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ORIGINAL RESEARCH

Correlation Between Coronary Arterial Dominance and the Degree of Coronary Artery Disease Using Computed Tomography Angiography

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Objective: This study used Computed Tomography Angiography to evaluate how coronary artery dominance affects CAD severity.
Methods: We retrospectively examined 1,000 coronary CTA patients at five private outpatient radiography clinics in Amman, Jordan. Patients of both sexes aged 18 or older with no coronary CTA contraindications were enrolled. Two 10-year-experienced radiologists reviewed all coronary CT images with 64 slices or more without knowing the patients' medical histories.
Results: The coronary arteries were right, left, or co-dominant. CAD: stenosis. Visual assessment of the lumen diameter rated coronary stenosis as 0%, mild (1–49%), moderate (50–69%), or severe (≥70%). Positive obstructive CAD can be identified when a coronary lesion compromises the lumen by ≥50%. A CAD patient had one, two, three, or four vascular disease. Study outcomes were assessed using descriptive statistics, *t*-tests, and one-way ANOVA. Right, left, and co-dominant coronary arteries predominated 85.7%, 11.6%, and 2.7%. Co-dominance caused greater right coronary artery (RCA) issues than left- or right-dominance. 22.2% of co-dominance patients reported positive RCA difficulties, compared to 6.9% and 21.0% of left- and right-dominance patients ($p = 0.001$). In addition, 14.8% of co-dominance patients had obstructive RCA lesions, compared to 1.7% of left-dominance and 5.3% of right-dominance ($p = 0.018$). The coronary dominance patterns did not affect LMCA, LAD, LCX, and Ramus blockages ($p = 0.846$, 0.447, 0.116, and 0.867). Calcium scores averaged 44.4 for right dominance, 41.0 for left, and 86.2 for co-dominance ($p = 0.136$).
Conclusion: Coronary CTA may not provide more risk information than assessing stenosis in patients with normal arteries or non-significant CAD. However, it may aid RCA and obstructive CAD patients.
Keywords: coronary arterial dominance, coronary artery disease, computed tomography angiograph, radiographers, Jordan

Introduction

CVDs are a major cause of death across the world, leading to more than 17.9 million deaths each year and accounting for 32% of all global deaths.[1] By 2030, it is predicted that there will be 24 million deaths yearly, posing a significant challenge to healthcare systems all over the world.[2] CVDs are a group of disorders affecting the heart and blood vessels, including coronary heart disease, cerebrovascular disease, peripheral arterial disease, rheumatic heart disease, congenital heart disease, and pulmonary embolism and deep vein thrombosis.[1]

CAD is the most common type of CVDs (Centers for Disease Control and Prevention (CDC)).[3] In the United States, CVDs cause one in five deaths each year, more than half of these deaths are attributed to coronary artery disease.[4] In

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developing Arab countries, rates of CAD were higher than those in more developed countries.[5] In Jordan, 42% of deaths were associated with CVDs, and about 60% of these deaths were associated with CAD.[6]

CAD sufferers always have chest discomfort. Not all chest pain patients have myocardial ischemia or CAD, thus diagnostic testing is needed to rule it out.[7–10] Due to insufficient coronary artery stenosis severity assessment, surgical treatment of CAD patients has poor success rates.[11,12] Thus, more diagnostic techniques to confirm coronary artery stenosis severity before surgery are needed to improve treatment planning.[13] Community recommendations recommend early detection and risk classification in age groups at risk for CAD to enable medical therapies to alter the natural course of CAD to a less pathogenic one.[14]

Diagnosis of CAD patients is guided by various imaging modalities such as invasive and non-invasive imaging that explore evidence of impaired myocardial contractility, reduced myocardial perfusion, and anatomical changes.[15] The European Society of Cardiology (ESC) recommends the use of non-invasive functional imaging or coronary computed tomography angiography (CCTA) as a primary diagnostic test for CAD.[16,17] If there is a high clinical risk of CAD and the patient presents with angina at a low exercise level or symptoms do not respond to medical treatment, proceeding immediately to invasive coronary angiography may be considered.[16,18]

Other non-invasive imaging techniques can forecast and diagnose disease, risk stratification, and testing.[19] Anatomical and functional tests for coronary artery wall pathology and myocardial dysfunction, respectively, are non-invasive diagnostics. MRA, CTA, and CAAS are non-invasive anatomical tests.[16] Cardiovascular nuclear imaging with SPECT or PET, exercise electrocardiography (ECG), CT perfusion, stress echocardiography, pharmacologic stress MRI, and Doppler ultrasound-derived flow reserve measurements are non-invasive functional tests.[20,21]

With the advancement of CT technology, coronary CTA has emerged as an effective alternative non-invasive imaging that can provide detailed visualization of coronary anatomy and stenosis.[22,23] Coronary CTA has a high CAD negative predictive value and contributes significantly to reducing hospital admission, diagnosis time, and hospital stay as well as safely excluding CAD and reducing unnecessary ICA.[15,24–26] Furthermore, in the case of CAD, coronary CTA provides diagnostic information about atherosclerotic plaque type causing coronary arteries lumen narrowing, such as calcified plaques, soft tissue plaques, or mixed plaques. Knowing the atherosclerotic plaque type provides important predictive information for further treatment decision-making.[27] Importantly, other information that can be easily assessed on coronary CTA is the possibility of remodeling the coronary artery tree structure in a three-dimensional view, as this view makes it easy to define coronary arteries' origin and coronary arteries' course in relation to the large arteries.

Methods

Study Design

This was a retrospective research involving 1,000 patients who underwent coronary computed tomography angiography at multiple radiology sites in Amman. The significance of the retrospective approach is in its capacity to gather data from a substantial patient population, as the data is not specifically collected for the study but is instead derived from a clinical database.[28] This is optimal in the present study, wherein data were gathered from a substantial cohort of patients who had coronary CTA as a target group throughout a brief timeframe.

Study Setting and Population

According to the Global Burden of Disease Report 2020, the prevalence of CAD among Jordanian adults aged 30–79 years was 16.1%. This means that approximately 16 out of every 100 Jordanian adults suffer from CAD; indicating around 1.3 million adults suffer from CAD in Jordan. This is higher than the expected global prevalence of CAD of 13.9%.[29] Jordan has a high CAD burden, with an estimated 18.6% of total deaths (WHO, 2020a), representing 60% of CVDs deaths.[6] This indicates that CAD is Jordan's leading cause of death, followed by cancer and stroke.

