often required for future interventions or as a conduit in coronary artery bypass grafting (CABG). Loss of radial patency may therefore limit future therapeutic options, emphasizing the importance of vessel preservation [4]. To address complications associated with proximal radial access, distal radial access via the anatomical snuffbox has been introduced as an alternative technique, potentially reducing proximal vessel occlusion while maintaining procedural effectiveness [5].

Current evidence highlights that radial artery patency is influenced not only by access site selection but also by procedural and pharmacological factors. The use of patent hemostasis, appropriate sheath-to-artery ratio, and adequate intra-procedural anticoagulation (e.g., unfractionated heparin ≥5000 IU) are key determinants of reduced RAO risk [7]. Recent studies also suggest that distal transradial access may not significantly reduce RAO compared to conventional access, as occlusion rates remain comparable between techniques [8].

Over the past two decades, increasing adoption of transradial intervention has been driven by improved safety profiles, particularly reduced bleeding and mortality after acute myocardial infarction [9]. However, structural changes in the radial artery following catheterization, including intimal thickening and luminal narrowing, may compromise its long-term usability for future procedures or bypass grafting [10].

Evidence indicates that RAO is primarily caused by mechanical injury and post-procedural thrombosis, highlighting the importance of ultrasound-guided access, weight-adjusted heparin administration, and optimized hemostatic techniques to preserve arterial flow [11]. Sheath-to-artery ratio has also been identified as a significant predictor of occlusion, particularly in patients with smaller arterial diameters, underscoring the need for appropriately sized equipment and the “slender approach” [12].

Although transradial access is generally safe, RAO continues to occur and is often underdiagnosed without imaging. Doppler ultrasonography is considered the most reliable method for assessing post-procedural radial artery patency, as clinical tests may miss partial or asymptomatic occlusions [19]. Preventive strategies, including adequate anticoagulation, patent hemostasis, and reduced compression time, have been shown to significantly reduce RAO incidence [20,21].

RAO has important long-term consequences, as it may limit future use of the radial artery for CABG or arteriovenous fistula creation in patients with chronic kidney disease [17]. Despite growing evidence, regional data on radial artery outcomes remain limited, particularly in developing regions such as Khyber Pakhtunkhwa, Pakistan, highlighting the need for localized research [15]. Therefore, this study aims to evaluate radial artery patency following transradial procedures and to identify factors associated with radial artery occlusion, with the ultimate goal of improving future vascular outcomes and preserving radial artery function.

Methodology

This research used a cross-sectional design to assess patients after transradial cardiac procedures. The study focused on the early post-procedural period to evaluate radial artery patency and immediate outcomes without long-term follow-up. This approach allowed consistent data collection from all participants and provided a clear understanding of short-term results and the relationship between access technique and post-procedural outcomes.

The study was conducted in the catheterization laboratory of a tertiary care hospital in Peshawar, Khyber Pakhtunkhwa, which routinely performs coronary angiography and PCI and serves a large cardiac patient population. Patients who met the eligibility criteria and underwent transradial procedures during the study period were included.

A total of 163 patients were enrolled in the study, calculated using a 95% confidence level, 5% margin of error, and an estimated prevalence of 12% from previous studies. This sample size was considered sufficient for reliable results.

Patients aged 40 to 60 years who had undergone transradial cardiac procedures in the post-intervention phase were included, while those undergoing transfemoral procedures or falling outside the specified age range were excluded.

Results

Overall Radial Artery Patency

This research comprised 163 individuals who had transradial cardiac operations. Following the surgery, the Allen test was used to evaluate radial artery patency. Of the 163 individuals, 77 (47.2%) had radial artery blockage and 86 (52.8%) had a patent radial artery. 47.2% of radial arteries were occluded overall. Patients with patent radial arteries were 50.8 ± 12.0 years old

on average, whereas those with occluded radial arteries were 51.9 ± 9.1 years old. The group as a whole had a median age of 55.

Overall Radial Artery Patency Rate (N = 163)

TABLE.01. Radial Artery Status Frequency (n) Percentage (%)

RADIAL ARTERY STATUS	FREQUENCY (n)	PERCENTAGE (%)
PATENT	86	52.8%
OCCLUDED	77	47.2
TOTAL	163	100.0%

Table 1 presents the radial artery status across a sample size of 163 observations, classifying the results into percentages and frequencies. Of the entire sample, 86 instances, or 52.8% of the total, had radial arteries that were still patent. On the other hand, it was discovered that the remaining 77 instances, or 47.2%, were obstructed. These two groups together make up the whole dataset that was assessed for the study.

