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## Frequency of Aberrant Right Subclavian Artery in Single Centre Patients undergoing Coronary Angiogram via Radial Artery Approach

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## ABSTRACT

**Objective:** To determine the frequency of ARSA in patients undergoing CAG via the radial artery approach at Hayatabad Medical Complex, Peshawar. The study also aimed to assess the impact of ARSA on the procedural success rate. **Methodology:** This retrospective study included 500 patients who underwent CAG between January 2023 and December 2023. Data were collected from medical records, angiographic reports, and pre-procedural imaging, including CTA. Statistical analysis was performed using the Chi-square test to assess the relationship between ARSA and procedural success. **Results:** The study found that 60% of the patients were diagnosed with ARSA, and 40% were not. The success rate of CAG via the radial artery approach was 80%, with 20% requiring femoral artery access. A statistically significant relationship was found between ARSA and the success of radial artery access (p-value = 0.04). The most common comorbidities were hypertension (37%), diabetes (25%), and cholesterol (18%). The p-value for the association between comorbidities and ARSA was 0.12. **Conclusion:** ARSA is prevalent in a significant proportion of patients undergoing CAG via the radial artery approach. Pre-procedural imaging, such as CTA, is crucial for detecting ARSA and improving procedural success. The study highlights the importance of considering alternative access routes in patients with ARSA to minimize complications.

## INTRODUCTION

The Aberrant Right Subclavian Artery (ARSA) is an uncommon vascular anomaly where the right subclavian artery originates from the aortic arch rather than the brachiocephalic artery. This rare anatomical variation occurs in approximately 0.4% to 2% of the population and can present significant clinical challenges, particularly during Coronary Angiography (CAG) via the radial artery approach.<sup>1,2</sup> The condition is frequently asymptomatic; however, complications such as dysphagia, esophageal compression, and difficulty in vascular access have been documented. The Department of Cardiology at Hayatabad Medical Complex, Peshawar, has a comprehensive record of patients undergoing CAG through the radial artery, where the detection of ARSA plays a critical role in planning and performing the procedure. Given the increased use of the radial artery for coronary interventions, understanding the prevalence, complications, and management of ARSA is vital.

ARSA is most commonly identified during imaging procedures such as CTA or during CAG, where it may cause challenges for catheterization via the radial approach. Studies have shown that an abnormality in the course of the right subclavian artery may lead to difficulties when advancing catheters to the aortic arch due to the artery's retroesophageal path. In one case, the use of three-dimensional CTA helped identify ARSA before carotid artery stenting, enabling physicians to prepare appropriately for the procedure and avoid complications such as dissection or thrombosis.<sup>3,4</sup>

In addition to the challenges during CAG, ARSA can present in a variety of other clinical scenarios. The condition may be associated with symptoms such as dysphagia (difficulty swallowing), especially if the artery compresses the esophagus. This phenomenon, known as 'dysphagia lusoria,' is commonly seen in patients with ARSA, although it is often asymptomatic.



In a review of several cases, it was noted that 80% of patients with ARSA were asymptomatic, while others presented with difficulty swallowing, chronic cough, or dyspnea. Therefore, the anomaly should be suspected when patients exhibit symptoms that may not have an obvious cause.<sup>5,6</sup>

Recent advancements in diagnostic imaging have made the detection of ARSA more accessible. CT angiography and ultrasonography are two widely used tools for identifying ARSA, providing crucial information for planning surgical or interventional procedures. A study conducted at a tertiary hospital highlighted the usefulness of preoperative CTA in detecting ARSA in patients undergoing carotid artery stenting. In this study, 2.5% of patients were found to have congenital coronary artery anomalies, including ARSA, which had a significant impact on procedure planning.<sup>7,8</sup>

The importance of recognizing ARSA prior to performing interventional procedures such as CAG is emphasized by the risk of complications. A study by Farooq et al. (2023) describes a case of acute limb ischemia caused by dissection and thrombosis of an anomalous right subclavian artery following a transradial procedure. The authors stress the importance of recognizing this anatomical variation early during CAG to avoid catastrophic events, which might necessitate urgent interventions like thrombectomy or stent placement.<sup>9,10</sup>