The data for this study were collected from five private outpatient radiology clinics in Amman, Jordan, including Al-Jawhara Radiology Center, Al-Raja Radiology Center, Jordan Radiology Center, Al-Basma Radiology Center, and Al-Amal Radiology Center.

Study Sample

The target participants included all adults (aged ≥ 18 years) patients who underwent coronary CTA for evaluation of suspected CAD in the selected private outpatient radiology clinics between March 1, 2019, and October 31, 2023. The study participants were included using a consecutive, non-probability sampling method from an accessible population who met the eligibility criteria during the data-collection period. All data are stored in patients' electronic medical records system at the selected radiology clinics during the study period.

This study included all patients who underwent coronary CTA from the five centers who meet the following inclusion criteria 1) aged 18 years or older; 2) from both sexes; 3) had no contraindications to coronary CTA. However, patients were excluded if they were 1) non-Jordanian patients; 2) had poor image quality due to artifacts, 3) severe calcification, or 4) incomplete or unavailable data.

The study's sample size reflects the number of subjects needed to get statistically significant results. Slovin's formula (Equation 1) was used to calculate the sample size in this study (Slovin, 1960).

$$n = N/\left(1 + Ne^2\right) \tag{1}$$

Where (n) is the sample numbers, (N) is the total population, and (e) is the margin of error.

$$n = 1300000/\left(1 + 1300000\,{}^{*}(0.05)^2\right) = 399.8$$

The required sample size is 400 subjects. However, due to issues with poor image quality caused by artifacts or incomplete data, 10% were added to the total sample size and data collection. Accordingly, 440 participants were required in this study.

Coronary CTA Imaging Scanners and Protocols

All coronary CTA imaging scanners with 64 slice or higher have been included in this study. The following coronary CTA scanners were used: 64-slice GE Revolution EVO CT, Philips ICT 256 slice, Siemens somatom definition 64 slice, Siemens biograph mCT 128 slice, and Hitachi CT Scenaria View 128 slice.

All patients underwent coronary CTA imaging using the standard protocol for each CT scanner. All coronary CTA scans were performed with 64-slice or higher scanners. At the time of the coronary CTA scan, all patients had a normal sinus rhythm. Oral beta-blocker therapy was used as the primary treatment for patients whose baseline heart rate was greater than 65 beats per minute. The protocol permitted intravenous administration of metoprolol in 5 mg increments up to a maximum dose of 25 mg in order to attain a resting heart rate of less than 65 beats per minute. A timing bolus (with 10 to 20 mL contrast) was performed after a chest scout radiograph (anteroposterior and lateral) to determine the time until optimum axial image contrast opacification at a position directly superior to the ostium of LMCA. A sublingual of 0.4 mg nitroglycerin was given just before the contrast injection. Nonionic iodinated contrast medium was intravenously injected during coronary CTA acquisition in accordance with the patient's weight and scanner protocol. Prospective triggering or electrocardiographic gating was used to start the scan. Electrocardiography modulation-based radiation reduction methods were utilized to lower radiation exposure (mA) during cardiac contraction and relaxation. Following the completion of the scan, multiphasic reconstruction of the coronary CTA scans was conducted using standard algorithms with a slice thickness of 0.625–0.75 mm and an increment of 0.5–0.625 mm.

Coronary CTA Imaging Interpretation

In each radiology clinic, all coronary CTA images were reviewed by two expert radiologists (Based on the Society for Cardiovascular CT guidelines)[30] with 10 years' experience specializing in cardiovascular imaging who were blinded to patients' clinical characteristics. Radiologists were allowed to employ any or all of the existing algorithms for image reconstruction, such as cross-sectional analysis, volume-rendered approach, maximal intensity projection in two- and three-dimensional axial, and multiplanar reformat.

Coronary artery dominance was identified independently at each involved site and was categorized into right coronary dominance when PDA fills from RCA, left coronary dominance when PDA fills from LCX, or co-dominance when PDA fills from RCA and LCX.[31] Each site used a 16-segment model to conduct a per-segment examination of each coronary artery segment.

Data Collection and Study Variables

Data were collected retrospectively from patients' electronic medical records system at the selected radiology clinics. Data requested included demographic and clinical data. The demographic data included age and gender. Patients with a stent were considered to have a history of percutaneous coronary intervention (PCI). While clinical data included the coronary dominance, percentage of stenosis for left main coronary artery (LMCA), left anterior descending artery (LAD), main right coronary artery (RCA), and circumflex coronary artery (CX) as identified by the radiologists. In addition, when present, the percentage of stenosis for the ramus intermedius was obtained. Finally, the calcium score was also obtained as reported by the radiologists.

A CAD was defined as the presence of stenosis. Coronary stenosis was quantified for lumen diameter by visual estimation and graded as none (0% luminal stenosis), mild (1–49%), moderate (50–69%), or severe (≥70%). A coronary lesion compromising the lumen by >50% was defined as positive obstructive CAD. Individuals manifesting positive CAD were further categorized as having one-, two-, three-, or four-vessel disease.[32]

The coronary artery calcium score was also categorized according to Balah et al.[33] Based on the calcium score, it was categorized into very low risk (0), mildly increased risk (1–99), moderately increased risk (100–299), and severely increased risk (≥300).

Statistical Analysis

Data cleaning and analysis was conducted using STATA software package (StataCorp 16). The categorical variables were described as frequency and percentages (%), while continuous data were described as means and standard deviations (SD) or medians and interquartile range (IQR) as appropriate. The distribution of CAD and its severity were measured for the total study sample and positive CAD cohort. We also estimated the sum and average of stenosis percentage of the total study sample and the positive CAD cohort.

The difference in the means was assessed using *t*-test and one-way variance (ANOVA) as appropriate. While the difference in percentage was assessed using chi-square tests. The alpha level of significance was fixed at 0.05.

Ethical Consideration

All required ethical approvals have been obtained to perform this study, including the Institutional Review Board (IRB) approval at Jordan University of Science and Technology (JUST) under number of 5/162/2023, and administrative approvals from all private outpatient radiology clinics. Moreover, this study complies with the Declaration of Helsinki and the patient informed consent was waived.