Fig.01

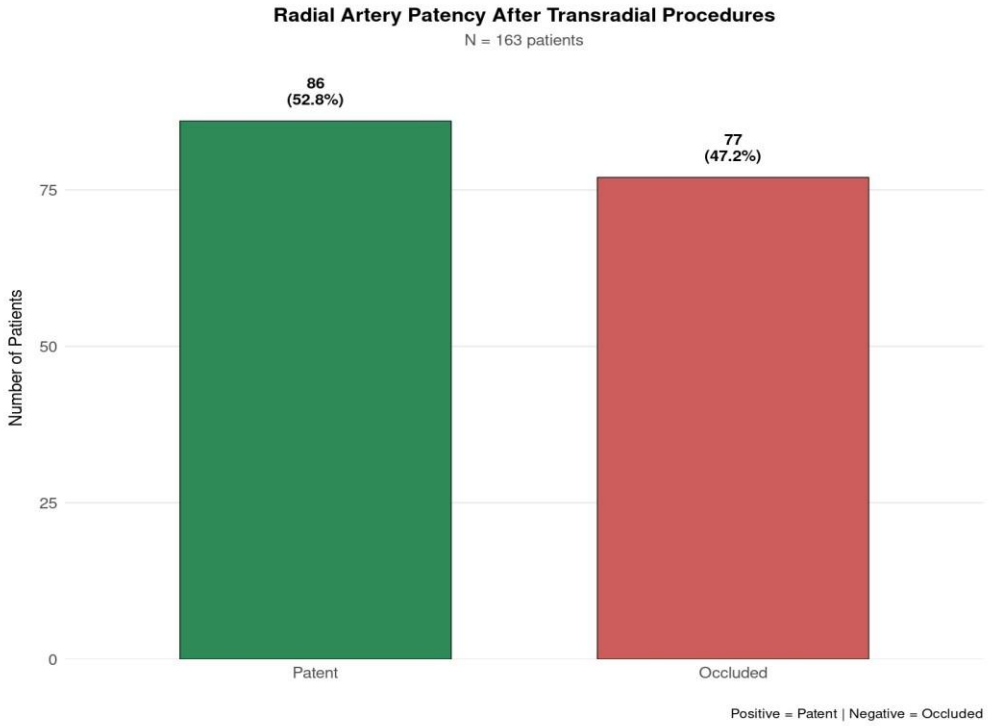


Fig. 1: The main study results for 163 participants are summarized in this bar graph. It reveals that 47.2% (n=77) of the group had occlusion and 52.8% (n=86) had radial artery patency. The graph clearly illustrates how the two clinical outcomes after transradial surgeries are distributed about equally.

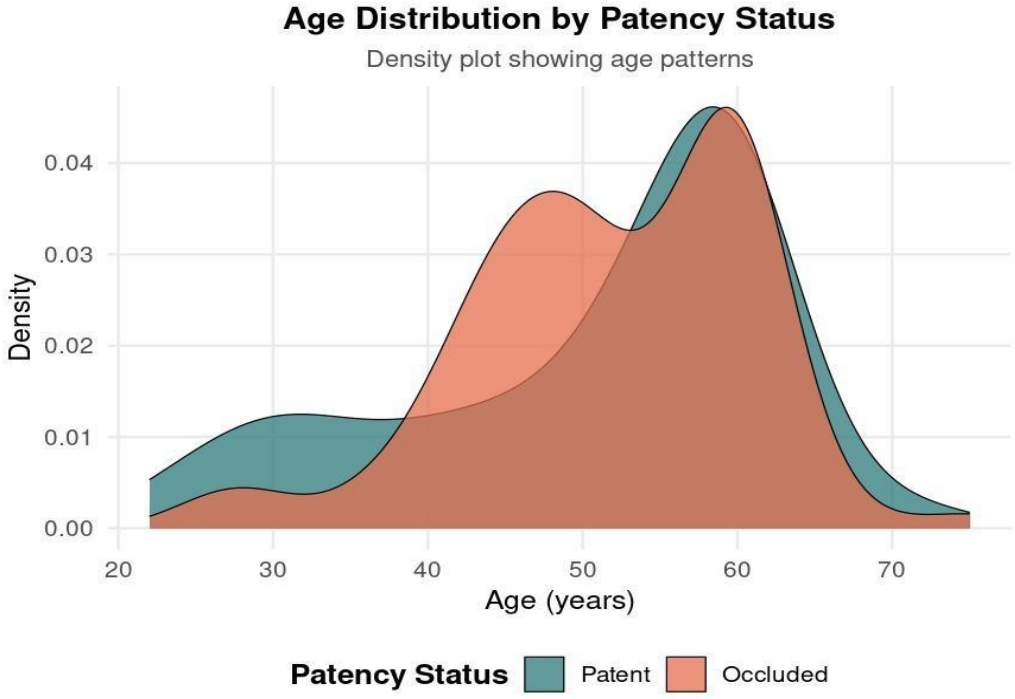
Patient Characteristics by Radial Artery Patency

TABLE NO 02: Patient Characteristics According to Radial Artery Patency Status

CHARACTERIST	PATENCY	OCCLUDED	TOTAL (N= 16)	P-VALUET
AGE (YEARS)				0.64
MEAN ± SD	50.8 ± 12.0	51.9 ± 9.1		
MEDIAN	55	52	55	
GENDER, n (%)				0.049
MALE	46 (57.0)	55 (71.4)	104 (63.8)	

FEMALE	37(43.0)	21(27.3)	58(35.6)	
PROCEDURE TYPE,n (%)				0.372
PCI	38 {44.2)	35(45.5)	73(44.8)	
ANGIOGRAGHY	19	23(29.9)	42(25.8)	
OTHER	29(33.7)	19(24.7)	48(29.4)a	

Patients with patent vs occluded radial arteries did not substantially vary in age or type of operation ($p = 0.64$ and $p = 0.372$, respectively), according to Table 2. PCI was the most common procedure in both groups. There was a noticeable difference between males and females, which was statistically significant (p = 0.049). Females showed higher radial artery patency rates (43.0%), while males had more cases of occlusion (71.4%).



The age distribution of patients with patent and occluded radial arteries is compared in Figure 2's density plot. The group with blocked radial artery shows a noticeable smaller rise in cases in the late 40s, but in both groups most patients are clustered around the age of 60. This illustrates how each clinical outcome frequency varies by age group.

