

# Patterns of Coronary Artery Dominance and Association with Severity of Coronary Artery Disease at a Large Tertiary Care Hospital in Pakistan

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## Abstract

**Background:** In cardiac anatomy, the term "dominance" refers to the supply of the posterior descending artery (PDA). Therefore, the PDA might arise from the left circumflex artery (LCX), the right coronary artery (RCA), or both, resulting in left dominant (LD), right dominant (RD), or co-dominant (CD) anatomy, respectively. Few studies have examined the relationship between coronary dominance and coronary artery disease (CAD) severity. CAD severity is defined as single, double, or triple vessel disease based on degree of stenosis. Our study intends to identify coronary dominance trends in Pakistan and show a correlation between coronary dominance and the severity of CAD. **Methods:** Between Jun 17, 2018 and August 4, 2018 data from coronary angiographies of 631 patients at a tertiary care hospital in Pakistan was collected. Patients were classified as LD, RD, or CD as reported in the results of coronary angiograms. We utilized a chi-square and multinomial logistic regression analyses to assess whether a correlation exists between coronary dominance and CAD severity. **Results:** Subjects were 78.9% RD, 10.5% LD, and 10.6% CD. A significant relation between dominance and severity of CAD was noted,  $\chi^2(8, N=631) = 17.58, p=0.025$ . Individuals with right dominance had a greater chance of developing triple-vessel disease than single-vessel ( $p = 0.025$ ; OR = 0.451; 95% CI for OR: 0.224–0.906) and two-vessel disease ( $p = 0.029$ ; OR = 0.471; 95% CI for OR: 0.239–0.926). **Conclusion:** In our study, right dominance has a positive correlation with severity of coronary artery disease.

**Key Words:** Coronary Artery Disease; Coronary Angiography; Coronary Circulation; Coronary Arteries (Source: MeSH-NLM).

## Introduction

The right and left coronary arteries are responsible for supplying blood to the entire heart. They originate from the anterior coronary sinus and the left posterior sinus respectively, both of which are present in the proximal part of the root of the aorta.<sup>1</sup> The left coronary artery (LCA) branches off into the left anterior descending artery (LAD) and the left circumflex artery (LCX), while the right coronary artery (RCA) diverges into the acute marginal arteries and the posterior descending artery (PDA).<sup>2</sup>

The term 'dominance' when considering coronary anatomy refers to the supply of the PDA. The PDA can thus originate from the LCX, RCA or both.<sup>3</sup> Consequently, the anatomy is described as left dominant, right dominant, or co-dominant, respectively. The reported patterns of coronary artery dominance vary, with studies reporting a majority of the general population as being right dominant, ranging from 82%- 89%. Studies show that 5%-12% of the population has a left dominant coronary system, and 3% - 7% of the population has co-dominant coronary vasculature.<sup>4-6</sup> Coronary artery disease refers to the disease process in which a

plaque forms within the wall of a coronary artery.<sup>7</sup> These plaques obstruct blood flow within the coronary vessels, resulting in their constriction or stenosis. This decreases blood circulation to the myocardium, resulting in ischemia.<sup>8,9</sup> A lack of a national database makes it difficult to determine the prevalence of CAD in Pakistan. Nevertheless, according to a 2017 global survey, CAD is the second leading cause of mortality and disability in Pakistan (DALY).<sup>10</sup> There are few prior studies exploring a relation between coronary dominance and severity of coronary artery disease (CAD). A study by Yan et al in 1654 patients in Shaanxi Province, China, concluded that right dominance correlates positively with the severity of CAD.<sup>11</sup> Another study in 2225 patients in Shanghai, China, by Peng et al offered similar conclusions, with a reported OR of 1.768 (95% CI 1.057–2.956).<sup>12</sup>

Scant data exists regarding the patterns of coronary dominance and their correlation with the severity of CAD in Pakistan. The aim of this study is to quantify the patterns of coronary dominance in Pakistan and compare these findings to existing literature.<sup>4-6</sup> We also aim to establish whether a correlation between dominance

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and severity of CAD exists in this patient population, which could impact decision making regarding intervention for patients with a certain pattern of coronary artery dominance. This can be true especially during cardiac catheterization for acute coronary syndrome. If a particular coronary artery dominance is directly associated with greater severity of coronary artery disease or increased morbidity and mortality, the decision to perform Percutaneous Coronary Intervention (PCI) in a patient with the said form of coronary dominance can become an important decision. Knowing that there would be greater chances of developing more severe CAD if PCI were to be delayed, ensures that early intervention can take place in patients with subcritical stenosis in their coronary vessels.<sup>13</sup>

## Methods

### Study Design and Population

This is a retrospective cross-sectional study based on data obtained from the coronary angiography reports of a total of 631 patients between June 17, 2018, and August 04, 2018, who presented to the Cardiology department in Mayo Hospital, located in Lahore, Pakistan. The instrument of evaluation used for this study was the STROBE checklist for a cross-sectional study. The Institutional Review Board at King Edward Medical University approved the study.

