

Research Article

Asymptomatic carotid artery stenosis and correlation with coronary artery stenosis among 200 patients undergoing CABG

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Abstract

AIM: To study the incidence of asymptomatic carotid artery stenosis among patients undergoing CABG. To find its correlation with age, sex and any predilection to side and site of carotid artery.

Methods: Doppler ultrasound of carotid arteries was done in 200 patients aged between 35 and 75 years undergoing Carotid Artery Bypass Grafting (CABG). Patients without any pre existing neurological deficits in the last 6 months were included in the study.

Results: Among the study population, 34 cases (17%) of carotid artery stenosis cases were found. The highest number of patients 17 (50%) was found in the age group of 56-65 years. The prevalence of carotid artery stenosis among patients aged more than 55 years (21.5%) is significantly high ($p < 0.05$), than patients less than 55 years (10.1%) old. Out of 34 cases, 38% had bilateral carotid artery stenosis. The commonest site involved was at carotid bulb and internal carotid artery (CB and ICA) in 61.9% of cases. The average IMT of patients who had normal carotid arteries was found to be 0.1193mm on right side and 0.1151mm on left side.

Conclusions: Males are at more risk than females. In the age group of 56-65yrs, there is a peak incidence of asymptomatic carotid artery stenosis. The carotid stenosis correlated with severity of coronary artery disease. The average IMT of carotid arteries of Indian patients who had normal carotid arteries was found to be 0.1193mm on right side and 0.1151mm on left side.

Keywords: atherosclerosis, screening, intima medial thickness, Indian population

1. Introduction

Atherosclerosis is the formation of fibrofatty plaques in intima, resulting in narrowing of the lumen of blood vessels. It is of interest to note that this atherosclerosis is a systemic process affecting not only coronary blood vessels but also other vessels including aorta, carotid arteries, iliac arteries etc.¹ Just like the general population there is not enough attention paid by medical fraternity to look into the status of other vessels in patients with significant coronary artery disease.

The pathogenesis of atherosclerosis results essentially in narrowing of the lumen of the artery. The disease may be silent and asymptomatic or obvious and symptomatic in any of the artery stenosis. Essentially a systemic disease, the atherosclerosis as already mentioned, can be silently progressive as in silent heart attack when coronaries are involved and transient cerebro vascular ischemic attack (TIA) when carotid arteries are affected.

The incidence of morbidity and mortality can be paralleled to coronary artery disease, now more and more in younger age group but continues to be less noticed. There is an increased incidence of Transient Ischemic Attack (TIA) and

stroke in patients undergoing Coronary Artery Bypass Grafting (CABG) surgery.² The risk of stroke is increased in patients with significant carotid artery stenosis. Because most of the patients with significant carotid stenosis are asymptomatic, it is mandatory to screen the status of carotid arteries prior to CABG³.

Thus the curiosity to know about the simultaneous progress and manifestations of disease in carotid arteries has prompted the author to study the parallels and modalities in both Coronary Artery disease and Carotid Artery stenosis. A patient having central neurological event with symptoms within last 6 months is labelled as symptomatic carotid artery disease and no symptoms in last 6 months is labelled as asymptomatic carotid artery disease.

There are many methods to diagnose the carotid artery disease. They are Doppler ultrasound, CT angiogram, MRI angiogram, cerebral angiography. There are different positive and negative aspects of each diagnostic tool. Among all, the most accurate test is carotid angiogram which is invasive and expensive. Doppler ultrasound has been widely accredited as the best screening tool with accuracy comparable to carotid angiogram in 93% of cases⁴.

Even though the atherosclerosis starts in the intimal layer of the arterial wall, the B mode ultrasound cannot measure the intimal thickness alone. It measures the combined thickness of the intima and medial layers, the so called intima medial complex. Many studies have shown a close correlation between the IMT of carotid artery measured by high resolution ultrasonography and presence of coronary artery disease or atherosclerotic risk factors. Because of this reason we selected Doppler ultrasound as the screening test to study the status of carotid arteries among 200 asymptomatic patients undergoing CABG^{5,6}.

