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Original Article

# Gender differences in the lumen of the left anterior descending artery—An autopsy based histomorphometric study

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ABSTRACT

*Introduction:* The prevalence of coronary artery disease is comparatively higher in males than females. The present research studies the sexual dimorphism in the luminal diameter of the left anterior descending artery.
*Methods:* The study was conducted on 35 male and 35 female cadaver hearts. This histomorphometric study was performed by using the computer assisted microscope, to understand the gender based variation in the arterial lumen.
*Results:* The study observed that the luminal diameter of the left anterior descending artery was higher in males. However, on correction with the weight of the heart, females showed a significantly wider coronary artery lumen, possibly indicating a better coronary flow in female hearts.
*Discussion:* The study observation suggests how the females are better protected from the coronary artery disease than the males. More elaborate studies on larger sample are suggested to confirm the observations of the present study.


## 1. Introduction

Coronary artery diseases (CADs) are associated with increased morbidity and mortality.[1] Among the various causes of sudden deaths, CADs are listed at the top of the list as the most common cause of sudden death.[2] It is described that the prevalence of CAD is much higher in men than in the women until the 5th decade of life.[3] The anterior interventricular artery is a branch of the left coronary artery and it is clinically known as the left anterior descending artery (LAD). The LAD supplies the apex of the heart and the left ventricle. The blood flow through arteries is influenced by several mechanical and hydraulic factors, which influence the blood flow in the coronary circulation.[4] Though there are a few studies that reported about the normal coronary artery luminal size in different populations,[5–10] the gender differences in the coronary artery lumen have not been analyzed.

The present study was aimed to analyse the histomorphometric feature of the LAD in South Indian population. The objective was to evaluate the sexual dimorphism in the luminal diameter of the LAD based on the histomorphometry and to provide a reference data for LAD dimensions in South Indian population.

## 2. Materials and Methods

The present study was conducted on 70 human hearts (35 males and 35 females) obtained during the medico-legal autopsies performed in the Department of Forensic Medicine and Toxicology at a medical institution. The age of the deceased ranged between 15 and 35 years. The age distribution of the study sample is shown in Fig. 1. The samples were collected after taking a written informed consent from the kith and kin of the deceased. Seventy apparently healthy cardiac autopsy specimens with intact coronary arteries were included in the present study. The age, sex, stature, total body weight and weight of the heart were recorded in a data sheet. Stature and body weight were measured using standard techniques followed during the medicolegal autopsy. The stature was measured as the length of the body from head to heel

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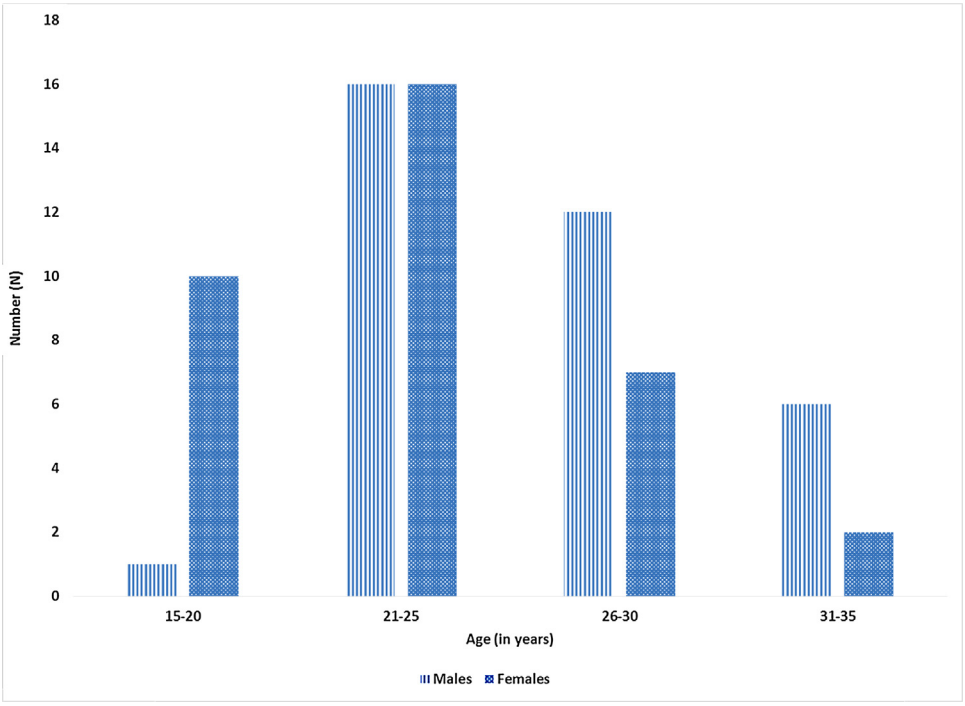


**Fig. 1.** Age distribution of the study sample.

in centimetres on the autopsy table, while the body weight was taken on the electronic body weighing scale. The weight of the heart was taken after cutting the great vessels closer to the heart and sparing the semilunar valves. The hearts were initially screened for any visible congenital anomalies and pathological changes. The hearts with any obvious pathology and those weighing more than 380 g in males and 280 g in females were excluded from the study, to avoid the inclusion of possible hypertensive/hypertrophied hearts. Apparently healthy hearts were thus, included in the present study.