### Definitions

**Coronary Artery Dominance:** The term 'dominance' when considering coronary anatomy refers to the supply of the PDA. The PDA supplies blood to the inferior one-third of the interventricular septum and the inferior part of the left ventricle.<sup>14</sup> Patterns of coronary dominance were recorded as left dominant, right dominant, or co-dominant.

**Coronary Artery Disease (CAD):** Presence of CAD was determined by the interventional cardiologist carrying out the angiographic procedure. CAD was denoted by findings of stenosis in any of the three main coronary arteries. Stenosis less than 50% was reported as non-obstructive CAD. Obstructive CAD, however, was further categorized as a single-, double-, or triple-vessel disease. Degree of obstructive occlusion as reported by at least two interventional cardiologists via visual estimation was noted as total occlusion being 100% stenosis of vessel, subtotal occlusion as 90-99% stenosis, severe stenosis as 70-89% occlusion, and moderate stenosis as 50-69% occlusion.

### Data Collection

The selection criteria included all those patients who presented for angiographies at our tertiary care hospital between June 17, 2018, and August 4, 2018. Demographic and clinical data was extracted from patient reports from the cardiac catheterization laboratory. The demographic variables included sex categorized as male or female, and age at the time of angiography.

The clinical data was obtained from the results of coronary angiography. It included coronary artery dominance, presence of

CAD for each patient as single-, double-, or triple-vessel disease. Disease (both obstructive and non-obstructive) in the middle and proximal segments of LAD, LCX, and proximal segments of PDA and Posterior Left Ventricular Artery was included in the study, as was disease in good sized first- third Obtuse Marginal arteries (OM1, OM2, OM3), and first-third Diagonal arteries (D1, D2, D3). Patients with congenital heart defects, previous angioplasties, those with missing/ambiguous data, and those with disease in the distal segments of LAD, LCX, small-, and fair-sized OM1, OM2, OM3, D1, D2, D3 were excluded from this study.

We were unable to account for risk factors, other than sex and age, due to lack of sufficient records.

### Data Analysis

All statistical tests were executed via SPSS Version 23.0 (IBM, Armonk, NY). A p-value of <0.05 was determined to be statistically significant. A chi-squared test of independence was computed for dominance and severity of CAD, age and severity, and sex and severity. Multinomial logistic regression analysis was carried out to examine a correlation between the severity of CAD with sex, age, and coronary artery dominance. The categorical variables were shown as percentages and numbers while quantitative variables were recorded as mean  $\pm$  Standard Deviation (SD).

## Results

Six hundred and thirty-one patients were studied, of which four hundred and forty-five (70.5%) were male and one hundred and eighty-six (29.5%) were female. The patients ranging in age from 23 years to 85 years (interquartile range = 15) were included in the study with a mean age of roughly 53.3 years and an SD of 10.7 years. Among the 631 patients that underwent coronary angiography, 78.9% (95% CI 75.5–82.0) were right dominant, 10.5% (95% CI 8.2–13.1) were left dominant and 10.6% (95% CI 8.3–13.3) were co-dominant. This data is detailed in [Table 1](#).

**Table 1.** Variables Used in the Study with their Mean Value and Standard Deviation from Mean.

Variables	Values
<b>Age (n <math>\pm</math> SD)</b>	53.3 $\pm$ 10.7
<b>Sex, n (%)</b>	
Male	445 (70.5)
Female	186 (29.5)
<b>Dominance, n(%)</b>	
Left dominance	66 (10.5)
Right dominance	498 (78.9)
Codominance	67 (10.6)
<b>Type of Disease, n (%)</b>	
CAD absent	48(7.6)
Single-vessel Disease	135 (21.4)
Double-vessel Disease	135 (21.4)
Triple-vessel Disease	247 (39.1)
Non-Obstructive CAD	66 (10.5)

A total of 7.6% of patient angiography reports showed absence of CAD. 10.5% had non-obstructive CAD (e.g., coronary artery ectasia, arterial wall thickening), 39.1% had triple-vessel disease, 21.4% had two-vessel disease and 21.4% had single-vessel disease. Details of the severity of disease in individual arteries are tabulated with percentages in [Table 2](#).

