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# Sonographic and Doppler Evaluation of Carotid Artery in Hypertension- A Correlative Study with Biochemical Parameters

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## A B S T R A C T

***Introduction*:** Hypertension is an important cause of cardiovascular diseases with around 80–95% of hypertensive patients diagnosed as having "essential" hypertension. An increase in Intima-media thickness (IMT) has been used as a marker of the early atherosclerotic process.***Material and Methods*:** A cross-sectional study was done at Department of Radiodiagnosis, SSIMS & RC, Davanagere, among 135 hypertensive patients above the age of 50 years, who were divided into two groups based on the grades of hypertension. Both grayscale (IMT and plaque assessment) and doppler (RI) parameters were assessed for bilateral CCA using high-frequency linear probe. All the patients' blood pressure parameters and Fasting lipid profile parameters were taken. A correlation of the data was performed & results were obtained after statistical analysis.***Results*:** Out of 135 cases with essential hypertension, 79 (58.5%) cases were Stage 1 hypertension [Subgroup I] and 56 (41.5%) cases were Stage 2 hypertension [Subgroup II] with almost equal distribution of both genders in each group.The Intima-Media Thickness (IMT) were higher in Subgroup II compared to Subgroup I. The Mean values of subgroup I were 0.725±0.017 and 0.731±0.019 respectively and that of subgroup II were 0.741±0.013 on both sides with statistically significant results.The correlation between ultrasound, Doppler, blood pressure and biochemical parameters - Systolic blood pressure showed a positive correlation with both the grayscale parameter or Doppler parameter which was statistically significant.***Conclusion*:** High frequency ultrasound with Color Doppler & biochemical parameters showed a significant correlation in the evaluation of Atherosclerosis involving carotid arteries.

**Keywords:** Intima-Media Thickness, plaque, Resistivity Index, Fasting lipid profile.

## INTRODUCTION

Hypertension is an important cause of serious cardiovascular diseases and premature mortality from such diseases [1].

Majority of hypertensive patients are diagnosed as having "essential hypertension". In the remaining 5–20% of hypertensive patients, a specific underlying disorder causing the elevation of blood pressure can be identified [2].

In India, hypertension is the leading non-communicable disease and is estimated to be attributable to nearly 10 per cent of all deaths [3].

Hypertension plays a critical role in atherosclerotic cardiovascular disease, but its impact is greatly influenced by coexistent contributors, particularly abnormalities in blood lipid and glucose metabolism [4].

An increase in Intima-media thickness (IMT) is a surrogate marker of the early atherosclerotic process [5].

Progressive atherosclerotic disease results in pathological intimal thickening, fibrous cap atheroma and plaque formation. Early detection helps to control the disease in patients who are at risk [7].

Though it is known that atherosclerosis reduces the distensibility of carotid arteries, their assessment is usually difficult. In contrast, the Resistive index (RI) is a hemodynamic parameter that is easily determined by Doppler sonography reflecting the vascular resistance, which in turn depends on the distensibility of the vessel. So, Intima media thickness (IMT) and Resistive index (RI) are complementary to each other in assessing the atherosclerosis of the vascular system [8].

Duplex Sonography combining high-resolution Imaging and Doppler spectrum analysis has proved to be a popular, noninvasive, accurate, cost- effective means of detecting and assessing carotid disease.

The present cross-sectional study was undertaken to assess the Carotid IMT changes and associated RI changes in hypertensive patients using high-frequency ultrasound and colour Doppler and to compare the findings in two subgroups of hypertensive subjects.

**MATERIALS AND METHODS**

The present study was conducted on patients diagnosed with hypertension and referred to the Department of Radiodiagnosis at SS Hospital.

**Study place:** Department of Radiodiagnosis, SSIMS & RC, Davanagere.

**Sample Size:** 135

**Inclusion Criteria:**

1. Known hypertensive patients on treatment
2. Newly diagnosed cases of hypertension
3. Cases of refractory hypertension

**Exclusion Criteria:**

1. Patients with high blood pressure but not pre-hypertensive or hypertensive
2. Hypertensive patients with severe complications
3. Patients with family history of hypertension having pre-hypertensive category blood pressure values
4. Those not willing to give consent

Equipment used –

1. GE LOGIQ S7
2. GE VOLUSON E6 Radiance BT19.

**Scanning Technique**

Both carotid arteries are evaluated by colourdoppler ultrasound using a high-frequency linear probe (7-12 MHz).

