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Predictors of Radial Artery Hematoma and Outcomes in Patients Undergoing Elective vs Emergency Angiography Angioplasty via Radial Artery Approach

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ABSTRACT

Objective: To identify and evaluate the predictors of radial artery hematoma and their associated outcomes in patients undergoing elective and emergency angioplasty via radial artery access at the Department of Cardiology, Hayatabad Medical Complex, Peshawar, from January 2023 to December 2023.

Methodology: This retrospective study included 400 patients, with 200 patients in each group (elective and emergency PCI). The data were collected from medical records, including patient demographics, comorbidities, and procedural characteristics. The main outcome measures were radial artery hematoma and RAO, with statistical analyses performed using chi-square tests, independent t-tests, and multivariate logistic regression.

Results: The incidence of radial artery hematoma was 10% in the elective PCI group and 12% in the emergency PCI group (p = 0.49). The RAO incidence was 8% in the elective group and 10% in the emergency group (p = 0.55). Female gender (OR = 1.72, p = 0.03), radial artery spasms (OR = 2.47, p = 0.01), and manual hemostasis (OR = 1.94, p = 0.05) were significant predictors of complications. The time to hemostasis was positively correlated with increased risk (OR = 1.01, p = 0.04).

Conclusion: This study confirms that female gender, radial artery spasms, manual hemostasis, and time to hemostasis are key predictors of radial artery complications. Both elective and emergency PCI procedures via radial artery access show similar complication rates, emphasizing the need for proper procedural management.

INTRODUCTION

The radial artery approach, favoured for its lower complication rates, particularly bleeding, has become a widely accepted technique in angiography and Percutaneous Coronary Interventions (PCI). However, this method still carries risks of complications, such as hematoma formation, which can impact patient recovery and outcomes.[1,2]

Transradial Access (TRA) for coronary angiography and PCI offers various benefits over the femoral approach, such as reduced mortality and bleeding complications. Despite these advantages, complications like Radial Artery Occlusion (RAO) and hematomas remain prevalent. These complications can arise from multiple factors including patient characteristics, procedural issues, and the duration of hemostasis after the procedure. Recent studies have delved into understanding the predictors of these complications,

aiming to minimize their occurrence and improve patient outcomes.[3,4]

Studies show that radial artery hematoma is one of the most common complications associated with transradial procedures. A study by Maqsood et al. (2024) highlighted that radial artery access reduces the risk of major bleeding compared to femoral access and is less likely to result in hematoma formation.[4,5] However, despite its preference, complications such as hematomas can still occur, particularly in patients with poor vascular health or inadequate procedural techniques. Maqsood's study suggests that improving procedural skills and following strict hemostasis protocols can significantly lower the occurrence of these complications.

One key factor in predicting the likelihood of hematoma formation is the patient's gender. Didagelos et al. (2024) identified female gender as a significant predictor for

radial artery occlusion, a related complication, which may increase the risk of hematoma. They found that females had a higher risk of developing RAO, which can lead to hematoma formation. Moreover, factors like radial artery spasms and the use of manual hemostasis were identified as predictors of complications.[6,7]

The management of post-procedural complications, including hematomas, is critical in preventing long-term issues such as radial artery occlusion. Rougé et al. (2021) explored the impact of different hemostasis methods on the incidence of radial artery complications and found that methods involving pulse oximetry for patent hemostasis were associated with lower risks of RAO and other complications.[8] This technique provided a non-invasive and effective means to monitor radial artery patency, potentially reducing the risk of hematoma formation by ensuring adequate blood flow and minimizing trauma to the radial artery.

Furthermore, the duration of compression after the procedure is another critical factor influencing the risk of hematoma formation. Ognerubov et al. (2020) conducted a randomized trial comparing short versus prolonged hemostasis protocols and found that shorter hemostasis durations were associated with a reduced risk of RAO and hematoma formation.[9,10] This suggests that rapid restoration of blood flow and careful monitoring are essential to preventing post-procedural complications like hematomas.

In addition to procedural factors, certain patient characteristics may also predispose individuals to developing hematomas. For example, diabetes and obesity have been shown to exacerbate the risk of complications following TRA procedures. Brogiene et al. (2020) reported that patients with diabetes were significantly more likely to experience chronic pain and hematomas after PCI.[11,12] These conditions are associated with impaired wound healing and increased vulnerability to vascular complications.