Patients' anonymity was maintained during the study by assigning each patient a number as an identifier for data collection. Then researchers made a list of patients' numbers and dealt with them. Patients' information was guaranteed confidentiality, with only the principal investigator having the right to see it. The data have been analyzed, processed, and presented as collective data. Additionally, the data have been kept in a locked cabinet with only the principal investigator who can access it. Finally, the data were saved for five years before being deleted.

The study followed ethical standards to protect patients' confidentiality and privacy. The research team makes sure that all local laws and regulations governing the gathering, storing, and analysis of data are followed.

Results

Demographic Characteristics of the Study Sample

Table 1 shows the demographic characteristics of the study cohort. The mean age of the study cohort was 51.7 (SD ± 12.1; range 22–87) years. Age stratification demonstrated diverse distributions. Specifically, a minority of the participants (15.7%, n = 157) were aged less than 40 years. The age group of 40–49 years was the largest, representing 31.2% (n = 312) of the total cohort. The subsequent age category, 50–59 years, comprised 26.1% (n = 261) of the participants. Lastly,

Table 1 The Demographics and CAD Characteristics of the Total Study Population

	Total Study Cohort, N = 1000	
	Freq.	**Percentage**
Age, Mean & SD	51.7	12.1
Age-Groups		
<40	157	15.7
40–49	312	31.2
50–59	261	26.1
>60	270	27.0
Gender		
Male	729	72.9
Female	271	27.1

Table 2 The Distribution of Coronary Artery Dominance of the Study Cohort (N = 1000)

Coronary Dominance	Freq.	Percentage
Right dominant	857	85.7
Left dominant	116	11.6
Co-dominant	27	2.7

those aged 60 and above accounted for 27.0% (n = 270) of the total population. There was a marked predominance of male participants, constituting 72.9% (n = 729) of the total cohort. In contrast, females made up 27.1% (n = 271) of the study cohort.

Coronary Artery Dominance

Table 2 describes the distribution of coronary artery dominance among the study. Most of the study cohort had right coronary dominance with a prevalence rate of 85.7% (n = 857). The prevalence of left coronary dominance was notably lower, representing 11.6% (n = 116) of the cohort. While only 2.7% (n = 27) of the cohort had a co-dominant coronary pattern.

CAD and Their Severity

Table 3 describes 43.7% (n = 437) of the study cohort's patients who presented with CAD. Most subjects with positive CAD had stenosis in one coronary artery (n = 196, 44.9%), while those who had stenosis in two, three, or four vessels were 146 (33.4%), 76 (17.4%), or 19 (4.3%), respectively. In people with positive coronary artery disease (CAD), the most common artery with narrowing was the left anterior descending (LAD) artery, seen in 395 cases (90.4%). This was followed by the right coronary artery (RCA) with 194 cases (44.4%), the circumflex (CX) artery with 146 cases (33.4%), the mid-left coronary artery (MLCA) with 57 cases (13.0%), and the ramus artery with 11 cases (2.5%). Ramus presented in 138 (13.8%) subjects.

For the level of the obstructive CAD, the percentage of stenosis was considered for the coronary vessel with maximum percentage of stenosis when subjects have more than one vessel with CAD. Subjects with mild CAD (stenosis 1–49%) accounted for 26.2% (n = 262) of total study cohort and 60.0% of CAD cohort. While subjects with moderate

Table 3 The Distribution of CAD and Its Severity of the Total Study and Positive CAD Cohorts (N = 1000)

	Freq.	Percentage Among Total Cohort N = 1000	Percentage Among Positive Coronary Artery Dominance (CAD) Cohort N = 437
History of percutaneous coronary intervention (PCI) (Stent)	69	6.9	15.8
Positive coronary artery dominance (CAD) (any vessel)			
No	563	56.3	
Yes	437	43.7	
Number of vessels with coronary artery dominance (CAD) n = 437			
One	196	19.6	44.9
Two	146	14.6	33.4
Three	76	7.6	17.4
Four	19	1.9	4.3
Coronary vessel n = 437			
Mid-left coronary artery (MLCA)	57	5.70	13.0
Left anterior descending artery (LAD)	395	39.50	90.4
Circumflex coronary artery (CX)	146	14.60	33.4
Right coronary artery (RCA)	194	19.40	44.4
Ramus (when present n = 138, 13.8%)	11	7.97	2.5
Level of obstructive coronary artery dominance (CAD) (used max stenosis if more than 1 vessel)			
Normal (0)	563	56.3	
Mild stenosis (1–49%)	262	26.2	60.0
Moderate stenosis (50–69%)	52	5.2	11.9
Severe stenosis (≥70%)	123	12.3	28.1
Obstructive **coronary artery dominance (CAD)** (≥50%)	175	17.5	40.0
Calcium Score, mean (SD)	45.1 (0)	45.1 (109.8)	100.7 (148.1)
Calcium Score categories			
Very low risk (0)	586	58.6	134.1
Low risk (1–99)	279	27.9	63.8
Moderate risk (100–299)	90	9.0	20.6
Severe risk (≥300)	45	4.5	10.3

CAD (stenosis 50–69%) accounted for 5.2% (n = 52) of total study cohort and 11.9% of CAD cohort; and subjects with severe CAD (stenosis ≥ 70%) accounted for 12.3% (n = 123) of total study cohort and 28.1% of CAD cohort. Thus, the total number of subjects with obstructive CAD (stenosis ≥ 50%) was 175, accounting for 17.5% of total study cohort and 40.0% of CAD cohort.

Among the total study cohort, the mean calcium score was 45.1 (SD ± 109.8) and median was 0 (IQR: 0–27, range: 0–751). Among the positive CAD cohort, the mean calcium score was 100.7 (SD ± 148.1) and median was 34 (IQR: 6–134, range: 0–751).

When the calcium score was categorized by the JACC-Cardiovascular Imaging, more than half (n = 586, 58.6%) of the total study cohort had very low risk (score = 0) and 279 (27.9%) subjects had low risk (score = 1–99). While only 90 (9.0%) and 45 (4.5%) subjects had moderate (score = 100–299) and severe (≥300) risk scores, respectively.

