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Original Research Article

Ultrasonographic Evaluation of Carotid Artery Atherosclerosis in Normotensive and Hypertensive Individuals

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Abstract: Hypertension is an important and independent risk factor for atherosclerosis which is a major killer throughout the world. Hence, it is very important to identify initial atherosclerotic changes so that more vigorous preventive measures can be taken. Various non-invasive markers of early arterial wall alteration are currently available. Of them, Intima-media thickness (IMT) and Resistive index (RI) of carotid are important parameters that can be assessed by Duplex sonography in a relatively simple way and represents safe, inexpensive, precise and reproducible measure. Intima-media thickness [IMT] as morphological value and Resistive index [RI] as a hemodynamic value reflects atherosclerotic process in an indirect manner and these can be assessed as a surrogate marker of generalized atherosclerosis. We, at PDVVPF'S Medical College & Hospital, conducted a Clinical Cross Sectional Study which evaluated Carotid Intima-media thickness [IMT], Peak systolic velocity [PSV], End diastolic velocity [EDV], Resistive index [RI], plaques & stenotic changes in carotid artery in hypertensive patients using High frequency B-scale ultrasound and Color Doppler. Then compared these findings with normotensive subjects. The Statistical software namely SPSS 11.0 and Systat 8.0 were used for analysis of data. We found that Intima media thickness [IMT] and Resistive index [RI] in hypertensives were significantly increased compared to normotensives. There was highly significant correlation between Systolic blood pressure [SBP], Diastolic blood pressure [DBP] and Mean arterial pressure [MAP] with IMT and RI. So, carotid assessment by above mentioned parameters can serve as a screening tool to predict outcome of future cardiovascular and cerebrovascular accidents.
Keywords: Ultrasonography, Doppler, Carotid Artery, Hypertension, Atherosclerosis, Intima-Media Thickness, Resistive Index

INTRODUCTION

Vascular system of human body is prone for atherosclerosis by various risk factors among which hypertension is an important and independent risk factor. It is one of the major killers throughout the world and Asians are more prone for atherosclerosis compared to western world. So, it is very essential to implement a comprehensive method for identification of initial atherosclerotic events in high-risk patients and also in general public so that more vigorous preventive measures can be taken. Various non-invasive markers of early arterial wall alteration are currently available. Of them, Intima-media thickness (IMT) and Resistive index (RI) of large artery walls, especially carotid are the important parameters that can be assessed by Duplex sonography in a relatively simple way and represents a safe, inexpensive, precise and reproducible measure. Intima- media thickness [IMT] as morphological value and Resistive index [RI] as a hemodynamic value reflects the atherosclerotic process in an indirect manner and these can be assessed as a surrogate marker of generalized atherosclerosis.

Stroke is the commonest life-threatening neurological disorder. It is also single most important cause of disability. According to World Health Organization estimates for the year 2020, stroke will be the second leading cause of death along with Ischemic heart disease, both in developing as well as developed countries. During the last three decades there is a decrease in the incidence of the stroke in the Western countries while the burden of the disease in South Asian countries (India, Pakistan, Sri Lanka and Bangladesh) has increased and is being predicted to rise further.

There are multiple risk factors that are associated with Stroke. They can be classified as modifiable and non-modifiable risk factors. Hypertension which is an independent and modifiable cause of serious cardiovascular diseases plays an important and critical role in atherosclerotic cardiovascular disease. The incidence of every clinical manifestation of cerebrovascular and coronary heart disease is increased in hypertensive patients as compared to the normotensive patients[1].

The human carotid arteries, located on each side of the neck, have the key role of carrying blood to the head. These arteries lends itself to study by high-resolution ultrasound devices because it is superficial in location, are relatively stationary, and runs parallel to the surface of the neck, at least to the level of the carotid bifurcation. Employing B-mode ultrasound, the 'double echo' pattern represents the combined width of the carotid artery intima and media, can be readily and reproducibly visualized in nearly all subjects.

