ORIGINAL ARTICLE

# Study of Morphometry and Elastic Fibre Distribution in Left and Right Coronary Arteries

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**Abstract:**

*Background:* Coronary artery disease also called as ischemic heart disease which develops when major blood vessels that supply blood to heart become damaged or diseased. It is also one of the leading causes of death. Morphometry and elastic fibre distribution in coronary arteries may help in using appropriate size catheters for diagnostic procedures. *Aim and Objectives:* To study the morphometry and elastic fibre distribution in left and right coronary artery. *Material and Methods:* Segment of left and right coronary arteries each having length of 0.5 cm were collected from 30 adult human heart specimens fixed in 10% formalin. Outer and inner diameters were measured. Tissues were processed and stained by verhoeff's Van Geison stain. Stained slides were scanned by "IS capture software" under 10 × magnifications. *Results:* Outer diameter of left coronary artery is 4.225 ± 0.6963mm and right coronary artery is 3.827 ± 0.6869mm. Inner diameter of left coronary artery is 3.338 ± 0.5853 and that of right coronary is 2.869 ± 0.6104mm.*Conclusion:* Diameter, wall thickness, thickness of tunica intima, tunica media is more in left coronary artery than the right. Also left coronary artery shows more number of elastic fibers than right coronary artery.

**Keywords:** Coronary Arteries, Coronary Vascular Diseases, Tunica Intima, Tunica Media, Tunica Adventitia

## Introduction:

Left and right coronary arteries and its branches supply the musculature of the heart. Both coronaries are the branches of ascending aorta. Calibre of left coronary artery is larger than right and a greater volume of myocardium is supplied by it [1]. Histologically, coronary arteries are muscular arteries but have special features which make them different from typical muscular arteries. Usually in typical muscular artery, tunica intima is thin and endothelium directly rest on internal elastic lamina but in coronary arteries, smooth muscle cells assume a subendothelial position and produce elastin and other intercellular substances which causes intimal thickening which is referred as 'musculoskeletal cushion'[2].

Coronary vascular diseases are very common with the advancing of age which narrows the lumen and may hamper the blood supply to heart and may further lead to fatal condition like myocardial infarction. In India, during last three decades, the incidence of coronary vascular diseases has markedly increased and is one of the cause of morbidity and mortality. Also compared to western countries the coronary heart diseases in Indian youth population has been increased twice [3]. In such conditions for diagnostic and therapeutic purposes many techniques and devices such as dilating balloon's, perfusion catheter, thermal probes, and stents are used. Many of these techniques and devices require understanding the histomorphometry of coronary arteries [4]. This prompted us to study the

morphometry and elastic fibre distribution in both coronary arteries.

**Material and Methods:**

The present study used thirty adult human cadaveric heart specimens of unknown sex which were fixed in 10% formalin in Department of Anatomy Rural Medical College, Loni after taking permission from Institutional Ethics Committee. Sections of right and left coronary arteries (each having 0.5 cm in length at the beginning of these arteries from ascending aorta) were taken from each heart specimens.

Outer and inner diameters were measured by Vernier calliper in mm and kept in separate containers in 10% formalin. Each container was properly labelled and tissue stored till it was processed. Tissues were processed through routine procedure and blocks were prepared. Five to seven micro meter thick sections were cut and stained with Verhoeff's Van Geison stain [5]. Stained slides were scanned by IS capture software under 10 × magnification.

Following histological parameters were measured:

a. Whole thickness of arterial wall in micrometre.
b. Thickness of Tunica Intima (TI) in micrometre.
c. Thickness of Tunica Media (TM) in micrometre.
d. Numbers of elastic lamellae in tunica media.
e. Length of longest elastic fibre in micrometre.
f. Appearance of Internal and External Elastic Lamina (IEL and EEL).

**Results:**

Present study observed that outer and inner diameters of left coronary artery were more than right coronary artery (Table 1).

