Original Article

# Evaluation of Coronary Arteries Diameter using an Intravascular Ultrasound during Coronary Angiography in a Tertiary Care Hospital of Rawalpindi

Muhammad Kashif, Atif Nazir, Asim Javed, Muhammad Mohsin, Khawar Naeem Satti, Waleed Abbasi, Mohsin Shah

**ABSTRACT**

**Objective:** To evaluate the diameter of coronary arteries using intravascular ultrasound (IVUS) in individuals presenting for coronary angiography.

**Methodology:** It was a cross-sectional descriptive study conducted at the Rawalpindi Institute of Cardiology, Rawalpindi from July to December 2020. A total of 80 patients with a normal segment on IVUS imaging and plaque burden less than 30% were enrolled in the study by non-probability convenient sampling. All these patients underwent IVUS during coronary angiography for guideline-directed clinical indication. Intravascular ultrasound images were taken from the left anterior descending artery (LAD), right coronary artery (RCA), and left circumflex artery (LCX), and their diameters were measured. Patient demographic details about age, gender, and risk factors for coronary artery disease such as body mass index (BMI), smoking, hypertension (HTN), & diabetes mellitus (DM) were noted. Data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.

**Results:** The mean diameter of LAD was 3.96±0.48 mm, RCA was 3.7±0.22 mm, and LCX was 3.4±0.43 mm. There was a significant association of LAD, LCX, and RCA diameter with gender, males having a greater diameter than females. Similarly, HTN and DM had a significant association with LAD diameter. Smoking was also associated with LCX and RCA diameter (p-value=0.001). In addition, age was also significantly associated with RCA diameter (p-value=0.002).

**Conclusion:** The diameter of coronary arteries determined by IVUS was larger as compared to visual assessment on coronary angiography. So, intravascular ultrasound provides a better measurement of the size of coronary arteries. The diameter of LAD, RCA, and LCX was significantly associated with gender.

**Keywords:** *Coronary arteries. Hypertension. Coronary angiography. Intravascular ultrasound.*

## INTRODUCTION

Cardiovascular diseases (CVDs) are still a significant cause of premature mortality, disability-adjusted life years, and financial burden, globally.[1] The mortality rate attributed to CVDs has risen by 12.5% across the world.[2] Cardiovascular diseases account for 17.8 million deaths worldwide, annually.[3] Coronary artery disease (CAD) is responsible for a major proportion of mortality and morbidity attributed to cardiovascular diseases.[4] Almost 85% of the deaths caused by CVDs are due to ischemic heart disease and stroke.[5] The burden of CVDs is particularly high in low and lower-middle-income countries.[2]

Evaluation of the severity of coronary artery disease has a crucial effect on the management and prognosis of the disease. The prevalence of CAD is high in the Asian population as compared to Caucasians. Almost one-fourth of the disease occurs in Asians less than 40 years of age. This refers to the smaller size of coronary arteries in Asians, according to previous research.[6] Coronary angiography has been well recognized as a diagnostic modality to guide percutaneous coronary intervention (PCI) in CAD. But with the latest advances in intravascular imaging technology, optical coherence tomography and intravascular ultrasound are extensively used with angiography in guiding PCI.[7] Coronary angiography provides a two-dimensional image of coronary arteries. Imaging techniques are more feasible for direct vessel visualization and give a better estimate of plague burden and vessel remodeling. In addition, better PCI outcomes are also attributed to intravascular imaging.[8] Determining the appropriate size for balloon dilation and stent size is an important step in planning the PCI procedure. It has been increasingly recognized that the original diameter of the vessel varies between IVUS analysis and assessment of conventional coronary angiography.[9]

The size of coronary arteries varies among individuals based on differences in age, gender, race/ethnicity, weight, the surface area of the body, left ventricular mass, and vasomotor tone.[10]

Different imaging modalities have long been used to assess vessel size, the severity of lesions, and plaque burden. Intravascular ultrasound provides an accurate assessment of vessel size. This study was

*Sharif Medical & Dental College, Sharif Medical City. Sharif Medical City Road, Off Raiwind Road, Jati Umra, Lahore 54000, Pakistan.*

*Correspondence: Dr. Muhammad Kashif*
*Medical Officer Department of Cardiology*
*Rawalpindi Institute of Cardiology, Rawalpindi*
*E-mail: kashifbbh@gmail.com*

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planned to evaluate the size of normal coronary arteries by IVUS. The smaller diameter of coronary arteries presents a significant therapeutic challenge associated with difficulties in percutaneous coronary angioplasty and stenting. Smaller coronary artery diameter is also a poor prognostic factor for coronary artery disease. Data on normal diameters of coronary arteries adjusted for age, gender, and other factors may be useful to interventional cardiologists and cardiac surgeons in improving PCI & coronary artery bypass grafting (CABG), and preventing short & long-term complications associated with under or oversizing of coronary arteries.