Colour Doppler sonography became a mainstay in evaluation of the extra-cranial territory and its accuracy in comparison with angiography is well established. Carotid sonography has largely replaced angiography for suspected extra-cranial Carotid atherosclerosis. The principal appealing points in favour of sonography are patient comfort, lack of risk and accuracy. In contrast the angiography is invasive and expensive. Moreover contrast related adverse effects can also be avoided.

Increased Intima-media thickness [IMT] of an artery has been used as a surrogate marker of the early atherosclerotic process[2]. Many studies have shown that the atherosclerotic process start to develop in the carotids approximately at the same time as in aorta, actually preceding plaque occurrence in coronary arteries. It has also been shown that there is significant correlation between Carotid atherosclerosis and extent of coronary artery atherosclerosis suggesting that thickening of Intima media complex reflects the local morphological alterations in the carotid arteries as well as corresponds to generalized atherosclerosis[3].

The Resistive index [RI] according to Pourcelot is a hemodynamic parameter that is easily determined by Doppler sonography basically reflecting the vascular resistance, which in turn depends on distensibility of the vessel. So,Intima media thickness [IMT] and Resistive index [RI] are complementary to each other in assessing the atherosclerosis of vascular system[4].

Measurement of carotid intima-media thickness (CIMT) with B-mode ultrasound is a non-invasive, sensitive, and reproducible technique for identifying and quantifying atherosclerotic burden and CVD risk. It is a well-validated research tool that has been translated increasingly into clinical practice for predicting future risks.

AIMS AND OBJECTIVES

1. To assess Carotid Intima-media thickness [IMT], Peak systolic velocity [PSV], End diastolic velocity [EDV], Resistive index [RI], plaques & stenotic changes in hypertensive patients using High frequency B-scale ultrasound and Color Doppler.
2. To compare these findings in hypertensive subjects with normotensive subjects.

MATERIALS AND METHODS

It was a Clinical Cross Sectional Study. Data for our study was collected from the patients referred to Department of Radio diagnosis with clinically diagnosed essential hypertension. They were evaluated with B-scale and color Doppler. The normotensive subjects were patient's relatives, hospital and clinical staff.

We selected 50 hypertensive patients aged between 40-55 years and 50 normotensive subjects of same age group. All 100 individuals, 50 normotensives & 50 hypertensives were subjected for bilateral carotid Doppler. It involved B-mode and Doppler evaluation of bilateral carotid vessels. Various criteria's are available for determining hypertension. In our study hypertension was defined according to the criteria established by the Fifth Joint National Committee on Detection, Evaluation, and Treatment of high blood pressure which defined Hypertension as blood pressure > 140mmHg systolic or > 90mmHg diastolic[5].

All hypertensive patients and normotensive subjects with history of secondary hypertension, diabetes mellitus, smoking, alcoholism and postmenopausal women were excluded from the study.

Technique of Carotid Duplex Sonography

In the study we used Philips En Visor CHD ultrasound machine with 7.5-10 MHZ linear array transducer. B/L carotid arteries were carefully examined with regard to wall changes. (Figure 1) The I-M thickness [IMT] was defined as the distance between the leading edge of the lumen-intima echo and the leading edge of the media-adventitia echo[6]. Plaques were screened for in the common, internal and external carotid arteries and any stenosis was graded according to Washington criteria[7].