In order to assess the incidence of carotid artery stenosis, we performed pre operative carotid Doppler among 200 patients posted for CABG. We got all the carotid Doppler scans done by single experienced radiologist on Hewlett-Packard sonos 5500 machine. We got all the picture prints of both the carotid arteries, with intima-medial thickness and degree of stenosis. We looked into the correlation between carotid artery stenosis and severity of coronary artery disease. We also looked for any correlation with site and side of carotid artery stenosis in the study population.

Zarins CK, *et al*¹⁰ observed that the carotid disease develops largely at carotid bifurcation because of local flow dynamics such as wall shear stress and tensile stress induced by blood flow. Furlan A J *et al*² retrospectively identified 144 patients who underwent CABG in the presence of ICA stenosis more than 50%. They found that 126 patients had bilateral carotid stenosis while only 18 had unilateral carotid stenosis. It was also shown that marked stenosis and ulcerated lesions have significant risk of subsequent cerebral infarction¹². Crouse JR *et al*¹³ have confirmed, using B mode ultrasonography of extra-cranial arteries to establish the extent of atherosclerosis. The intimal thickening and atherosclerosis develop largely in regions like carotid artery bifurcation where flow departs from a laminar, unidirectional to a turbulent non laminar flow state..

Langsfeld M *et al*⁴ showed that early phases of atherosclerotic plaque formation may result in thickened arterial walls. Thus there is a growing interest in measuring Intima-medial thickness (IMT) to study the natural history of atherosclerosis. George Howard PH *et al*^{4,22} found that Median Intima Medial Thickness (IMT) ranged between 0.5mm to 1.0mm at all ages and both in men and women. Men had uniformly larger IMT than women. Crouse J R *et al*¹³ concluded that the IMT mean at CCA and bifurcation correlated with status of coronary atherosclerosis. The IMT at common carotid artery alone may be justifiable and preferable for analysis.

Evangelopoulos N *et al*¹ found that out of 18,050 patients, 77.6% had Triple vessel disease. Among 18,050 patients 313 (1.73%) had both coronary and carotid stenosis. 27.8% had right ICA stenosis, 24% had left ICA stenosis and 48.2% had bilateral carotid stenosis. Among patients with both coronary and carotid disease, 59.1% were asymptomatic for carotid disease. Depairon M *et al*¹⁹ studied healthy women (53) and men (45) aged between 20-60 years using Doppler ultrasound. They observed that the mean IMT among women was 0.556mm and among men was 0.573mm. The age was significantly correlated to the increase in carotid IMT. Francesca Cirilo *et al*,² concluded that one patient out of 6 triple vessel disease has a significant carotid lesion which may cause severe postoperative complications. Bradshaw PJ *et al*,¹⁴ studied 602 persons aged between 18-74 years using Doppler ultrasound. They evaluated the risk factors and carotid IMT. They found high prevalence (40%) of carotid plaques among study population. The abnormal IMT cut off was 0.71mm in males and 0.62mm in females.

2. Methodology

In this study Doppler ultrasound of carotid arteries was done in 200 patients undergoing Carotid Artery Bypass Grafting (CABG). Patients were aged between 35 and 75 years. Both males and females were included in the study. The

author restricted the study only to asymptomatic carotid stenosis patients. The patients without any pre existing neurological deficits like paralysis, seizures or history of neurological event like Transient Ischemic Attack (TIA) or Stroke in the last 6 months were labelled as asymptomatic carotid artery stenosis group. The author recorded the findings of coronary angiogram of all 200 patients, accordingly labelled them as Triple Vessel Disease (TVD), Double Vessel Disease (DVD) or Single Vessel Disease (SVD).