## METHODOLOGY

It was a cross-sectional descriptive study conducted at the Rawalpindi Institute of Cardiology, Rawalpindi. A sample size of 80 was calculated using the standard deviation of the diameter of proximal LAD as 0.23 mm and 5% margin of error.[11] Patients with a normal segment on IVUS imaging and plaque burden less than 30% were enrolled in the study by non-probability convenient sampling. All these patients underwent IVUS during coronary angiography for guideline-directed clinical indication. The exclusion criteria included the patients with image distortion on IVUS due to artifacts and the absence of a normal segment in the desired segment. The patient demographic details about age, gender, BMI, smoking, and risk factors such as HTN & DM were noted on a proforma sheet.

Informed consent was taken from the patients. Intravascular ultrasound images were taken at any time during the procedure at the operator's discretion after injecting 200 micrograms of glyceryl trinitrate. An IVUS catheter (Volcano Eagle Eye Short Tip) was introduced into the distal left anterior descending artery, left circumflex artery, and right coronary artery over a 0.014-inch guide wire. After optimal adjustment of gain and contrast, continuous ultrasound imaging was performed for better visualization of lumen-intima and medial-adventitial interfaces. Intravascular ultrasound images were taken from proximal LAD, proximal RCA, and proximal LCX. Only the healthy segments on IVUS imaging or segment with a plaque burden of less than 30% were part of the study. Measurements from proximal LAD (before the origin of large septal or diagonal), proximal LCX (before the origin of the first marginal branch), and proximal RCA (within the first 2 cm after its origin) were taken. The vessel diameter and luminal area of the artery at the given reference points were noted on IVUS images by defining the distance from media to media.

## STATISTICAL ANALYSIS

Data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. The qualitative variables such as gender were presented as frequency and percentage. The quantitative variables, such as age and coronary artery diameter were expressed using mean and standard deviation (SD). The association of coronary artery diameters with various variables, such as age, gender, BMI, etc. was determined using an independent t-test and one-way Analysis of Variance (ANOVA). A p-value of $\leq 0.05$ was considered significant.

## RESULTS

The mean age of the study participants was 54.61±10.19 years, with a minimum age of 34 years and a maximum age of 78 years. Majority of them (33.7%) were of the age group 51-60 years followed by 41-50 years (30%). Out of 80 study subjects, 55(68.7%) were males and 25(31.3%) were females. Fifty (62.5%) subjects were diabetic, 57.5% were hypertensive, and 38.7% were smokers. The mean BMI was 27.31±3.23 kg/m$^2$. The minimum and maximum BMI were 21.3 kg/m$^2$ and 34.5 kg/m$^2$, respectively. The majority of the participants (55%) had a BMI ranging from 25-29.9 kg/m$^2$ followed by 18.5-24.9 kg/m$^2$ (25%) (Table 1). The mean diameter of LAD was 3.96±0.48 mm, LCX was 3.4±0.43 mm, and RCA was 3.7±0.22 mm (Table 2). There was a significant association of LAD, LCX, and RCA diameter with gender, with males having a greater diameter than females. Similarly, HTN and DM had a significant association with LAD diameter. Smoking was also associated with LCX and RCA diameter with a significant p-value. In addition, age was also significantly associated with RCA diameter (Table 3).

## DISCUSSION

There is a wide variation in the diameter of coronary arteries across different populations.[12] Data regarding the size of coronary vessels is very limited among Pakistani population. The dilemma of the size of coronary vessels in the Pakistani population versus the western population has yet to be resolved. Many studies have reported the small size of coronary vessels in the Pakistani population. But in these studies, size was measured from patients undergoing CABG or from specimens taken from autopsy, which may be a reason for smaller coronary artery size.[13] In addition, coronary angiography is often used to estimate the diameter of coronary vessels which is less accurate and dependent on operator observation.[14]

In our study, the study participants had a mean age of 54.61±10.19 years, and 68.7% of them were males. Similarly, in a study done in Turkey, the mean age of the

