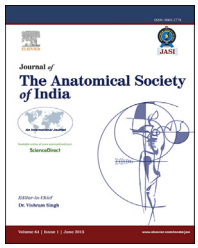
Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jasi



Original Article

Coronary artery dimensions in the Nepalese population

Arun Dhakal [a,*], *Ratindra Nath Shrestha* [b], *Arun Maskey* [c], *Sushma Pandey* [d]

[a] *Assistant Professor, Department of Anatomy, Chitwan Medical College, Bharatpur, Chitwan, Nepal*
[b] *Professor (Anatomy), Tribuvan University Teaching Hospital, Institute of Medicine, Maharajgunj, Kathmandu, Nepal*
[c] *Consultant Cardiologist, Sahid Gangalal National Heart Center, Bansbari, Kathmandu, Nepal*
[d] *Assistant Professor, Oral Medicine and Radiology, Chitwan Medical College, Bharatpur, Chitwan, Nepal*

ARTICLE INFO

Article history:
Received 25 December 2014
Accepted 31 March 2015
Available online 5 May 2015

Keywords:
Coronary anatomy
Coronary arteries
Coronary angiography
Dominant pattern
Diameter

ABSTRACT

Introduction: This study is an attempt to document normal dimensions of the coronary artery branches during life by using quantitative coronary angiography and compare them with international studies.
Method: Quantitative coronary angiography (QCA) of 100 patients undergoing evaluation of ischemic heart disease but found to be free of coronary artery disease. Measurement was done using catheter tip as a calibrating object.
Results: Out of 57% right dominant circulation 56.1% were of males and 44% of females. Left coronary dominance was seen in 17% of which 52.9% were male and 47% female, by contrast 26% subjects had co-dominant hearts with 61.5% male and 38.4% female. The mean diameter of the right coronary artery was significantly smaller ($p < 0.05$) in left dominant hearts as compared to that of dominant right. In contrast the mean diameter of the circumflex artery was significantly smaller ($p < 0.05$) in right dominant pattern as compared to that of patients with dominant left. Similarly the diameter of circumflex artery was significantly smaller in case of co-dominant type of circulation when compared to that of left coronary pattern of dominancy.
Discussion: The distribution pattern of coronary artery in the Nepalese population is distinct from that specified in the literature and the diameters of right coronary artery and circumflex artery are significantly influenced by the nature of dominance.

1. Introduction

At present there is no accessible document on normal coronary artery size in the Nepalese population. This population represents approximately 2% of the South-Asian population.[1] In this study the dimensions of the coronary artery branches during life was evaluated by using quantitative coronary angiography.

* *Corresponding author*. Chitwan Medical College, Bharatpur 10, Nepal. Tel.: +977 9803168089 (mobile).
E-mail address: arund@mail.ru (A. Dhakal).
http://dx.doi.org/10.1016/j.jasi.2015.03.001

In the 1960s, Sones and Shirey and subsequently Judkins, as cited in coronary artery surgery study (CASS)[2] reported effective means of radiographically visualizing the coronary circulation in subjects with coronary artery disease. CASS[2] classified the nomenclature of coronary anatomy and defined the criteria of dominance of coronary circulation. The criteria established by CASS[2] for dominance of vessels were used in this study. According to this, in right dominance the PD (posterior descending artery) takes origin from the RCA (right coronary artery) and no less than one branch extends beyond the PD in the atrioventricular groove, supplying posterolateral (PLV) branch to the inferior surface of the left ventricle. Distal circumflex artery in this scenario tends to be small or absent. In the case of left dominance the PD and PLV arteries arise from the CX (circumflex artery); the RCA in this situation is small whereas in co-dominant pattern of circulation the right coronary artery gives the posterior descending artery only (Figs. 1–3).