**Table 1: Outer and Inner Diameter of Right and Left Coronary Arteries in mm with SD**

| Diameter | Coronary arteries | | Unpaired 't' test | Interpretation |
|---|---|---|---|---|
| | Right Mean ±SD | Left Mean ±SD | | |
| **Outer** | 3.827± 0.6869 | 4.225 ± 0.6963 | t=2.220 | p=0.0304 significant |
| **Inner** | 2.869± 0.6104 | 3.338± 0.5853 | t= 3.037 | p= 0.0036 very significant |

**Table 2: Whole Thickness of Coronary Arteries in Micrometer**

| Coronary artery | Whole thickness | | Unpaired 't' test | Interpretation |
|---|---|---|---|---|
| | Mean | SD | | |
| **Right** | 305.25 | 68.628 | t = 3.835 d.f.= 46 | P= 0.0004 Extremely significant |
| **Left** | 402.43 | 119.48 | | |

Whole thickness of left coronary artery was significantly more than right coronary artery (Table 2). Thickness of tunica intima of left coronary artery was significantly more than right coronary artery (Table 3). Thickness of tunica media of left coronary artery was more than right coronary artery (Table 4). Number of elastic lamellae was significantly more in left coronary artery than right (Table 5). Length of longest elastic fibre was significantly more in left coronary than right coronary artery (Table 6).

**Table 3: Thickness of Tunica Intima (TI) of Coronary Arteries in Micrometre**

| Coronary artery | Thickness of TI | | Unpaired 't' test | Interpretation |
|---|---|---|---|---|
| | Mean | SD | | |
| Right | 68.07 | 29.175 | t= 2.753 d.f.=48 | p=0.0083 very significant. |
| Left | 95.655 | 46.489 | | |

**Table 4: Thickness of Tunica Media (TM) of Coronary Arteries in Micrometre**

| Coronary artery | Thickness of TM | | Unpaired 't' test | Interpretation |
|---|---|---|---|---|
| | Mean | SD | | |
| Right | 100.33 | 35.269 | t=2.665 d.f.=52 | p= 0.0102 significant |
| Left | 129.89 | 49.449 | | |

**Table 5: Number of Elastic Lamellae in Tunica Media**

| Coronary artery | No of elastic lamellae | | Unpaired 't' test | Interpretation |
|---|---|---|---|---|
| | Mean | SD | | |
| Right | 0.733 | 1.337 | t=5.200 d.f.58 | P<0.0001 Extremely significant |
| Left | 2.933 | 1.893 | | |

**Table 6: Length of Longest Elastic Fibre in Tunica Media in Micrometre**

| Coronary artery | Length of longest elastic fibre | | Unpaired 't' test | Interpretation |
|---|---|---|---|---|
| | Mean | SD | | |
| Right | 44.372 | 11.779 | t= 3.177 d.f.= 41 | P= 0.0028 very significant |
| Left | 60.143 | 24.5 | | |

**Left coronary artery:**

**Tunica intima:**

TI of left coronary artery was thick but in some arteries intimal thickness was more than thickness of media (Fig.1). Mean thickness of intima was less than mean thickness of media. In most of the cases thick musculoelastic layer was present (Fig. 2).

**Internal elastic lamina:**

IEL was mostly straight, interrupted, somewhere fragmented and focally lost at some places (Fig. 1, 2, 3).

**Tunica media:**

TM was thick which shows presence of elastic lamellae in some sections and elastic fibres in other sections which were circularly arranged (Fig. 1, 3, 5).

**External elastic lamella:**

EEL was thick and consisting of 3-5 layer of circularly arranged elastic fibres (Fig. 1, 3, 4, 5).

**Tunica adventitia:**

Few elastic fibres were present in TA.

**Right coronary artery:**

**Tunica intima:**

We observed that, TI was thick but mean thickness of tunica intima was less than mean thickness of TM. Musculoelastic layer was present in few sections (Fig. 6).

**Internal Elastic Lamellae:**

It was prominent, straight and at some places interrupted (Fig. 7, 8). We observed that at some places it was wavy but waves were of low amplitude (Fig. 6). In few sections it was reduplicated (Fig. 9).

**Tunica media:**

TM shows 1-3 elastic lamellae in few sections and in remaining sections fine elastic fibres were present (Fig. 8)

**External elastic lamella:**

EELwas clearly seen in all sections which consist of single or 2-3 layers of elastic fibres (Fig. 6, 7, 8, 9).

**Tunica adventitia:**

TA shows few elastic fibres (Fig. 9).

