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STUDY OF DOMINANCE, CALIBRE AND BRANCHING PATTERN OF THE CORONARY ARTERIES USING ANGIOGRAPHY: A PROSPECTIVE STUDY

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ABSTRACT
Background: Variations in coronary artery dominance, branching patterns, and arterial calibre have important anatomical and clinical implications, particularly in the interpretation of coronary angiography and planning of cardiovascular interventions.
Objective: To determine the prevalence of coronary dominance, measure the calibre of major coronary arteries, assess its relationship with body mass index (BMI), and describe coronary branching patterns using angiography.
Methods: This prospective, non-interventional, hospital-based study included 100 consecutive coronary angiograms performed over three months at S. Nijalingappa Medical College and Hospital, Bagalkote. Patients aged >20 years undergoing coronary angiography were included, while those aged <20 years and those with congenital cardiac anomalies were excluded. Coronary dominance, branching pattern, Proximal calibres of the right coronary artery (RCA), left main coronary artery (LCA), circumflex artery (LCX), and left anterior descending artery (LAD) were assessed using quantitative coronary analysis.
Results: Right coronary dominance was observed in 60% of cases, while left dominance and co-dominance were each present in 20%. Mean calibres of the RCA, LCA, LCX, and LAD were 2.99±0.65, 4.13±0.63, 3.01±0.61, and 3.07±0.49 mm, respectively. Correlations between BMI and arterial calibre were weak.
Conclusion: Right coronary dominance was the most frequent pattern. Considerable anatomical variability was observed in coronary calibre and branching patterns, emphasizing the importance of detailed anatomical assessment during coronary angiography.

KEYWORDS: Coronary arteries; Coronary angiography; Coronary dominance; Coronary artery calibre; Branching pattern; Quantitative coronary analysis

INTRODUCTION

The coronary arterial system demonstrates substantial interindividual variation in vessel calibre, dominance, course, and branching pattern. A detailed understanding of these variations is important for anatomists, cardiologists, radiologists, and cardiovascular surgeons because coronary dimensions and anatomical patterns influence the interpretation of diagnostic angiography and the planning of interventional and surgical procedures. Quantitative assessment of coronary artery dimensions has therefore been an important component of anatomical and clinical cardiovascular research.

Coronary artery calibre is influenced by several physiological and anatomical factors. Normal coronary artery dimensions are associated with factors such as myocardial mass and coronary dominance, indicating that coronary vessel size should be interpreted in relation to the underlying cardiac anatomy rather than as an isolated measurement.[1] Earlier cinearteriographic observations also established considerable variation in coronary artery size during life and provided an important basis for angiographic assessment of coronary dimensions.[2]

Population-related differences in coronary artery dimensions have received particular attention because relatively small coronary arteries may have clinical implications in the development and management of coronary artery disease. Angiographic studies comparing coronary artery size among Asian and Caucasian populations have investigated whether Asian individuals have smaller coronary arteries.[3] Similarly, evaluation of normal human coronary artery lumen diameter has demonstrated that coronary dimensions may vary according to sex, anatomical characteristics, and cardiac structural factors.[4] These observations emphasize the need for population-specific information regarding normal coronary artery dimensions.

Studies in Indian populations have provided further insight into coronary arterial dimensions and contributed reference data relevant to cardiovascular practice in the Indian population.[5] Subsequent assessment of coronary artery dimensions in normal Indian subjects has further highlighted the importance of defining population-specific coronary measurements.[6] Such data are particularly relevant because coronary vessel calibre may influence procedural decisions during percutaneous coronary intervention and coronary artery bypass surgery.

Ethnic differences in coronary anatomy have also been investigated, with studies examining whether Indo-Asians have smaller coronary arteries and highlighting the potential importance of ethnic variation in coronary

dimensions.[7] Vessel diameter has clinical relevance beyond anatomical description. Coronary artery diameter may influence outcomes in patients undergoing coronary artery bypass surgery, emphasizing the potential prognostic and surgical significance of vessel size.[8]
Sex-related variation represents another important determinant of coronary artery calibre. Volumetric analyses have reported gender-related differences in coronary artery dimensions.[9] Such observations indicate that interpretation of coronary calibre should take demographic and anatomical factors into consideration. Body habitus may also potentially influence coronary dimensions, although the extent of this relationship remains uncertain and warrants further investigation.
In addition to calibre, coronary dominance and branching patterns represent important components of coronary anatomy. Dominance is determined by the arterial supply to the posterior interventricular region and may be right dominant, left dominant, or co-dominant. Variations in the termination and branching of the right coronary artery, left main coronary artery, left anterior descending artery, and circumflex artery can influence angiographic interpretation and may have implications during coronary interventions.
The present prospective angiographic study was therefore undertaken to determine the prevalence of right, left, and co-dominant coronary circulation; measure the proximal calibre of the major coronary arteries using quantitative coronary analysis; assess the relationship between coronary artery calibre and BMI; and document the branching patterns of the coronary arteries in 100 consecutive angiograms.