Intima media thickness was measured on greyscale ultrasound followed by Doppler measurements.

Parameters measured included:

1. Peak systolic velocity (PSV)
2. Peak end diastolic velocity (EDV)
3. Resistive index (RI)

RI= peak systolic velocity – end-diastolic velocity peak systolic velocity

Blood pressure measurements were performed with a mercury sphygmomanometer with a standardized cuff size adjusted to the circumference of the right arm at the level of the heart. After 5 minutes of rest in the supine position, three consecutive brachial artery blood pressure measurements were recorded at one-minute intervals. Mean value of the three supine blood pressure measurements was used for the analysis.

The hypertensive patients were divided into two broad sub-groups on the clinical stage of essential hypertension based on 2017 American College of Cardiology/American Heart Association guidelines for different stages of HTN.

**Subgroup I** –Stage 1 HTN: SBP 130-139 mm Hg and /or DBP 80-89 mm Hg

**Subgroup II** – Stage 2 HTN: SBP ≥140mm Hg and /or DBP ≥ 90 mm Hg

The Chi-square test has been used to find the significance of the proportions of hypertensives in different age groups.

Student t-test have been used to find the significance of Blood Pressure parameters and Intima media thickness [IMT] between Subgroup 1 and Subgroup 2 hypertensives.

Mann Whitney U test have been used to find the significance of the Resistive index between Subgroup 1 and Subgroup 2 hypertensives.

Pearson correlation coefficient 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 Subgroup 1 and Subgroup 2 hypertensives.

**Statistical Method**

Statistical data analyzed by statistical software IBM SPSS 21.0 with appropriate tests of significance.

**RESULTS**

Out of 135 cases with essential hypertension, 79 (58.5%) cases were in subgroup I and 56 (41.5%) cases were in subgroup II.

**Table 1: Effect of hypertension on CCA Intima Media Thickness (IMT) & on mean CCA Resistive Index (RI)**

| | Subgroup I | Subgroup II | 'P' Value (ANOVA) |
|---|---|---|---|
| Right CCA IMT | 0.725 ± 0.017 | 0.741 ± 0.013 | <0.001* |
| Left CCA IMT | 0.731 ± 0.019 | 0.741 ± 0.013 | <0.001* |
| Doppler (Mean RI) | 0.763 ± 0.061 | 0.785± 0.077 | <0.001* |

**(*-Significant)**

The mean of bilateral CCA Intima Media Thickness (IMT) was significantly higher in Subgroup II patients when comparing to Subgroup I patients.

**Table 2: Effect of hypertension on biochemical parameters**

| Biochemical parameters | Subgroup I | Subgroup II | 'P' Value (ANOVA) |
|---|---|---|---|
| TC | 160.20 ± 6.49 | 168.26±4.552 | <0.001* |
| TG | 137.27 ± 3.8 | 138.34±6.548 | >0.05 |
| LDL | 70.30 ± 4.73 | 71.18±3.061 | 0.975 |
| HDL | 51.93± 5.04 | 48.96±2.618 | 0.461 |

**(*-Significant)**

Triglyceride, LDL and HDL showed no significant correlation with the grayscale parameter (IMT) or Doppler parameter (RI). Diastolic blood pressure (DBP), Mean blood pressure (MBP) and total cholesterol also showed no significant correlation to the grayscale parameter (IMT) but showed moderate correlation with the Doppler parameter (RI) which were significant.

Systolic blood pressure showed a positive correlation with both the grayscale parameter (IMT) or Doppler parameter (RI) which was statistically significant.