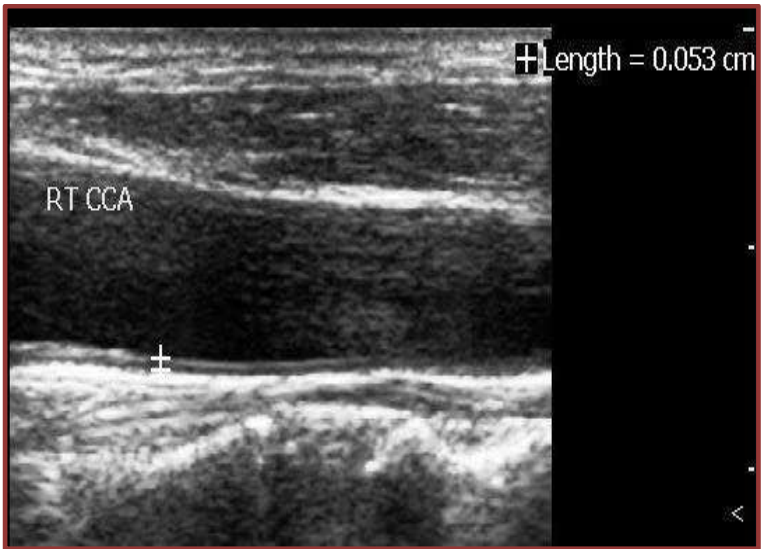

Fig- 1: Measurement of Intima-media thickness [IMT]

The measurement was done in an optimal longitudinal freeze-frame image by manual cursor placement. The far wall of the common carotid artery (CCA) at 1-2 cm proximal to carotid bulb was used for measurement of Intima media thickness [IMT]. The optimum magnification was used for Intima media thickness [IMT] measurement.

Measurement of Resistive index [RI]

The maximum systolic and minimum diastolic flow rates were determined and Resistive index [RI] was calculated automatically in a cycle by means of inbuilt software. (Figure 2)

The RI was calculated as follows:

$$\frac{\text{Peak Systolic Velocity} - \text{Minimum Diastolic Velocity}}{\text{Peak Systolic Velocity}}$$

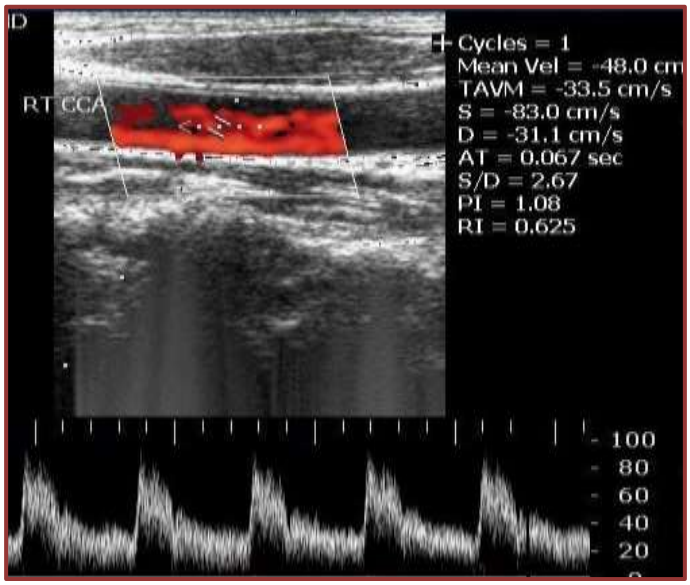

Fig-2: Color & Spectral Doppler Image Showing RI Value

Finally, based on bilateral measurements of Common carotid artery in 50 hypertensives and 50 normotensive subjects, the curves and graphs of the Intima media thickness [IMT] and Resistive index [RI] calculations were prepared.

Statistical Methods

Chi-square test has been used to find the significance of proportions of hypertensives in different age groups. Student‘t’ test has been used to find the significance of Blood Pressure parameters and Intima media thickness [IMT] between normotensives and

hypertensives. Mann Whitney U test has been used to find the significance of Resistive index between normotensive and hypertensives. Pearson correlation co-efficient has been used to find the degree of relationship between blood pressure parameters and the Intima-media thickness [IMT] and Resistive index [RI] for the normotensives and hypertensives. Student 't' test has been used to test the significance of Pearson correlation co-efficient[8,9]. The Statistical software namely SPSS 11.0 and Systat 8.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc**.**

RESULTS

Common carotid artery Intima media thickness [IMT] in normotensives was 0.49 mm and 0.50 mm for the right and left sides respectively. Resistive index [RI] in normotensives was 0.55 on both the sides. Intima media thickness [IMT] in hypertensives was 0.97 mm and 0.96 mm for right and left sides respectively. Resistive index [RI] in hypertensives was 0.77 on both the sides. So, Intima media thickness [IMT] and Resistive index [RI] in hypertensives were significantly increased compared to normotensives.