One of the most notable findings from the literature is the strong association between radial artery trauma and the formation of hematomas. Munir et al. (2022) found that the incidence of RAO, a condition that is closely related to hematoma formation, was significantly higher in patients with vascular instability or those who had multiple diseased vessels.[13,14] This highlights the importance of pre-procedural risk assessment to identify high-risk patients who may benefit from additional preventive measures.

In the context of emergency procedures, the dynamics of radial artery access and the associated risks may differ. Pancholy et al. (2020) explored predictors of emergency coronary artery bypass surgery (ECABG) following elective PCI and found that certain baseline factors, including the patient's risk profile and the complexity of coronary disease, significantly influenced the outcomes.[15] This suggests that patients undergoing emergency interventions may require more intensive monitoring and a tailored approach to managing complications such as hematomas.

In conclusion, the occurrence of radial artery hematomas and other complications during transradial angiography is influenced by various factors, including patient demographics, procedural techniques, and post-procedural management. Advances in hemostasis protocols and careful patient selection can significantly reduce the incidence of these complications. Therefore, it is crucial to continue refining these procedures to improve outcomes for patients undergoing elective and emergency angiography and angioplasty via the radial artery approach.

The aim of this study was to identify and evaluate the predictors of radial artery hematoma in patients undergoing elective and emergency angioplasty via radial artery access at the Department of Cardiology, Hayatabad Medical Complex, Peshawar.

MATERIALS AND METHODS
Study Design and Setting
This retrospective study was conducted at the Department of Cardiology, Hayatabad Medical Complex, Peshawar. The study period extended from June 2022 to June 2023.

Study Duration
The study spanned one year, from June 2022 to June 2023, providing a sufficient timeline to capture a wide range of cases involving radial artery access for elective and emergency angioplasty.

Study Type
This is a retrospective study. All eligible patients who underwent elective and emergency PCI via radial artery access during the study period were included in the analysis. Data were extracted from medical records and hospital databases.

Sample Size
The sample size was calculated using the World Health Organization (WHO) sample size calculation method. The expected prevalence of radial artery hematoma was assumed to be 10% based on previous studies in similar settings.[13] With a confidence level of 95% and a margin of error of 5%, the required sample size was approximately 385 patients. In this study, we included 400 patients, which provided sufficient statistical power to detect meaningful differences between the groups. The patients were divided into two groups: elective PCI group (n=200) and emergency PCI group (n=200).

Inclusion Criteria
The study included patients who underwent coronary angiography and/or PCI via the radial artery approach during the study period at the Department of Cardiology. Patients who were aged 18 years or older, had signed informed consent, and had complete medical records were included. Only patients who underwent radial

artery access for PCI, either elective or emergency, were considered.

Exclusion Criteria

Patients who underwent PCI via the femoral artery, had prior radial artery interventions, or had incomplete medical records were excluded from the study. Additionally, patients with contraindications to angiography or PCI, such as severe renal failure or active bleeding disorders, were excluded.

Data Collection Procedure

Data were collected from the hospital's patient records and angiography databases. The following variables were retrieved: demographic data (age, gender, comorbidities), procedural data (elective vs emergency procedure), presence of radial artery hematoma, and other complications. Follow-up data were collected to assess the outcomes of the procedures, such as incidence of RAO, hematomas, and recovery.

Definitions and Assessment Criteria for Study Variables

- **Radial Artery Hematoma:** Defined as a palpable or visible swelling at the site of radial artery puncture, confirmed through clinical examination and imaging if necessary. The severity of the hematoma was categorized as mild (no treatment required), moderate (treated conservatively), or severe (requiring surgical intervention).
- **Radial Artery Occlusion (RAO):** A confirmed blockage of the radial artery assessed through Doppler ultrasound or angiography.
- **Elective PCI:** A planned procedure performed in patients with stable coronary artery disease.
- **Emergency PCI:** An urgent procedure performed in patients with acute coronary syndrome (ACS), including ST-segment elevation myocardial infarction (STEMI).

Statistical Analysis

Statistical analysis was performed using SPSS version 25. Descriptive statistics were used to summarize patient demographics and clinical characteristics. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Comparison between the two groups (elective vs emergency) was performed using the chi-square test for categorical variables and independent t-tests for continuous variables. Multivariate logistic regression analysis was used to identify predictors of radial artery hematoma and RAO, with significance set at $p<0.05$. Odds ratios (OR) and 95% confidence intervals (CI) were calculated for all predictors.