Aims and objectives:
- To study the prevalence of right and left coronary artery dominance through angiograms.
- To measure the caliber of the proximal segment of the major coronary arteries using QCA (quantitative coronary analysis).
- To study the relation of the caliber of the coronary arteries with the body mass index (BMI).
- To study the branching pattern of the coronary arteries using angiography in 100 consecutive angiograms.

MATERIALS AND METHODS

Study Design and Setting
A non-interventional, prospective, hospital-based study was conducted in collaboration with the Interventional Cardiology and Catheterization Laboratory at S. Nijalingappa Medical College and Hospital, Bagalkote. The study included 100 consecutive coronary angiograms performed over a period of three months.

Study Population
Patients aged more than 20 years who underwent coronary angiography during the study period were included (n=100)

Inclusion Criteria
Patients aged >20 years undergoing coronary angiography during the study period were eligible for inclusion.

Exclusion Criteria
Patients were excluded if they:
1. Were younger than 20 years of age; or
2. Had congenital cardiac anomalies.

Data Collection
Data were collected personally by the investigator from patients' medical case records and recorded coronary angiograms available in the catheterization laboratory. A specially designed proforma was used for systematic documentation of relevant demographic, clinical, and angiographic information.
The recorded variables included age and sex as demographic characteristics. Clinical information included diabetes mellitus, hypertension, smoking, and dyslipidemia. Angiographic assessment included coronary dominance, proximal calibre of the major coronary arteries, and branching and termination patterns of the coronary arteries.

Assessment of Coronary Dominance
Coronary dominance was evaluated angiographically and categorized as:
- Right dominant
- Left dominant
- Co-dominant

Dominance patterns were evaluated separately in males and females and for the overall study population

Assessment of Coronary Artery Calibre
The calibre of the proximal segments of the major coronary arteries was assessed using quantitative coronary analysis (QCA). Measurements were obtained for the:

- Right coronary artery (RCA)
- Left main coronary artery (LCA)
- Circumflex artery (LCX)
- Left anterior descending artery (LAD)

The measurements were expressed in millimetres (mm). Mean and standard deviation were used to describe coronary artery calibre.

The relationship between BMI and the calibre of each major coronary artery was evaluated using correlation coefficients.

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Assessment of Coronary Branching and Termination Patterns

The branching and termination patterns of the major coronary arteries were evaluated from the recorded angiograms. The termination of the RCA was categorized according to its relationship with the inferior border and crux of the heart.

The left coronary artery trunk was evaluated for bifurcation, trifurcation, quadrifurcation, and pentafurcation. The LAD was assessed for its termination pattern and for whether the first septal or first diagonal artery arose first. The number of diagonal branches arising from the LAD was also recorded.

Similarly, the LCX was assessed for the number of marginal branches and its termination before, at, or beyond the crux.

RESULTS

A total of 100 consecutive coronary angiograms were evaluated. The analysis focused on coronary dominance, calibre of the major coronary arteries, relationship between coronary calibre and BMI, and branching and termination patterns of the coronary arterial system.

Coronary Dominance

Right coronary dominance was the most common pattern and was observed in **60%** of the overall study population. Left dominance and co-dominance were each observed in **20%**.

Among males, right dominance was present in 60%, left dominance in 25%, and co-dominance in 15%. Among females, right dominance was present in 56%, left dominance in 7%, and co-dominance in 37%.

Table 1. Distribution of coronary artery dominance according to sex

Dominance pattern	Male (%)	Female (%)	Overall (%)
Right dominant	60	56	60
Left dominant	25	7	20
Co-dominant	15	37	20

Right dominance therefore represented the predominant coronary circulation pattern in both sexes. The proportion of co-dominance was higher among females, whereas left dominance was more frequent among males.