**Table 1: Demographic Variables of the Study Subjects**

| Demographic Variables | | Frequency & Percentage |
|---|---|---|
| **Age (Years)** | **31-40** | 9(11.3%) |
| | **41-50** | 24(30%) |
| | **51-60** | 27(33.7%) |
| | **61-70** | 14(17.5%) |
| | **71-80** | 6(7.5%) |
| **Gender** | **Male** | 55(68.7%) |
| | **Female** | 25(31.3%) |
| **Diabetes Mellitus** | **Present** | 50(62.5%) |
| | **Not Present** | 30(37.5%) |
| **Hypertension** | **Present** | 46(57.5%) |
| | **Not Present** | 34(42.5%) |
| **Smoking** | **Smoker** | 31(38.7%) |
| | **Non-smoker** | 49(61.3%) |
| **BMI ($kg/m^2$)** | **18.5-24.9** | 20(25%) |
| | **25-29.9** | 44(55%) |
| | **≥30** | 16(20%) |

**Table 2: Diameter and Lumen Area of Coronary Arteries**

| Coronary Artery Size | | Coronary Artery | | |
|---|---|---|---|---|
| | | **LAD** | **LCX** | **RCA** |
| **Diameter (mm)** | **Mean±SD** | 3.96±0.48 | 3.4±0.43 | 3.7±0.22 |
| | **Minimum Diameter** | 3.3 | 2.9 | 3.4 |
| | **Maximum Diameter** | 5.6 | 4.1 | 4 |
| **Lumen Area ($mm^2$)** | **Mean±SD** | 13.09±2.9 | 11.8±2.13 | 13.44±2.04 |
| | **Minimum Lumen Area** | 9.3 | 9.3 | 10.42 |
| | **Maximum Lumen Area** | 21.1 | 16.1 | 17.1 |

**Table 3: Association of Various Variables with Diameter of LAD, LCX, and RCA**

| Study Variables | | LAD Diameter (mm) | p-value | LCX Diameter (mm) | p-value | RCA Diameter (mm) | p-value |
|---|---|---|---|---|---|---|---|
| **Age (Years)** | **31-40** | 3.84±0.34 | 0.884 | 3.45±0.21 | 0.249 | 3.5±0.11 | 0.002* |
| | **41-50** | 3.99±0.7 | | 3.8±0 | | 3.53±0.2 | |
| | **51-60** | 3.98±0.3 | | 3.61±0.5 | | 3.92±0.11 | |
| | **61-70** | 4.04±0.28 | | 3.05±0.19 | | 3.63±0.11 | |
| | **71-80** | 3.76±0.4 | | 3.1±0 | | 3.62±0.22 | |
| **Gender** | **Male** | 4.06±0.49 | 0.012* | 3.85±0.2 | 0.001* | 3.84±0.12 | 0.001* |
| | **Female** | 3.66±0.27 | | 3.07±0.15 | | 3.44±0.05 | |
| **Diabetes Mellitus** | **Present** | 3.84±0.31 | 0.05* | 3.4±0.46 | 0.82 | 3.73±0.24 | 0.496 |
| | **Not Present** | 4.11±0.61 | | 3.45±0.21 | | 3.65±0.17 | |
| **Hypertension** | **Present** | 4.06±0.52 | 0.03* | 3.47±0.56 | 0.72 | 3.69±0.21 | 0.77 |
| | **Not Present** | 3.75±0.3 | | 3.38±0.4 | | 3.72±0.24 | |
| **Smoking** | **Smoker** | 3.94±0.52 | 0.843 | 3.86±0.22 | 0.001* | 3.88±0.12 | 0.001* |
| | **Non-smoker** | 3.97±0.45 | | 3.15±0.28 | | 3.58±0.18 | |
| **BMI ($kg/m^2$)** | **18.5-24.9** | 4.01±0.74 | 0.684 | 3.05±0.19 | 0.108 | 3.7±0 | 0.636 |
| | **25-29.9** | 3.9±0.36 | | 3.5±0.46 | | 3.74±0.21 | |
| | **≥30** | 4.04±0.3 | | 3.75±0 | | 3.63±0.28 | |

**Significant p-value*

study subjects was 57.3±11.4 years, and 53.6% were males.[11] Ahmed et al. reported that the mean age of the participants was 45.85±10.12 years. The majority of them were males (73.3%).[13] In another study done in Pakistan, participants had a mean age of 54.35±12.39 years.[15] The mean BMI was 27.31±3.23 kg/$m^2$ in our study. The participants had a BMI of 28.25±4.56 kg/$m^2$ and a body surface area (BSA) of 1.88±0.13 $m^2$ in another study.[11] The results are similar to the present study. Ozdemir et al. reported mean BMI and BSA as 29.0±5.3 kg/$m^2$ and 1.9±0.2 $m^2$, respectively in their study.[16] The BMI was less in other studies. The mean BMI was 24.59±1.48 kg/$m^2$ in a study by Raut et al.[17] The mean BMI was 26.5kg/$m^2$ and BSA was 1.81 $m^2$ in another study.[18]