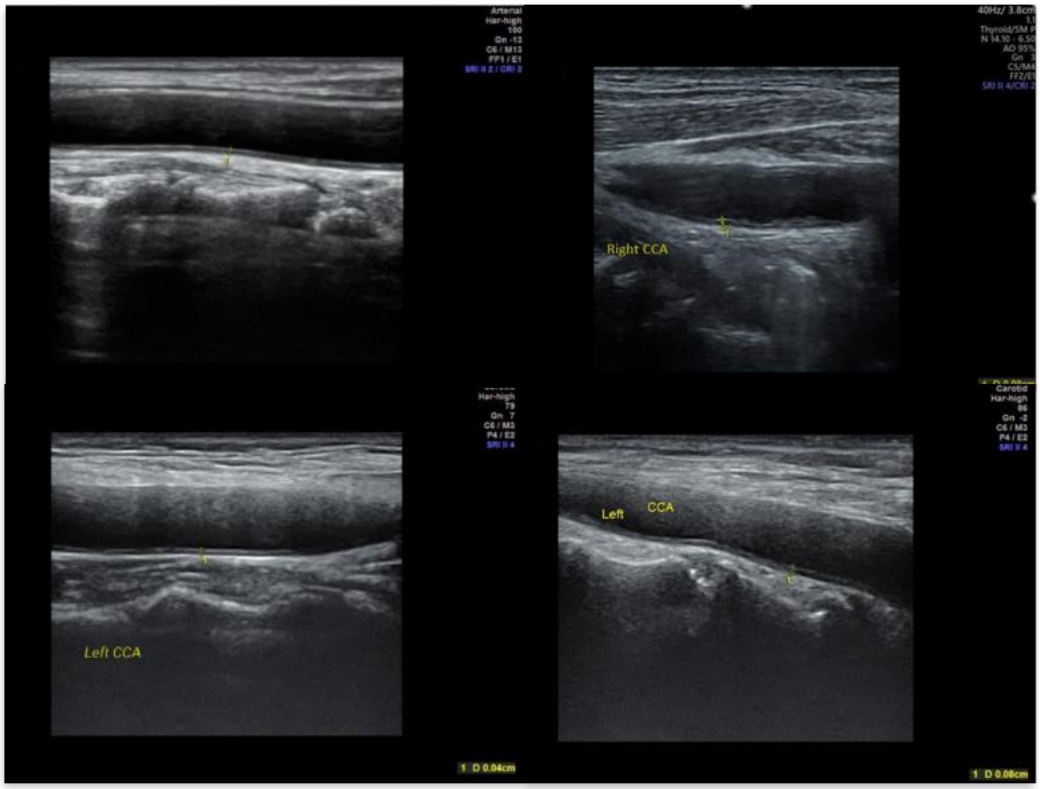


**Figure 1: Normal & Increased Intimal Medial Thickness - Bilateral CCA**

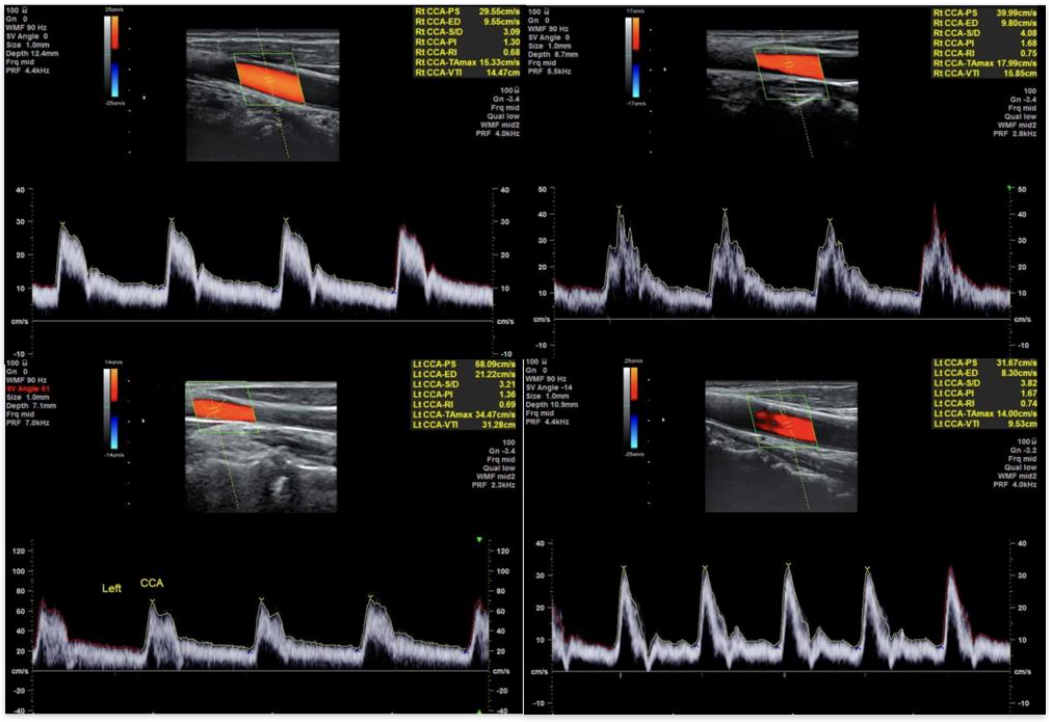


**Figure 2: Normal & Increased Resistivity Index - Bilateral CCA**

## DISCUSSION

We examined bilateral common carotid arteries of all patients with duplex sonography and IMT and RI were assessed. By measuring IMT and RI, we assessed both morphological and hemodynamic changes.

The drawback of measuring only Intima media thickness [IMT] measurement is that it is more prone to intraobserver and interobserver variability [9, 10]. However this is not the problem with Intima media thickness [IMT] combined with Resistive index [RI] because, when Resistive index [RI] and Intima media thickness [IMT] measurements

are compared, the essential advantages of the former are; the easier data acquisition by the use of simple duplex apparatus, the tendency to have less interobserver and intraobserver variability and the smaller side difference [6].

When RI and IMT measurements are compared, the essential advantage of the former was easier data acquisition by the use of simple duplex apparatus, the tendency to have less interobserver and intraobserver variability and the smaller side difference [12].

Although some authors have found an even better correlation with the degree of atherosclerosis when using IMT values for a combination of ICA and CCA values, we have restricted ourselves to the determination of IMT in the CCA. Because IMT measurements in the ICA have a massive scatter and IMT measurement of CCA is easier to obtain, more reliable, and had been proved by many studies (92). We found the mean IMT and RI to be 0.741±0.013mm and 0.785±0.077 respectively in Subgroup II whereas in the Subgroup I group the corresponding values were 0.728±0.119mm and 0.763±0.061. The results obtained were analyzed statistically. The results of our study show a significant relationship between hypertension (both subgroups) and an increase in IMT and RI ($P<0.001$) of CCA.