Calibre of Major Coronary Arteries

The left main coronary artery had the largest mean calibre, measuring 4.13 ± 0.63 mm overall. The corresponding mean calibres of the RCA, LCX, and LAD were 2.99 ± 0.65 mm, 3.01 ± 0.61 mm, and 3.07 ± 0.49 mm, respectively.

The mean calibre was numerically greater among males than females for the RCA, LCA, and LCX. The LAD showed only a small difference between males and females.

Table 2. Calibre of major coronary arteries according to sex and coronary dominance

Artery	Male (mm), Mean ± SD	Female (mm), Mean ± SD	Overall (mm), Mean ± SD	Right dominant (mm), Mean ± SD	Left dominant (mm), Mean ± SD
RCA	3.02 ± 0.65	2.80 ± 0.66	2.99 ± 0.65	2.99 ± 0.64	2.98 ± 0.65
LCA	4.24 ± 0.64	4.00 ± 0.63	4.13 ± 0.63	4.12 ± 0.63	4.12 ± 0.63
LCX	3.11 ± 0.62	2.89 ± 0.61	3.01 ± 0.61	2.99 ± 0.61	3.04 ± 0.61
LAD	3.09 ± 0.50	3.05 ± 0.50	3.07 ± 0.49	3.07 ± 0.50	3.09 ± 0.49

Differences according to dominance were small. The RCA measured 2.99 ± 0.64 mm in right-dominant hearts and 2.98 ± 0.65 mm in left-dominant hearts. LCA calibre was identical at 4.12 ± 0.63 mm in both groups. LCX and LAD calibres were marginally greater in left-dominant hearts.

Relationship Between BMI and Coronary Artery Calibre

Weak positive correlations were observed between BMI and the calibre of all four major coronary arteries. The correlation coefficient was highest for the LAD (r = 0.10), followed by the RCA (r = 0.08), LCA (r = 0.07), and LCX (r = 0.04).

Table 3. Correlation between BMI and calibre of the major coronary arteries

Coronary artery	Correlation coefficient ®
RCA	0.08
LCA	0.07
LCX	0.04
LAD	0.10

These findings indicate only a weak positive relationship between BMI and coronary artery calibre in the study population.

Branching and Termination Patterns of the RCA and Left Coronary Artery

The RCA terminated **at or beyond the crux in 60%** of cases. In 20%, it terminated at or before the inferior border, while in another 20%, termination occurred between the inferior border and the crux.

Considerable variation was also observed in the branching pattern of the left coronary artery trunk. Bifurcation was the predominant pattern and was reported in **63%**, followed by trifurcation in **30%**, quadrifurcation in **4%**, and pentafurcation in **1%**. The LCA was reported as absent in two cases.

Table 4. Branching and termination patterns of the RCA and left coronary artery trunk

Artery/feature	Pattern	Frequency (%)
RCA termination	At or before inferior border	20
	Between inferior border and crux	20
	At or beyond crux	60
LCA trunk branching	Bifurcation	63
	Trifurcation	30
	Quadrifurcation	4
	Pentafurcation	1
	LCA absent	2

Thus, termination of the RCA at or beyond the crux and bifurcation of the left coronary artery trunk were the predominant anatomical patterns.

LAD and LCX Branching Patterns

Type C was the most frequent LAD termination pattern, accounting for **81%** of cases, followed by Type B in 17% and Type A in 2%.

The first diagonal artery arose before the first septal artery in **75%** of cases, while the first septal artery arose first in 14%. In the remaining 11%, the angiographic appearance was equivocal and it was difficult to determine which branch arose first.

Three diagonal branches were the most frequent LAD branching pattern, occurring in **48%** of cases. Four diagonal branches were observed in 21%, five in 20%, and two in 11%. No case demonstrated zero or one diagonal branch.

For the LCX, two marginal arteries were most frequent (40%), followed by one marginal artery (38%), three marginal arteries (18%), and four marginal arteries (4%). The LCX terminated before the crux in 60%, at the crux in 20%, and beyond the crux in 20%.

Table 5. Branching and termination characteristics of the LAD and LCX

Artery/characteristic	Pattern	Frequency (%)
LAD termination	Type A	2
	Type B	17
	Type C	81
First LAD branch	First septal	14
	First diagonal	75
	Equivocal	11
Number of LAD diagonal branches	2	11
	3	48
	4	21
	5	20
Number of LCX marginal branches	1	38
	2	40
	3	18
	4	4
LCX termination	Before crux	60
	At crux	20

	Beyond crux	20

Overall, the angiographic findings demonstrated substantial variability in the branching and termination patterns of the coronary arteries. Right coronary dominance was the predominant circulation pattern, while the LCA was the largest of the measured major coronary arteries. The observed correlations between BMI and coronary calibre were weak.