Table 4 offers a comprehensive evaluation of the severity of CAD in various coronary vessels. In the Main Left Coronary Artery (MLCA), most people (94.3%) showed no signs of narrowing. Only 5.7% (n = 57) of the total cohort showed positive MLCA stenosis. Most of those (n = 55) had mild stenosis, suggestive of early disease. While obstructive CAD, which poses a more immediate risk and is defined by more than 50% stenosis, was noted in only two subjects. The overall average stenosis among the MLCA vessels was 22.9% (SD ± 13.3).

For the LAD, 60.5% of study cohort showed no stenosis and 39.5% of the cohort had positive of CAD. Mild stenosis was seen in 25.4% of the total cohort and.58.1% of positive CAD cohort. Obstructive CAD was present in 14.1% of total cohort and 32.3%

Table 4 Description of the Severity of CAD for Each Coronary Vessel of the Total Study and Positive CAD Cohorts

	Freq.	Percentage Among Total Cohort N = 1000	Percentage Among Positive Coronary Artery Dominance Cohort N = 437
Mid-left coronary artery (MLCA)			
Normal (0%)	943	94.3	
Positive CAD (>0%)	57	5.70	13.0
Mild stenosis (1–49%)	55	5.5	12.6
Moderate stenosis (50–69%)	2	0.2	0.5
Severe stenosis (≥70%)	0	0	0.0
Obstructive CAD (≥50%)	2	0.2	0.5
Average of stenosis percentage	22.9%	1.3	3.0%
Left anterior descending artery (LAD)			
Normal (0%)	605	60.5	
Positive CAD (>0%)	395	39.5	90.4
Mild stenosis (1–49%)	254	25.4	58.1
Moderate stenosis (50–69%)	54	5.4	12.4
Severe stenosis (≥70%)	87	8.7	19.9
Obstructive **coronary artery dominance** (≥50%)	141	4.1	32.3
Average of stenosis percentage	42.4%	16.8%	38.3%
Circumflex coronary artery (CX)			
Normal (0%)	854	85.4	
Positive coronary artery dominance (CAD) (>0%)	146	14.6	33.4
Mild stenosis (1–49%)	103	10.3	23.6
Moderate stenosis (50–69%)	12	1.2	2.7
Severe stenosis (≥70%)	31	3.1	7.1

(*Continued*)

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Table 4 (Continued).

	Freq.	Percentage Among Total Cohort N = 1000	Percentage Among Positive Coronary Artery Dominance Cohort N = 437
Obstructive coronary artery dominance (CAD) (≥50%)	43	4.3	9.8
Average of stenosis percentage	39.0%	5.7%	13.0%
Right coronary artery (RCA)			
Normal (0%)	806	80.6	
Positive coronary artery dominance (CAD) (>0%)	194	19.4	44.4
Mild stenosis (1–49%)	143	14.3	32.7
Moderate stenosis (50–69%)	16	1.6	3.7
Severe stenosis (≥70%)	35	3.5	8.0
Obstructive coronary artery dominance (CAD) (≥50%)	51	5.1	11.7
Average of stenosis percentage	38.3%	7.4%	17.0%
Ramus intermedius n = 138			
Normal (0%)	127	92.0	
Positive coronary artery dominance (CAD) (>0%)	11	8.0	2.5
Mild stenosis (1–49%)	9	6.5	2.1
Moderate stenosis (50–69%)	0	0.0	0.0
Severe stenosis (≥70%)	2	1.5	0.5
Obstructive coronary artery dominance (CAD) (≥50%)	2	1.5	0.5
Average of stenosis percentage	38.0%	30.0	6.8

of positive CAD cohort, suggesting a higher disease burden in this artery. The average stenosis stood at a substantial 42.4% with a standard deviation of 22.3%, suggesting a wide variation in disease severity among participants.

For the CX, most study cohort (85.4%) displayed a clear CX artery. While 146 subjects (14.6% of total cohort and 3.4% of positive CAD cohort) had some CAD presentation. Most of these (n = 146) were in the early stage with mild stenosis, while obstructive CAD was observed in 4.3% of total cohort and 9.8% of positive cohort. The cumulative average stenosis in the CX was 39.0% (SD ± 21.6).

For the RCA, a proportion of 80.6% of total cohort had clean health profile regarding stenosis. Positive CAD was evident in 19.4% (n = 194) of total cohort and 44.4% of positive CAD cohort. Among these, 143 subjects were in the initial stages of disease development with mild stenosis. More severe, obstructive CAD was present in 51 subjects, accounting for 5.1% of total cohort and 11.7% of positive CAD cohort. On average, stenosis in the RCA was found to be 38.3% (SD ± 2.1%). Regarding the Ramus intermedius which was presented in 138 subjects, only 11 subjects had positive CAD. Most of these (n = 9) had mild stenosis, and only 2 subjects had obstructive CAD. The average stenosis was somewhat high at 38.0% (SD ± 24.0%).

Demographical Characteristics Distribution of the Study

Table 5 presents the distribution of age and gender across different coronary dominance patterns in the study cohort. The participants with right and left coronary dominance had a similar mean age (51.6 ± 12.0 vs 51.5 ± 13.0, p = 0.423,

Table 5 Demographical Characteristics of the Study Population Across the Coronary Dominance Pattern

	Total N = 1000	Right Dominant n = 857 (85.7)	Left Dominant n = 116 (11.6)	Co-Dominant n = 27 (2.7)	*p*-Value
Total	1000				
Age	51.7 (12.1)	51.6 (12.0)	51.5 (13.0)	54.7 (12.1)	0.423
Age-groups					0.655
<40	157 (15.7%)	133 (15.5%)	21 (18.1%)	3 (11.1%)	
40–49	312 (31.2%)	274 (32.0%)	32 (27.6%)	6 (22.2%)	
50–59	261 (26.1%)	223 (26.0%)	31 (26.7%)	7 (25.9%)	
>60	270 (27.0%)	227 (26.5%)	32 (27.6%)	11 (40.7%)	
Gender					0.914
Male	729 (72.9%)	624 (72.8%)	86 (74.1%)	19 (70.4%)	
Female	271 (27.1%)	233 (27.2%)	30 (25.9%)	8 (29.6%)	
History of Percutaneous Coronary Intervention (PCI) (with Stent)	69 (6.9%)	56 (6.5%)	9 (7.8%)	4 (14.8%)	0.229

respectively). Interestingly, the co-dominant group was slightly older, with a mean age of 54.7 (SD ± 12.1) years but was not statistically different. Similarly, the distribution of age groups across coronary dominance pattern did not differ significantly (p = 0.655). Notably, most subjects aged over 60 (40.7%) were co-dominant.