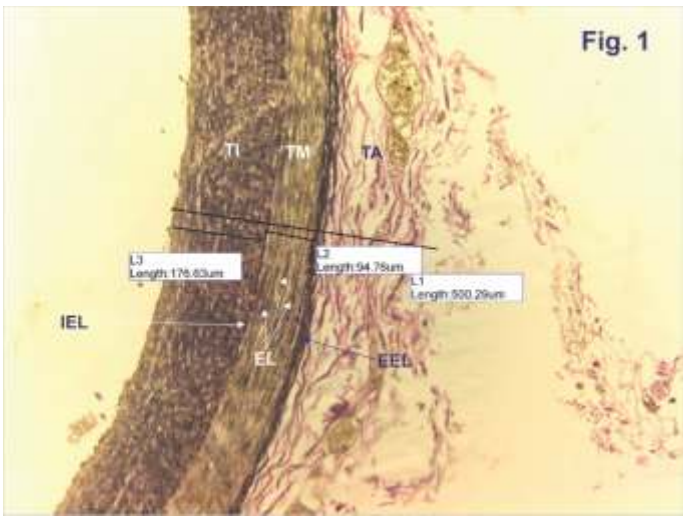


**Fig. 1: Photomicrograph of Left Coronary Artery showing thickTunica Intima (TI), Internal Elastic Lamina (IEL), Tunica Media (TM), Elastic Lamellae (EL) in tunica media, External Elastic Lamina (EEL), Tunica Adventitia (TA), Collagen Fibres (CF). (Verhoeff's Van-Geisons stain) (10 × magnification)**

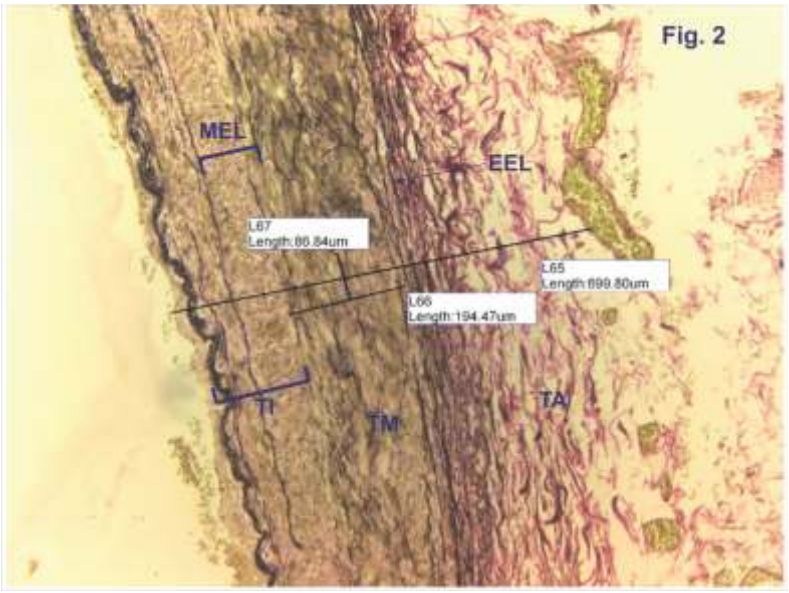


**Fig. 2: Photomicrograph of Left Coronary Artery showing Tunica Intima (TI), Internal Elastic Lamina (IEL), Musculo Elastic Layer (MEL),Tunica Media (TM), External Elastic Lamina (EEL), Tunica Adventitia (TA), Collagen Fibres (CF). (Verhoeff's Van-Geisons stain) (10 × magnification)**