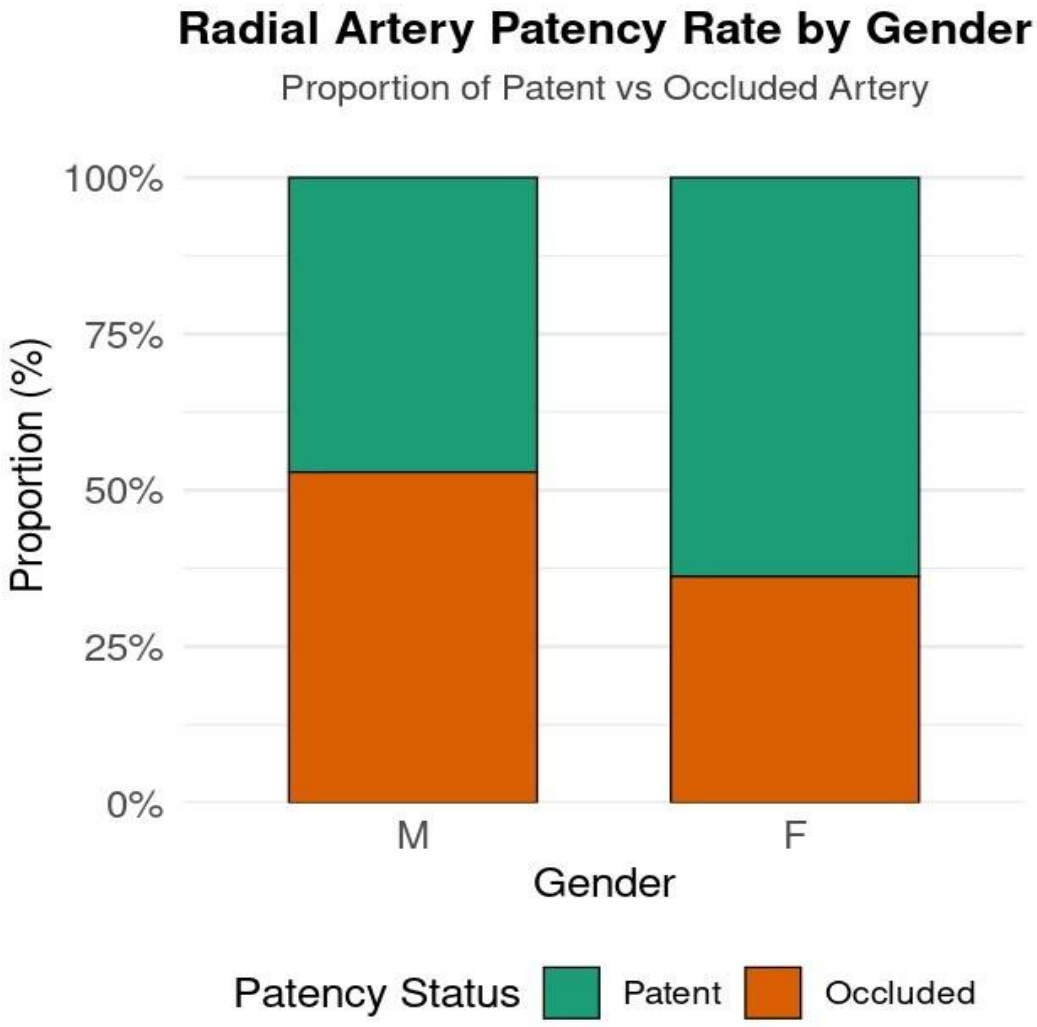


Fig.3 This 100% Stacked Bar Chart compares artery status between genders. It shows that females have a higher proportion of patent (green) arteries than males, while the male group exhibits a larger relative share of occlusions (orange).