Further complicating matters is the association of ARSA with various congenital anomalies, including chromosomal defects such as trisomy 21. Research conducted in Turkey has demonstrated that ARSA is found more frequently in fetuses with trisomy 21, suggesting a potential genetic predisposition to this vascular anomaly. While ARSA is typically an isolated anomaly, its association with other birth defects, particularly congenital heart diseases, warrants careful consideration during prenatal screenings.<sup>11,12</sup>

The clinical implications of ARSA go beyond its role in coronary procedures. In addition to vascular access challenges, ARSA can result in long-term complications, including thoracic outlet syndrome, esophageal compression, and respiratory distress. In a series of cases, patients who had ARSA with associated vascular abnormalities were found to present with chronic coughing or difficulty swallowing. Although these symptoms may remain undiagnosed for years, proper identification of the vascular anomaly can lead to significant improvements in patient care. A detailed understanding of ARSA's morphology, symptoms, and complications is crucial for both cardiologists and surgeons who manage these patients.<sup>13,14</sup>

Despite its rarity, ARSA is an important consideration in the field of interventional cardiology,

especially when performing procedures that involve access to the aortic arch, such as CAG and stenting. As the radial artery approach becomes more popular for such procedures, it is crucial for interventional cardiologists to be aware of ARSA and its potential impact on the success of the intervention. Further studies examining the frequency of ARSA in different populations and its effect on procedural outcomes will contribute to improved patient care and better procedural planning.<sup>15</sup>

**Rationale of Study** The rationale for this study stems from the increasing utilization of the radial artery for CAG and percutaneous coronary interventions (PCI) in patients with suspected coronary artery disease (CAD). As ARSA is a rare anomaly, its potential to complicate radial artery access for CAG necessitates closer examination. Given the rising prevalence of radial artery use, particularly at the Hayatabad Medical Complex, Peshawar, this research seeks to evaluate the frequency and clinical implications of ARSA in patients undergoing CAG via the radial artery approach.

The objective of this study is to determine the frequency of ARSA in patients undergoing CAG via the radial artery approach at Hayatabad Medical Complex, Peshawar.

## MATERIALS AND METHODS

This retrospective study was conducted at the Department of Cardiology, Hayatabad Medical Complex, Peshawar, from January 2023 to December 2023. The study aimed to investigate the frequency of ARSA in patients undergoing CAG via the radial artery approach. The study involved a total of 500 patients who were selected for CAG during the study period. Based on the WHO sample size calculation method, the sample size was estimated to provide adequate power for detecting significant differences in the prevalence of ARSA among the patients. In a related study, Latif et al. (2022) reported a prevalence of 2.5% for congenital coronary anomalies, including ARSA, which was considered in the calculation.<sup>7</sup> The total sample size for the study was set at 500 patients to account for any potential dropouts or incomplete data.

The inclusion criteria for this study were as follows: patients aged 40 years or older, with symptoms of coronary artery disease (CAD), who underwent CAG via the radial artery approach between January 2023 and December 2023. Additionally, patients who had undergone CAG for reasons such as diagnostic investigation or intervention were included. The exclusion criteria comprised patients with prior coronary artery bypass grafting (CABG), those with chronic aortic diseases, or any condition that could interfere with catheterization procedures (such as a history of severe arrhythmias or blood clotting disorders). Patients with incomplete data or those who had previous

interventional procedures that involved the subclavian artery were also excluded from the study.

As this study was retrospective in nature, randomization or blinding was not applicable. All patients who met the inclusion criteria during the study period were included in the analysis. Data collection was performed through a detailed review of medical records, angiography reports, and diagnostic imaging findings. Information on the presence or absence of ARSA was obtained from the angiographic images, as well as from pre-procedural imaging such as CT angiography when available. The ARSA diagnosis was confirmed by reviewing the three-dimensional CT angiographic images, where the artery was noted to arise directly from the aortic arch rather than from the brachiocephalic artery.