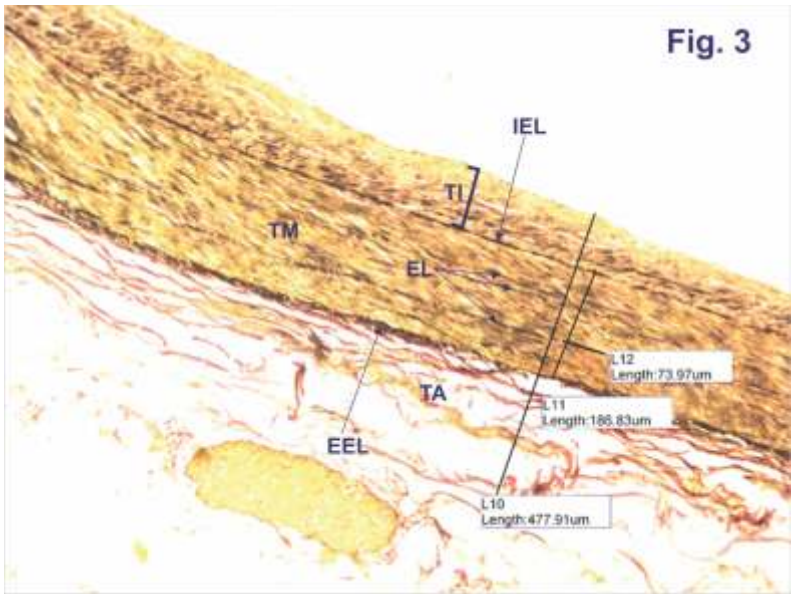


**Fig. 3: Photomicrograph of Left Coronary Artery showing Tunica Intima (TI), Internal Elastic Lamina (IEL), Musculo Elastic Layer (MEL),Tunica Media (TM), External Elastic lamina (EEL), Tunica Adventitia (TA), Collagen Fibres (CF). (Verhoeff's Van-Geisons stain) (10 × magnification)**

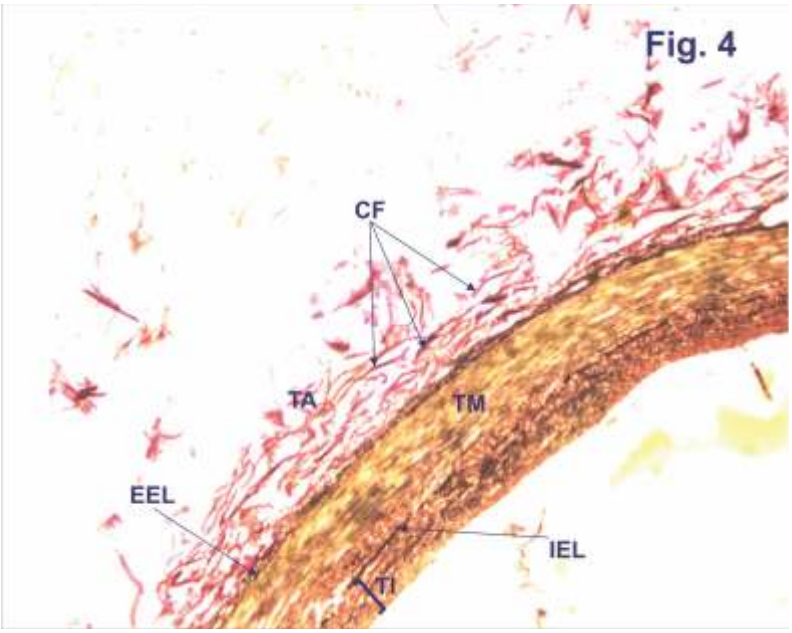


**Fig. 4: Photomicrograph of Left Coronary Artery showing Tunica Intima (TI), Internal Elastic Lamina (IEL), Tunica Media (TM), External Elastic Lamina (EEL), Tunica Adventitia (TA), Collagen Fibres (CF). (Verhoeff's Van-Geisons stain) (10 × magnification) (Internal elastic lamina is interrupted)****

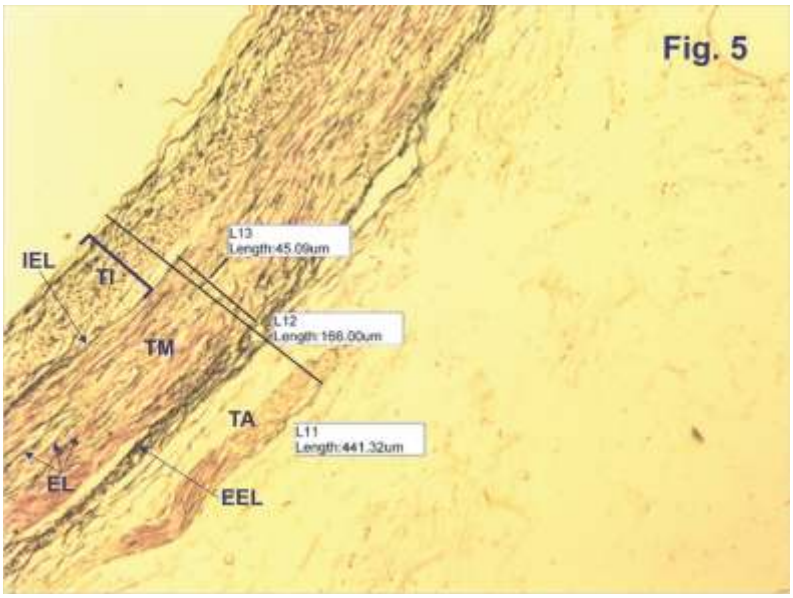


**Fig. 5: Photomicrograph of Left Coronary Artery showing Tunica Intima (TI), Internal Elastic Lamina (IEL), Tunica Media (TM),Elastic Lamellae (EL) in tunica media,External Elastic Lamina (EEL), Tunica Adventitia (TA), Collagen Fibres (CF). (Verhoeff's Van-Geisons stain) (10 × magnification)**