The course and branching pattern of the coronary arteries were examined. The hearts were sectioned and the coronary artery segments, from the LAD were taken 5 mm from its origin. The coronary artery segments were taken into histokinatte- automated tissue processor, for fixing, dehydration and clearing. The segments were then embedded in freshly melted wax, using Leuckhart's embedding moulds and the blocks were prepared using the rotary microtome. The sectioned tissue was placed over the egg albumin coated slide, which acts as a tissue adhesive. The wrinkles of paraffin wax were removed by putting the slide in water bath and the slides were later placed over a hot plate for the fixation. The excess paraffin wax was removed from the tissue by immersing the slides in xylene and the excess xylene was removed by using the alcohol. The slides were washed under the running tap water to remove the alcohol. The slides were then stained using the dyes Haematoxylin and Eosin (H & E). The slides thus prepared were examined using the computer assisted olympus research microscope BX41, with a 2X objective for the magnification of the

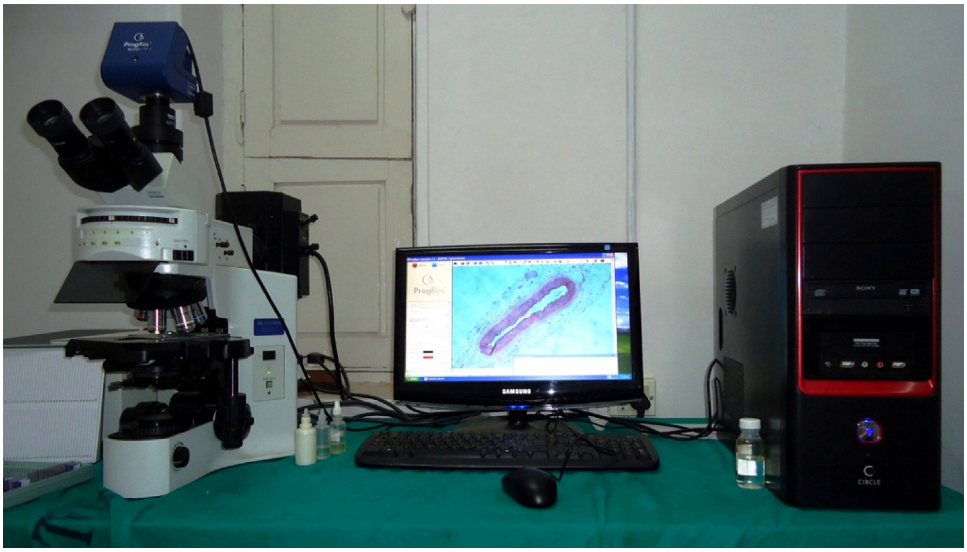

**Fig. 2.** Computer assisted Olympus Research Microscope BX41.

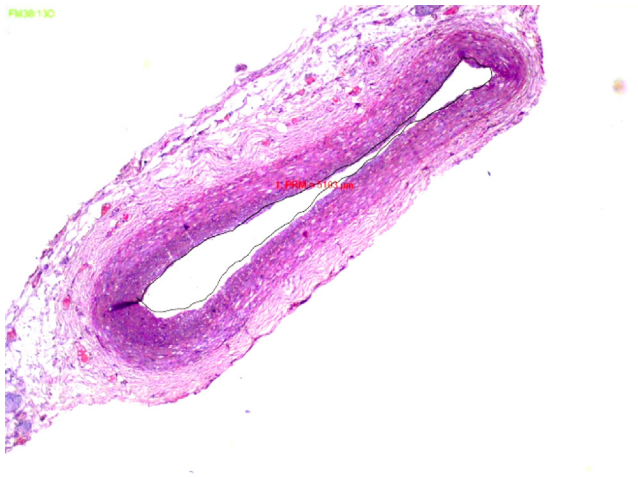

**Fig. 3.** Histomorphometry of the left anterior descending artery 5 mm from its origin.

section, which is fixed over the slide (Fig. 2). The ProgRes® Capture Pro 2.8 Jenoptik optical system that is installed in the computer captures the image and allows the accurate measurement of the lumen diameter of the LAD (Fig. 3).

