



Some Anatomical Variations of the Coronary Circulation among Sri Lankan Adults

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

The coronary circulation has been the centre of focus of many anatomists, pathologists, cardiologists, cardiothoracic surgeons, physiologists and even the general public especially since the introduction of coronary angiography during the 1960's. Though a large number of data regarding the coronary circulation of the Western populations are available, research about coronary circulation of the Sri Lankan population is comparatively rare. This study comprises of data from 150 autopsy specimens of adult Sri Lankans died due to non-cardiac causes. 99.3% had a tricuspid aortic valve while only in 0.7% the aortic valve was bi-cuspid. The incidence of the ectopic origin of the left and the right coronary artery was equal (1.3%), and the posterior sinus was devoid of coronary ostia. A 55.3% of the study population had a single coronary artery ostium for each main coronary artery. The corresponding figure for the left coronary artery was 91.3%. Six percent (06%) of the right coronary ostia were positioned significantly above the sinus while the corresponding figure for the left coronary ostia was higher (17.5%). The average left ventricular wall thickness for males and females were 13mm and 12mm respectively. Significant muscular bridging (in relation to at-least one coronary artery) was found in 19.3% of the study population. The study concludes that variations in the cardiac anatomy are commoner than expected. As per Kitzman chart, cardiac dimensions of the Sri Lankans are somewhat smaller compared to the dimensions of the Western populations.

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1. INTRODUCTION

The coronary circulation has been a topic of interest that captured the attention of many clinicians, anatomists, pathologists, physiologists and even the general public largely owing to the increase of the incidence of coronary disease contributing as a significant cause for mortality and morbidity, especially among adult and elderly populations worldwide. Improvement of coronary imaging techniques as well as the medical and surgical techniques of the modern era have certainly increased the quality and the quantity of data as well as the interest of the subject. Yet, the amount of details available regarding the coronary circulation of the Sri Lankan population is much limited. This study was conducted using 150 adult autopsy specimens of hearts of those who died due to non-cardiac-related causes at Colombo South Teaching Hospital, Sri Lanka during a period of 10 months. The objectives of the study were to study the anatomical variation of the coronary circulation and certain selected variables of the myocardium and the valves of the heart. The number of aortic sinuses, the number of coronary ostia and their positions, the number of main coronary arteries, the number of divisions in the left coronary artery, variations of the course of the left anterior descending artery, cardiac dominance and the cardiac dimensions were the main areas of concern in this study.

2. METHODOLOGY

Ethical clearance had been obtained from the ethics review committee of the Faculty of Medical Sciences, University of Sri Jayawardenepure, though the information obtained for the research were within the limits of a routine medico-legal autopsy and the individual identity was not traceable. The written informed consent of the senior next of kin of the deceased was obtained though it was not in fact required as the dissections were within the purview of a standard medico-legal autopsy. Both male and female dead bodies above the age of eighteen years, where there was no convincing past medical history of ischaemic heart disease, valvular heart disease, cardiomyopathy, hypertension or any form of cardiac intervention (angioplasty or coronary artery by-pass grafting) and where the cause of death (at the end of the autopsy) had been confirmed as non-cardiac in origin were

selected for the study. The heart was taken out with the origins of the great vessels during the routine autopsy, examined macroscopically and then, the coronary vasculature was carefully dissected by making approximately 2-3 mm slices along and across the coronary vessels. All dissections and recording of variables were done by the same researcher using the same instruments in order to minimize the operator bias. All measurements were taken at the time of the dissection of the fresh body. The weights were measured to the nearest gram using a Salter scale and the thickness of the cardiac walls was measured using a standard caliper, using the average of three readings to the nearest millimeter. A standard diagram of coronary vasculature and a spread sheet were used for each case to manually (and case by case) record the findings. The findings were analyzed manually.