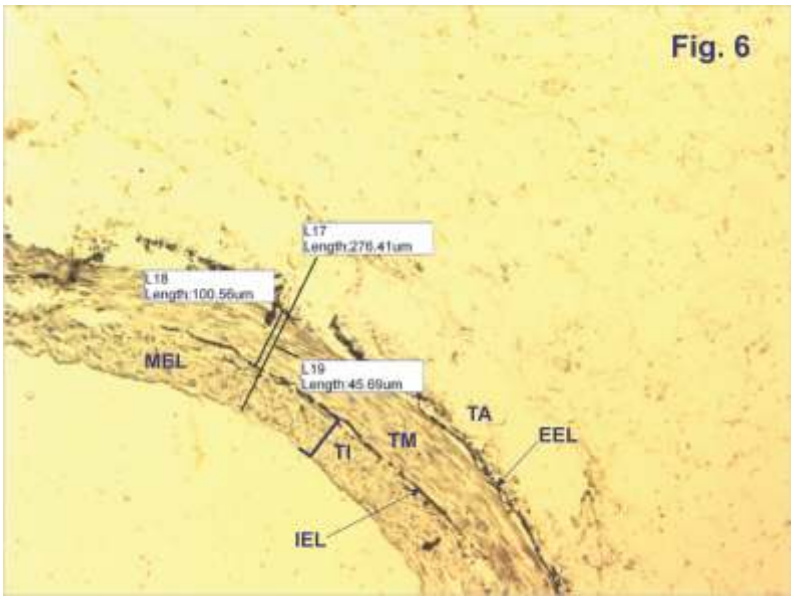


**Fig. 6: Photomicrograph of Right Coronary Artery showing Tunica Intima (TI), Internal Elastic Lamina (IEL), Tunica Media (TM), External Elastic Lamina (EEL), Tunica Adventitia (TA). (Verhoeff's Van-Geisons stain) (10 × magnification)**

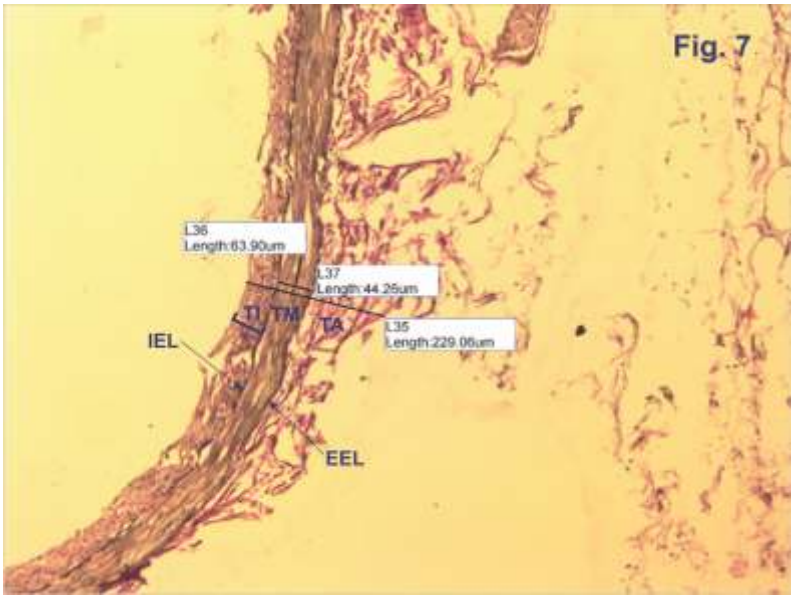


**Fig. 7: Photomicrograph of Right Coronary Artery showing Tunica Intima (TI) interrupted Internal Elastic Lamina (IEL), Tunica Media (TM), External Elastic Lamina (EEL), Tunica Adventitia (TA). (Verhoeff's Van-Geisons stain) (10 × magnification)**

