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Atherosclerosis and its Relation to Anthropometric Measurements: An Autopsy Based Study

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Abstract

Atherosclerosis accounts for a large proportion of cardiovascular system associated morbidity and mortality. The aim of the study is to know the relationship between atherosclerosis of various arteries and anthropometric indices with the help of simple indicators of obesity such as body weight, body length, body mass index, waist circumference, hip circumference, waist-hip ratio, abdominal subcutaneous fat thickness and wrist circumference. The study included 100 autopsies conducted in the Government Medical College, Thrissur during a one and a half years period. The heart was dissected following standard autopsy protocol. A 5 cm section of the right coronary artery (RCA) in the atrio-ventricular groove from its origin, a 5 cm segment of the left anterior descending artery (LADA) distal to the origin of the circumflex artery (including the region of origin of the circumflex branch) and left coronary artery(LCA) from its origin till the circumflex branch were excised, marked for identification and histopathologically analysed. The study showed a positive correlation of age, body weight, body mass index, waist circumference, waist-hip ratio and abdominal subcutaneous fat thickness with atherosclerotic changes in the various arteries. No significant relation was observed between the grade of atherosclerosis and anthropometric indices of height, hip circumference and wrist circumference.

Keywords: Atherosclerosis; Body Mass Index; Hip Circumference; Waist Circumference; Waist Hip Ratio.

Introduction

Atherosclerosis is a chronic degenerative condition of arteries responsible for significant cardiovascular morbidity and mortality worldwide. It can result in complications like myocardial infarction, stroke, embolization, ulceration and thrombosis. The incidence of coronary artery disease has doubled in Indians during the past three to four decades. It will soon emerge as the single disease accounting for nearly one third of all death in india [1].

There are many studies on Correlation between grade of atherosclerosis, coronary heart diseases and anthropometrical measurements. While such studies are expensive and harmful in living subjects due to radiation exposure from CT scan and injection of contrast media it can be done easily in autopsy cases [2].

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The studies conducted in various parts of world showed that mild to moderate overweight, short stature, increased body mass index, increased amounts of abdominal subcutaneous fat and myocardial hypertrophy were strongly associated with atherosclerosis in the aorta and coronary arteries.

The Indian studies also confirm an association between anthropometric measurements/indices of obesity, grade of atherosclerosis and the number of arteries affected with atherosclerosis. But no such studies have so far been conducted in this part of Kerala. So here lies the importance of our study.

This autopsy based study is aimed to correlate the anthropometric measurements and indices of obesity such as waist circumference (WC), hip circumference (HC), body mass index (BMI), waist hip ratio (WHR), abdominal subcutaneous fat thickness and wrist circumference with the degree of atherosclerosis in the right coronary artery (RCA), main branch of the left coronary artery (LCA), the left anterior descending artery (LAD), circumflex artery, both carotid arteries and aorta.

Materials and Methods

This Cross sectional study was conducted in the Department of Pathology and Forensic Medicine, Government Medical College, Thrissur. A prior approval was obtained from the Institutional Ethics committee. Informed Consent was taken from the relatives of the deceased before taking various body measurements and preserving samples (sections of aorta, coronary and carotid arteries) for histopathological examination. Anthropometric measurements were taken in the mortuary and histological analysis to grade the degree of atherosclerosis in various arteries was conducted at the Department of Pathology, Government Medical College, Thrissur. The sample size was 100 and the study included both sexes and all age groups. Putrefied and decomposed bodies, mutilated bodies and fragmentary remains, bodies with congenital and acquired skeletal deformities affecting the stature and cases where death occurred due to burns or a prolonged illness were excluded from the study.

Anthropometric Measurements

Body Weight

The body weight was measured to the nearest kilogram using the cadaveric weighing machine.

Body Length

The length of the cadaver was measured from the vertex of the cranium to the base of the heel to the nearest centimeter, with the cadaver in supine position. One cardboard sheet was placed at the head end of body (vertex) and another at the foot end (heel). The distance between these two flat surfaces was taken as the length of the cadaver.

Body Mass Index (BMI)

BMI was calculated as body weight (kg)/square of body length (m^2) [3].

Waist Circumference (WC)

Waist circumference was measured to the nearest 0.5 cm using a measuring tape, at the level of the umbilicus, with the cadaver in a supine position [3].