3. RESULTS

The study sample consisted of 105 (70%) males and 45 (30%) females. The average weight of the heart for males was 260g while the average heart weight for females being 225g. The heart weight for males ranged between 160g-365g. while it was 130g-340g for the females. The average thickness of the left ventricle of the male heart was 13mm and for the female heart, it was measured to be 12mm. The average circumference of the tricuspid valve of the male heart was 120mm and the average circumference of the tricuspid valve of the female heart was 110mm. The pulmonary valve measured 73mm in average for male hearts and it was 67mm in average for the female heart. The average circumference of the Mitral and Aortic valves of males measured 100mm and 65mm respectively whilst the corresponding values for the females were 91mm and 58mm respectively.

Out of the 150 specimens dissected, 144 (96%) of the coronary circulations comprised of two main coronary arteries (as the right and the left main coronary artery) while 2 (1.3%) had only a single coronary artery arising from the aorta and another 4 (2.7%) of the specimens had three coronary arteries arising from the aorta. In this 3rd group, instead of a left main trunk, the circumflex and the anterior descending branch were arising separately from the left sinus of Valsalva (Table. 1).

Table 1. Variations in the number of main coronary arteries

Number of main coronary arteries	Percentage
1	1.3%
2	96%
3	2.7%

The probability of ectopic origin (from the root of the aorta well above the sinuses) of the left and right coronary arteries was found to be 1.3% for each, accounting to a total of 2.6%.

The number of right coronary sinus ostia varied in the range of 0-4. Majority (55.3%) had a single ostium in the right coronary sinus. Thirty percent (30%) had two ostia, 12% had three, 1.3% had four and a further 1.3% had none situated in the right coronary sinus (Table 2). Out of a total of 235 right coronary ostia discovered during dissection of the 150 specimens, 94% were within the sinus where as a further 6% was situated significantly above the sinus (Table 3).

Table 2. Variations in the number of ostia in the right coronary sinus

Number of ostia in the right coronary sinus	Percentage
0	1.3%
1	55.3%
2	30%
3	12%
4	1.3%

Table 3. Variations in the position of the right coronary ostia in relation to the sinus

Position of the right coronary ostia	Percentage
Within the sinus	94%
Significantly above the sinus	6%

The number of left coronary ostia was found to vary in the range of 0-3. Majority (91.3%) of the specimens revealed to have a single ostium where as a 6.7% had two, 0.7% had 3 and a further 1.3% had no coronary ostia situated in the left coronary sinus (Table 4). A total of 160 ostia were discovered on the left and 17.5% of those were situated significantly above the left coronary sinus, while the rest of the 82.5% were within the sinus (Table 5).

Table 4. Variations in the number of ostia in the left coronary sinus

Number of ostia in the left coronary sinus	Percentage
0	1.3%
1	91.3%
2	6.7%
3	0.7%

Table 5. Variations in the position of the left coronary ostia

Position of the left coronary sinus	Percentage
Within the sinus	82%
Significantly above the sinus	18%

No ostia were found in the posterior sinus during this study.

Pertaining to the left coronary artery, in 2.7% of the study population, no left common (main) trunk was found. Instead, the circumflex and the anterior descending branches were originating as separate trunks. In 58%, the left common trunk branched to form two divisions. 32.7% had three divisions in the left main trunk and 6.6% showed four divisions in the left main trunk (Table 6).

Table 6. Variations in the number of divisions in the left coronary artery

Number of divisions in the left coronary trunk	Percentage
No left common trunk	2.7%
Two divisions	58.0%
Three divisions	32.7%
Four divisions	6.6%

Considering the variation of the course of the anterior descending branch of the left coronary artery, 80% revealed an epicardial route. A 0.7% was found to have a sub-epicardial course and 19.3% showed an epicardial course with muscular bridging (Table 7). The commonest site of this muscular bridge was the mid-course (middle one third) where the incidence was 62%. Bridging occurred in the distal course (distal one third of the artery) in 31% and in the proximal course (proximal one third of the artery) in a further 7% (Table 8).

Table 7. Variations of the course of the anterior descending branch of the left coronary artery

Variation of the course of the anterior descending branch of the left coronary artery	Percentage
Epicardial course	80%
Sub-epicardial course	0.7%
Epicardial course with muscular bridging	19.3%

Table 8. Site of muscular bridging of the anterior descending branch

Site of muscular bridging (anterior descending br.)	Percentage
Mid-course (medial one third)	62%
Distal course (distal one third)	31%
Proximal course (proximal one third)	7%

When considering the circumflex branch of the left coronary artery, 98.7% was found to run an epicardial course while a 1.3% ran an epicardial course with significant muscular bridging (Table 9).