DISCUSSION

The present prospective angiographic study evaluated coronary artery dominance, proximal calibre, its relationship with BMI, and branching and termination patterns in 100 consecutive coronary angiograms. The principal findings were a predominance of right coronary circulation, relatively larger calibre of the left main coronary artery, weak correlations between BMI and coronary artery calibre, and considerable variability in the branching and termination patterns of the coronary arteries.

Right coronary dominance was the most frequent pattern, occurring in 60% of the study population, while left dominance and co-dominance were each observed in 20%. Sex-related variation was also noted: right dominance remained the most common pattern in both sexes, whereas co-dominance was proportionally more frequent among females and left dominance among males. Variations in coronary dominance are clinically relevant because the dominant artery supplies an important proportion of the inferior and posterior myocardium and may influence the consequences of coronary occlusion as well as planning of revascularization procedures. Altin et al., in a coronary angiographic study of coronary anatomy and anatomical variations, similarly demonstrated considerable variability in coronary arterial anatomy and dominance patterns.[10]

The mean calibres of the RCA, LCA, LCX, and LAD in the present study were 2.99 ± 0.65, 4.13 ± 0.63, 3.01 ± 0.61, and 3.07 ± 0.49 mm, respectively. The LCA therefore had the largest mean proximal calibre. Male participants had numerically larger mean calibres of the RCA, LCA, and LCX compared with females, whereas the difference in LAD calibre was small. Sex-related differences in coronary dimensions have previously been investigated, although body size alone may not fully account for these variations. Hiteshi et al. reported that gender differences in coronary artery diameter were not explained by body habitus or left ventricular mass.[11]

In the present study, the calibre of the major coronary arteries showed only weak positive correlations with BMI, with correlation coefficients ranging from 0.04 for the LCX to 0.10 for the LAD. These observations suggest that BMI alone may have limited association with proximal coronary artery calibre in this study population. More recent data from a South Indian population have also examined the influence of sex, age, and coronary dominance on normal coronary artery calibre, supporting the importance of considering multiple demographic and anatomical determinants when interpreting coronary dimensions.[12]

The clinical importance of coronary artery size has also been examined in Asian-Indian populations. Makaryus et al. investigated coronary artery diameter as a potential risk factor for acute coronary syndromes among Asian-Indians, emphasizing the possible clinical implications of coronary vessel dimensions.[13] Intravascular ultrasound-based evaluation in a North Indian population by Reddy et al. further provided detailed information regarding coronary artery size in Indians.[14] Together with the present angiographic observations, these findings reinforce the importance of population-specific anatomical information when interpreting coronary artery dimensions.

Marked variability was observed in the branching and termination patterns of the coronary arteries. The RCA terminated at or beyond the crux in 60% of cases. The left coronary artery trunk most commonly bifurcated (63%), followed by trifurcation (30%), while quadrifurcation and pentafurcation were uncommon. Anatomical assessment using multidetector computed tomography by Christensen et al. has also demonstrated variability in the bifurcation and branching configuration of the left main coronary artery.[15] Recognition of these variations is particularly important during angiographic interpretation and coronary interventions.

The LAD predominantly demonstrated a Type C termination pattern (81%). Three diagonal branches represented the most frequent branching pattern, occurring in 48% of angiograms. The first diagonal artery arose before the first septal artery in 75% of cases. Variation was also observed in the LCX: two marginal branches were most frequent (40%), and the artery terminated before the crux in 60% of cases. These observations demonstrate the wide range of normal coronary branching configurations encountered angiographically.

CONCLUSION

Right coronary dominance was the predominant pattern, occurring in 60% of the studied angiograms, while left dominance and co-dominance were each observed in 20%. The left main coronary artery demonstrated the largest mean proximal calibre. Only weak positive correlations were observed between BMI and the calibre of the major coronary arteries.

Considerable variation was identified in coronary branching and termination patterns, particularly involving the left coronary artery trunk, LAD, and LCX. Knowledge of these anatomical variations and coronary dimensions is important for accurate interpretation of coronary angiograms and may assist cardiologists and cardiovascular surgeons during diagnostic, interventional, and surgical procedures. Larger studies with more detailed statistical analysis may further clarify the demographic and clinical determinants of coronary artery morphology.

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