**Table 2.** Severity of Disease in Left Anterior Descending Artery (LAD), Right Coronary Artery (RCA), Left Circumflex Artery (LCX), and Ramus Intermedius, described as either Absent, Mild, Moderate, or Severe Disease, Based on Percentage Occlusion in the Respective Arteries.

Vessel Name	Absent disease, n(%)	Mild disease, n(%)	Moderate disease, n(%)	Severe Disease, n(%)	Subtotal Occlusion, n(%)	Total Occlusion, n(%)
Left Anterior Descending	174 (27.6)	16 (2.5)	84 (13.3)	258 (40.9)	18(2.9)	81(12.8)
Left Circumflex	296 (46.9)	17 (2.7)	86 (13.6)	167 (26.5)	26 (7.8)	39 (6.2)
Right Coronary artery	287 (45.5)	12 (1.9)	54 (8.6)	188 (29.8)	14 (2.2)	76 (12.0)
Ramus Intermedius	608 (96.4)	0 (0)	5 (0.8)	14 (2.2)	0 (0)	1 (0.2)

To examine the relation between coronary dominance, sex, and severity/type of disease in our cohort of patients a chi-square test of independence analysis was conducted. A significant correlation between dominance and severity of disease in patients was found  $\chi^2(8, N = 631) = 17.58, p = 0.025$ . The strength of association was moderate with Cramer V = 0.118. Moreover, we found a significant association between sex and type (severity) of disease  $\chi^2(4, N = 631) = 67.113, p = 0.000$ , with a strong strength of association; Cramer V = 0.326.

To examine the effect of the independent variables (dominance, age, and sex) on the dependent variable (type/severity of disease), a multinomial logistic regression test was utilized. The regression model was identified with triple-vessel disease as the reference category. Regression analysis showed that individuals with right dominance were less likely to develop single vessel ( $p = 0.025$ ; OR = 0.451 ; 95% CI for OR: 0.224–0.906) and two vessel disease ( $p = 0.029$ ; OR = 0.471; 95% CI for OR: 0.239–0.926) as compared to triple vessel disease. Moreover, the chances of developing triple-vessel disease increased significantly with age as compared to other types of diseases ( $p = 0.00$ , OR = 0.887, 0.948, 0.978, 0.934 for CAD absent, single-vessel disease, two vessel disease and non-obstructive CAD respectively). A significant relation between sex and type of disease was also found, whereby patients were more prone to mild disease such as non-obstructive CAD and absent CAD than three-vessel disease if they were female. Results of the multinomial logistic regression analysis are shown in [Table 4](#). Only significant values are shown.

## Discussion

Coronary dominance is divided into RD, LD and CD on the basis of the artery supplying the posterior descending artery. Coronary

**Table 3.** Distribution of Obstructive (Single-, Double-, and Triple-Vessel Disease) and Non-Obstructive Coronary Artery Disease Among Patients with Left, Right and Codominance.

Dominance	Severity of Disease					Total
	CAD* Absent	Single-vessel Disease	Double-vessel Disease	Triple-vessel Disease	Non-Obstructive Coronary disease	
Left Dominance	5(7.6%)	21 (31.8%)	13 (19.7%)	17 (25.8%)	10 (15.2%)	66 (100%)
Right Dominance	40(8.0%)	95 (19.1%)	102 (20.5%)	211 (42.4%)	50 (10.0%)	498 (100%)
Codominance	3 (4.5%)	19 (28.4%)	20 (29.9%)	19 (28.4%)	6 (9.0%)	67 (100%)
Total	48 (7.6%)	135 (21.4%)	135 (21.4%)	247 (39.1%)	66 (10.5%)	631 (100%)