The machine used was Hewlett-Packard Sonos 5500 which can perform duplex scan with accuracy. The scan was performed in longitudinal and transverse planes with anterior, lateral and posterior approaches. The common carotid, carotid bifurcation (carotid bulb), internal carotid and external carotid arteries were studied in all subjects. The IMT was defined as the distance between the leading edge of lumen – intima echo and the leading edge of media-adventitia echo²³. All the measurements like Intima-Medial Thickness (IMT) at common carotid (CCA), carotid bulb (CB), internal carotid (ICA) and external carotid (ECA) arteries along with flow-velocity and percentage of stenosis were recorded and saved on video tape. The printouts of each patient were taken for subsequent analysis.

The data was statistically analysed using chi square test and standard error of difference of means appropriately.

2.1 Measurements

Measurements were made on carotid arteries of both sides. The common carotid artery (CCA) was studied for a length of 3 cm proximal to bifurcation. The internal carotid artery (ICA) and external carotid artery (ECA) were studied 1.5 cm distal to the bifurcation. The thickest IMT in mm was recorded, at the common carotid (CCA), carotid bulb (CB), internal carotid artery (ICA) and external carotid artery (ECA).

Figure 1. Duplex scan of carotid arteries with IMT (mm)

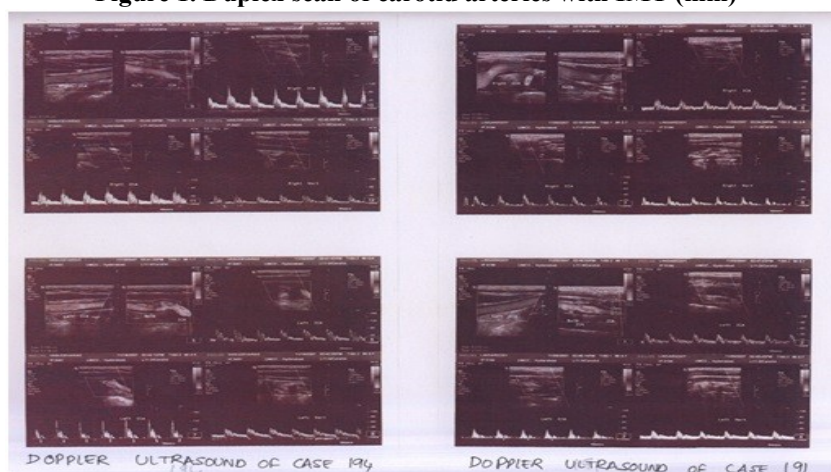


Table No.1 Format For Data And Results Of Each Of 200 Subjects

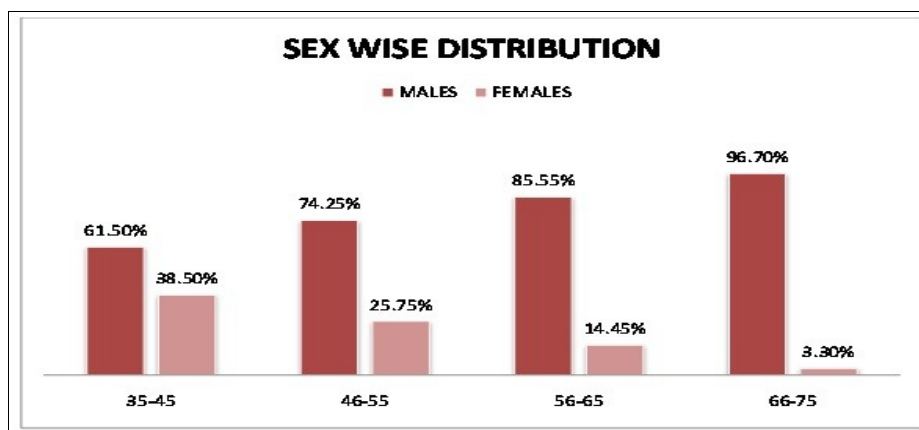
Sl. No	
Name	
Ip.No.	
Age	
Sex	
History of Neurological Symptoms (Last 6 Months)	
Findings of Coronary Angiogram(TVD/DVD/SVD)	
Doppler Ultrasound Findings:	
Side (Right/Left)	
Site (CCA/CB/ICA/ECA)	
Percentage of Stenosis (Right/Left)	
Intima Medial Thickness (Mm) Right/Left	