Table 9. Variation of the course circumflex coronary artery

Variation of the course circumflex branch of the left coronary artery	Percentage
Epicardial course	98.7%
Muscular bridging	1.3%

The right coronary artery was found to have a complete epicardial route without muscular bridging.

4. DISCUSSION

It was found in this study that the average weight of a male heart was 260g which is a value comparatively lesser than the average heart weight values for men in the Western Europe and North American populations. A prospective study done in the USA, using 232 hearts from healthy men aged 18 to 35 years, dying from sudden traumatic deaths revealed that their heart weights ranged between 188 g to 575 g with an average of 331g and an SD of 56.7 g for the males [1]. This shows that the average heart weight for Sri Lankan males is significantly lesser than the average heart weight of Caucasoid males. In our study it was found that the average weight of the female heart was 225g. A study conducted in the USA using 102 female hearts obtained from persons died from ballistic or blunt force injuries revealed that the heart weights ranged from 156 g to 422 g with an average of 245 g and a standard deviation of 52 g for the females [2]. This shows that the average heart weight for Sri Lankan females is lesser than the value for North American populations. At the same time, it has to be emphasized that the difference between the averages of Caucasoid male hearts and Sri Lankan male hearts is 71 g while the difference between the averages of Caucasoid female hearts and Sri Lankan female hearts is only 20 g.