Many studies have been done in the past to determine the dimensions of coronary vessels and have been published in literatures with varying results.[3,4] Coronary artery is the major artery which supplies the heart muscles. The right coronary artery and the left main coronary artery derive their origin from the ascending aorta in its anterior and left posterior sinuses respectively. Some studies show variations in the number of openings in the aortic sinuses,[5] together with multiple ostia mostly seen in the anterior sinus.[6]

Comparison of diameters of vessels in relation to their dominance were studied in number of cases.[7] Ilia et al[8] compared the length of the left anterior descending artery with coronary dominance and found that in left dominance it frequently extended and wrapped around the apex. In addition, study showed a relationship of coronary dominance pattern and valvular heart disease.[9] It has been documented in angiographic studies that dominant left coronary arterial system is at greater risk during valvular replacement surgery.[10] These findings show the clinical implication and importance of the knowledge of dominance pattern of heart.

There is a broad divergence in the epidemiological records on the incidence and prevalence of cardiovascular disease in different countries. In the black population of the West Indies and Africa coronary heart disease is rare, but is comparatively frequent in the Indo-Asian population from the Indian subcontinent. Dhawan and Bray[11] in their study found that Caucasians had significantly larger total vessel diameter relative to the Asians. This observation has vital therapeutic implication concerning coronary intervention like coronary angioplasty (PTCA) and coronary artery by-pass grafting (CABG) in this ethnic group. For this reason an extensive study on the anatomic variations of coronary artery in the populations of the region is the necessity.

2. Materials and method

This study was conducted in Shahid Gangalal National Heart Centre, Bansbari, Kathmandu, Nepal in the month of May and June of 2012. In this study 100 digital coronary angiograms were included of the patients who were 18 years and above undergoing coronary angiography for diagnostic purposes. There were 57 males and 43 females with mean age of 56.0 ± 10.8 year. In the study, normal appearing coronary angiograms with the catheter tip and artery in the center of the frame (minimizes Pincushion defect) and arteries apart from severe degree of tortuosity as classified in the work of Dodge et al[7] and without overlap were included. Patient's angiograms showing entire proximal occlusions or anomalous arteries and patients below 18 years of age were excluded.

Cannulation of the arteries was carried out by the Judkins technique with known dimensions (5F/6F) of catheters of Cordis-Corp Johnson & Johnson's. The contrast agent Optiray (350 ng I/ml) was used with 1 ml/kg body weight dosage. The digital arteriograms were obtained in the Philips Digital Cardio

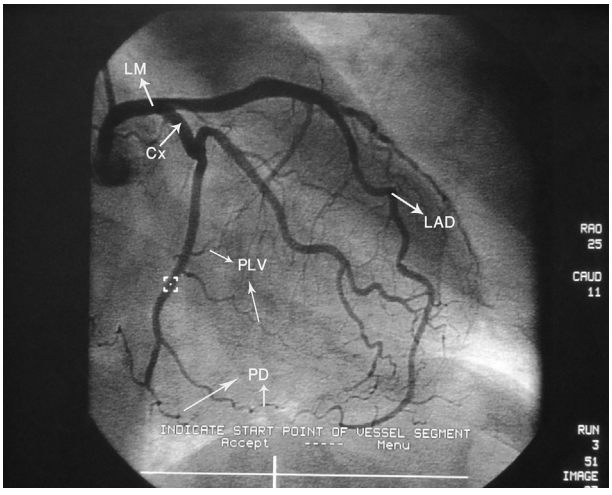


Fig. 1 – Displaying LCA in a left dominant pattern of coronary circulation. LM – Left main coronary artery, Cx – Circumflex artery, LAD – Left anterior descending artery, PLV – Posterolateral ventricular branch, PD – Posterior descending artery.

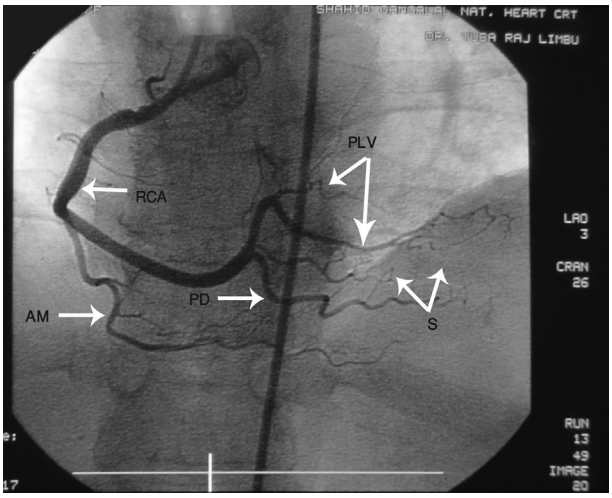


Fig. 2 – Displaying RCA in a right dominant pattern of coronary circulation. RCA – Right coronary artery, AM – Acute marginal artey, PD – Posterior descending artery, PLV – Posterolateral ventricular branch, S – Septal arteries.