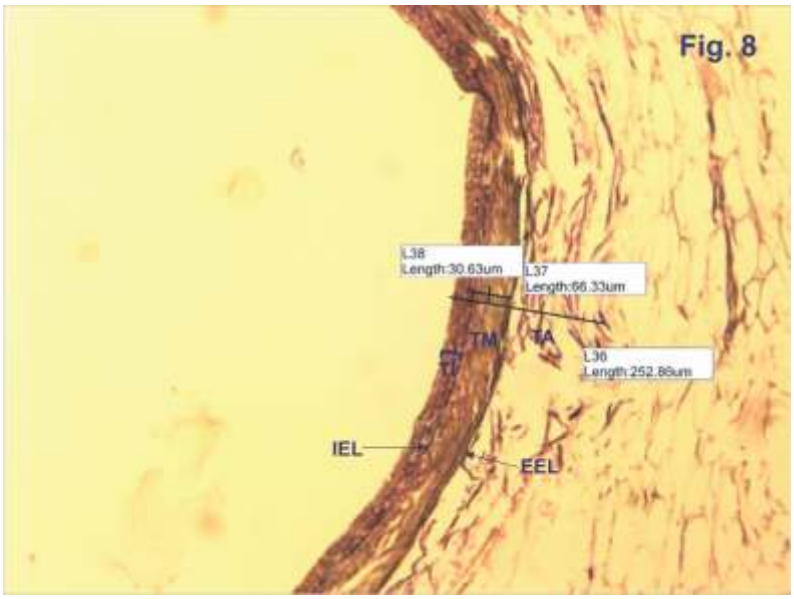


**Fig. 8: Photomicrograph of Right Coronary Artery showing Tunica Intima (TI), Internal Elastic Lamina (IEL), Tunica Media (TM), External Elastic Lamina (EEL), Tunica Adventitia (TA). (Verhoeff's Van-Geisons stain) (10 × magnification)**

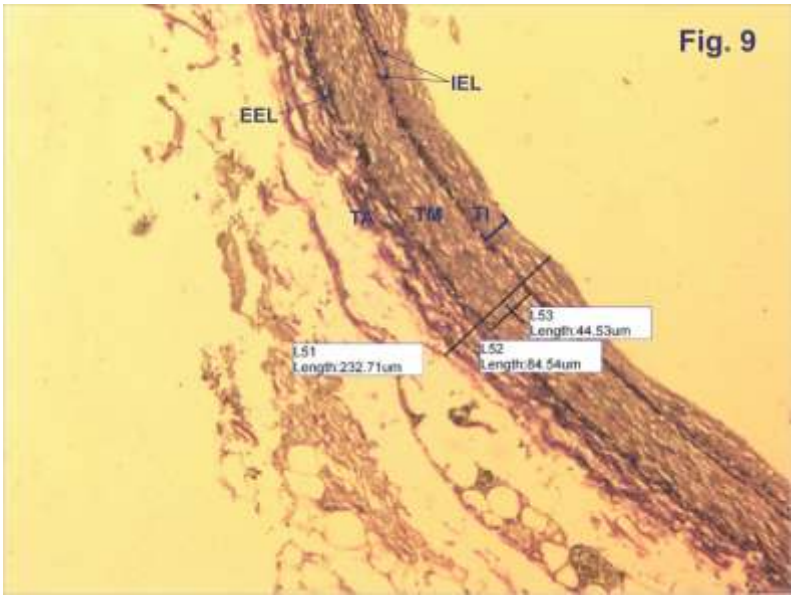


**Fig. 9: Photomicrograph of Right Coronary Artery showing Tunica Intima (TI), reduplicated Internal Elastic Lamina (IEL), Tunica Media (TM), External Elastic Lamina (EEL), Tunica Adventitia (TA). (Verhoeff's Van-Geisons stain) (10 × magnification)**

**Discussion:**

Knowledge of size of coronary artery has great importance while doing percutaneous coronary interventional procedures like angioplasty and coronary artery bypass surgery.

According to Waller *et al*., inner diameter of left coronary artery was 2.0-5.5 mm (mean 4 mm) and right coronary artery was 1.5-5.5 mm (mean 3.2 mm) [4]. Raut *et al*. observed inner diameter of left main coronary artery was 4.08 ± 0.44 mm and right main coronary artery was 3.20 ± 0.37 mm which showed the diameter of left was more than right [6]. Our study has reported similar findings which were reported by above authors.