Hip Circumference (HC)

Hip circumference was measured to the nearest 0.5 cm, using a measuring tape at the level of the greater trochanter, with the cadaver in a supine position [4].

Waist Hip Ratio (WHR)

Waist to hip ratio was calculated as WC/HC [4].

Abdominal Subcutaneous Fat Thickness

The thickness of subcutaneous abdominal fat was measured at the internal rectus sheath, midway between xiphoid and umbilicus [5].

Wrist Circumference

Wrist circumference was measured to the nearest 0.1 cm using a tape meter. Held their wrist as anterior surface up. The superior border of the tape measure was placed just distal to the prominences of radial and ulnar bones. The wrist circumference was measured without any tape pressure over it [6].

Preparation of the Arteries

The heart was dissected using Modified Virchow method. A 5 cm section of the right coronary artery (RCA) in the atrio-ventricular groove from its origin, a 5 cm segment of the left anterior descending artery (LAD) distal to the origin of the circumflex artery, circumflex branch from its origin and left coronary artery (LCA) from its origin till the Circumflex branch were excised and dissected out after macroscopic examination of stenosis. 5cm of tissue sections of both right and left proximal common carotid arteries at their branching point and section from aorta where maximum atherosclerotic lesion seen macroscopically, were also dissected out. All the sections of arteries from each case were fixed in 10% formalin, marked for identification using different colours and histopathological analysis was done. Paraffin sections were made and the sections stained using Hematoxylin and Eosin (H & E) dyes. Thus, sections from a total of 700 arteries were examined for the degree of atherosclerosis in 100 individuals during a one and a half years period between 2014 and 2015.

The grading of atherosclerosis was done according to criteria suggested by the *American Heart Association (AHA)*

Grade 0: Sections showing normal histology or adaptive thickening without macrophages or foam cells. (Figure 1A)

Grade 1: Presence of isolated macrophages and foam cells. (Figure 1B)

Grade 2: Mainly intracellular lipid accumulation. (Figure 2A)

Grade 3: Grade 2 lesions along with small extracellular lipid pools (Figure 2B).

Grade 4: Grade 2 changes along with a core of extracellular lipid. (Figure 3A)

Grade 5: Lipid core and fibrotic layer or multiple lipid cores and fibrotic lipid layers; mainly calcific or fibrotic. (Figure 3B & 4A)

Grade 6: Surface defect, hematoma, hemorrhages or thrombus formation (Figure 4B).

The degree of atherosclerosis was classified as unremarkable (Grade 0), Mild (Grade 1-2), Moderate (Grade 3-4), and Severe (Grade 5-6). Grades of atherosclerosis as observed in our study cases are shown in Figure 1 to Figure 4.

Statistical analysis was done by frequency measurements and cross tabulations using SPSS software version 21. Each anthropometric measurement and the derived index was classified into groups and further analyzed in relation to degree of atherosclerosis in each case. While comparing the mean anthropometric measurements and indices of obesity for the grades of atherosclerosis, ANOVA one way analysis was performed. The p value of less than 0.05 was considered to be significant.

Observation and Results

Mean age of the study sample was 47.6±18.7 years and 73 cases were males and 27 cases were females. Descriptive summary for the anthropometric measurements and the derived indices of obesity and overweight are shown in Table 1. Sections of a total of 700 arteries from 100 individuals were examined for the degree of atherosclerosis. Majority of the arteries (98.4%, n=689) showed atherosclerotic changes. Only 1.6% (n=11) arteries were unremarkable. Mild atherosclerosis was observed in 24.6% (n = 172), moderate atherosclerosis in 41.7% (n = 292) and severe atherosclerosis was observed in 32.1% (n = 225) of the total arteries examined (Figure 5).

The degree of atherosclerosis in individual arteries were also studied. Severe degree of atherosclerosis (Grade 5 and 6) was observed maximum in LCA (50%) and LAD(50%) followed by aorta (41%). Moderate degree of atherosclerosis (Grade 3 and 4) was observed maximum in left and right carotid arteries (58% and 57% respectively) followed by aorta (43%). Mild degree of atherosclerosis (Grade 1 and 2) was observed maximum in circumflex artery (33%) followed by left carotid artery (32%). Whereas grade zero (Unremarkable) atherosclerosis was observed only in circumflex and RCA (together constitute 1.6% only). The mean grade of atherosclerosis was found to be maximum for LAD and LCA followed by Aorta.