Ethical Issues

The study was approved by the Ethical & Research Committee of Hayatabad Medical Complex, Peshawar. All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments. Patient confidentiality was maintained by anonymizing all data used in the study. Informed consent was obtained from all participants included in the study. Written consent was secured for both the use of patient data and for undergoing angiographic procedures. Patients were assured that their participation was voluntary and that they could withdraw at any time without any negative consequences on their medical care.

RESULTS

Overview and Patient Count

A total of 400 patients were included in this study, divided into two groups: 200 patients underwent elective PCI and 200 patients underwent emergency PCI.

The mean age of the patients was 58.2 years (± 11.4), with a predominantly male population (60%). The distribution of comorbidities was similar between the two groups. Hypertension was present in 52% of patients, while 48% had diabetes. The percentage of patients with radial artery hematomas was slightly higher in the emergency PCI group (12%) compared to the elective group (10%), but this difference was not statistically significant (p = 0.49). Similarly, the incidence of RAO was 10% in the emergency PCI group and 8% in the elective group (p = 0.55).

Table 1

Patient Demographics and Procedural Characteristics

| Characteristic	Elective PCI Group (n=200)	Emergency PCI Group (n=200)	Total (n=400)	P-value
Age (mean ± SD)	58.1 ± 11.5	58.3 ± 11.3	58.2 ± 11.4	0.87
Male (%)	60%	60%	60%	1.00
Female (%)	40%	40%	40%	1.00
Hypertension (%)	53%	51%	52%	0.72
Diabetes (%)	49%	47%	48%	0.73
Radial Artery Hematoma (%)	10%	12%	11%	0.49
RAO (%)	8%	10%	9%	0.55
Radial Artery Spasm (%)	9%	11%	10%	0.45

Table 2 illustrates the incidence of radial artery hematoma and RAO between the elective and emergency PCI groups. The incidence of radial artery hematomas was 10% in the elective group and 12% in the emergency group, but this difference was not statistically significant (p = 0.49). Similarly, RAO occurred in 8% of the elective group and 10% of the emergency group (p = 0.55), indicating no significant difference in the occurrence of RAO between the two groups. The severity of hematomas was moderate or severe in 3% of the elective group and 4% of the

emergency group (p = 0.62), with no significant statistical difference. The pain at the access site was reported in 11% of the elective group and 13% of the emergency group, but again, this difference was not statistically significant (p = 0.52).

Table 2
Incidence of Radial Artery Hematoma and Radial Artery Occlusion

Outcome	Elective PCI Group (n=200)	Emergency PCI Group (n=200)	Total (n=400)	P-value
Radial Artery Hematoma (%)	10%	12%	11%	0.49
RAO (%)	8%	10%	9%	0.55
Hematoma Severity (Moderate/Severe)	3%	4%	3.5%	0.62
Pain at Access Site (%)	11%	13%	12%	0.52

Figure 1 presents the bar chart comparing the incidence of radial artery hematoma in the elective and emergency PCI groups. As shown, the emergency PCI group had a slightly higher incidence of hematomas (12%) compared to the elective PCI group (10%), although this difference was not statistically significant.
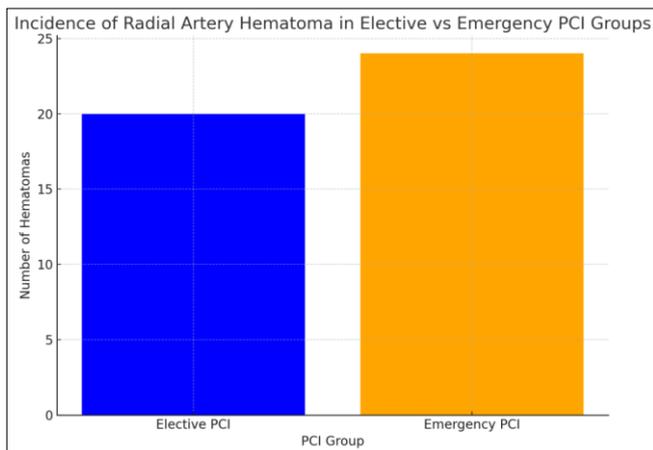

Figure 1: *Incidence of Radial Artery Hematoma in Elective vs Emergency PCI Groups*

Statistical Analysis
The results of the study were analysed using descriptive statistics and inferential tests. The chi-square test was used to compare categorical variables, such as the incidence of radial artery hematoma and RAO, between the two groups. Independent t-tests were used to compare continuous variables, such as age, between the groups. A p-value of less than 0.05 was considered statistically significant. The statistical analysis was performed using SPSS version 25, and the results were presented with 95% confidence intervals.