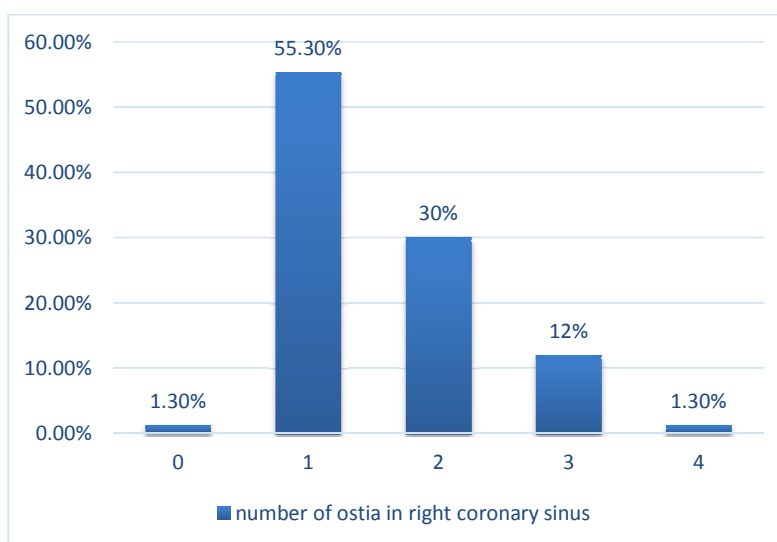


Fig. 1. Variations in the number of ostia in right coronary sinus

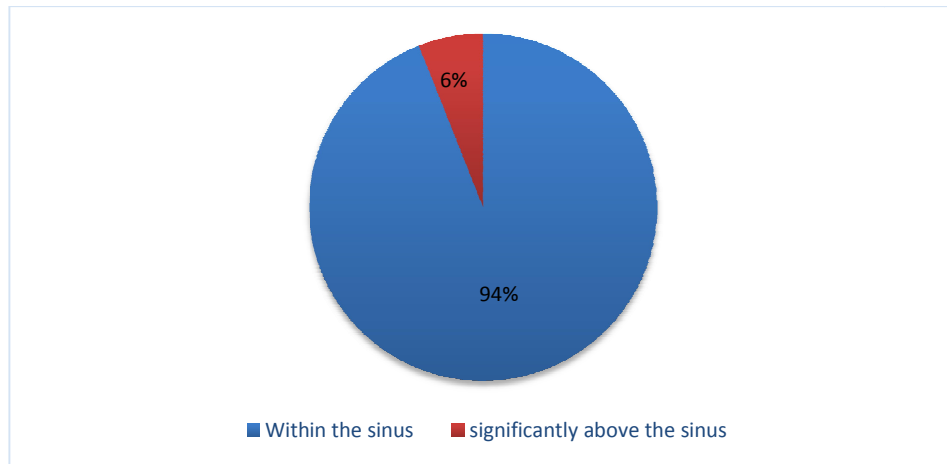


Fig. 2. Position of ostia in relation to the right coronary sinus

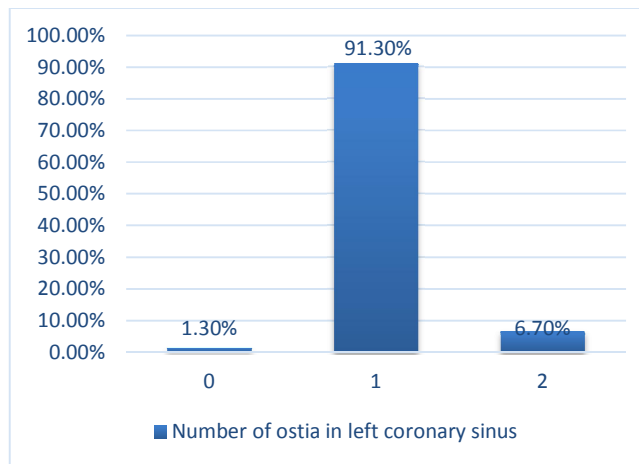


Fig 3. Variation in the number of ostia in left coronary sinus

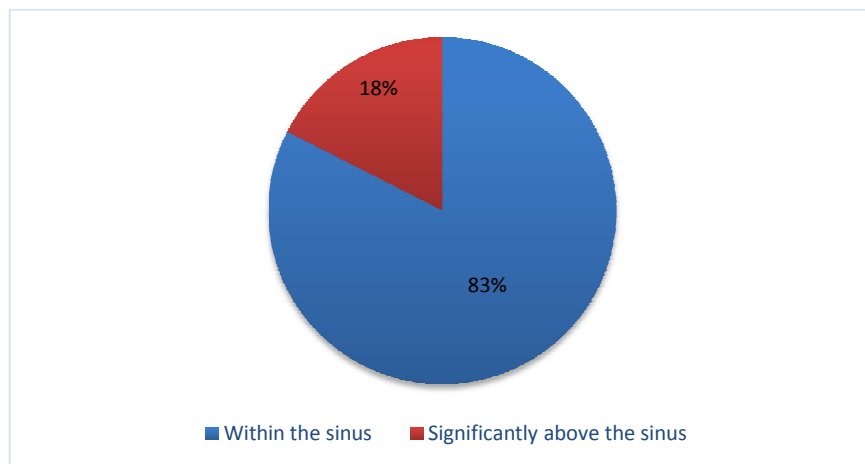


Fig. 4. Position of ostia in relation to the left coronary sinus

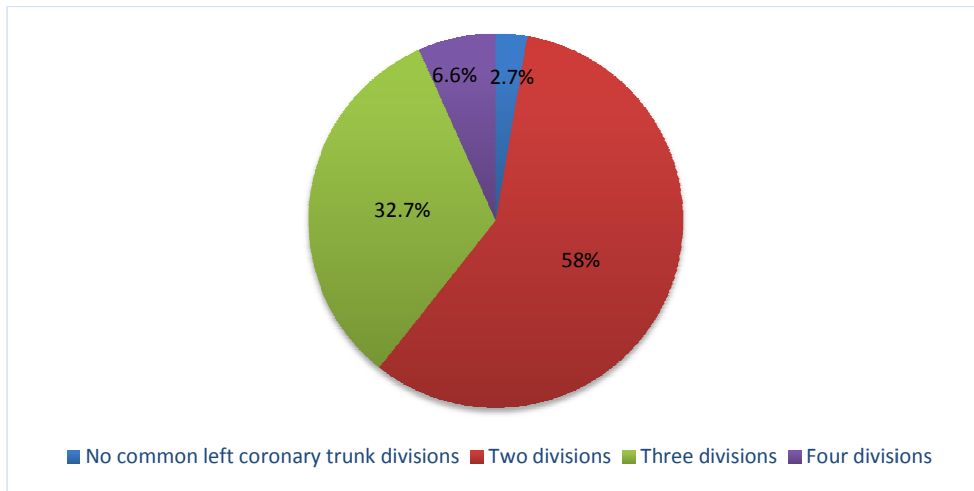


Fig. 5. Number of divisions in the left coronary trunk

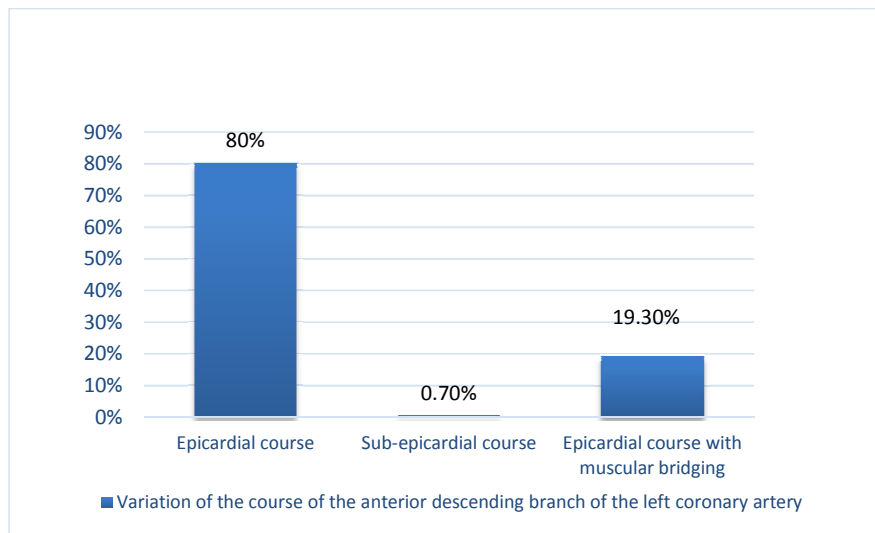


Fig. 6. Variation of the course of the anterior descending branch of the left coronary artery

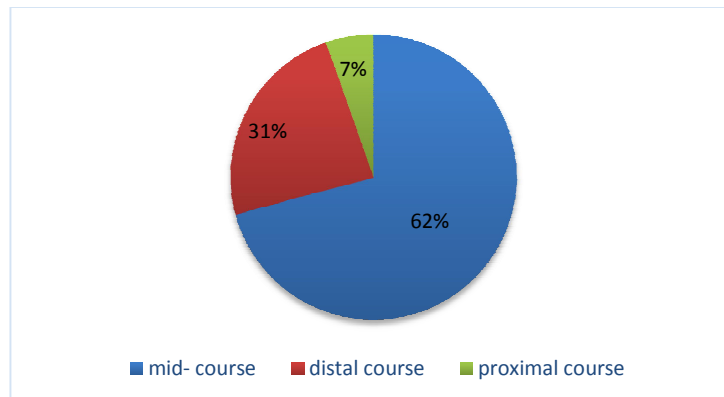


Fig. 7. Sites of muscular bridging of the anterior descending branch of the left coronary artery

Findings of our study showed that the average thickness of the left ventricle for the male hearts was 13mm and the average thickness of the left ventricle for the female hearts was 12mm. A study done in 1966 in the Washington University Hospital had shown similar findings for the Western populations [3].

In the context of the anatomy of the heart, cardiac valves have an uncontestable significance. According to our findings, the average circumference of the tricuspid valve of the male hearts was 120 mm and the same for the female hearts was 110 mm. The average circumference of the male pulmonary valve was 73 mm while the same for the female gender was 67 mm.