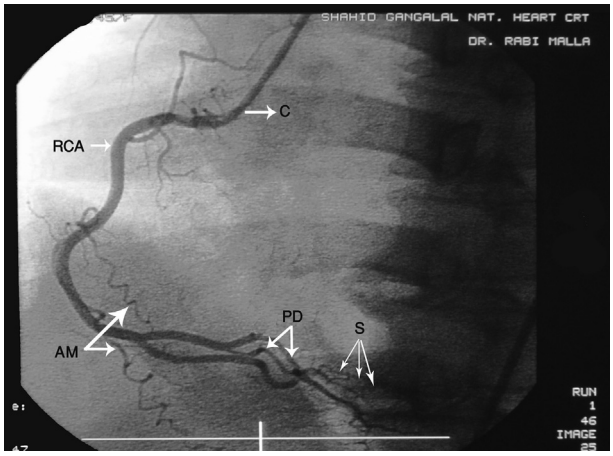


Fig. 3 – Displaying RCA in a co-dominant pattern of coronary circulation. RCA – Right coronary artery, C – Catheter, AM – Acute marginal artery, PD – Posterior descending artery, S – Septal arteries.

Imaging (DCI) system[3,7,12] utilizing 512 × 512 pixels density resolution and Quantitative coronary analysis (QCA) was performed with an inbuilt digital image analysis system Philips, Integris-3000 (Philips Medical system, Nederland).

Calibration of the QCA system was performed by a technique where the catheter used for angiography itself was employed as the object of calibration by automated edge detection system.[13–16] For the vessel size measurement the known diameter of catheter tip was used as a reference.

Standard angiographic views[11,15] were obtained for all the patients' i.e, around 30° RAO (Right anterior oblique) projections chosen to evaluate the left coronary artery (Fig. 1) whereas approximately 60° LAO (Left anterior oblique) projection preferred to evaluate the right coronary artery (Fig. 2). Also images with some deviation in projection angle from the above mentioned figures were included in cases where the desired sections of the artery were precise for measurement.

In each of the coronary arteriogram the anatomic segments were located. Although the anatomy of coronary artery is likely to be a bit more variable than that given in the literature, it was possible in every case to specify segments that corresponded approximately to those as specified in the CASS[2] study. To determine the coronary artery dominance, criterion employed in coronary artery surgery study (CASS)[2] was used.

Diameters of the largest dimension in each segment were taken. Measurements were recorded of the left coronary artery which is left main coronary artery (LM), the left anterior descending artery (L) prior to the beginning of the first septal branch (S) and the proximal circumflex (Cx) before origin of the first obtuse marginal. The right coronary artery included proximal right coronary artery before the beginning of acute marginal artery (AM).

Statistical analysis was carried out with the SPSS software package for Windows version 16 .0. Diameters of the vessels were recorded and their mean values compared with each other to examine their variation in sizes in relation to the pattern of arterial dominance. This was achieved using the ANOVA test. Also the dimensions of coronary arteries in the male and female was determined and their comparison made using the student 't' test. A p-value of less than 0.05 was considered statistically significant.

3. Results

In this study 100 arteriograms were evaluated. Of the 100 patients 57 (57%) had right dominant circulation with 56.1% males and 44% females. Left coronary dominance was seen in 17 (17%) of which 52.9% were male and 47% female, by contrast 26 (26%) subjects had co-dominant hearts with 61.5% male and 38.4% female (Table 1).

A contrast on coronary arterial supply found by different investigators with present study is shown in Table 2.