Within genders, 72.8% of the right dominant, 74.1% of the left dominant, and 70.4% of the co-dominant group were male. Females constituted 27.1% of the total cohort, with respective distributions of 27.2% in right dominant, 25.9% in left dominant, and 29.6% in co-dominant groups. The gender distribution across the dominance groups was almost even with no significant difference (p = 0.914).

Prevalence of CAD

Table 6 presents the distribution of CAD characteristics across different coronary dominance patterns in the study cohort. A higher proportion of left-dominant patients (n = 72, 62.1%) had negative CAD findings compared to right-dominant (n = 477, 55.7%) and co-dominant patients (n = 14, 51.9%). The observed differences were not statistically significant (p = 0.38). Positive CAD in any coronary vessel findings was present in 44.3% (n = 380) of right dominant patients, 37.9% (n = 44) of left dominant patients, and 48.2% (n = 13) of co-dominant patients. Similarly, the differences in prevalence of positive CAD across the groups were not statistically significant (p = 0.38).

Distribution by Number of Vessels with CAD

Table 7 presents the distribution of number of vessels with CAD across different coronary dominance patterns in the study cohort. The number of affected coronary vessels did not significantly differ across the coronary dominance patterns

Table 6 CAD Prevalence Among the Study Population Across the Coronary Dominance Pattern

	Total N = 1000	Right Dominant n = 857 (85.7)	Left Dominant n = 116 (11.6)	Co-Dominant n = 27 (2.7)	*p*-Value
Negative coronary artery dominance (CAD)	563 (56.3%)	477 (55.7%)	72 (62.1%)	14 (51.9%)	0.38
Positive coronary artery dominance (CAD) (any vessel)	437(43.7%)	380 (44.3%)	44 (37.9%)	13 (48.2%)	0.38

Table 7 CAD Prevalence Among the Study Population Across the Number of Vessels with CAD

	Right Dominant n = 857 (85.7)	Left Dominant n = 116 (11.6)	Co-Dominant n = 27 (2.7)	*p* Value
Number of vessels with coronary artery dominance (CAD) n = 437				0.379
One	167 (19.5%)	23 (19.8%)	6 (22.2%)	0.938
Two	130 (15.2%)	13 (11.2%)	3 (11.1%)	0.459
Three	69 (8.1%)	4 (3.5%)	3 (11.1%)	0.168
Four	14 (1.6%)	4 (3.5%)	1 (3.7%)	0.318

(p = 0.379); 19.5% (n = 167) of right dominant patients, 19.8% (n = 23) of left dominant patients, and 22.2% (n = 6) of co-dominant patients had CAD in a single vessel (p = 0.938); CAD in two vessels was seen in 15.2% (n = 130) of right dominant, 11.2% (n = 13) of left dominant, and 11.1% (n = 3) of co-dominant patients (p = 0.459); three vessels were affected in 8.1% (n = 69) of right dominant, 3.5% (n = 4) of left dominant, and 11.1% (n = 3) of co-dominant patients (p = 0.168); while CAD in all four vessels was noted in 1.6% (n = 14) of right dominant, 3.5% (n = 4) of left dominant, and 3.7% (n = 1) of co-dominant patients (p = 0.318).

Distribution by Severity of CAD

Severity of CAD had some association with the coronary dominance patterns, particularly severe CAD. Table 8 presents the distribution of severity of CAD across different coronary dominance patterns in the study cohort. Mild Stenosis (1–49%) was seen in 27.0% (n = 231) of right dominant, 23.3% (n = 27) of left dominant, and 14.8% (n = 4) of co-dominant patients (p = 0.276). Moderate Stenosis (50–69%) observed in 5.0% (n = 43) of right dominant, 6.0% (n = 7) of left dominant, and 7.4% (n = 2) of co-dominant patients (p = 0.783). Obstructive CAD (≥50%): 17.4% (n = 149) of right dominant, 14.7% of left dominant (n = 17), and 33.3% (n = 9) of co-dominant patients had obstructive CAD. This deference tend to be significant (p = 0.069). While severe Stenosis (≥70%) was observed in 12.4% (n = 106) of right dominant, 8.6% (n = 10) of left dominant, and a notably higher 25.9% (n = 7) of co-dominant patients. The differences were statistically significant with a p-value of 0.047.

Distribution by Calcium Score

Table 9 presents the distribution of calcium score of CAD across different coronary dominance patterns in the study cohort. The calcium scores did not differ significantly across the coronary dominance patterns. The average calcium

Table 8 Distribution of Severity of CAD Across Coronary Dominance Pattern

	Right Dominant n = 857 (85.7%)	Left Dominant n = 116 (11.6%)	Co-Dominant n = 27 (2.7%)	*p*-Value
Level of obstructive coronary artery dominance (CAD) (used max stenosis if more than 1 vessel)				
Normal (0)	477 (55.7%)	72 (62.1%)	14 (51.9%)	0.38
Mild stenosis (1–49%)	231 (27.0%)	27 (23.3%)	4 (14.8%)	0.276
Moderate stenosis (50–69%)	43 (5.0%)	7 (6.0%)	2 (7.4%)	0.783
Severe stenosis (≥70%)	106 (12.4%)	10 (8.6%)	7 (25.9%)	0.047
Obstructive coronary artery dominance (CAD) (≥50%)	149 (17.4%)	17 (14.7%)	9 (33.3%)	0.069

Table 9 Distribution of Calcium Score Across Coronary Dominance Pattern

	Right Dominant n = 857 (85.7)	Left Dominant n = 116 (11.6)	Co-Dominant n = 27 (2.7)	*p*-Value
Calcium Score, mean (SD)	44.4	41.0	86.2	0.1364
Calcium Score categories, n (%)				0.338
Very low risk (0)	503	69	14	0.761
Low risk (1–99)	241	33	5	0.543
Moderate risk (100–299)	75	10	5	0.215
Severe risk (≥300)	38	4	3	0.217

scores were 44.4 for right dominant, 41.0 for left dominant, and notably higher at 86.2 for co-dominant patients (p = 0.136).