**Legend:** \*CAD: Coronary Artery Disease

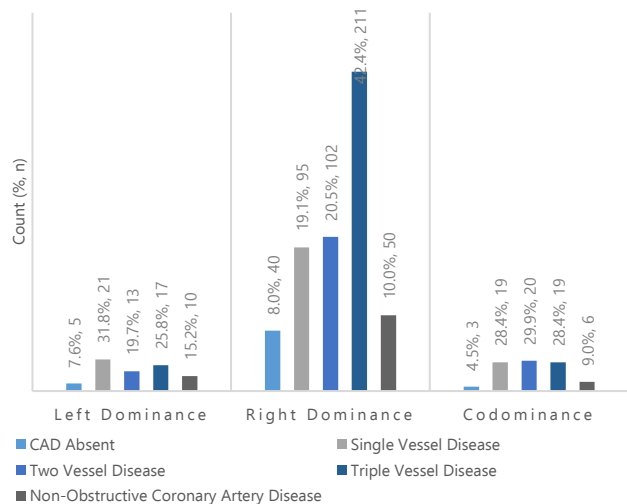
**Table 4.** Outcomes of Multinomial Logistic Regression with Triple-Vessel Disease as the Reference Category.

Type of Disease	B	Std. Error	Wald	P-value	OR	95% Confidence Interval for OR	
						Lower Bound	Upper Bound
<b>CAD Absent</b>							
Age	0.120	0.019	39.985	0.000	0.887	0.855	0.921
Sex	2.523	0.386	42.795	0.000	12.465	5.854	26.544
<b>Single-vessel Disease</b>							
Age	0.054	0.011	24.064	0.000	0.948	0.928	0.968
Right Dominance	0.797	0.356	5.004	0.025	0.451	0.224	0.906
<b>Two Vessel Disease</b>							
Age	0.022	0.011	4.298	0.038	0.978	0.958	0.999
Right Dominance	0.753	0.345	4.764	0.029	0.471	0.239	0.926
<b>Non-Obstructive Coronary Artery Disease</b>							
Age	0.069	0.014	22.574	0.000	0.934	0.908	0.961
Sex	1.333	0.302	19.553	0.000	3.794	2.101	6.851

**Legend:** CAD: Coronary Artery Disease. A multinomial regression analysis was carried out to determine a correlation between the severity of CAD with sex, age, and coronary artery dominance, with triple-vessel disease as the reference category.

artery dominance patterns vary with different geographical areas. The coronary artery dominance pattern that we observed in our population sample was 78.9% right dominant, 10.5% Left

**Figure 1.** Patterns of Coronary Artery Dominance and the Severity of the CAD in Pakistan.



dominant and 10.6% Codominant, with sex having no significant effect on the pattern of dominance. This is significantly different from previous literature whereby RD and LD have a general prevalence of 82–89% and 5–12% respectively, while CD is reported to have a prevalence of 3–7%.<sup>4–6</sup> In a study conducted in Islamabad, Pakistan in 2011 by Mian et al, it was found that the percentage of RD, LD and CD patients was 60.5%, 19.5%, and 20%, respectively.<sup>15</sup> In another study conducted in 2020 among the Kashmiri population by Samoon et al, the pattern of dominance was 86.67%, 10% and 3.33% for RD, LD, and CD respectively.<sup>16</sup> Another study conducted in Nepal in 2017 reported RD, LD, and CD circulation in 85.5%, 10%, 4.5% patients, respectively.<sup>17</sup> In another study conducted in Tehran, Vashegani et al found that 84.2% were RD, 10.9% were LD, 4.8% were CD.<sup>18</sup> Khona et al in India, after studying coronary artery anatomy in cadaveric hearts, found that 83% were RD and 17% were LD.<sup>19</sup> This again, differs from the findings in the present study.

The differences in patterns of coronary artery dominance may be due to a number of reasons. First, prevalence of artery dominance is likely to vary among different regions owing to differences in population characteristics including sex and ethnicity. Secondly, differences may be attributable to factors determining what proportion of the general population presents to the hospital and undergoes angiographic evaluation. However, one thing that can be said with certainty is that RD is more prevalent than either LD or CD in all reported studies.<sup>4–6</sup> This is in accordance with our results as well. That being said, it should be noted that patterns of coronary artery dominance in different areas/communities within Pakistan itself greatly vary. A large-scale multi-institution research could be carried out to ascertain the differences in coronary dominance between the hospital and general population, and to map the differences in patterns among different communities as well.