The average circumferences of the Mitral and Aortic valves of the males were 100 mm and 65 mm respectively while the same for the female gender were 91 mm and 58 mm respectively. These results are compatible with findings in the literature. For example a similar study done in the USA using 160 postmortem hearts of healthy adults, shows quite similar figures though they are slightly higher (by 2-3 mm) compared to our figures [4].

Out of the 150 specimens dissected, 4 (2.7%) specimens had three separate coronary arteries arising from the aorta. This is due to the separate origins of the two main branches (the circumflex and the anterior descending) of the left common trunk as individual arteries. There are contrasting findings in the literature with regard to the percentage prevalence of a third coronary artery (TCA). A similar study conducted by the University of Belgrade, Serbia in 2004, found that 8 heart specimens out of 23 (percentage prevalence 34.8%) had a third coronary artery [5]. A study conducted in India had TCA in 24% out of 100 specimens while another study conducted in Pune, India using 150 specimens had TCA in 32% of the study sample [6,7]. The reason for this difference in the results (ie: low prevalence data in our study compared to the studies done elsewhere) may be explicable by the inclusion and exclusion criteria and sampling methods of the researches. Since in our study we included only the hearts of those who had no previous traceable cardiovascular pathology and who died due to non-cardiac-related causes while in the three other studies mentioned above they have used all cases without excluding those who died due to cardiovascular pathology, our study tends to get low prevalence data for a

TCA. The figure (2.7%) in our study represents the prevalence of a TCA among those who have no evidence of cardiovascular pathology while the figures in other three studies represent the prevalence of a TCA among the general population. Further, the Serbian study in 2004 has numerically constricted numbers (n=23) which may have a faulty impact on statistical data.

The number of coronary ostia in the right coronary sinus varied from 0-4 and the majority (55.3%) of the study population had single ostium in the right coronary sinus and 30% had an accessory ostium. Similar study done in Pakistan using 30 postmortem hearts showed that 29 out of the 30 had only one coronary ostium. The difference of the findings may be due to the smaller sample size of the study done in Pakistan [8].

Location of the coronary ostia was assessed in relation to the coronary sinus. In relation to the right sinus of Valsalva, 94% of the ostia were located within the sinus and only 6% were located above it. On the left side, the corresponding values were 82.5% and 17.5%. These results re-confirm the findings in the literature [8,9].

The most frequent variant found in the number of divisions in the left coronary trunk/left main trunk was the bifurcation as the anterior descending branch and the circumflex branch (58%). Other variants were the trifurcation (32.7%), tetra-furcation (6.7%) and the absence of divisions in the left common coronary trunk (2.7%). These findings were repeatedly confirmed by two studies done in India using 55 cadaveric heart specimens and 100 specimens respectively and by another study done in Oman [6,10,11].

5. LIMITATIONS

Postmortem coronary angiography had not been employed. It would have given more detailed information about the branches of coronary arteries, had this technique been used. Furthermore, the study population was limited to those who did not have pre-existing cardiac disease. If they too were included certain prevalence data would have been different.

6. CONCLUSIONS

14% of the study population had anatomically abnormal/variable numbers of coronary ostia in

right coronary sinus and nearly 9% in the left coronary sinus. 16% right coronary ostia and 17.5% left coronary ostia were abnormal/variable in anatomical location in relation to the respective sinus of Valsalva. Posterior sinus was devoid of ostia. 4% had anatomically variable/ abnormal numbers of main coronary arteries. 2.6% had ectopic origins of coronary arteries. Anatomical variations/ abnormalities were also seen in the number of divisions and the pathway of the left coronary vessel and its branches. A slight male preponderance was seen in right cardiac dominance. Variations in the cardiac anatomy even within the Sri Lankan population not known to be suffering from any cardiovascular pathology, are commoner than appreciated. Cardiac dimensions (wall thicknesses and valve circumferences) are relatively smaller in Sri Lankan population compared to the Western and North American populations and those given in text-books including Kitzman chart.

CONSENT

As per international standard or university standard, senior next written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

Ethical clearance had been obtained from the ethics review committee of the Faculty of Medical Sciences, University of Sri Jayawardenepure, though the information obtained for the research were within the limits of a routine medico-legal autopsy and the individual identity was not traceable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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