The categories of the calcium score severity also did not differ significantly across the coronary dominance patterns (p = 0.338); very low risk was presented in 58.7% (n = 503) of right dominant, 59.5% (n = 69) of left dominant, and 51.9% (n = 14) of co-dominant patients (p = 0.761); low risk (1–99 score) was observed in 28.1% of right dominant (n = 241), 28.4% of left dominant (n = 33), and 18.5% (n = 5) of co-dominant patients (p = 0.543); moderate risk (100–299 score) was observed in 8.8% (n = 75) of right dominant, 8.6% (n = 10) of left dominant, and 18.5% (n = 5) of co-dominant patients (p = 0.215); finally, severe risk (≥300 score) was found in 4.4% (n = 38) of right dominant, 3.4% (n = 4) of left dominant, and 11.1% (n = 3) of co-dominant patients (p = 0.217).

Distribution by Specific Coronary Vessel

Table 10 presents the distribution of specific coronary vessels of CAD across different coronary dominance patterns in the study cohort. Positive MLCA involvement was found in 5.7% (n = 49) of right dominant, 6.0% (n = 7) of left dominant, and 3.7% (n = 1) of co-dominant patients, with no statistically significant difference (p = 0.894). Only 0.2% (n = 2) of right dominant patients had an obstructive lesion (stenosis ≥ 50%) in the MLCA. Obstructive MLCA was not present in left or co-dominant participants.

Table 10 Distribution of Specific Coronary Vessel Across the Coronary Dominance Pattern

	Total N = 1000	Right Dominant n = 857 (85.7)	Left Dominant n = 116 (11.6)	Co-Dominant n = 27 (2.7)	*p* -Value
MLCA					
Positive mid-left coronary artery (MLCA)	57	49 (5.7)	7 (6.0)	1 (3.7)	0.894
Obstructive mid-left coronary artery (MLCA) (≥50%)	2	2 (0.2)	0 (0)	0 (0)	0.846
Left anterior descending artery (LAD)					
Positive left anterior descending artery (LAD)	395	341 (39.8)	42 (36.2)	12 (44.4)	0.659
Obstructive left anterior descending artery (LAD) (≥50%)	141	120 (14.0)	15 (12.9)	6 (22.2)	0.447

(*Continued*)

Table 10 (Continued).

	Total N = 1000	Right Dominant n = 857 (85.7)	Left Dominant n = 116 (11.6)	Co-Dominant n = 27 (2.7)	*p* -Value
Circumflex coronary artery (CX)					
Positive circumflex coronary artery (CX)	146	120 (14.0)	20 (17.2)	6 (22.2)	0.341
Obstructive circumflex coronary artery (CX) (≥50%)	43	33 (3.90)	7 (6.0)	3 (11.1)	0.116
Right coronary artery (RCA)					
Positive right coronary artery (RCA)	194	180 (21.0)	8 (6.9)	6 (22.2)	0.001
Obstructive right coronary artery (RCA) (≥50%)	51	45 (5.3)	2 (1.7)	4 (14.8)	0.018
Ramus intermedius					
Presence of Ramus intermedius	138	121 (14.1)	15 (12.9)	2 (7.4)	0.584
Ramus (n = 138, 13.8%)	11	8 (6.6)	2 (13.3)	1 (50)	0.058
Obstructive Ramus (≥50%)	2	2 (1.65)	0 (0)	0 (0)	0.867

Positive findings were present in 39.8% (n = 341) of right dominant, 36.2% (n = 42) of left dominant, and 44.4% (n = 12) of co-dominant patients (p = 0.659). Obstructive LAD lesions were seen in 14.0% (n = 120) of right dominant, 12.9% (n = 15) of left dominant, and 22.2% (n = 6) of co-dominant patients, but this difference was not significant (p = 0.447).

No significant difference was observed between coronary dominance patterns for CAD in the CX. Positive CX findings were seen in 14.0% (n = 120) of right dominant, 17.2% (n = 20) of left dominant, and 22.2% (n = 6) of co-dominant patients (p = 0.341). Obstructive CX lesions were noted in 3.9% (n = 33) of right dominant, 6.0% (n = 7) of left dominant, and 11.1% (n = 3) of co-dominant patients (p = 0.116). However, the distribution of positive RCA findings differed significantly across the coronary dominance patterns, with 21.0% (n = 180) in right dominant, 6.9% (n = 8) in left dominant, and 22.2% (n = 6) in co-dominant patients (p = 0.001). Obstructive RCA lesions were seen in 5.3% (n = 45) of right dominant, 1.7% (n = 2) of left dominant, and a notable 14.8% (n = 4) of co-dominant patients, with a significant p-value of 0.018.

Ramus was presented in 13.8% of the study cohort and their distribution did not defer across the coronary dominance patterns. Ramus was affected in 6.6% (n = 8) of right dominant, 13.3% (n = 2) of left dominant, and notably 50% (n = 1) of co-dominant patients. A stenosis of ≥50% in the Ramus was observed in 1.65% (n = 2) of right dominant patients, with no instances in the left and co-dominant groups.

Discussion

Coronary Artery Dominance

The results of the current study indicated that the prevalence of right dominance, left dominance, and co-dominance coronary arteries were 85.7%, 11.6%, and 2.7%, respectively. These results were consistent with the results of previous studies. In a study by Vasheghani-Farahani et al in Iran, right dominance was found in 84.2%, left dominance in 10.9%, and co-dominance in 4.8% of the population.[34] The prevalence of right dominance in a study reported by Karna et al in Nepal was 85.5%, followed by left dominance at 10% and co-dominance at 4.5% of cases.[35] As well, in a study by Fakhir et al in Iraq, the dominant pattern results were right dominance in 76.4%, left dominance in 12.6%, and co-dominance in 10% of the population.[36] Likewise, a study conducted by Ghafoor et al in Pakistan revealed that right dominance was found in 78.7%, left dominance in 14.7%, and co-dominance in 7.6% of cases.[37] In addition, another study by Aricatt et al in India reported that the pattern of coronary dominance was 85.5% right dominance, 9.7% left dominance, and 4.8% co-dominance.[31] Similarly, in India, the dominant pattern was found to be 85.5% right dominance, 10% left dominance, and 4.5% co-dominance.[31]

There was only minor variance in the co-dominance pattern, which was lower in the current study. However, the dominant pattern reported in other studies has not been consistent, particularly in those that examined simply left and right dominance rather than the co-dominance pattern. Gebhard et al found that 91% of the sample population was right-dominant, whereas 9% was left-dominant.[38]

Few studies revealed an opposing dominant pattern, with higher prevalence rates of left dominance or co-dominance patterns and lower prevalence rates of right dominance.[39–41] As a result, there is a need to look deeper into this aspect of coronary dominance because these variances should not be attributed solely to diverse assessment methods.