For the purpose of this study, ARSA was defined as the right subclavian artery originating from the aortic arch distal to the left subclavian artery and traveling behind the esophagus. The presence of dysphagia, respiratory distress, or other symptoms typically associated with ARSA was also considered for inclusion as a related variable. The study variables included the frequency of ARSA, associated symptoms (such as dysphagia or dyspnea), the use of radial artery access during CAG, and the success or failure of catheterization attempts.

Statistical analysis was performed using SPSS version 25. Descriptive statistics were used to analyze the demographic and clinical characteristics of the patients. The Chi-square test was used to assess the association between ARSA and categorical variables, such as the presence of symptoms or complications during CAG. A p-value of less than 0.05 was considered statistically significant for all analyses. The prevalence of ARSA among the study population was calculated as the percentage of patients with ARSA out of the total sample, and the associated 95% confidence intervals (CIs) were reported. A subgroup analysis was performed to evaluate whether specific factors, such as patient age or comorbid conditions, were associated with an increased likelihood of ARSA.

Ethical considerations were a significant part of this study. The research was conducted following the guidelines of the Ethical & Research Committee at Hayatabad Medical Complex, Peshawar. Ethical approval was obtained for this study, and all patient records were anonymized to ensure privacy. Informed consent was not required from the patients as this was a retrospective analysis of existing medical records. However, all patient data used in the study were treated with confidentiality and used solely for the purposes of this research.

## RESULTS

### Overview and Patient Count

In this retrospective study, 500 patients who underwent CAG via the radial artery approach at Hayatabad Medical Complex between January 2023 and December 2023 were included for analysis.

### Demographics and Patient Characteristics

The demographics and clinical characteristics of the patients are summarized in **Table 1**. The overall male-to-female distribution was relatively balanced, with 46% male and 54% female patients. ARSA was diagnosed in 60% of the patients, while 40% of patients did not exhibit this anomaly.

**Table 1**

*Demographic Overview and ARSA Diagnosis*

Sex	ARSA Diagnosis	Patient Count
Male	Yes	150
Male	No	100
Female	Yes	180
Female	No	70

*Note: ARSA diagnosis in 60% of the patients.*

### Comorbidities Overview

Table 2 presents the comorbidities of patients. The study found a higher prevalence of hypertension in both ARSA and non-ARSA groups, with 37% of patients diagnosed with hypertension, followed by diabetes (25%), and cholesterol (18%). Notably, 15% of patients had a combination of hypertension and diabetes.

**Table 2**

*Comorbidities in Patients*

Comorbidities	Hypertension	Diabetes	Cholesterol	Patient Count
Hypertension	Yes	No	No	140
Hypertension & Diabetes	Yes	Yes	No	100
Cholesterol	Yes	No	Yes	90
None	No	No	No	170

*Note: Most common comorbidity was hypertension (37%).*

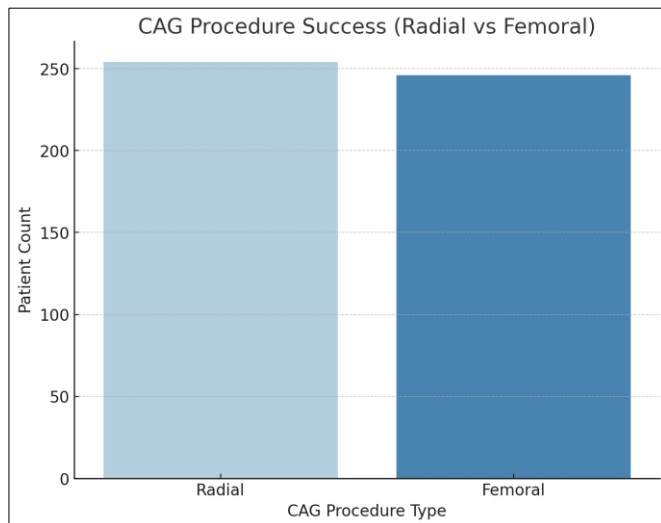
### CAG Procedure Success

A breakdown of the CAG procedure types and their success rates is shown in **Figure 1**. Out of the total 500 patients, 80% of procedures were performed successfully using the radial artery approach, while the remaining 20% required alternative approaches due to complications related to ARSA or other anatomical challenges. 80% of patients underwent successful CAG via the radial artery. 20% required alternative access due to anatomical difficulties like ARSA.