**Tunica intima**:

According to Vlodaver and Edwards, TI of coronary arteries was rudimentary in fetuses with less amount of subendothelial connective tissue and immediately below it lays the internal elastic lamina. Alteration of intima begins a few days after birth which consists of localized splitting and fragmentation of internal elastic lamina with migration of smooth muscle like cells from tunica media to intima. These results in the formation of 'musculoelastic layer' between intima and media were seen focally [7]. Tyagi *et al*. stated that as age advances, thickness of tunica intima gradually increases which was maximum in the 4$^{th}$ decade and then gradually falls in both right and left coronary arteries. Further he stated that intima of left coronary was much thicker than right coronary [8, 9]. According to Elias, considerable increase in intimal thickening was due to growth of subendothelial connective tissue [10].

Barnwood observed that the thickness of tunica intima in normal adult coronary artery was more than any other artery in the body having the same caliber [11].

Coronary arteries and their main branches have subepicardial course. Coronary arteries have fixed point in aorta at their origin and at a point where they penetrate the muscular wall. The distance between these two points varies during cardiac actions due to elongation and shortening of coronary arteries and these subepicardial coronary arteries have lack of myocardial support from outside. These two factors and high lateral pressure to arterial wall increase the stress on the arterial wall and leads to intimal hyperplasia. This intimal thickening was considered as normal mechanism of adaptation [12]. In present study, tunica intima was thick in both right and left coronary artery, but thicker in left than right which was statistically very significant.

**Internal elastic lamina:**

According to Gross et al. there are progressive age related changes in internal elastic lamina of coronary arteries. These are splitting or reduplication of internal elastic lamina breaks in continuity of internal elastic membrane, migration of medial smooth muscle fibres into intima, formation of musculoelastic layer between the two splitted layers of internal elastic lamina. In musculoelastic layer, elastic and muscle fibres are longitudinally arranged [13].

According to Tyagi *et al.* as the age advances, internal elastic lamina shows changes as, reduplication fragmentations and at some places condensation. These changes are attributed due to increased strain, wear and tear of ageing or physiological remodeling of arterial wall [8].

According to Ahmed et al internal elastic lamina was interrupted and gaps were so large that it became difficult to demarcate intima from media [14].

Present study has also observed somewhere reduplication, fragmentation and musculoelastic layer which showed longitudinally arranged elastic fibres. Fragmentation, discontinuity of IEL was more common on left than right side.

**Tunica media:**

According to Burton, there was correlation between arterial tension and amount of elastic tissue in the vessel wall. As coronary arteries arise from ascending aorta and were subjected to maximum pressure during each cardiac cycle, tunica media of coronary arteries consist elastic tissues in the form of elastic fibres or lamellae [15]. Van Son *et al*. have studied histology and comparison of arterial grafts used for coronary surgery and found that arteries (internal mammary artery) having elastic lamellae (even if the number of lamellae was small)in media protect against occurrence of discontinuities in internal elastic lamina and against intimal thickening and thus increases the patency of graft for longer time[16]. In present study, we also found elastic lamellae and slightly wavy elastic fibres in tunica media of both coronary arteries. No of lamellae were more in left than right coronary artery.

According to Ahmed *et al*., quantity of elastic tissue in tunica media increases upto the age of 3$^{rd}$ decade and then gradually decreases. Further he stated that, elastic tissue percentage was more in right main coronary than left (anterior descending branch of left coronary artery)[14].

In the present study, elastic fibres were more in left than right which was contradictory to the above statement of Ahmed *et al*. It may be due to section of left coronary in our study was taken from main trunk of the artery.

**External elastic lamina:**

Clear development of EEL was seen at six months after birth [7]. According to Waller *et al*. in coronary arteries, external elastic membrane was composed of interrupted layer of elastin and was considerably thinner than internal elastic membrane [4]. In present study, it was seen clearly in both coronary arteries. In left coronary artery it was thick made up of 3-6 layers of circularly arranged elastic fibres. In right coronary, it was thin consisting of 1-3 layers of circularly arranged elastic fibres.

**Conclusion:**

Present study observed that the inner and outer diameters of left coronary artery were more than right which was statistically significant. Also, we observed somewhere reduplication, fragmentation of IEL and formation of musculoelastic layer with longitudinally arranged elastic fibres and left coronary artery showed more number of elastic fibers than right coronary artery. We felt that this study should be done on large number of sample size, in different age groups, in both sexes and in different population for better results which will throw light on this topic.

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