Descriptive statistics for the age, anthropometric measurements and the derived indices for individual arteries according to their grade of atherosclerosis are shown in Tables 2,3,4,5. It was observed that the grades of atherosclerosis in all the arteries were significantly related to age. That is, as the age increases, the degrees of atherosclerosis in all the arteries were also increased. (p value < 0.05) (Table 2).

It was noted that BMI was significantly related to the degree of atherosclerosis in LAD and weight was significantly related to the degree of atherosclerosis in circumflex artery. For other arteries no significant relation was observed between the grade of atherosclerosis and anthropometric indices of height, weight and BMI (Table 3).

It was observed that WC was significantly related to the degrees of atherosclerosis in LAD and right and left carotid arteries (p value < 0.05). Whereas WHR was significantly related to the degrees of atherosclerosis in LAD, LCA and right and left carotid arteries. (p value < 0.05) (Table 4). It was observed that Abdominal subcutaneous fat thickness (ASFT) was significantly related to the degree of atherosclerosis in LAD and circumflex artery (Table 5).

Table 1: Descriptive summary for the age, anthropometric measurements and the derived indices of obesity and overweight

	Mean	Standard deviation (SD)	Minimum	Maximum
Age (years)	47.6	18.7	12	90
Height (cm)	163.9	10.6	140	190
Weight (kg)	56.2	14.6	32	90
BMI	20.8	4.3	12.8	30.4
Waist circumference(cm)	76.5	10.3	59	98
Hip circumference (cm)	84	8	65	105
WHR	0.91	0.08	0.75	1.15
ASFT (cm)	2.8	0.87	1	5
Wrist circumference(cm)	15.6	1.1	13	18

Table 2: Descriptive statistics: Age according to the degree of atherosclerosis in individual arteries

Arteries	Degree of Atherosclerosis	Age—Mean, SD
Aorta	Mild	34.7 (15.7)
	Moderate	41.8 (16.8)
	Severe	58.7 (15.6)
	P value	0.00
Rt Carotid	Mild	40 (19.1)
	Moderate	49 (18)
	Severe	58.6 (13.6)
	P value	0.006
Lt Carotid	Mild	38.6 (18.4)
	Moderate	52 (18.4)
	Severe	50.4 (9.9)
	P value	0.003
RCA	Unremarkable	22 (7.8)
	Mild	41.9 (17.9)
	Moderate	45.9 (17.9)
	Severe	55.9 (16.5)
	P value	0.000
LCA	Mild	37.6 (19.9)
	Moderate	47 (18.7)
	Severe	51.4 (17.2)
	P value	0.02
LAD	Mild	37.7 (16.4)
	Moderate	46.5 (20.1)
	Severe	51.7 (17.9)
	P value	0.02
Circumflex	Unremarkable	31.7 (15.6)
	Mild	41.2 (17.7)
	Moderate	53.7 (18.4)
	Severe	51.8 (16.5)
	P value	0.002

Table 3: Descriptive statistics: anthropometric measurements (Ht, Wt, BMI) according to the degree of atherosclerosis in individual arteries