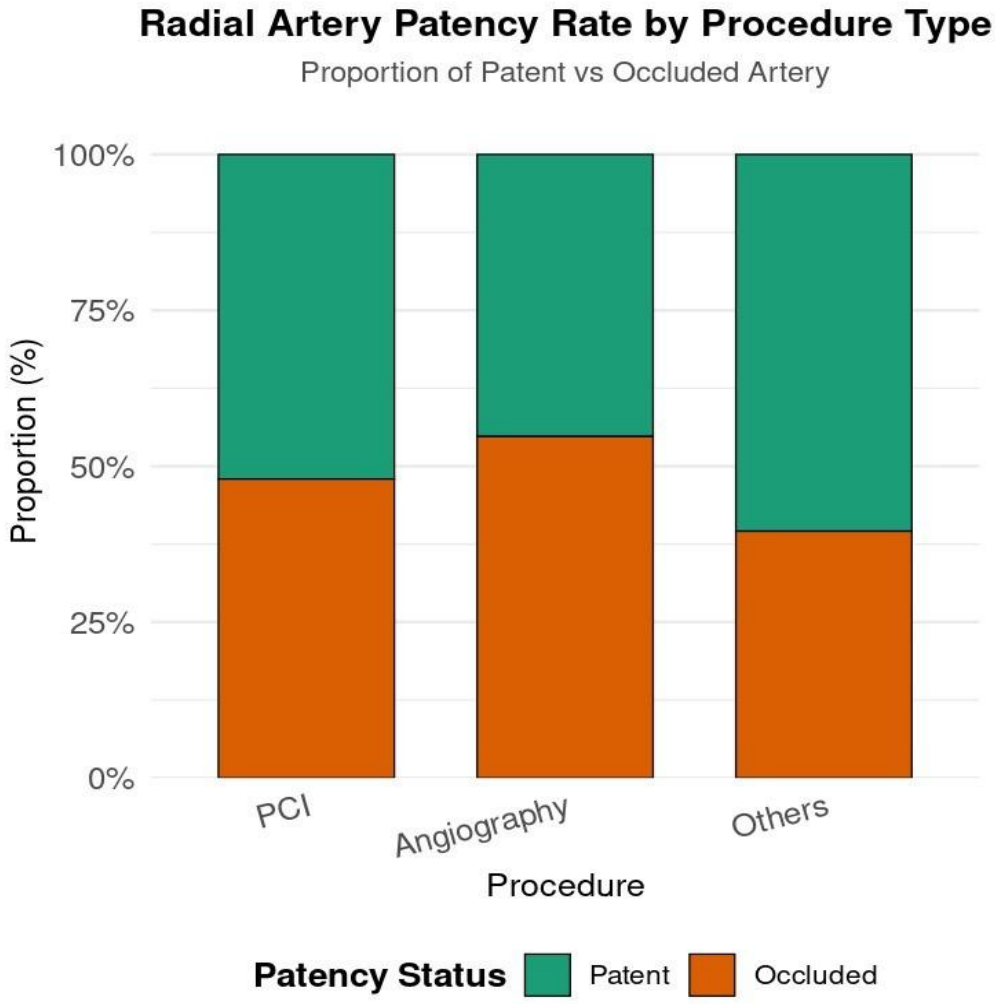


Fig.4 This 100% Stacked Bar Chart displays the patency rates for different procedures. It shows that Angiography has the highest proportion of occluded (orange) arteries, while the Others category shows the highest rate of patent (green) cases. This comparison highlights which procedure types were most associated with arterial occlusion.

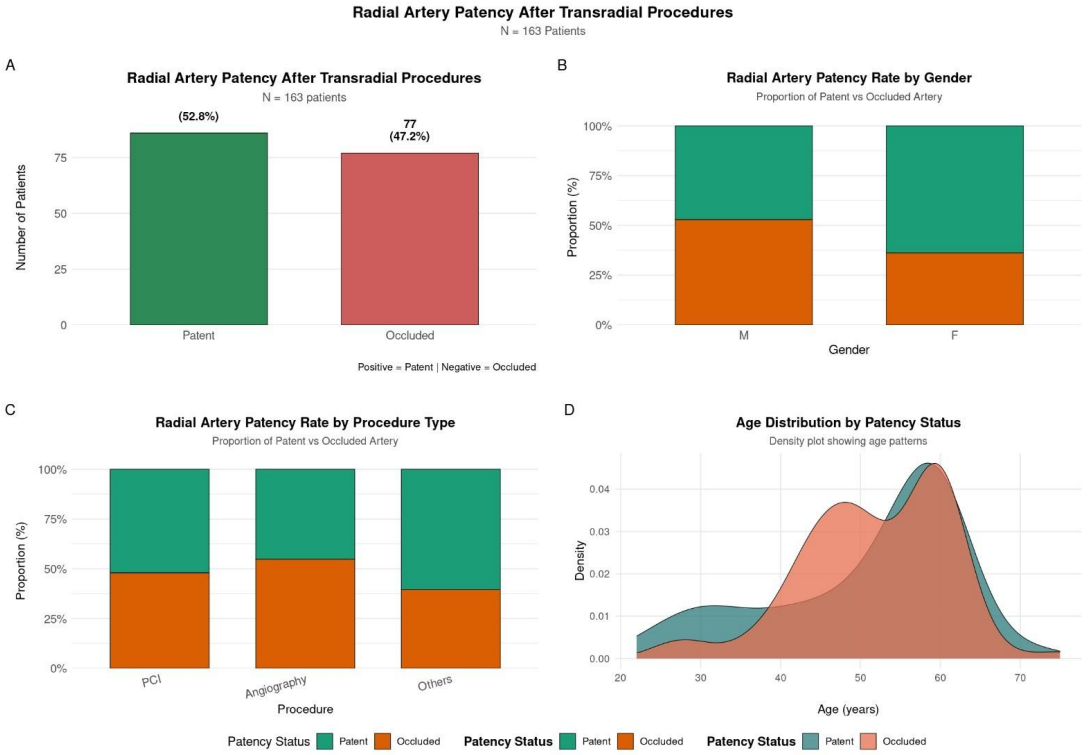
Factors Associated with Radial Artery Patency Multivariable Analysis

TABLE NO.03. Multivariable Logistic Regression Analysis of Factors Associated with Radial Artery Patency

VARIABLLE	ADJUSTED 95% CI	P-VALUE	p- VALUE
AGE (per year increase)	0.991	0.953 – 1.030	0.64
GENDER			
MALE	1	REFRENCE	
FEMALE	0.499	0.244 – 0.999	0.053
PROCEDURE TYPE			
PCI	1	REFRENCE	
ANGIOGRAPGHY	1,418	0.647 – 3.148	0.385
OTHERS	0.756	0.294 – 1.907	0.555

Note: Outcome variable = Patent vs Occluded radial artery. Adjusted Odds Ratio (OR) < 1 indicates higher likelihood of maintaining patency.

Fig.05 combined plot



Summary of Key Findings

Following transradial surgeries, the total rate of radial artery blockage was 47.2%.

Radial artery patency was more common in women than in men, with a marginally significant correlation (Fisher's Exact Test, p = 0.049).