3. Results

3.1 Carotid Stenosis and Sex

Among study population the highest percentage (96.7%) of male patients and female (38.5%) patients in study population were found in the age group of 35-45 years. This finding is shown in figure no.2

Figure No. 2 Sex wise Distribution



3. 2. Carotid Stenosis and Age

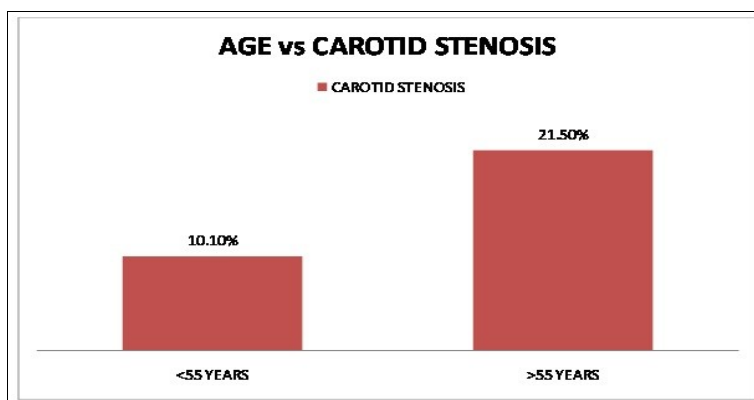
Among patients aged below 55years, the carotid stenosis was found in 8/79 (10.1%) and among patients aged above 55 years, 26/121 (21.5%) had carotid stenosis which is statistically significant ($p < 0.05$) as shown in Figure 3 and Table 2 below.

Table 2 Carotid Stenosis vs Age

Age	Carotid Stenosis	Percentage	Normal Carotid	Percentage	Total
< 55 Years	8	10.10%	71	89.90%	79
> 55 Years	26	21.50%	95	78.50%	121
Total	34		166		200

$X = 4.37$, $p < 0.05$, $d.f = 1$

Figure 3 Age Vs Carotid Stenosis



3.3 Side Wise Involvement of Carotid Stenosis

The author has studied the sidewise involvement of carotid arteries in total 34 cases of carotid artery stenosis and observed that, 13 cases had bilateral involvement of carotid artery stenosis, the incidence being 38%. 21 cases had unilateral

carotid artery involvement. Among these, 11 cases had right side carotid artery stenosis, the incidence being 32% and 10 cases had left side carotid artery stenosis, the incidence being 30%. This is shown in Table 3

Table 3 Side Wise Involvement Of Carotid Artery Stenosis

Side	Number	Percentage
Right	11	32.00%
Left	10	30.00%
Percentage	13	38.00%
Total	34	100.00%

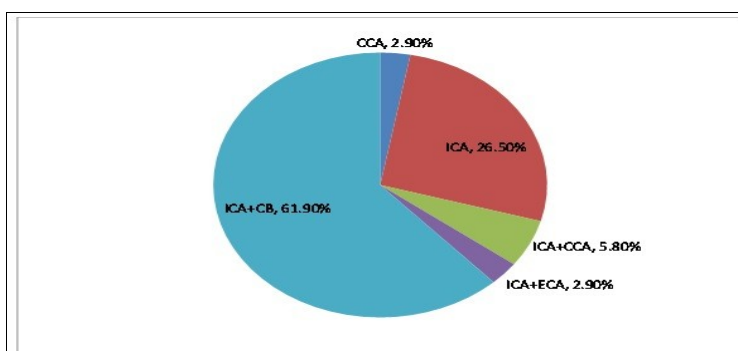
3.4 Site Wise Involvement Of Carotid Artery Stenosis

The author has studied the site of involvement of carotid artery stenosis. In some of the cases more than two sites were involved. Out of total 34 cases of carotid artery stenosis, In 21 cases there is a involvement of both I.C.A and C.B., the incidence being 61.9% and In 9 cases the ICA is involved, the incidence being 26.5%. In 2 cases the ICA and CCA were involved, incidence being, 5.8% CCA alone was involved in 1 case, incidence being 2.9% ICA and ECA were involved in 1 case, incidence being 2.9%. These findings are shown in Table 4 and figure 4.