Arteries	Degree of Atherosclerosis	Height Mean, SD	Weight Mean, SD	BMI Mean, SD
Aorta	Mild	162.9 (9)	52 (9)	19.6 (3.3)
	Moderate	164.8 (11.8)	55.9 (13.6)	20.5 (4.8)
	Severe	163.3 (9.9)	58 (16.9)	21.4 (4.8)
	P value	0.74	0.38	0.33
Rt Carotid	Mild	163.5 (12.2)	53.9 (11.4)	20.1 (3.7)
	Moderate	164.4 (10.2)	56.3 (15.2)	20.6 (4.4)
	Severe	162.9 (8.5)	61 (17.9)	22.6 (4.9)
	P value	0.86	0.34	0.21
Lt Carotid	Mild	163 (11.4)	54.4 (10)	20.4 (3.2)
	Moderate	163.9 (10.5)	55.7 (15.8)	20.5 (4.6)
	Severe	166.3 (8.8)	64.5 (17.8)	23.2 (5.3)
	P value	0.70	0.14	0.17
RCA	Unremarkable	162.7 (14.5)	50.5 (13.2)	18.9 (4.2)
	Mild	164 (10.9)	55.6 (14.4)	20.4 (3.9)
	Moderate	164.3 (10.4)	55.7 (10.2)	20.7 (3.6)
	Severe	163.6 (10.5)	57.6 (17.9)	21.3 (5.1)
	P value	0.98	0.79	0.69
LCA	Mild	164 (10.5)	54 (12.5)	20 (3.9)
	Moderate	164.6 (11.1)	55.5 (13.6)	20.4 (4.1)
	Severe	163.5 (10.5)	57.3 (15.9)	21.2 (4.5)
	P value	0.9	0.69	0.49
LAD	Mild	161.9 (9.7)	55.5 (11.5)	21 (3.5)
	Moderate	164.7 (12)	52.7 (13.2)	19.3 (3.8)
	Severe	164 (9.9)	58.7 (16)	21.6 (4.6)
	P value	0.67	0.17	0.04
Circumflex	Unremarkable	160.5 (11.2)	53.4 (13.4)	20.7 (4.8)
	Mild	163.6 (11.4)	53.9 (11.9)	20 (3.3)
	Moderate	162.5 (10)	53.9 (12.3)	20.4 (4)
	Severe	167.6 (9.7)	63.4 (19)	22.3 (5.4)
	P value	0.23	0.04	0.22

Table 4: Descriptive statistics: anthropometric measurements (WC, HC, WHR) according to the degree of atherosclerosis in individual arteries

Arteries	Degree of Atherosclerosis	WC Mean, SD	HC Mean, SD	WHR Mean, SD
Aorta	Mild	71.9 (7.4)	81.4 (8.7)	0.89 (0.08)
	Moderate	76.4 (9.8)	84.8 (7.3)	0.90 (0.07)
	Severe	78.5 (11.3)	84.5 (8.4)	0.93 (0.08)
	P value	0.09	0.33	0.09
Rt Carotid	Mild	72.6 (9.1)	83.5 (7.3)	0.86 (0.7)
	Moderate	77.5 (10.4)	84 (8.5)	0.92 (0.07)
	Severe	81.2 (10.6)	85.8 (7.7)	0.94 (0.08)
	P value	0.02	0.70	0.001
Lt Carotid	Mild	72.7 (8.1)	83.3 (7.7)	0.87 (0.08)
	Moderate	77.6 (10.7)	84.2 (8.2)	0.92 (0.06)
	Severe	82.4 (11.3)	85.8 (8.3)	0.96 (0.08)
	P value	0.01	0.68	0.002
RCA	Unremarkable	71 (8.3)	83.5 (11.6)	0.85 (0.04)
	Mild	76.3 (9.8)	83.9 (8.2)	0.91 (0.08)
	Moderate	76.4 (8)	84.3 (4.9)	0.91 (0.08)
	Severe	77.4 (12.6)	84 (9.8)	0.92 (0.08)
	P value	0.71	0.99	0.43
LCA	Mild	74.8 (9.2)	84.6 (8.1)	0.88 (0.06)
	Moderate	74.1 (10.4)	83.9 (7.2)	0.88 (0.07)
	Severe	78.8 (10.3)	84 (8.6)	0.94 (0.07)
	P value	0.09	0.96	0.001
LAD	Mild	76.6 (9)	85.1 (6.9)	0.89 (0.06)
	Moderate	73 (8.9)	82.6 (7.1)	0.88 (0.06)
	Severe	78.8 (11)	84.8 (8.9)	0.93 (0.08)
	P value	0.04	0.41	0.025
Circumflex	Unremarkable	73.3 (10.2)	84 (9.5)	0.87 (0.06)
	Mild	74.8 (8.9)	83.3 (7.2)	0.89 (0.08)
	Moderate	75.8 (9.8)	83.4 (7.4)	0.90 (0.07)
	Severe	81 (12)	86.2 (9.6)	0.94 (0.08)
	P value	0.09	0.55	0.08

Table 5: Descriptive statistics: anthropometric measurements (ASFT, Wrist circumference)according to the degree of atherosclerosis in individual arteries