Table-1:Demographic Data of two groups

Demographic characteristics	Normotensive	Hypertensive	p value
Age	43.50±5.26	44.82±4.78	0.197
Sex	Female-40.0% Male-60.0%	Female-46.% Male-54.0%	>0.05
SBP	110.96±6.82	152.18±4.66	<0.01
DBP	75.96±5.11	99.08±2.93	<0.01
MAP	87.60±5.02	116.80±3.24	<0.01
HR	79.64±5.51	81.93±5.46	0.379
BMI	23.33±1.19	23.60±1.32	0.421
TC	145.8±8.21	169.57±3.60	>0.05
TG	137.25±9.25	177.17±5.23	<0.01

Table-2: Age distribution of Normotensives and Hypertensives (n = 100)

Age in years	Normotensives (n = 50)	Hypertensives (n = 50)	Total (n=100)	P value
41 - 45	21(42.0)	24(48.0)	45	0.527
46 - 50	18(36.0)	19(38.0)	37	0.183
51 - 55	11(22.0)	7(14.0)	18	0.582

Table-3: Effect of Hypertension on Intima media thickness [IMT] (Table and Diagram)

M- IMT	Normotensive	Hypertensive	Student t
Left	0.50 ± 0.09	0.96 ± 0.09	25.473**
Right	0.49 ± 0.09	0.97 ± 0.09	24.560**
Average	0.50 ± 0.09	0.97 ± 0.09	25.859**

Table-4: Effect of Hypertension on Resistive index [RI]

M-RI	Normotensive	Hypertensive	Mann Whitney U test
LEFT	0.55 ± 0.04	0.77 ± 0.03	P < 0.001**
RIGHT	0.55 ± 0.03	0.77 ± 0.04	P < 0.001**
AVERAGE	0.55 ± 0.04	0.77 ± 0.04	P < 0.001**

Table 5- Relationship between blood pressure parameters and IMT and RI in both groups

Blood pressure status	Normotensive(Pearson correlation)		Hypertensive(Pearson correlation)	
	IMT	RI	IMT	RI
Systolic	0.357* (0.024)	0.060 (0.714)	0.527** (0.000)	0.422** (0.000)
Diastolic	0.321* (0.043)	0.172 (0.288)	0.453** (0.000)	0.483** (0.000)
MAP	0.357* (0.024)	0.137 (0.399)	0.541** (0.000)	0.508** (0.000)

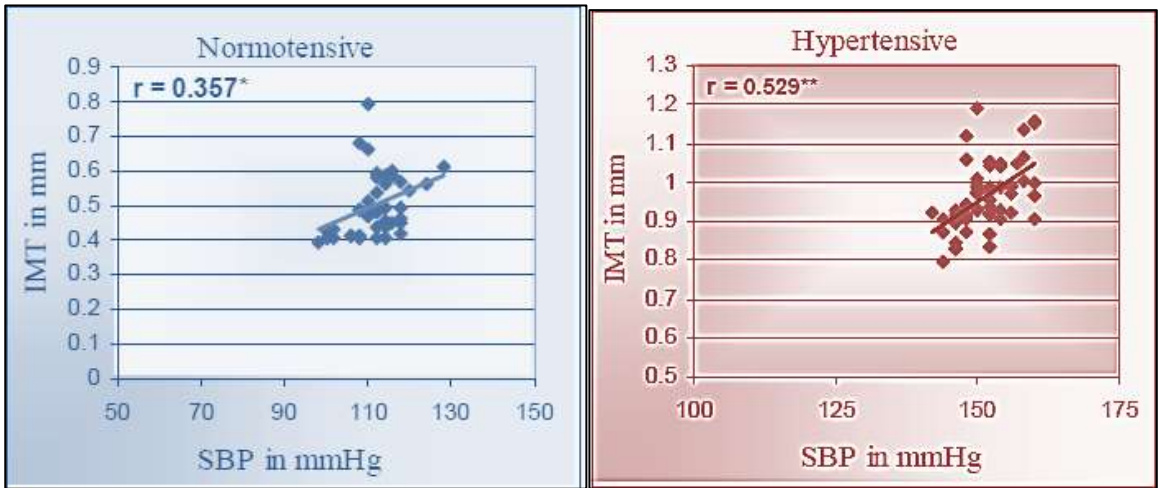

Fig- 1: Relationship between Systolic blood pressure and IMT in both groups

It was observed that, there was highly significant correlation between Systolic blood pressure [SBP], Diastolic blood pressure [DBP] and Mean arterial pressure [MAP] with IMT and RI.