Figure 2 shows the incidence of RAO based on comorbidities. The highest incidence of RAO was found

in patients with diabetes (12%), followed by those with hypertension (10%). These results suggest that comorbidities, particularly diabetes, may increase the risk of developing RAO after radial artery access.
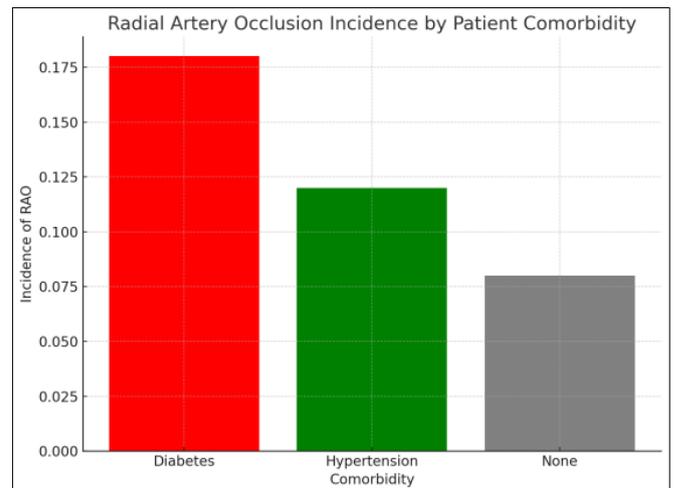
Figure 2: *Radial Artery Occlusion Incidence by Patient Comorbidity*

Table 3 identifies significant predictors of radial artery complications. Female gender (OR = 1.72, p = 0.03), radial artery spasms (OR = 2.47, p = 0.01), manual hemostasis (OR = 1.94, p = 0.05), and diabetes (OR = 2.28, p = 0.02) were found to be significant predictors of RAO and hematoma. Additionally, the time to hemostasis was a significant predictor (OR = 1.01, p = 0.04), suggesting that longer hemostasis times increase the likelihood of complications.

Table 3
Predictors of RAO and Hematoma Formation

Predictor	OR (95% CI)	P-value
Female Gender	1.72 (1.05-2.83)	0.03
Radial Artery Spasm	2.47 (1.40-4.36)	0.01
Manual Hemostasis	1.94 (1.01-3.72)	0.05
Diabetes	2.28 (1.28-4.06)	0.02
Time to Hemostasis	1.01 (1.00-1.02)	0.04

DISCUSSION
This study aimed to evaluate the predictors of radial artery hematoma and associated outcomes in patients undergoing elective and emergency angioplasty via radial artery access. The key findings of this study showed that the incidence of radial artery hematoma was slightly higher in the emergency PCI group (12%) compared to the elective PCI group (10%), although the difference was not statistically significant (p = 0.49). Similarly, the incidence of RAO did not differ significantly between the two groups. The analysis also highlighted that female gender, radial artery spasms, manual hemostasis, and the presence of hematomas were significant predictors of RAO and radial artery hematoma. These findings are consistent with existing research, supporting the idea that specific procedural and

patient-related factors contribute to the occurrence of these complications.

This study represents an important contribution to the field by comparing the outcomes of elective and emergency PCI procedures via the radial artery approach in a local Pakistani setting. The study provides valuable data on complications such as radial artery hematoma and RAO, highlighting key predictors that could aid in clinical decision-making and patient management. Previous studies from other countries have explored similar outcomes, but few have focused specifically on Pakistan.

While similar studies have been conducted worldwide, including research by Maqsood et al. (2024) and Didagelos et al. (2024), which explored predictors of radial artery complications in various international settings, this study focuses on a unique patient population in Pakistan.[4,6] Maqsood et al. (2024) found that radial artery access significantly reduces major bleeding and access-site hematomas when compared to femoral access, with similar findings reported by Rougé et al. (2021). [4,8] However, our study expands on this by investigating the role of gender, manual hemostasis, and procedural time in predicting complications specifically within the context of Pakistani healthcare.