Arteries	Degree of Atherosclerosis	ASFT, Mean, SD	Wrist circumference Mean, SD
Aorta	Mild	2.6 (0.61)	15 (0.96)
	Moderate	2.7 (0.9)	15.7 (1.2)
	Severe	3 (0.9)	15.6 (0.99)
	P value	0.07	0.08
Rt Carotid	Mild	2.6 (0.78)	15.4 (1.2)
	Moderate	2.9 (0.88)	15.6 (1.1)
	Severe	2.9 (1.03)	15.8 (0.93)
	P value	0.24	0.58
Lt Carotid	Mild	2.6 (0.6)	15.3 (1.1)
	Moderate	2.9 (0.9)	15,6 (1.1)
	Severe	2.9 (1.3)	15.9 (0.9)
	P value	0.08	0.32
RCA	Unremarkable	2.8 (0.5)	15 (1.4)
	Mild	2.7 (0.8)	15.4 (1.2)
	Moderate	2.7 (0.7)	15.7 (1)
	Severe	3 (1.1)	15.6 (1.1)
	P value	0.43	0.6
LCA	Mild	2.7 (0.9)	15.1 (1.1)
	Moderate	2.6 (0.8)	15.6 (1.1)
	Severe	3 (0.9)	15.7 (1)
	P value	0.10	0.27
LAD	Mild	2.9 (0.78)	15.3 (1)
	Moderate	2.4 (0.69)	15.5 (1.3)
	Severe	3 (0.91)	15.7 (1)
	P value	0.001	0.49
Circumflex	Unremarkable	2.7 (0.95)	15.6 (1.3)
	Mild	2.6 (0.6)	15.4 (0.96)
	Moderate	2.8 (0.8)	15.6 (1.2)
	Severe	3.3 (1.2)	15.7 (1)
	P value	0.01	0.79

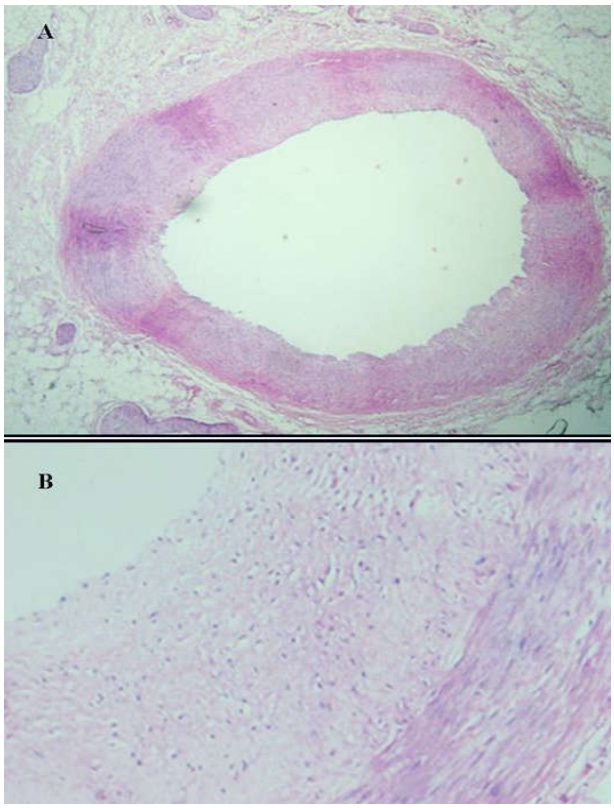

Fig. 1A: Photomicrograph from circumflex artery showing normal histology— Grade 0 in AHA classification. (H&E, X40) **B.** Photomicrograph from right coronary artery showing scattered foam cells within the intima—Grade 1 in AHA classification. (H&E, X100)