DISCUSSION

Our study was a clinical cross sectional study done on hypertensive and normotensive subjects to know the effect of hypertension on Intima-media thickness [IMT] and Resistive index [RI] of carotid arteries which can be effectively done using high frequency ultrasound and Color Doppler sonography.

Our study results showed that there is highly significant [P<0.001] increased in Intima media thickness [IMT] and Resistive index [RI] of CCA in hypertensives compared with normotensives. Pearson correlation test was used to show the relationship between blood pressures parameters [SBP, DBP and MAP] with Intima media thickness [IMT] and Resistive index [RI] values of CCA. The results of the Pearson correlation test showed that there is highly significant [significance at 1%] relationship between hypertension and Intima-media thickness [IMT] and Resistive index [RI] values of CCA. The results of our study closely correlate with results of other previous studies[10-12].

In spite of many significant medical advances, atherosclerotic cerebrovascular disease such as stroke and atherosclerotic coronary artery disease such as myocardial infarction are responsible for more deaths than all other causes combined[13-14]. The strongest risk factor for atherosclerotic diseases is hypertension. The risk of cardiovascular diseases increases with isolated systolic hypertension and isolated borderline hypertension and these conditions are also associated with higher risk of subclinical atherosclerotic disease[15].

The arteries involved by atherosclerosis are the coronary, cerebral, and peripheral arteries which are of clinical importance[16]. The clinical manifestations of atherosclerosis tend to coexist, and the presence of one manifestation increases the likelihood of developing others because, major risk factors tend to affect all arterial territories. Also, clinical atherosclerosis in one area which may directly predispose the patient to occurrence of atherosclerosis in another vascular territory.

The adaptive thickening of the intima and the media was thought to be explanation for the Intima media thickening [IMT] along with increased LDL cholesterol and triglyceride levels occurring in hypertensives[17]. Such a thickening is characterized by remodeling to counteract the rise in wall tension observed as medial hypertrophy in the presence of hypertension. In contrast, maladaptive thickening involving monocyte recruitment and lipid accumulation in the intima occurs in the high BP group, in which endothelial Damage is more likely to be sufficient to initiate atherogenesis[18]. The ACAPS study supported these findings where the effect of the lipid-lowering lovastatin intervention was larger in hypertensive patients than in the normotensive group[19].

CONCLUSION

Hypertension is a well known major risk factor for atherosclerosis. Ultrasonography is an easy, safe, quick, accurate, noninvasive and non-expensive method of investigation of vessel wall changes in atherosclerosis. Early atherosclerotic changes represent increase in intima media thickness (IMT) & resistive index (RI). Intima media thickness is considered a morphological parameter and Resistive index [RI] as a hemodynamic parameter. These parameters can be assessed easily, accurately, noninvasively and in a cost effective way by high frequency ultrasound and Doppler study. Study we performed revealed that

Intima-media thickness [IMT] and Resistive index [RI] of common carotid artery are significantly increased in all hypertensive patients compared with normotensives.

Resistive index [RI] is the widely studied hemodynamic parameter that shows alteration in its value along with Intima media thickness [IMT] as the atherosclerosis progresses. This finding can help us to predict future cardiovascular and cerebrovascular pathologies. Moreover when both parameters are studied together they are less prone for inter-observer and intra-observer variability and will be more accurate.

Hence carotid assessment by above mentioned parameters can serve as a screening tool to predict outcome of future cardiovascular and cerebrovascular accidents.

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