Table 4. Distribution According To Site Wise Involvement Of Carotid Artery Stenosis

Site	Number	Percentage
CCA	1	2.90%
ICA	9	26.50%
ICA+CCA	2	5.80%
ICA+ ECA	1	2.90%
ICA+CB	21	61.90%
Taotal	34	100.00%

Figure No.4 Distribution According To Site Wise Involvement Of Carotid Artery Stenosis



3.5 Mean IMT in Study Population

The author has calculated the mean intima media thickness (IMT) of right and left sides in both carotid artery stenosis group and normal carotid group. The mean intima media thickness (IMT) of normal carotid groups On the right side 0.1193mm, On the left side 0.1151mm. The mean intima media thickness (IMT) of carotid artery stenosis group. On the right side 0.2482m, On the left side 0.2323mm. This finding is shown in Table 5 and figure 5.

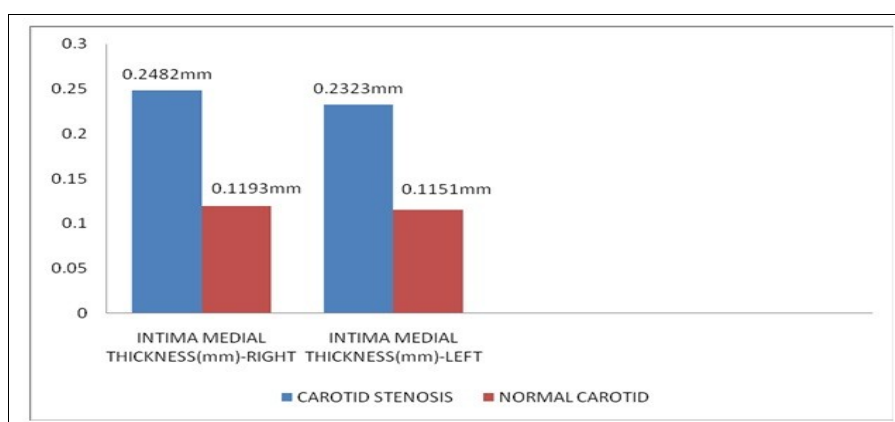
The author calculated the standard error of difference (SED) between two means and below values are observed. The standard error of difference between two means on the right side is 0.000123 and t value is 103.22 and $p < 0.01$ which is statistically significant. The standard error of difference between two means on the left side is 0.000156 and t value is 73.74 and $p < 0.01$ which is statistically significant. The mean intima media thickness (IMT) on right side for carotid artery stenosis cases was 0.2482 compared to 0.1193 in normal carotid groups. This difference in the intima media thickness was statistically highly significant.

The mean intima media thickness(IMT) on left side for carotid artery stenosis cases was 0.2323 compared to 0.1151 in normal carotid groups. This difference in the intima media thickness was statistically highly significant.

Table 5. Mean Intima Medial Thickness in Study Population

	Right Side			Left Side		
	Mean Intima Medial thickness	S.E.D	T value	Mean Intima Medial thickness	S.E.D	T value
Carotid Stenosis (34)	2.2482	0.000123	103.22	0.2323	0.000156	73.74
Normal Carotid (166)	0.1193		P<0.01	0.1151		P<0.01

Figure 5 Intima media thickness(IMT) of right and left sides in both groups



3.6 Carotid Stenosis and Severity of Coronary Disease

The author has observed that among 34 cases of carotid artery stenosis, there were 27 cases of triple vessel disease, 7 cases of double vessel disease. There were no patients with single vessel disease with carotid artery stenosis.