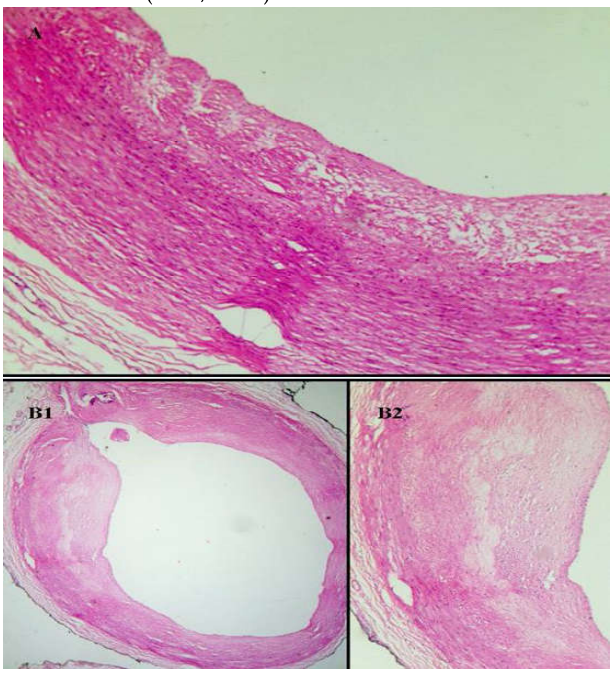

Fig. 2 A: Photomicrograph from right coronary artery showing mild thickening of intima with layers of lipid laden macrophages — Grade 2 in AHA classification. (H&E, X100) **B.** Photomicrograph from cicumflex artery shows thickening of intima with foam cells and focal pools of extracellular lipid— Grade 3 in AHA classification. **(B1)** H&E, X40, **(B2)** H&E, X100

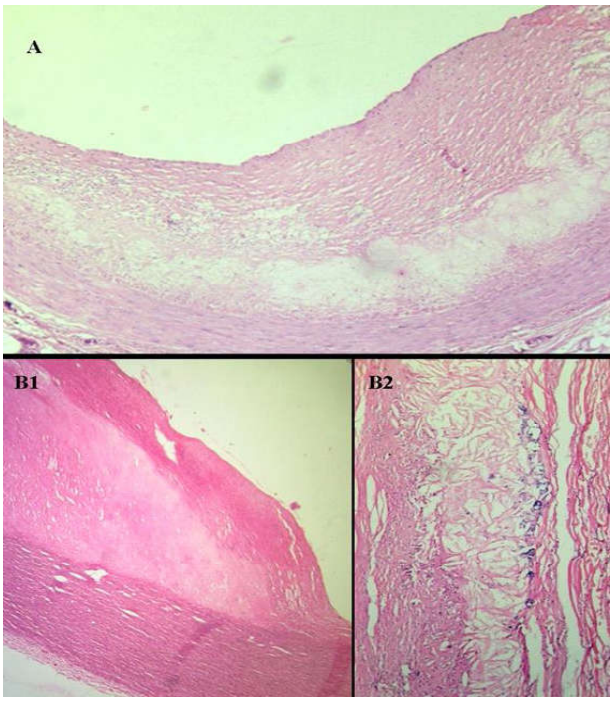

Fig. 3A: Photomicrograph from carotid artery shows confluent core of extracellular lipid in the intima — Grade 4 in AHA classification. (H&E, X100). **B.** Photomicrograph of grade 5 lesion in aorta. (B1) Intima shows lipid core covered by a thick fibrous cap (H&E, X100) , (B2) Plaque showing cholesterol clefts (H&E,X400)

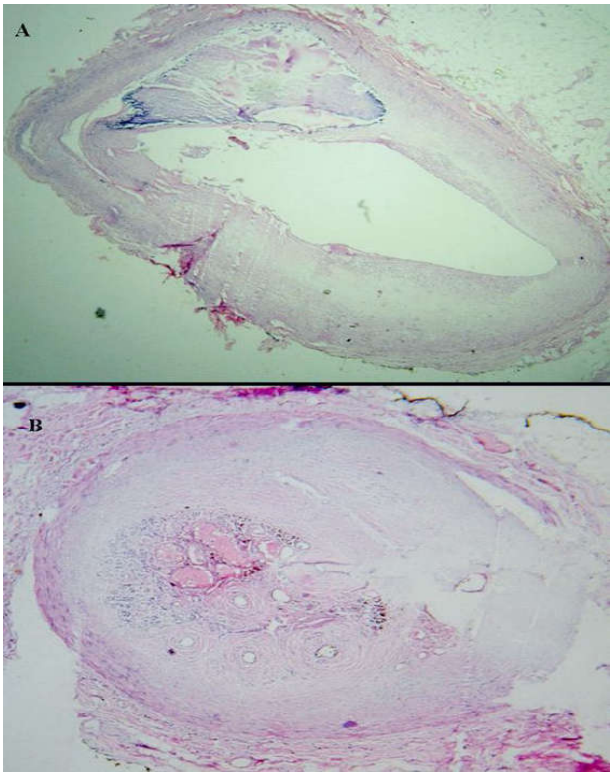

Fig. 4A: Photomicrograph from left coronary artery showing plaque with extensive calcification in the wall—Grade 5 in AHA classification (H&E, X40) **B.** Photomicrograph from LAD showing complete occlusion by an atheromatous plaque with a thrombus in the lumen—Grade 6 in AHA classification. (H&E, X40)