The details were recorded in a data capture sheet and analyzed by using the SPSS version 11.5. The body surface area (BSA) was calculated by using the Mostellar formula; BSA = square root of (weight of the body × height/3600). BMI was calculated as body weight (kg)/square of body length ($m^2$). The coronary artery diameter was corrected by the heart weight (HWC), to rule out any effect of the heart weight on the coronary arteries. It was calculated by dividing the coronary artery diameter by heart weight. The coronary artery diameter corrected for body surface area (BSA C) was calculated to rule out any effect of body surface area on the size of the lumen. It was calculated by dividing the coronary artery diameter by the body surface area. The coronary artery diameter corrected for body mass index (BMI C) was calculated to rule out any effect of body mass index on the size of the lumen. It was calculated by dividing the coronary artery diameter by the body mass index. Male female differences in different measurements were studied using the Student's *t*-test and correlations were derived using Pearson's correlation coefficient. Statistical significance was set at P-value $<0.05$.

## 3. Results

In the present investigation, BSA, stature and body weight were significantly higher in males. BMI however, did not show any significant differences between males and females included in the study (Table 1).

Correlation of heart weight was analysed with stature, body weight, BMI and BSA. A significant correlation of heart weight was observed with stature, body weight and BMI in males and body weight, BMI and BSA in females (Table 2). Similarly correlation of luminal diameter of LAD was drawn with stature, body weight, BMI, BSA and heart weight among males, females and total sample. It was observed that the diameter of LAD significantly correlated with stature, body weight, BMI and heart weight in males. No such correlation was however, observed among females (Table 3).

The heart weight and the mean luminal diameter of the LAD was found to be significantly higher in males than in females (Table 4). In males, the diameter of the LAD measured $1.69 \pm 0.20$ mm while in females, it measured $1.49 \pm 0.29$ mm. The mean luminal diameter of the LAD after correcting with weight of the heart, were found to be significantly higher in females ($0.008 \pm 0.002$ mm) when compared to males ($0.007 \pm 0.001$ mm). The mean luminal diameter of the LAD after correcting with BSA and BMI did not show any significant difference between males and females (Table 4).

**Table 1**
Descriptive Statistics (Mean ± SD) for the various baseline parameters of the study sample.

| | Total (N = 70) | Males (N = 35) | Females (N = 35) | Gender differences |
|---|---|---|---|---|
| Stature (cm) | 163.94 ± 9.57 | 169.03 ± 9.60 | 158.86 ± 6.36 | t = 5.224; p < 0.001 |
| Body Weight (kg) | 56.44 ± 11.78 | 61.40 ± 13.02 | 51.49 ± 7.86 | t = 3.857; p < 0.001 |
| BMI ($kg/m^2$) | 20.96 ± 3.77 | 21.48 ± 4.26 | 20.44 ± 3.18 | t = 1.158; p = 0.251 |
| BSA ($m^2$) | 01.59 ± 0.26 | 01.68 ± 0.32 | 01.50 ± 0.12 | t = 3.127; p = 0.003 |

SD–Standard deviation; BMI–Body Mass Index; BSA–Body Surface Area.

**Table 2**
Correlation of heart weight with stature, body weight, BMI and BSA.

| Heart weight correlation to | Males (N = 35) | Females (N = 35) | Total (N = 70) |
|---|---|---|---|
| Stature (cm) | R = 0.405, p = 0.016 | R = 0.054, p = 0.760 | R = 0.535, p < 0.001 |
| Body Weight (kg) | R = 0.659, p < 0.001 | R = 0.574, p < 0.001 | R = 0.715, p < 0.001 |
| BMI ($kg/m^2$) | R = 0.487, p = 0.003 | R = 0.539, p = 0.001 | R = 0.475, p < 0.001 |
| BSA ($m^2$) | R = 0.348, p = 0.041 | R = 0.545, p = 0.001 | R = 0.498, p < 0.001 |

BMI–Body Mass Index; BSA–Body Surface Area.