In comparison to females, males had larger coronary artery size (Table 3). They had a statistically significant larger coronary artery diameter in the left anterior descending artery ($p < 0.05$). The difference however was not significant in the left main coronary artery, the left circumflex and the right coronary artery. The relationship between coronary artery distribution pattern and their diameters is shown in Table 4. The mean diameter of the right coronary artery was significantly smaller ($p < 0.05$) in left dominant hearts (2.9 ± 0.5) as compared to that of right dominant (3.25 ± 0.55) or co-dominant (3.10 ± 0.37) hearts. In contrast the mean diameter of the circumflex artery was significantly smaller ($p < 0.05$) in right dominant pattern (2.98 ± 0.46) as compared to that of the patients with dominant left (3.38 ± 0.55). Similarly the diameter of circumflex artery was significantly smaller in case of co-dominant (3.01 ± 0.42) type of circulation when compared to that of left coronary pattern (3.38 ± 0.55) of dominancy.

In other coronary arteries the variation in diameter was statistically insignificant.

4. Discussion

In a range of studies the criteria pioneered by the work of Schlesinger et al[17] has been employed for determining coronary arterial dominance. As per the classification of Schlesinger, the foundation for the differentiation of right, left and co-dominant hearts is the artery that supplies the crux of the heart. CASS[2] study recommends similar criterion for defining coronary dominance.

There are a very few normal (undiseased) coronary artery size estimation studies conducted during life. This is the first study on the dimensions of coronary arteries conducted in the

Table 1 – Variation in distribution of coronary artery.

Artery	Dominant pattern n = 100	Male n = 57	Female n = 43
	No (%)	No (%)	No (%)
RD	57 (57)	32 (56.1)	25 (44)
LD	17 (17)	9 (52.9)	8 (47.0)
CO	26 (26)	16 (61.53)	10 (38.46)

RD: Right dominant, LD: Left dominant, CO: Co-dominant.

Table 2 – Coronary arterial distribution reported by different investigators.

Different studies	Right dominant	Left dominant	Co-dominant
Current study	57%	17%	26%
Murphy et al[9]	79%	9%	12%
Hutchins et al[10]	70%	10%	20%
Vasko[19]	48%	16%	36%
Mac Alpin[4]	55%	9%	35%
Kaimkhani et al[20]	60.45%	15%	24.5%

Table 3 – Relationship of coronary vessel sizes among males and females.

Vessels	Mean diameter ± SD		p-Value
	Male (n = 57)	Female (n = 43)	
LCA	4.42 ± 0.457	4.34 ± 0.545	0.42
CX	3.10 ± 0.5	3 ± 0.47	0.89
LAD	3.30 ± 0.37	3.21 ± 0.317	0.031*
RCA	3.23 ± 0.5	3.03 ± 0.57	0.161
TCA	9.65 ± 0.67	9.25 ± 1.03	0.235

*p-value is <0.05, SD: Standard deviation, RCA: Right coronary artery, LCA: Left coronary artery, LAD: Left anterior descending artery, CX: Circumflex artery.

Nepalese population. The study was carried out on normal appearing coronary angiograms of patients undergoing investigation for diagnostic purposes (unstable angina, hypercholesterolemia, obesity, chest pain etc.) and such patients may not describe a 'normal' population. However, taking angiography on healthy asymptomatic controls would be impractical and unethical. This aspect of our study conveys the limitations of this work.

In the normal population the size of the coronary vessels are very irregular. Genetic factors, age, sex, body weight, body surface area, weight of the heart[8] and ethnic/racial factors[11,15] have all been associated with variations in the anatomy of coronary vessels in different studies. Most of these were dissection or injection studies in post mortem specimens.[18] From these studies various associations between lumen size of the coronary vessel and weight of the heart has been made.[7,10] Different issues concerning the preservation, fixation, procurement and the study of epicardial vessels has been the basic limitation of these studies. Though determining dominance by these studies is indisputable the validity of these studies in estimating the accurate caliber of coronary vessels is debatable. Hence QCA of coronary arteriograms was used in this study which attempts a precise geometric and functional measurement of coronary vessels. By employing the operator-independent edge detection technique, geometric measurements permits the evaluation of coronary sizes in two dimensions, Mac Alpin.[4]

This study shows a pattern of arterial supply which is comparable to the work of Vasko[19] and Kaimkhani et al[20] but showed wide variations from other authors as shown in Table 2.