Neither univariate nor multivariable analysis revealed a significant correlation between radial artery patency and age or the kind of operation (PCI, Angiography, or Others)

RESULT DISCUSSION

58% of the patients included for this radial artery patency investigation were female and 104% were male. When the cases were assessed for patency outcomes, it was found that 21% of females had negative radial artery patency and 37% had positive radial artery patency. Male patients, on the other hand, had 55% negative results and 49% favorable results.The current data investigate the relationship between radial artery patency and age after transradial operations. Although the association is not absolutely linear, a distinct pattern starts to show when the findings are analyzed across age groups. Nearly all instances show favorable patency results in the younger age ranges, especially in the twenties and early thirties. Younger patients tend to have fewer negative outcomes after transradial procedures. In most cases, their radial arteries are healthy and more elastic, so they recover easily after cannulation. Long-term diseases are also less common in this group, which may explain the better results. In patients around 40 to 55 years of age, a slight change in pattern is usually seen. Most still have good radial artery patency, but a small number may show reduced or poor outcomes. This could be due to early vessel changes that develop with age, such as mild loss of elasticity or early atherosclerotic changes. These changes are not usually severe, but they can still affect how the artery responds after the procedure. In older patients, especially those near 60 years, negative outcomes are seen more often compared to younger groups. Even then, many patients still maintain a patent radial artery. Age-related factors such as stiff blood vessels, thickened vessel walls, and common conditions like diabetes or hypertension may contribute to these results. Overall, most patients in all age groups still show positive outcomes. This suggests that the transradial approach remains a safe method across different ages. At the same time, the findings indicate that extra care during the procedure and aftercare becomes more important as patient age increases.

Disscussion on radial artery patency

In transradial cardiac surgeries, radial artery patency is essential because loss of patency might limit future vascular access and result in problems such radial artery blockage. Maintaining arterial patency is still a clinical problem,

despite the transradial approach's widespread preference because to lower bleeding risks and better patient comfort. Radial artery patency is influenced by a number of variables, including patient-related characteristics such vascular size and comorbidities, as well as operative methods, compression duration, and anticoagulant administration. Because of their smaller radial artery diameter and greater vascular sensitivity, female patients may be more vulnerable to decreased patency rates, which may lead to higher rates of occlusion or spasm. However, male patients may have patency loss because to hemodynamic or procedural variables, even though their vessels are typically bigger. Future procedures may be greatly impacted by radial artery non-patency, especially in patients who need frequent catheterization or are being investigated for coronary artery bypass grafting, where the radial artery may operate as a conduit. Keeping the radial artery healthy after the procedure is very important. It helps in preventing complications and also keeps future treatment options open for the patient. For this reason, attention should be given to how the procedure is performed and how the patient is managed afterwards. Simple steps during and after the procedure can make a difference. Using proper anticoagulation, applying gentle technique to avoid injury to the artery, and following correct hemostasis methods all help in reducing the risk of radial artery occlusion. Care after the procedure is also important, especially monitoring the puncture site and checking for any early signs of reduced blood flow. Patient awareness also plays a role. When patients are informed about what to watch for and when to report symptoms, problems can be identified earlier. Regular observation by healthcare staff can also help in detecting issues before they become serious. Overall, better outcomes are achieved when careful technique during the procedure is combined with good post-procedure care and patient monitoring. These simple measures can help maintain radial artery patency and improve long-term results in patients undergoing transradial intervention.

CONCLUSION

This study shows that keeping the radial artery open after transradial procedures is a key because it preserves future access for cardiac procedures and helps reduce vascular complications. The results give a clear idea of early post-procedure outcomes and the factors that may affect radial artery patency. Overall, a high patency rate was observed in patients treated at a tertiary care hospital in Khyber Pakhtunkhwa, which maintains the safety and usefulness of the transradial approach in coronary interventions. The findings are also consistent with previous work that shows radial access is generally safer than femoral access, mainly due to lower bleeding complications and better overall patient tolerance. In this study, most patients were male, while fewer were female. This reflects the usual pattern seen in cardiovascular disease, where

men are affected earlier and more frequently, whereas women often present later in life. Most of the patients were in the middle to older age group, showing that age still has an influence on clinical decision-making and outcomes. With increasing age, changes such as smaller radial artery size and stiffer blood vessels can make the procedure slightly more difficult and possibly will also affect how well the artery remains open afterwards. Even with these differences, the transradial approach worked well across all age groups. However, extra care may be needed in elderly patients and females because of anatomical differences that can make the procedure more challenging. Paying attention to these details can help improve results in these groups. Overall, the study suggests that simple factors such as age and gender should be considered when planning procedures, as they can help improve patient safety and long-term outcomes in transradial interventions.

RECOMMENDATIONS

Implement mandatory patent hemostasis training for staff to maintain active anterograde blood flow via adjusted, minimal compression pressures.
Enforce universal pre-discharge clinical screenings using the Modified Allen Test to catch asymptomatic occlusions within 24 hours.
Standardize weight-adjusted intra-procedural heparin protocols to chemically prevent thrombus formation caused by catheter-induced endothelial trauma.

REFERENCES

1. Campeau L. Percutaneous radial artery approach for coronary angiography. Cathet Cardiovasc Diagn 1989;16:3-7.
2. Kiemeneij F, Laarman GJ, de Melker E. Transradial artery coronary angioplasty. Am Heart J 1995;129:1-7.
3. Rao SV, Ou FS, Wang TY, et al. Trends in the prevalence and outcomes of radial and femoral approaches to percutaneous coronary intervention: a report from the National Cardiovascular Data Registry. JACC Cardiovasc Interv 2008;1:379-86.
4. Asrar Ul Haq M, Tsay IM, Dinh DT, et al. Prevalence and outcomes of trans-radial access for percutaneous coronary intervention in contemporary practise. Int J Cardiol 2016;221:264-8.
5. Baklanov DV, Kaltenbach LA, Marso SP, et al. The prevalence and outcomes of transradial percutaneous coronary intervention for ST-segment elevation myocardial infarction: analysis from the National Cardiovascular Data Registry (2007 to 2011). J Am Coll Cardiol 2013;61:420- Gutierrez A, Tsai TT, Stanislawski MA, et al. Adoption of Transradial Percutaneous Coronary Intervention and Outcomes According to Center Radial Volume in the Veterans Affairs Healthcare

System Insights From the Veterans Affairs Clinical Assessment, Reporting, and Tracking (CART) Program. Circ Cardiovasc Interv 2013;6:336-46.