Our results showed that 62.5% of the subjects were diabetic, 57.5% were hypertensive, and 38.7% were smokers. The frequency of these risk factors was very high as compared to another study, in which HTN was present in 25.6%, smoking in 22.8%, hyperlipidemia in 12.9%, and DM in 7.7% of the study participants.[16] Kurt et al. reported HTN in 46.3%, DM in 12.2%, smoking in 43.6%, hyperlipidemia in 11.2%, and a family history of CAD in 11.2% of the participants.[11]

In our study, the mean diameter of LAD was 3.96±0.48 mm, LCX was 3.4±0.43 mm, and RCA was 3.7±0.22 mm. In a study by Ahmed et al. in Pakistan, computed tomographic (CT) angiography of coronaries was used to determine the diameter of coronary arteries. The mean diameter of the left main artery was 3.96±0.585 mm, LAD was 3.62±0.515 mm, LCX was 2.99±0.629 mm, and RCA was 3.13±0.532 mm.[13] In another study done in Pakistan, the size of the left main coronary artery (LMCA) was 4.065±0.363 mm, proximal LAD was 3.559±0.33 mm, proximal LCX was 3.182±0.38 mm, and proximal RCA was 2.996±0.33 mm as determined by coronary arteriography. Raut et al. reported the size of LAD, RCA, and LCX as 3.27±0.23 mm, 3.2±0.37 mm, and 2.97±0.37 mm, respectively.[17] These studies showed that the diameter of coronary arteries in our study was greater than in other studies. This might be due to the reason that intravascular ultrasound was used in our study to determine the coronary arteries' diameter. In contrast, coronary angiography or CT angiography was used in other studies.

Intravascular ultrasound provides a more accurate measurement of the size of coronary arteries. A study in India compared the diameter of coronary arteries measured by IVUS and coronary angiography. The size of LAD was significantly greater when measured by IVUS (3.71 mm) than by angiography (3.45 mm). Similarly, the diameter of LCX was 3.55 mm by IVUS and 3.16 mm by angiography. Right coronary artery dimensions were 3.85 mm and 3.27 mm by IVUS and angiography, respectively.[19]

A study reported the size of LMCA, LAD, RCA, and LCX as 4.5±0.9 mm, 3.5±0.7 mm, 3.8±0.8 mm, and 3.5±0.8 mm, respectively in Caucasian men using coronary arteriogram. The diameter of LMCA, LAD, RCA, and LCX was 4.6±0.9 mm, 3.5±0.8 mm, 3.5±0.8 mm, and 3.4±0.8 mm, respectively in Asian men. No significant difference was found between the two groups. The study population had no history of CAD or its risk factors, and both groups were matched for age, weight, height, BMI, and body surface area.[11]

There was a significant association of LAD, LCX, and RCA diameter with gender, with males having a greater diameter than females in our study. In a study by Ozdemir et al., the diameter of LMCA and LCX were the same in both males and females. On the other hand, LAD and RCA diameters were significantly greater in males than in females.[16] A study conducted in Pakistan revealed that the size of coronary arteries is significantly associated with gender, BMI, and body surface area.[13] In contrast, the diameter of coronary arteries was not linked to BMI in our study.

Skowronski et al. enrolled an equal number of Caucasians and Asians in their study. Study participants were matched for age, gender, and BSA. The study reported that the luminal area and coronary vessel diameter are significantly larger in all the proximal segments of Caucasians as compared to Asians. The differences in the lumen area and diameter of the proximal segments of LAD were 13% and 6%, LCX were 14% and 8%, and RCA were 8% and 4%.[20] Another study also revealed that Caucasians had a larger diameter of coronary arteries than Asians. But when matched to body surface area, the difference was insignificant, suggesting that the smaller diameter of coronary arteries in the Asians might be attributed to their relatively small size.[13]

## CONCLUSION

The diameter of coronary arteries determined by IVUS was larger as compared to visual assessment on coronary angiography. So, intravascular ultrasound provides a better measurement of the size of coronary arteries. The diameter of LAD, RCA, and LCX was significantly associated with gender.

## LIMITATIONS & RECOMMENDATIONS

The study participants were recruited from a single tertiary care hospital in Pakistan, so these results cannot depict the overall Pakistani population. Further studies should be conducted by enrolling study participants from multiple healthcare institutions. The study had a small sample size, as IVUS is an expensive diagnostic modality. Future research should be done on a larger sample size.

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