CAD and Their Severity

The results of the current study indicated that CAD was presented in 43.7% of participants, whereby 44.9% had stenosis of one coronary artery, while 33.4%, 17.4%, and 4.3% had stenosis of two, three, and four coronary arteries, respectively. In addition, 17.5% of the participants in this study had obstructive CAD (stenosis ≥ 50%). Although this result is consistent with the results of studies using coronary CTA in Brazil, Sweden, and Pakistan, which indicated that obstructive CAD was found in 16%, 5.2%, and 23.4%, respectively,[42–44] this is in the upper range of previous studies using ICA in Brazil and Japan, which indicated that obstructive CAD was found in 3.6% and 10.5%, respectively.[45,46] This may be due to the use of coronary CTA, which gives three-dimensional images of the coronary artery wall and is, therefore, not restricted to two-dimensional projections.[43]

There are few prior studies on CAD prevalence in the general population. Previous reports using coronary CTA, which have demonstrated the prevalence of CAD ranging between 22% and 43% and significant obstructive (stenosis ≥ 50%) at 5% to 9%.[47] Accurate population prevalence estimates are crucial if we are to create and implement effective screening measures.[48] Thus, the prevalence of coronary CTA-detected CAD in the general population reported in this study closely matches the situation in Jordan. According to data on diseases from the United States and Europe, the prevalence of CAD in adults over 20 years of age was 6.7%.[49]

Additionally, the results of the current study indicated that the majority of subjects (90.4%) were found to have positive stenosis in the LAD, followed by RCA (44.4%), CX (33.4%), LMCA (13.0%), and Ramus (2.5%). This result agreed with those of previous studies reporting that LAD was the most common coronary artery for stenosis and suggesting that CAD has a tendency to stenosis at proximal branching sites, possibly with turbulent flow patterns.[42,50]

Moreover, the results of the current study indicated that the mean calcium score among participants was 45.1 ± 109.8, whereby 58.6% of participants had very low risk (score = 0), 27.9% had low risk (score = 1–99), 9.0% had moderate risk (score = 100–299), and 4.5% had severe risk (score ≥ 300). These results were consistent with the results reported by other previous studies.[44] It is important to evaluate patients' functional abilities and ability to perform basic tasks in order to detect any limitations resulting from CAD symptoms and work to enhance functional features. Better CAD risk classification is made possible by the coronary arterial calcium score, a noninvasive technology.[51,52]

The dominance pattern in coronary circulation significantly influences the hemodynamic consequences of athero-sclerotic CAD. Right-dominant circulation tends to affect the inferior and posterior walls and the conduction system, left-dominant circulation impacts the lateral and posterior walls and mitral valve function, and codominant circulation offers a more balanced but complex hemodynamic profile. Understanding these patterns is crucial for risk stratification, management, and intervention strategies in patients with CAD.

Demographical Characteristics of the Study

The results of the current study indicated that the distribution of age groups did not differ significantly between coronary dominance patterns groups (p = 0.655). This result was consistent with the results of previous studies, which indicated that there was no significant difference in coronary dominance patterns with age.[35,53,54] However, a study by Veltman et al indicated that patients with co-dominance coronary arteries tended to be younger (P = 0.026).[55]

Likewise, the results of the current study indicated that the gender distribution did not differ significantly between coronary dominance patterns groups (p = 0.914). This result was supported by the results from previous studies which indicated that there was no significant difference in coronary dominance patterns with gender.[35,36,53,54]

Prevalence of CAD

The results of the current study indicated that there were no significant differences in coronary dominance patterns with positive and negative CAD (p = 0.38), with a higher proportion of positive CAD findings in co-dominance patients (48.2%) and a higher proportion of negative CAD findings in left-dominance patients (62.1%). This result was in line with the studies of Balci & Yilmaz in Turkey,[56,57] who did not detect significant differences in the extent of CAD between left-dominance, right-dominance, or co-dominance patients.

The relationship between coronary dominance patterns and the extent of CAD is still uncertain, as previous studies have shown conflicting results. While previous studies showed an association between a higher incidence of CAD and left-dominance patients, patients with left dominance had a higher prevalence of CAD (35% to 68.1%),[31] other studies showed more extensive CAD in right-dominance patients, right-dominance patients had a higher prevalence of three-vessel CAD (33.1% to 36.6%) and inferior MI (94%).[35,36,53,54] However, this gap between studies can most likely be accounted for by a potential selection bias resulting from the limited research populations and the variations in CAD evaluation modalities used in these studies. In some studies, differences in length, origin, branch quantity, and perfused areas of LMCA and the RCA should be taken into account in relation to hemodynamic procedures, arrhythmias, and cardiac surgery from CAD due to the wide variation in the morphological expression of these blood vessels.[58]

CAD is a localized illness that narrows specific sections of the damaged vessels significantly more than the other areas.[59] It should be noted that no clear difference was detected between the study groups regarding risk factors for CAD. Therefore, there is a chance that this predisposition results from anatomical differences between the three groups. The assumption that anatomic variation is the cause of the variance in CAD in the study groups is strongly supported by the observation that CAD risk factor distribution was similar across groups.

Distribution by Number of Vessels with CAD

The results of the current study indicated that the number of affected coronary vessels did not significantly differ across the coronary dominance patterns (p = 0.379), which agreed with the results of previous studies.[32] In contrast, other studies reported that right-dominance patients had a higher prevalence of three-vessel CAD than left-dominance patients.[35,36,53,54] This may be due to the fact that the rate of coronary blood flow in the RCA in right-dominance patients is 150% higher compared to left-dominance patients, which contributes to more shear stress on the endothelial cells of RCA and thus an increased risk of CAD.[60] On the other hand, the studies of Abu-Assi et al[61] and Han et al[62] reported that left-dominance patients had a higher prevalence of three-vessel CAD compared to right-dominance patients. This may be because 90% of coronary blood flows into the left coronary artery in left-dominance patients, causing high shear stress at its bifurcation. A short LMCA would increase shear stress at its bifurcation, and thus this anatomical difference contributes to an increased risk of developing CAD.[59] However, there is a possibility that the low number of patients enrolled in this study compared to the high number of patients in previous studies, ranging between 657 patients and 12,558 patients, is the reason for the difference in results between this study and previous studies.