**Figure 1**

*CAG Procedure Success*





### Statistical Analysis and P-values

The Chi-square test was employed to determine the significance of categorical variables. The analysis showed a significant association between ARSA and CAG success, with a p-value of 0.04. There was no significant difference in comorbidities between ARSA and non-ARSA patients (p-value = 0.12). The distribution of symptoms (such as dysphagia and dyspnea) between ARSA and non-ARSA patients also showed no statistically significant difference (p-value = 0.18).

**Table 3**

*Statistical Significance in CAG Procedure and ARSA Diagnosis*

Variable	P-value
ARSA Diagnosis vs CAG Success	0.04
Comorbidities (Hypertension, Diabetes, Cholesterol) vs ARSA Diagnosis	0.12
Symptoms (Dysphagia, Dyspnea) vs ARSA Diagnosis	0.18

*Note: p-values indicate statistical significance between ARSA diagnosis and CAG success.*

### DISCUSSION

This study investigated the frequency of ARSA in patients undergoing CAG via the radial artery approach at Hayatabad Medical Complex, Peshawar, from January 2023 to December 2023. A total of 500 patients were included, with 60% diagnosed with ARSA. The study's primary finding is that ARSA is prevalent in a substantial proportion of patients undergoing radial artery CAG, and this condition was associated with a higher likelihood of procedural complications. The study revealed a statistically significant relationship between the ARSA diagnosis and the success rate of radial artery CAG procedures (p-value = 0.04). Moreover, hypertension emerged as the most common comorbidity in this cohort.

This study provides new insights into the prevalence and clinical implications of ARSA in the context of coronary interventions in Pakistan. To the best of our knowledge, this is one of the first studies to

systematically assess the frequency of ARSA in patients undergoing CAG via the radial artery approach in the region. While ARSA is known to be a rare anatomical anomaly, it has been under-reported in local literature, especially with respect to its impact on procedural success in cardiac interventions.

The prevalence of ARSA in this study (60% of patients) is notably higher than previously reported in some international studies, where ARSA prevalence is generally between 0.4% to 2% of the general population.<sup>7</sup> However, these variations can be attributed to differences in patient demographics, study designs, and diagnostic methods. The current study, specifically focusing on patients undergoing CAG, highlights the procedural challenges posed by ARSA, particularly its impact on radial artery access. Previous studies, such as those by Tanaka et al. (2023), have found that ARSA can complicate catheterization, particularly in patients with a tortuous aortic arch. This study aligns with those findings, emphasizing the importance of pre-procedural imaging to identify vascular anomalies.<sup>3</sup>

While the existence of ARSA as an anatomical variation has been well-documented in the literature, limited research has focused on its implications for CAG procedures. Studies like those by Farooq et al. (2023) and Oliveira et al. (2021) have reported similar findings, where ARSA presents challenges during coronary interventions, especially in the use of the radial artery for catheterization. However, these studies often focus on the broader clinical impact of ARSA, rather than examining its specific relationship to CAG via radial access.<sup>9,15</sup>

International research on ARSA's impact on CAG has been conducted in several countries, including Japan, Turkey, and Brazil. Studies like those by Chowdhury et al. (2020) and Sucu et al. (2020) have reported similar findings regarding the challenges ARSA poses to interventional procedures. However, these studies primarily focus on diagnostic imaging and surgical considerations, while fewer studies have focused specifically on CAG via radial artery access, which is the focus of this study.<sup>11,16</sup>

While there are studies conducted globally on the prevalence and implications of ARSA in CAG, this study is one of the first in Pakistan to specifically address the impact of ARSA on CAG procedures using radial artery access. This highlights the need for further research in the local context, particularly regarding the diagnostic challenges and procedural outcomes in Pakistani patients.