6. Doyle BJ, Rihal CS, Gastineau DA, et al. Bleeding, blood transfusion, and increased mortality after percutaneous coronary intervention: implications for contemporary practice. J Am Coll Cardiol 2009;53:2019-27.
7. Jolly SS, Amlani S, Hamon M, et al. Radial versus femoral access for coronary angiography or intervention and the impact on major bleeding and ischemic events: a systematic review and meta-analysis of randomized trials. Am Heart J 2009;157:13240.
8. Agostoni P, Biondi-Zoccai GG, De Benedictis ML, et al. Radial versus femoral approach for percutaneous coronary diagnostic and interventional procedures: systematic overview and meta-analysis of randomized trials. J Am Coll Cardiol 2004;44:349-56.
9. Jolly SS, Yusuf S, Cairns J, et al. Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): a randomised, parallel group, multicentre trial. Lancet 2011;377:1409-20.
10. Agostoni P, Biondi-Zoccai GG, de Benedictis ML, Rigattieri S, Turri M, Anselmi M, Vassanelli C, Zardini P, Louvard Y, Hamon M. Radial versus femoral approach for percutaneous coronary diagnostic and interventional procedures; systematic overview and meta-analysis of randomized trials. J Am Coll Cardiol. 2004;44:349 – 356.
11. Eichhofer J, Horlick E, Ivanov J, Seidelin PH, Ross JR, Ing D, Daly P,Mackie K, Ridley B, Schwartz L, Barolet A, Dzavik V. Decreased complication rates using the transradial compared to the transfemoral approach in percutaneous coronary intervention in the era of routine stenting and glycoprotein platelet IIb/IIIa inhibitor use: a large singlecenter experience. Am Heart J. 2008;156:864–870.
12. Jolly SS, Yusuf S, Cairns J, Niemela K, Xavier D, Widimsky P, Budaj A, Niemela M, Valentin V, Lewis BS, Avezum A, Steg PG, Rao SV, Gao P, Afzal R, Joyner CD, Chrolavicius S, Mehta SR. Radial Versus Femoral Access for Coronary Angiography and Intervention in Patients With Acute Coronary Syndromes (RIVAL): a randomised, parallel group, multicentre trial. Lancet. 2011;377:1409 –1420.
13. Jolly SS, Amlani S, Hamon M, Yusuf S, Mehta SR. Radial versus femoral access for coronary angiography or intervention and the impact on major bleeding and ischemic events: a systematic review and meta-analysis of randomized trials. Am Heart J. 2009;157:132–140.
14. Cooper CJ, El-Shiekh RA, Cohen DJ, Blaesing L, Burket MW, Basu A, Moore JA. Effect of transradial access on quality of life and cost of

cardiac catheterization: a randomized comparison. Am Heart J. 1999;138: 430–436.

15. Bertrand OF, De Larochelliere R, Rodes-Cabau J, Proulx G, Gleeton O, Nguyen CM, Dery JP, Barbeau G, Noel B, Larose E, Poirier P, Roy L. A randomized study comparing same-day home discharge and abciximab bolus only to overnight hospitalization and abciximab bolus and infusion after transradial coronary stent implantation. Circulation. 2006;114: 2636–2643.
16. Louvard Y, Lefevre T, Allain A, Morice M. Coronary Angiography Through the Radial or the Femoral Approach: the CARAFE study. Catheter Cardiovasc Interv. 2001;52:181–187.
17. Mann T, Cowper PA, Peterson ED, Cubeddu G, Bowen J, Giron L, Cantor WJ, Newman WN, Schneider JE, Jobe RL, Zellinger MJ, Rose GC. Transradial coronary stenting: comparison with femoral access closed with an arterial suture device. Catheter Cardiovasc Interv. 2000; 49:150 – 156.
18. Zhou YJ, Zhao YX, Cao Z, Fu XH, Nie B, Liu YY, Guo YH, Cheng WJ, Jia DA. Incidence and risk factors of acute radial artery occlusion following transradial percutaneous coronary intervention. Zhonghua Yi Xue Za Zhi. 2007;87:1531–1534.
19. Stella PR, Kiemeneij F, Laarman GJ, Odekerken D, Slagboom T, van der Wieken R. Incidence and outcome of radial artery occlusion following transradial artery coronary angioplasty. Cathet Cardiovasc Diagn. 1997; 40:156 –158.
20. Alsubaiei, A. A., et al. (2026). Direct oral anticoagulants are effective in preventing but not resolving radial artery occlusion: a systematic review and meta-analysis of randomized controlled trials. Frontiers in Cardiovascular Medicine, 13.
21. Bernat, I., Aminian, A., Pancholy, S., Mamas, M., Gaudino, M., Nolan, J., ... & Group, R. I. (2019). Best practices for the prevention of radial artery occlusion after transradial diagnostic angiography and intervention: an international consensus paper. JACC: Cardiovascular Interventions, 12(22), 2235–2246.
22. EuroIntervention. (2026). Distal access and procedural anticoagulation to prevent radial artery occlusion after coronary angiography – the randomised RAPID trial. EuroIntervention, 22(9).
23. Frontiers in Cardiovascular Medicine. (2025). Short-term outcomes of unfractionated heparin vs. low molecular weight heparin in trans-radial coronary angiography: a comparative study. Frontiers in Cardiovascular Medicine, 12.
24. Bernat, I., Horak, D., Stasek, J., et al. (2014). ST-segment elevation myocardial infarction treated by radial or femoral approach in a

multicenter randomized clinical trial: the STEMI-RADIAL trial. Journal of the American College of Cardiology, 63(10), 964–972. https://doi.org/10.1016/j.jacc.2013.08.1651 Cited by: 24211309 (PMID)