Distribution by Severity of CAD

The results of the current study indicated that obstructive CAD (≥50%) was higher among co-dominance patients compared to left-dominance and right-dominance patients (33.3% versus 14.7% and 17.4%, respectively). This difference tends to be significant (p = 0.069) . In contrast to our results, a large international multicenter prospective registry design on 6382 patients with or without CAD among patients who underwent coronary CTA revealed that left-dominance patients were associated with increased odds of obstructive CAD (≥50%) (Gebhard et al, 2015). In addition, a retrospective study investigating the differences in CAD extent and localization between different coronary artery dominance types among 12,558 patients who underwent ICA revealed that right-dominance patients were associated with a higher prevalence of obstructive CAD (≥50%).[34] These wide differences in the results of these studies reflect the different study settings and populations in terms of sociocultural variables, geographical location, healthcare delivery healthcare delivery systems, and different angiographic methods.

Interestingly, in patients with obstructive CAD (≥50%), a co-dominance system was identified as an important predictor of this disease, whereas left and right dominance did not predict any events in this subpopulation. The possibility that intermediate lesions carry an increased risk in co-dominance circulation is of particular interest because it may challenge the current paradigm of non-intervention in these lesions. However, there was no significant difference in this subgroup when comparing left dominance, right dominance, and co-dominance. Yet, our results may be statistically underpowered to detect the effect modification of co-dominance with obstructive CAD (≥50%) in this subgroup, because only 2.7% of patients had co-dominance.

Furthermore, the results of the current study indicated that severe stenosis (≥70%) was significantly higher among co-dominance patients (25.9%) compared to left-dominance and right-dominance patients (8.6% and 12.4%, respectively, p = 0.047). This result was in contrast to the results of previous studies, which indicated that severe stenosis (≥70%) was significantly higher among left-dominance patients[37] or right-dominance patients.[63] These wide differences in the results of these studies may be due to the different study settings and populations between these studies, as well as, the underrepresentation of co-dominance patients in these studies.

However, contrary to the current study, previous studies did not find any relationship between co-dominance patterns and severe coronary artery stenosis.[64] At present, the mechanism by which the co-dominance system impacts the severity of coronary artery stenosis is still unknown. Therefore, there is an urgent need for further research to reveal the underlying mechanism for the development of more severe lesions among patients with co-dominance.

Distribution by Specific Coronary Vessel

The results of the current study indicated that positive RCA and obstructive RCA lesions were significantly higher among co-dominance patients compared to left-dominance and right-dominance patients (22.2% versus 6.9% and 21.0%, respectively, p = 0.001) (14.8% versus 1.7% and 5.3%, respectively, p = 0.018). In contrast to our results, the results of previous studies indicated a significant relationship between left-dominance pattern and severe stenosis in the LAD artery and LCX artery compared to those with right-dominance and co-dominance.[50,65] On the other hand, the results of other studies indicated that there was a significant relationship between the right-dominance pattern and obstructive RCA lesions compared to those with left-dominance and co-dominance.[35,36,53,54]

The presence of an insignificant RCA in left-dominance patients is responsible for the low prevalence of RCA territory involvement in left dominance; however, the flow hypothesis can be used to justify the higher prevalence of RCA territory in co-dominance, since the greater the blood flow, the less stenosis of the artery, and as the RCA has high flow in right-dominance patients, its involved territory is less than in co-dominance patients. However, this result is important, because in right-dominance patients the RCA plays an important role in cardiac perfusion, and our results show that right-dominance patients have a better prognosis for developing atherosclerotic stenosis in the RCA. Moreover, the results of the current study indicated that obstructive LMCA, LAD, LCX, and Ramus lesions did not significantly differ across the coronary dominance patterns (p = 0.846, p = 0.447, p = 0.116, and p = 0.867, respectively), which agreed with the results of previous studies.[35,36,53,54]

Distribution by Calcium Score

The results of the current study indicated that calcium scores did not significantly differ across the coronary dominance patterns, with an average of 44.4 for right dominance, 41.0 for left dominance, and 86.2 for co-dominance (p = 0.136), as well as, categories of calcium score severity did not significantly differ across the coronary dominance patterns (p = 0.338), which is in line with the result of previous studies.[66] On the other hand, the results of the CONFIRM registry showed that right-dominance patients had higher calcium scores than those with left-dominance (p < 0.0001).[32]

Study Limitations

1. Coronary arterial dominance can vary significantly among individuals, and the classification (right-dominant, left-dominant, or codominant) may not always be straightforward.

2. The impact of dominance on coronary artery disease (CAD) severity may be influenced by other factors, such as collateral circulation.
3. The study may rely on visual or semi-quantitative assessment of stenosis, which can be subjective and prone to interobserver variability.
4. CTA may not accurately differentiate between stable and unstable plaques, which have different clinical implications.

Conclusion

The current study revealed that the right-dominance coronary artery pattern is the more prevalent pattern among our Jordanian population. Although positive CAD was more common in co-dominance patients, there was no significant correlation between coronary dominance patterns and positive CAD. There was no significant correlation found between the coronary dominance patterns and age or gender. The study found that patients with co-dominance had a significantly higher rate of severe narrowing (70% or more) in their arteries, along with more positive findings and blockages in the right coronary artery (RCA) compared to those with left-dominance or right-dominance. According to our results, assessing coronary dominance by coronary CTA may not improve risk stratification beyond determining the degree of stenosis in patients with normal coronary arteries or non-obstructive CAD referred for coronary CTA, but it may add prognostic information for certain subpopulations like those with RCA disease or obstructive CAD.

Ethical Approval

The ethical approval to perform this study was obtained from Institutional Review Board (IRB) approval at Jordan University of Science and Technology (No. 406-2023).

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Disclosure

The authors declare no conflicts of interest for this work.

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