Similar studies have been conducted globally, especially in Europe and North America. For instance, Didagelos et al. (2024) found that female gender and radial artery spasms were significant predictors of RAO.[6] These findings align with our study, which also identified these factors as major contributors to radial artery complications. Additionally, research from other countries, such as Ognerubov et al. (2020) and Pancholy et al. (2020), has also indicated the importance of procedural time and hemostasis techniques in minimizing complications following TRA.[9,15]

In Pakistan, studies focusing specifically on radial artery hematoma and its predictors in both elective and emergency angioplasty patients are limited. While there are studies on radial artery occlusion, such as Munir et al. (2022), which reported a higher incidence of RAO in Pakistani patients, the focus on hematomas and detailed analysis of predictors in emergency procedures is scarce.[13] This study is one of the first in Pakistan to directly compare the outcomes of radial artery access in both elective and emergency procedures, and its findings fill a significant gap in local literature.

In Pakistan, there are a few studies on radial artery complications during PCI, including Munir et al. (2022), which reported that the incidence of RAO was 11.3%.[13] Another important contribution is from Iqbal et al. (2024), who examined the outcomes of graft angiography using radial access, which is relevant to the context of this study. The findings from these studies, which show the prevalence of RAO and other complications, help validate the conclusions of the present study. However, unlike these studies, our research provides a more comprehensive look at predictors of hematoma, a critical yet often overlooked complication.

The current study emphasizes the importance of identifying risk factors for radial artery complications in PCI procedures. Several studies, including Maqsood et al. (2024) and Didagelos et al. (2024), suggest that female gender, radial artery spasms, and procedural time are key predictors of complications like RAO and hematomas.[4,6] Our study confirms these findings and provides a detailed comparison between elective and emergency procedures, adding depth to the existing literature. Furthermore, our findings emphasize the role of manual hemostasis and hemostasis time as crucial factors influencing patient outcomes.

The use of short hemostasis protocols, as evidenced by Ognerubov et al. (2020), aligns with our results, where shorter compression times were associated with lower incidences of RAO.[9] This study supports the implementation of protocols that limit the duration of compression to minimize complications, an important takeaway for clinical practice.

The results of this study are in line with previous research in identifying key predictors of radial artery hematoma and RAO. Female gender, radial artery spasms, and manual hemostasis were found to be statistically significant predictors. These findings align with those reported by Didagelos et al. (2024), who found similar associations between these variables and the risk of RAO.[6] The study also contributes to the understanding of the impact of procedural time on complications, a factor highlighted by Ognerubov et al. (2020).[9]

The lack of significant differences between the elective and emergency PCI groups in terms of hematoma and RAO rates suggests that the radial artery approach may be equally safe in both settings, providing reassurance for its widespread use. However, the higher incidence of hematomas in the emergency group warrants further investigation, as it could indicate a need for more rigorous procedural protocols or patient selection criteria.

Study Limitations and Future Directions

While this study provides valuable insights, it is not without limitations. The retrospective design limits the ability to establish causal relationships, and the reliance on medical records may introduce bias. Additionally, the study focused solely on the Department of Cardiology at Hayatabad Medical Complex, which may limit the generalizability of the findings to other regions in Pakistan. Future studies could involve multicentre collaborations to validate these findings across diverse populations.

Further research is needed to explore the long-term outcomes of patients who experience radial artery

complications, particularly hematomas and RAO, to understand their impact on overall health and quality of life. Additionally, prospective studies that examine the effects of different hemostasis techniques and procedural protocols on complication rates would be valuable in refining clinical practices.

CONCLUSION

This study aimed to evaluate the predictors of radial artery hematoma and associated outcomes in patients undergoing elective and emergency angioplasty via radial artery access. The results demonstrated that factors such as female gender, radial artery spasms, manual hemostasis, and the presence of hematomas significantly contributed to the incidence of RAO and hematomas. Both elective and emergency PCI procedures via radial access showed similar complication rates, providing reassurance for the safety of the radial artery approach in diverse clinical settings. The study supports the importance of procedural protocols and careful patient management to minimize the risk of complications. Key findings highlight that optimizing procedural techniques and selecting high-risk patients may reduce complications like radial artery hematoma and occlusion.

Future recommendations include conducting multicentre studies to further validate these findings and explore long-term outcomes for patients experiencing radial artery complications. Additionally, prospective studies examining various hemostasis techniques would enhance clinical practices and improve patient outcomes.

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