4. Discussion

4.1 Age and Sex

Evangelopoulos *et al*¹ retrospectively studied 18,050 patients who underwent CABG. They found that the males comprised of 76.7% and females comprised of 23.3%, with mean age of 66.4 years. Ciril *et al*,⁸ have studied 302 patients comprising of 83.8% males and 16.2% females. The mean age was 63 years. Deangeles *et al*,⁹ have studied 365 patients comprising of 46.8% males and 53.2% females. The mean age was 67 years as displayed in table 6.

In the present study 200 patients comprising of 82% males and 18% females. The percentage of males among carotid stenosis (34) cases was 85.3% and that of females was 14.7%. The mean age of study population was 57.5 years. The incidence of carotid stenosis among patients with age <55 years was 10.1% and that among patients with age >55 years was 21.5% with p<0.05. This analysis suggests that the incidence of carotid stenosis was higher in higher age group as noted in earlier studies.

Table 6. Showing Comparative Study of Age and Sex Wise Distribution

S. No	Author's Name	Total Number of Study Population	Male	Female	Mean Age in Years
1.	Evangelopoulos	18,050	76.7%	23.3%	66.4
2.	Ciril <i>et al</i>	302	83.3%	16.2%	63
3.	Deangeles <i>et al</i>	365	46.85	53.2%	67
4.	Present study	200	85.3%	14.7%	57.5

4.2 Incidence Of Carotid Artery Stenosis:

Evangelopoulos¹ observed in his study that among 18,050 cases 313(1.7%) had carotid stenosis. The patients with triple vessel disease were 77.6% among the study population and they had direct correlation between severity of carotid and coronary artery stenosis. Cirilo *et al*⁸, have noted in their study among 302 cases, 186 (61.6%) had carotid stenosis (symptomatic and asymptomatic). The incidence of asymptomatic carotid stenosis was 7.6%. The patients with triple vessel disease were 55.2% among 302 cases and they also correlated severity of carotid and coronary artery disease. Rajamani *et al*⁹: They observed that among 101 patients with ischemic heart disease, 37% had carotid artery stenosis. Henning *et al*²³ observed that the incidence of carotid artery stenosis among 431 patients was 14%. In another group of patients of 483 cases, the incidence was 21% as shown in table 7.

In the present study we observed that among 200 cases, the incidence of carotid stenosis was 34(17%). The patients with triple vessel disease were 76.5% among study population. Among the cases of triple vessel disease, 27 cases have shown carotid artery stenosis thereby making the incidence of carotid stenosis in patients with triple vessel disease is 79.4%, double vessel disease was 20.6% none of them had single vessel disease. It suggests that the severity of carotid stenosis was correlated to severity of coronary artery disease as noted in above studies.

Table 7. Showing Comparative Study of The Incidence of Carotid Artery Stenosis

S. No	Author's Name	Number Of Study Population	Incidence Of Carotid Artery Stenosis
1.	Evangelopoulos	18050	1.7%
2.	Cirilo <i>et al</i>	302	61.6%
3.	Rajamani <i>et al</i>	101	37%
4	Henning <i>et al</i>	431 & 483	14% & 21%
5.	Bradshaw <i>et al</i>	602	40%
6.	Present study	200	17%

4.3 Side Of The Carotid Artery Stenosis:

Furlan *et al*² found that among 144 patients who had coronary and carotid artery stenosis, 126(87.5%) had bilateral carotid stenosis and 18(13.5%) had unilateral carotid stenosis. Evangelopoulos *et al*¹ have studied 313 patients using carotid Doppler. Among (313) patients with carotid artery stenosis, 27.8% had right carotid stenosis, 24% had left carotid stenosis and 48.2% had bilateral carotid stenosis.

In the present study, among 34 carotid stenosis cases, 32% had right carotid artery stenosis, 30% had left carotid and 38% had bilateral carotid stenosis. This observation is correlating with the studies of Furlan et.al and Evangelopoulos *et al*. as seen in table 8.