25. Jolly, S. S., Yusuf, S., Cairns, J., et al. (2011). Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): a randomised, parallel group, multicentre trial. The Lancet, 377(9775), 1409–1420.
26. https://doi.org/10.1016/S0140-6736(11)60404-2 Cited by: 21470671 (PMID)
27. Kiemeneij, F., Laarman, G. J., Odekerken, D., Slagboom, T., & van der Wieken, R. (1997). A randomised comparison of percutaneous transluminal coronary angioplasty by the radial, brachial and femoral approaches: the access study. Journal of the
28. American College of Cardiology, 29(6), 1269–1275. https://doi.org/10.1016/S07351097(97)00064-8
29. Mason, P. J., Shah, B., Tamis-Holland, J. E., et al. (2018). An update on radial artery access and best practices for transradial coronary angiography and intervention in acute coronary syndrome: a Scientific Statement From the American Heart Association.
    a. Circulation: Cardiovascular Interventions, 11(9), e000035.
30. https://doi.org/10.1161/HCV.0000000000000035 Cited by: 30354598 (PMID)
31. Valgimigli, M., Gagnor, A., Calabró, P., et al. (2015). Radial versus femoral access in patients with acute coronary syndromes undergoing invasive management: a randomised multicentre trial. The Lancet, 385(9986), 2465–2476. https://doi.org/10.1016/S0140-6736(15)60292-6 Cited by: 25791214 (PMID)
32. Gaudino, M., Benedetto, U., Fremes, S., Biondi-Zoccai, M., Sedrakyan, A., Puskas, J.
33. D., Angelini, G. D., Buxton, B., Frati, G., Hare, D. L., Hayward, P., Nasso, G., & Moat, N. (2018). Radial-artery or saphenous-vein grafts in coronary-artery bypass surgery. New England Journal of Medicine, 378(22), 2069-2077.
34. PMC7525670. (2018). The radial artery in coronary surgery. PMC - NIH.
35. PMC13094899. (2026). Effect of TR Band™ radial artery compression device—screw
36. coronary bypass. Heart, Lung and Circulation, 26(3), 296-300.
37. SciELO. (2026). Biomarker-based prediction of radial artery occlusion after cardiac catheterization. Brazilian Journal of Medical and Biological Research

38. Indolfi, C.; Passafaro, F.; Sorrentino, S.; Spaccarotella, C.; Mongiardo, A.; Torella, D.; Polimeni, A.; Sabatino, J.; Curcio, A.; De Rosa, S. Hand Laser Perfusion Imaging to Assess Radial Artery Patency: A Pilot Study. J. Clin. Med. 2018, 7, 319.
39. Wang, H.; Yin, D.; Feng, L.; Song, W.; Wang, H.; Zhu, C.; Dou, K. Early radial artery occlusion following the use of a transradial 7-French sheath for complex coronary interventions in Chinese patients. Catheter. Cardiovasc. Interv. 2021, 97, 1063–1071. [Google Scholar] [CrossRef]
40. Buturak, A.; Gorgulu, S.; Norgaz, T.; Voyvoda, N.; Sahingoz, Y.; Degirmencioglu, A.; Dagdelen, S. The long-term incidence and predictors of radial artery occlusion following a transradial coronary procedure. Cardiol. J. 2014, 21, 350–356.
41. Aykan, A.; Gökdeniz, T.; Gül, I.; Kalaycıoğlu, E.; Çetin, M.; Hatem, E.; Çavuşoğlu, I.G.; Karabay, C.Y.; Güler, A.; Aykan, D.A.; et al. Comparison of low dose versus standard dose heparin for radial approach in elective coronary angiography? Int. J. Cardiol. 2015, 187, 389–392.
42. Ognerubov, D.V.; Provatorov, S.I.; Tereshchenko, A.S.; Romasov, I.V.; Pogorelova, O.A.; Tripoten, M.I.; Balakhonova, T.V.; Merkulov, E.V.; Samko, A.N. Rate of Complications at Early Removal of Compression Bandage after Transradial Coronary Angiography. Kardiologiia 2019, 59, 79–83.
43. Sadaka, M.A.; Etman, W.; Ahmed, W.; Kandil, S.; Eltahan, S. Incidence and predictors of radial artery occlusion after transradial coronary catheterization. Egypt. Heart J. 2019, 71, 12.
44. Pancholy, S.B.; Bertrand, O.F.; Patel, T. Comparison of A Priori Versus Provisional Heparin Therapy on Radial Artery Occlusion After Transradial Coronary Angiography and Patent Hemostasis (from the PHARAOH Study). Am. J. Cardiol. 2012, 110, 173– 176
45. Mamas MA, Fraser DG, Ratib K, Fath-Ordoubadi F, El-Omar M, Nolan J, Neyses L. Minimising radial injury: Prevention is better than cure. EuroIntervention 2014; 10: 824–832.
46. Abdelaal E, Molin P, Plourde G, Machaalany J, Bataille Y, Brousseau-Provencher C, Montminy S, Larose E, Roy L, Gleeton O, Barbeau G, Nguyen CM, Noël B, Costerousse O, Bertrand OF. Successive transradial access for coronary procedures: Experience of Quebec Heart-Lung Institute. Am Heart J 2013; 165: 325–331.
47. Dahm JB, Vogelgesang D, Hummel A, Staudt A, Völzke H, Felix SB. A randomized trial of 5 vs. 6 French transradial percutaneous coronary interventions. Catheter Cardiovasc Interv 2002; 57: 172–176.
48. Uhlemann M, Möbius-Winkler S, Mende M, Eitel I, Fuernau G, Sandri M, Adams V, Thiele H, Linke A, Schuler G, Gielen S. The Leipzig prospective vascular ultrasound registry in radial artery catheterization: Impact of