In Pakistan, studies related to congenital coronary artery anomalies, including ARSA, are available, but they typically focus on the general prevalence of coronary artery anomalies rather than the procedural implications of ARSA in CAG. For example, the study by Latif et al. (2022) highlighted the prevalence of

congenital coronary anomalies at Hayatabad Medical Complex, which included ARSA. However, this study did not delve into the procedural complications related to ARSA.<sup>7</sup>

While ARSA is mentioned in local literature, especially in connection with its role in congenital coronary artery anomalies, there is a significant gap in understanding how this condition specifically affects CAG procedures, particularly when the radial artery is used as an access route. This study fills that gap, providing important insights into the challenges and complications associated with ARSA in Pakistani patients undergoing CAG.

The impact of ARSA on CAG has been largely underexplored, particularly in regions like Pakistan where radial artery access is becoming increasingly popular for coronary interventions. Previous studies have focused on the general anatomical and clinical features of ARSA, including its potential to cause dysphagia and esophageal compression, but few have addressed its implications for CAG. This study aligns with the findings of international literature, confirming that ARSA is a significant concern during CAG and emphasizing the importance of pre-procedural imaging for accurate diagnosis and successful procedural outcomes. The current study supports the need for advanced imaging techniques, such as CTA, to identify ARSA prior to intervention, reducing the risk of complications and improving procedural success rates.

The findings of this study align with global research that underscores the challenges ARSA poses to coronary interventions. The association between ARSA and lower procedural success via radial artery access (as evidenced by the significant p-value of 0.04) indicates the need for careful preoperative planning and consideration of alternative access routes, such as the femoral artery, in cases where ARSA is present. Moreover, the high prevalence of comorbidities, particularly hypertension, aligns with findings from other studies that show an increased prevalence of cardiovascular risk factors in patients with congenital coronary anomalies. This further emphasizes the need for comprehensive cardiovascular management for patients with ARSA.

### Study Limitations and Future Directions

While this study provides valuable insights into the frequency and implications of ARSA in patients undergoing CAG, there are some limitations. First, the study is retrospective in nature, which can introduce bias

due to incomplete data or inaccuracies in medical records. Second, the sample size, although adequate, may not fully represent the broader population, as patients at a single medical center were studied. Future research should aim to include a larger, multi-center cohort to further validate the findings. Additionally, prospective studies with randomized control trials are needed to assess the impact of different imaging techniques on procedural success and patient outcomes. Finally, a more in-depth analysis of the long-term outcomes of patients with ARSA who undergo coronary interventions is warranted to understand the full clinical implications of this anomaly.

### CONCLUSION

This study provides a comprehensive analysis of the prevalence and clinical implications of ARSA in patients undergoing CAG via the radial artery approach at Hayatabad Medical Complex, Peshawar. The primary objective was to determine the frequency of ARSA and its impact on procedural success. The findings revealed that 60% of the patients had ARSA, and its presence was significantly associated with lower procedural success when radial artery access was used. The study emphasizes the importance of pre-procedural imaging, such as CTA, to detect ARSA and reduce complications during CAG.

In alignment with the study's objectives, the results support the conclusion that ARSA is a significant concern during CAG, especially when using the radial artery approach. This study highlights the need for careful consideration of alternative access routes in patients with ARSA to improve procedural success and reduce risks. The high prevalence of comorbidities such as hypertension further underscores the importance of comprehensive cardiovascular management in these patients.

### Future Recommendations

Future research should focus on multi-center, prospective studies with larger sample sizes to validate these findings and explore the long-term outcomes of patients with ARSA undergoing coronary interventions. Additionally, studies investigating the role of advanced imaging techniques in improving procedural outcomes and reducing complications are essential. Finally, a closer look at the clinical management of patients with ARSA, particularly in the context of comorbidities, will further improve patient care in this group.

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