According to Last anatomy[21] and Clinical anatomy by region,[22] 90% coronary vessels are right dominant and the remaining10% is left dominant. Nonetheless Gray's Anatomy,[23] notes that 60% of coronary vessels are right dominant, 10% left dominant and the remaining 30% are co-dominant. These results reflect the variations which are far more common than being documented. In our study the difference in the pattern of dominance of coronary vessels in relation to gender was not observed.

The principle of functional dominance in comparison to anatomical dominance is founded on perfusion studies which regard the left coronary artery as the dominant vessel since it is the main origin of blood supply to the left ventricle, even in those with anatomical right dominance. This is in agreement with the postmortem coronary vessel perfusion rate studies performed in humans.[19] It is because of this that the left coronary artery is usually regarded as the more important vessel than the dominant right coronary artery.

There are chief therapeutic and diagnostic considerations for smaller sized coronary vessel segments as the overall diameter of the artery does influence the method of intervention on that artery.[3] The vessel diameter size of less than 2.5 mm has been accounted for the tendency of the vessel to suffer thrombosis or occlusion.[15] Dodge et al[7] made it clear that the diameter of right coronary artery and circumflex artery are influenced by anatomic differences. They reported that the average size of the right coronary artery was significantly smaller in left dominant hearts as compared to that of dominant right whereas in contrast the mean diameter of the circumflex artery was significantly smaller in right dominant pattern as compared to that of patients with dominant left. Their study also shows a significant association between the diameters of the right coronary artery, circumflex artery and the type of coronary

Table 4 – Relationship of size of coronary vessel (mm) with coronary dominance.

Vessels	Dominant pattern			p-Value		
	RT (n = 57)	LT (n = 17)	CO (n = 26)	p-Value1	p-Value2	P-Value3
LCA	4.39 ± 0.48	4.5 ± 0.74	4.29 ± 0.27	0.369	0.159	0.417
CX	2.98 ± 0.46	3.38 ± 0.55	3.01 ± 0.42	0.003*	0.014*	0.829
LAD	3.28 ± 0.33	3.28 ± 0.42	3.22 ± 0.35	0.894	0.585	0.382
RCA	3.25 ± 0.55	2.9 ± 0.5	3.10 ± 0.37	0.017*	0.225	0.222
TCA	9.5 ± 0.8	9.55 ± 1.07	9.32 ± 0.88	0.912	0.402	0.330

LCA: Left coronary artery, LAD: Left anterior descending artery, CX: Circumflex artery, RCA: Right coronary artery, TCA: Total coronary area (RCA + LAD + CX), RT: Right dominant, LT: Left dominant, CO: Co-dominant, p-Value1 (comparison between RT & LT), p-Value2 (comparison between LT & CO), p-Value3 (comparison between RT & CO), *p-Value is <0.05.

vascular distribution. Our results are comparable to that established by their study (Table 4).

In concern with the caliber of coronary arteries between males and females our study found that females typically had a smaller coronary vessel size in contrast to that of the males (Table 3). They had a significantly smaller coronary vessel size in the left anterior descending artery (LDA) similar to that found by Saikrishna et al.[3] The variation however was not significant in the left coronary, the circumflex and the right coronary artery.

5. Conclusion

This study is an attempt to document normal dimensions of coronary artery branches of the Nepalese population during life by using quantitative coronary angiography on coronary angiograms performed for diagnostic purposes (unstable angina, hypercholesterolemia, obesity, chest pain etc.) and found to be normal and disease free. Our study demonstrates that the pattern of coronary vessel distribution is distinct from that specified in the literature. This study also shows the relation of right coronary artery and the circumflex artery with the coronary pattern of dominance. Nevertheless, it is not clear what forms the basis of this relation.

Conflicts of interest

All authors have none to declare.