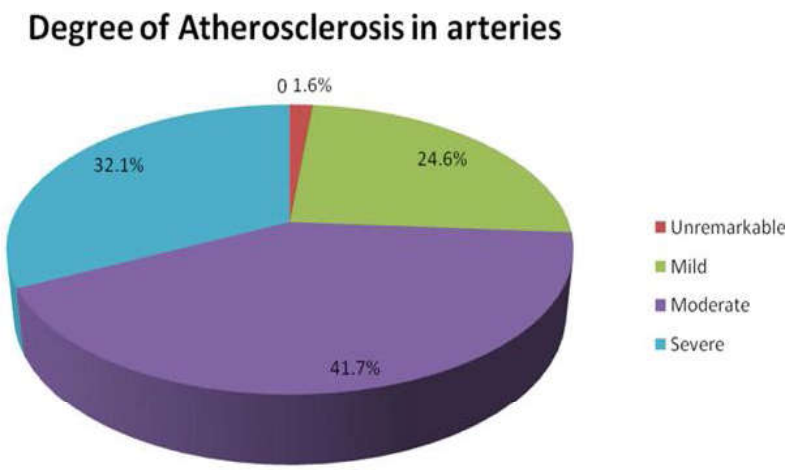

Fig. 5: Degree of atherosclerosis in arteries

Discussion

It was observed that the grades of atherosclerosis in all the arteries were significantly related to age. This was comparable to the Bogalusa Heart Study [7] and various other studies conducted by Soren Dalger et al [8], Laura R Loehr et al [9], Jennifer G Robinson et al [10] and Bryant J Webber et al [11]. In the present study the mean grade of atherosclerosis was found to be maximum for LAD and LCA followed by Aorta. This was comparable to the study done by Prateek Rastogi et al [12] which also showed a maximum mean grade of atherosclerosis in LAD followed by LCA and RCA.

In our study weight was significantly related to the degree of atherosclerosis in circumflex artery only. Seven Countries Study [13] and massive autopsy study by Henry C. McGill, Jr [14] revealed little correlation between body weight and incidence of CHD. Our study showed a significant relation between BMI and degree of atherosclerosis in LAD and not in other arteries. This was comparable with the Pathological Determinants of Atherosclerosis in Youth study [3] which also showed a positive association between BMI and atherosclerotic lesions in LAD and RCA.

According to WHO, Waist Circumference along with the Waist Hip Ratio, is an approximate indicator of intra-abdominal fat mass and total body fat [15]. A study by Alexander showed a strong association between coronary heart disease and central obesity [16]. In the present study WC was significantly related to the degree of atherosclerosis in LAD and both carotid arteries (p value < 0.05), WHR was significantly related to the degree of atherosclerosis in LAD, LCA and both carotid arteries (p value < 0.05) and ASFT was significantly related to the degree of atherosclerosis in LAD and circumflex artery. Wrist circumference may be an easy to detect measure of skeletal frame size that's not severely confounded by body fat variation around the time of puberty. Tehran Lipid and Glucose Study [6] showed significant associations between wrist circumference and diabetes risk factors. But our study showed no significant relation between the grade of atherosclerosis and wrist circumference.

Conclusion

The study showed a positive correlation of age, body weight, BMI, WC, WHR and ASFT with atherosclerotic changes in the various arteries. The grades of atherosclerosis in all the arteries were significantly related to age. BMI and weight were significantly related to the degree of atherosclerosis in LAD and circumflex artery respectively. WC and WHR were significantly related to the degrees of atherosclerosis in LAD and both carotid arteries. ASFT was significantly related to the degrees of atherosclerosis in LAD and circumflex artery. No significant relation was observed between the grade of atherosclerosis and height, HC and wrist circumference.

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