**Table 3**
Correlation of the diameter of LAD with stature, body weight, BMI, BSA and heart weight.

| LAD diameter correlation to | Males (N = 35) | Females (N = 35) | Total (N = 70) |
|---|---|---|---|
| Stature (cm) | R = 0.631, p < 0.001 | R = 0.080, p = 0.648 | R = 0.459, p < 0.001 |
| Body Weight (kg) | R = 0.973, p < 0.001 | R = 0.054, p = 0.757 | R = 0.574, p < 0.001 |
| BMI ($Kg/m^2$) | R = 0.662, p < 0.001 | R = 0.009, p = 0.958 | R = 0.333, p = 0.005 |
| BSA ($m^2$) | R = 0.244, p = 0.158 | R = 0.076, p = 0.662 | R = 0.261, p = 0.029 |
| Heart weight (gm) | R = 0.672, p < 0.001 | R = 0.083, p = 0.633 | R = 0.491, p < 0.001 |

LAD–Left Anterior Descending Artery; BMI–Body Mass Index; BSA–Body Surface Area.

**Table 4**
Descriptive Statistics (Mean ± SD) for the heart weight and LAD diameter.

| | Total (N = 70) | Males (N = 35) | Females (N = 35) | Gender differences |
|---|---|---|---|---|
| Heart weight (gm) | 227.57 ± 53.45 | 260.54 ± 51.21 | 194.60 ± 30.60 | t = 6.540; p < 0.001 |
| LAD (mm) | 01.59 ± 0.26 | 01.69 ± 0.20 | 01.49 ± 0.29 | t = 3.206; p = 0.002 |
| BMI C | 0.08 ± 0.01 | 0.08 ± 0.01 | 0.07 ± 0.02 | t = 1.486; p = 0.142 |
| BSA C | 01.00 ± 0.21 | 01.03 ± 0.20 | 01.00 ± 0.21 | t = 0.651; p = 0.517 |
| HW C | 00.007 ± 0.002 | 00.007 ± 0.001 | 00.008 ± 0.002 | t = 3.201; p = 0.002 |

SD–Standard Deviation; LAD–Left Anterior Descending Artery; BMI C–Body Mass Index Correction; BSAC–Body Surface Area Correction; HW C–Heart Weight Correction.

## 4. Discussion

The arterial supply of the heart is interesting to the medical community. The heart receives its own blood supply from the coronary arteries. The two coronary arteries branch off from the aorta at the point where the aorta and the left ventricle meet. These arteries along with their branches supply all parts of the cardiac muscle. The coronary capillaries deliver oxygenated blood (nutrients) to all the cardiac cells.[11] The coronary arteries are classified as functional end arteries, since they represent the only source of blood supply to the myocardium. There is very little of redundant blood supply to the heart, which is the reason that blockage of these vessels can be fatal.[12] The LAD is the most commonly affected artery in myocardial infarction that is involved in about 66.7% of the cases.[13]

On one side, coronary arteries are blamed for pathological occurrence of CAD leading to sudden death and on the other side, the coronary arteries showed high variability of dimensions in the normal population. The genetic factors, ethnicity, age, sex, body weight, body surface area and weight of the heart; all have been correlated with the coronary artery anatomy in various studies[6,8,9,14,15] for such reasons. The present study was undertaken to highlight some of the histomorphometric differences in the male and female LAD, which may help to explain the sex differences in the incidence of CAD. It was observed that the mean lumen diameter of the LAD was more in males as compared to the females, which is consistent with the observations in the previous studies.[1,6,7] Each measurement was corrected for BMI, BSA and weight of the heart to check if the gender difference in LAD diameter was because of differences in the body build or the weight of the heart. This correction revealed that the LAD was wider in relation to the weight of the heart in females, which is indicative of a better coronary flow in females than in males. Our observation in this regard, is consistent with the earlier study by Ilayperuma et al.[7] However, the differences were not significant between males and females when lumen of LAD was corrected with BSA, as analyzed by Saikrishna et al.[5]

## 5. Conclusions

The mean lumen diameter of the LAD was more in males as compared to the females. LAD was wider in relation to the weight of the heart in females, indicating a better coronary flow in females. There was not much difference between males and females on correction with BSA and BMI. The limitation of the present study is the smaller sample size and hence, it is recommended that similar studies are conducted on larger samples. The population considered for the present study was of South Indian origin. Future studies can be taken up in other population groups and study the influence of regional and geographic variations on coronary lumen. The present study considered, only the lumen diameter of the LAD. There is a scope for further research on other coronaries and to assess the sexual dimorphism in the thicknesses of the tunica intima, tunica media and their significances in the pathogenesis of CADs.

In the present study, the LAD was initially observed by computer assisted, olympus research microscope BX41′ and subsequently, the images were captured by the ProgRes® Capture Pro 2.8 Jenoptik optical system, from which the diameters were measured. The images captured using the ProgRes® Capture Pro 2.8 Jenoptik optical system can be stored easily as a data. This technique gives magnified and fixed images of the coronary artery segments, which can be made use for the research studies.

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