REFERENCES

1. Ministry of Health and Population (MOHP), New ERA, and ICF International Inc. *Nepal Demographic and Health Survey. Kathmandu, Nepal*. Calverton, Maryland: Ministry of Health and Population, New ERA, and ICF International; 2011, 396 p.
2. The National Heart, Lung, and Blood Institute. Coronary artery surgery study (CASS). *Circulation*. 1981;(63 suppl 1):15–16.
3. Saikrishna Cheemalapati, Talwar Sachin, Gulati Gurpreet, et al. Normal coronary artery dimensions in Indians. *Indian J Thorac Cardiovasc Surg*. 2006;22:159–164.
4. Mac Alpin RN, Abbasi AS, Grollman JH, et al. Human coronary artery size during life. *Diagn Radiol*. 1972;108:567–576.
5. Lewis CM, Dagenais GR, Friesinger GC, et al. Coronary arteriographic appearences in patients with left bundle branch block. *Circulation*. 1970;41:299–307.
6. Joshi Subhash D, Joshi Sharda S, Athavale Sunita Arvind. Origins of the coronary arteries and their significance. *Clinics*. 2010;65:79–84.
7. Dodge Jr JT, Brown BG, Bolson EL, et al. Lumen diameter of normal human coronary arteries. Influence of age, sex, anatomic variation, and left ventricular hypertrophy or dilation. *Circulation*. 1992;86:232–246.
8. Ilia Reuben, Rosenshtein Gabriel, Marc Weinstein Jean, et al. Left anterior descending artery length in left and right coronary artery dominance. *Coron Artery Dis*. 2001;12:77–78.
9. Murphy ES, Rosch J, Rahimtoola SH. Frequency and significance of coronary arterial dominance in isolated aortic stenosis. *Am J Cardiol*. 1977;39:505–509.
10. Hutchins GM, Nazarian IH, Bulkley BH. Association of left dominant coronary arterial system with congenital bicuspid aortic valve. *Am J Cardiol*. 1978;42:57–59.
11. Dhawan J, Bray CL. Are Asian coronary arteries smaller than Caucasian? A study on angiographic coronary artery size estimation during life. *Int J Cardiol*. 1995;49:267–269.
12. Ratib OM, Mankovich NJ. Quantitative coronary arteriography: design and validation. *Radiology*. 1988;167:743–747.
13. Hermiller JB, Cusma JT, Spero LA, et al. Quantitative and qualitative coronary angiographic analysis: review of methods, utility, and limitations. *Cathet Cardiovasc Diagn*. 1992;25:110–131.
14. Funabashi Nobusada, Kobayashi Yoshiki, Perlroth Mark, et al. Coronary artery: quantitative evaluation of normal diameter determined with electron-beam CT compared with cine coronary angiography—Initial experience. *Radiology*. 2003;226:263–271.
15. Lip GYH, Rathore VS, Katira R, et al. Do Indo-Asians have smaller coronary arteries? *Postgrad Med J*. 1999;75:463–466.
16. Brown BG, Bolson E, Frimer M, et al. Quantitative coronary arteriography: estimation of dimensions, hemodynamic resistance, and atheroma mass of coronary artery lesions using the arteriogram and digital computation. *Circulation*. 1977;55:329–337.
17. Schlesinger MI. Relation of anatomic pattern to pathologic condition of the coronary arteries. *Arch Pathol*. 1940;30:403–415.
18. Wilsens SL, Plair CM, Henderson D. Size of the major epicardial coronary arteries at necropsy: relation to age, weight and myocardial infarction. *JAMA*. 1966;198:1325–1329.
19. Vasko JS, Gutelius J, Sabiton DC. A study of predominance of human coronary arteries determined by arteriographic and perfusion techniques. *Am J Cardiol*. 1961;8:374–384.
20. Kaimkhani ZA, Ali MM, Faruqi AM. Pattern of coronary arterial distribution and its relation to coronary artery diameter. *J Ayub Med Coll Abbottabad*. 2005 Jan–Mar;17(1):40–43.
21. Sinnatamby CS. *Last's Anatomy Regional and Applied. Middle Mediastinum and Heart*. 10thed. New York: Churchill Livingstone; 1999:197–198.
22. Snell Richard S. *Clinical Anatomy by Regions. The Thoracic Cavity – Heart: Arterial Supply of the Heart*. 8th ed. Lippincott Williams & Wilkins; 2008:113–115.
23. Standring Susan. *GRAY'S Anatomy (The Anatomical Basis of Clinical Practice). Heart and Great Vessels*. 40th ed. Churchill Livingstone; 2008:978–980.