sheath size on vascular complications. J Am Coll Cardiol Intv 2012; 5: 36–43.

49. Rashid M, Kwok CS, Pancholy S, Chugh S, Kedev SA, Bernat I, Ratib K, Large A, Fraser D, Nolan J, Mamas MA. Radial artery occlusion after transradial interventions: A systematic review and meta-analysis. J Am Heart Assoc 2016; 5: e002686.
50. Yonetsu T, Kakuta T, Lee T, Takayama K, Kakita K, Iwamoto T, Kawaguchi N, Takahashi K, Yamamoto G, Iesaka Y, Fujiwara H, Isobe M. Assessment of acute injuries and chronic intimal thickening of the radial artery after transradial coronary intervention by optical coherence tomography. Eur Heart J 2010; 31: 1608–1615.
51. Aminian A, Dolatabadi D, Lefebvre P, Zimmerman R, Brunner P, Michalakis G, Lalmand J. Initial experience with the Glidesheath Slender for transradial coronary angiography and intervention: A feasibility study with prospective radial ultrasound follow-up. Catheter Cardiovasc Interv 2014; 84: 436–442.
52. Aminian A, Saito S, Takahashi A, Bernat I, Jobe RL, Kajiya T, Gilchrist IC, Louvard Y, Kiemeneij F, Van Royen N, Yamazaki S, Matsukage T, Rao SV. Comparison of a new slender 6 Fr sheath with a standard 5 Fr sheath for transradial coronary angiography and intervention: RAP and BEAT (radial artery patency and bleeding, efficacy, adverse evenT), a randomised multicentre trial. EuroIntervention 2017; 13: e549–e556.
53. Kotowycz MA, Johnston KW, Ivanov J, Asif N, Almoghairi AM, Choudhury A, Nagy CD, Sibbald M, Chan W, Seidelin PH, Barolet AW, Overgaard CB, Džavík V. Predictors of radial artery size in patients undergoing cardiac catheterization: Insights from the good radial artery size prediction (GRASP) study. Can J Cardiol 2014; 30: 211–216.
54. Saito S, Ikei H, Hosokawa G, Tanaka S. Influence of the ratio between radial artery inner diameter and sheath outer diameter on radial artery flow after transradial coronary intervention. Catheter Cardiovasc Interv 1999; 46: 173–178.
55. Bernat, I., Aminian, A., Pancholy, S., Mamas, M., Chieffo, A., Bertrand, O. F., ... & Gilard, M. (2019). Best practices for the prevention of radial artery occlusion after transradial procedures: a consensus document from the Platinum Corporation. EuroIntervention, 15(10), 910-919.
56. Dharma, S., Kedev, S., Patel, T., Standish, B., & Rao, S. V. (2015). A novel approach to reduce radial artery occlusion after transradial catheterization: a randomized controlled trial. Catheterization and Cardiovascular Interventions, 85(5), 815-825.
57. Saito, S., Tanaka, S., & Asakura, Y. (2023). Evaluation of radial artery patency using high-resolution duplex ultrasonography after transradial coronary interventions. Journal of Cardiology, 81(3), 241-247.

58. Sparks, A. R., Custom, J. M., & Brady, W. J. (2022). Comparison of clinical assessment vs. color Doppler ultrasound in detecting subclinical radial artery occlusion postcardiac catheterization. American Heart Journal, 244, 112-119.
59. Yonetsu, T., Kakuta, T., Lee, T., Takayama, K., Kakita, K., Iwamoto, T., ... & Isobe, M. (2013). Assessment of vascular response after transradial catheterization using optical coherence tomography. Circulation: Cardiovascular Interventions, 6(3), 295-303.
60. Avdikos, G., Karatasakis, A., Tsoumeleas, A., Lazarus, G., & Tousoulis, D. (2017). Radial artery occlusion after transradial catheterization: From patho-physiology to prevention and treatment. Cardiovascular Revascularization Medicine, 18(2), 135-142.
61. Rashid, M., Kwok, C. S., Pancholy, S., Chugh, S., Kedev, S. A., Nolan, J., ... & Mamas, M. A. (2016). Radial artery occlusion after transradial catheterization: a systematic review and meta-analysis. Journal of the American Heart Association, 5(1), e002686.
62. Shah, S. Z., Khan, M., & Ali, M. (2021). Frequency and predictors of radial artery occlusion after percutaneous coronary intervention in a tertiary care hospital of Khyber Pakhtunkhwa. Journal of Postgraduate Medical Institute, 35(2), 88-92.
63. Valgimigli, M., Frigoli, E., Leonardi, S., Rothenbühler, M., Gagnor, A., Calabrò, P., ... & MATRIX Investigators. (2015).