This study evaluating a relation between patterns of coronary dominance and severity of CAD, to our knowledge, is the first of its kind to be conducted in Pakistan. Previous studies in Pakistan have solely focused on the prevalence of coronary artery dominance. Our study shows a significant correlation between right sided coronary dominance and severity of CAD. In a study conducted on 12,558 patients in Tehran, Iran by Vasheghani et al (2018),<sup>18</sup> patients with RD were more predisposed to triple-vessel disease than others. According to our study, people with right dominant coronary artery vasculature are more prone to developing triple-vessel disease in comparison to other types of disease, thus confirming the finding in an earlier study done by Vasheghani et al (2018).<sup>18</sup> This finding is also consistent with the study done by Yan B et al (2018) on patients in 1654 patients in Shanxi Province, China.<sup>11</sup>

In contrast, a study by Goldberg et al<sup>3</sup> (2007) showed a greater correlation of mortality in patients with left dominance. It must be noted however, that the patient population included in the above study was followed prior PCI and looked at mortality instead of presence of CAD.

Our study demonstrates that increasing age has a positive correlation with severity of CAD, as would make sense, considering older age leads to greater chances of coronary events/atherosclerosis. Moreover, the present study also concluded that females are more predisposed to absent CAD and non-obstructive CAD than to severe, triple-vessel disease. This finding is in accordance with previous literature.<sup>20</sup>

#### Limitations of the study

This is a retrospective review based on past coronary angiography data. The sample size is modest. In addition, patient sampling was from a population of patients presenting to the hospital. Consequently, our study showed more than twice as many men as women subjects. An ideal study design to determine true population prevalence of coronary artery dominance would involve a multi-center study with random sampling from various population groups in Pakistan to accurately analyze patterns of dominance. While our study accounted for age and sex in the impact of coronary patterns on CAD, there are likely other confounding variables including comorbid conditions, family history and medications that might contribute to the severity of CAD. Furthermore, the angiographies were done by different cardiologists, thus a bias may be present in this study since angiograms may be interpreted differently. This study was unable to link CAD in individual coronary arteries with dominance; extensive studies are recommended for that.

#### Conclusion

This study showed that the prevalence of coronary dominance of the population presenting to a large tertiary hospital in Lahore, Pakistan is significantly different from estimates reported in literature. The study shows a correlation between right sided coronary artery dominance and severity of disease. We further note a strong relationship between age, sex, and severity of

disease. The cause of this difference and association is yet to be ascertained and warrants further investigation.

## Summary – Accelerating Translation

**Title:** Patterns of Coronary Artery Dominance and Association with Severity of Coronary Artery Disease at a Large Tertiary Care Hospital in Pakistan.

**Main Problem to Solve:** The study aims to investigate the patterns of coronary dominance in Pakistan and determine if there is a correlation between coronary dominance and the severity of coronary artery disease (CAD) in the Pakistani patient population.

**Aim of Study:** The study aims to quantify the prevalence of different patterns of coronary dominance in Pakistan and compare these findings to existing literature. It also seeks to determine if there is a relationship between coronary dominance and the severity of CAD in Pakistani patients.

**Methodology:** The study is a retrospective cross-sectional analysis based on data obtained from coronary angiography reports of 631 patients who presented to the Cardiology department in Mayo Hospital, Lahore, Pakistan. The study utilized the STROBE checklist for cross-sectional

studies. Demographic and clinical data were collected from patient reports, including coronary artery dominance, presence and severity of CAD, and patient characteristics such as age and sex. Statistical analyses, including chi-squared tests and multinomial logistic regression, were conducted to examine the relationship between coronary dominance, age, sex, and severity of CAD.

**Results:** The study found that among the 631 patients, 78.9% had right dominance, 10.5% had left dominance, and 10.6% had co-dominance. The prevalence of coronary dominance in the Pakistani population differed from previous literature. A significant correlation was observed between right dominance and the severity of CAD. Increasing age was positively correlated with the severity of CAD, and females were more prone to absent or non-obstructive CAD.

**Conclusion:** The study concluded that the patterns of coronary dominance in the Pakistani population differed from those reported in previous studies. Right-sided coronary dominance was associated with a higher severity of CAD. The study also highlighted a relationship between age, sex, and the severity of CAD. However, due to limitations, further research is needed to confirm these findings and explore other potential factors influencing CAD severity.

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**Author Contributions**

Conceptualization, Project Administration, Formal Analysis, Resources, Visualization, Writing - Original Draft: AUH, TKR. Data Curation, Investigation: AUH, TKR, RH, ASH, SAK. Methodology: AUH, TKR, RH, AS. Software: AUH. Supervision, Validation: AUH, TKR, MAA. Writing - Review Editing: AUH, TKR, MAA, NK.

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