Table 8. Showing Comparative of Study of Side of The Carotid Artery Stenosis

S. No	Studies by	Right	Left	Bilateral	Number of cases Studied
1.	Furlan <i>et al</i>	Unilateral 13.5%	-	87.5%	144
2.	Evangelopoulos <i>et al</i>	27%	24%	48.2%	303
3.	Present study	32%	30%	38%	34

4.4 Site of Carotid Artery Stenosis

Golledge *et al*^{12,20}, have observed in their study on carotid artery stenosis, that the carotid artery bifurcation has a remarkable predilection for the development of atherosclerosis typically at the origin of internal carotid artery.

In the present study the highest incidence of carotid stenosis was found at ICA and CB (carotid artery bifurcation) in 61.9% of cases strengthening the above factors and findings.

4.5 Intima Media Thickness

Depairon *et al*¹⁹, have noted the reference values of IMT of carotid arteries among 98 cases aged between 20-60 years. They found that mean IMT was 0.573mm among males and 0.556mm among females. Arbel *et al*¹⁵ have noted that the mean IMT among men on right side was 0.625mm and among women IMT was 0.622mm. The mean IMT among men

on left side was 0.626mm and among women IMT was 0.615mm. Bradshaw *et al*¹⁴ have studied 602 persons aged between 18-74 years. They found that abnormal cut off for males was 0.71mm and 0.62mm for females.

In the present study the IMT in normal carotid group was 0.1193mm on right side and 0.1151mm on left side. The IMT in carotid stenosis group was 0.2482mm on right side and 0.2323mm on the left side. On calculation with standard error of difference between two means, the difference between two means was statistically significant ($p < 0.01$).

The author calculated the average IMT in carotid stenosis cases based on severity of stenosis. The author observed that the IMT in stenosis of <25% was 0.19mm, 26-50% it was 0.26mm, 51-75% it was 0.31mm and 76-99% it was 0.46mm linearly increasing with stenosis as displayed in table 9.

Table 9. Showing Coparative Study of The Intima Media Thickness of Carotid Artery Stenosis

Carotid IMT	Male	Female
Depairon	0.573mm	0.556mm
Bradshaw	0.71mm	0.62mm
Carotid IMT	Right	Left
Arbel	0.625mm	0.626mm
Present study	0.2482mm	0.2323mm

5. Conclusions

Among the total 200 cases of study population, 34 cases (17%) of carotid artery stenosis cases were found. Among these cases, 29(85.3%) were males and 5 (14.7%) were females, suggesting that males are at more risk than females. The highest number of patients 17 (50%) were found in the age group of 56-65 years suggesting that in this age group there is a peak incidence of asymptomatic carotid artery stenosis.

Among 34 carotid artery stenosis cases, there were 27(80%) triple vessel disease cases suggesting that the carotid stenosis is highly prevalent among patients with severe coronary artery disease. This observation confirms that the atherosclerosis parallelly progresses in both coronary and carotid vascular beds in the presence of atherosclerotic risk factors.

5.1 Age: The prevalence of carotid artery stenosis among patients aged more than 55 years (21.5%) is significantly high ($p < 0.05$), when compared with patients of less than 55 years (10.1%) of age.

5.2 Side : Among 34 carotid artery stenosis cases, 38% had bilateral carotid artery stenosis, 32% had right side and 30% had left side carotid stenosis suggesting higher incidence of bilateral carotid artery stenosis. This result is consistent with other studies.

5.3 Site: Among 34 cases of carotid artery stenosis, the commonest site involved was at carotid bulb and internal carotid artery (CB and ICA) in 61.9% of cases. The next commonest site involved was internal carotid artery (ICA) seen in 26.5% of cases. This confirms the findings of previous studies that atherosclerosis predominantly affects the carotid artery bifurcation due to its typical flow characteristics.

5.4 Intima Medial Thickness: The average IMT of carotid arteries of 164 patients who had normal carotid arteries was found to be 0.1193mm on right side and 0.1151mm on left side. The average IMT of carotid arteries of 34 patients who had carotid stenosis was found to be 0.2482mm on right side and 0.2323mm on left side.

Further studies are required to know the incidence of carotid artery disease among patients without any risk factors among Indian population.

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