The results of our study closely correlate with the results of the previous Indian study done by M Adaikkappan*et al.*, in 2002 [11]. They studied the IMT of two hundred and sixty subgroup II patients compared with seventy subgroup I patients over a period of three years. They also studied the associated Doppler parameter changes along with IMT. They concluded that IMT is significantly elevated in subgroup II patients when compared with subgroup I patients. The mean value of IMT in subgroup II in their study was around 1.01mm and 1.09mm for the Right and Left sides respectively with a P value of <0.001. In our study, the mean IMT measurement in hypertensive was 0.741 mm and 0.742 mm with a P value of <0.001, which is indicative of a highly significant relationship. Their study also showed an increase in the resistive index in subgroup II patients compared to subgroup I patients. Our study also showed a similar increase in mean RI in subgroup II with a mean value of 0.785 with a P value of <0.001 (significant) compared to subgroup I. Our study showed significantly higher LDL cholesterol, total cholesterol and triglycerides levels in subgroup II, which was also seen in their study. Even though the majority of the hypertensive patients had dyslipidemia the mean value appears to be in normal limits. The reason for this is that majority of the patients were on treatment for hyperlipidemia

Our study also correlates with the study conducted by Srinivas Prasad R. H *et al*., They also found a significant increase in intima-media thickness and resistive index in subgroup II patients compared to the subgroup I patients with similar elevation of LDL cholesterol and triglycerides in the subgroup II group.

The role of hypertension in the development of LDL cholesterol and triglycerides mediated atherosclerosis measured by Common carotid artery IMT was confirmed by the study of Sun *et al*., in 2000 [13]. They observed that elevated LDL cholesterol and triglycerides were associated with increased IMT in higher blood pressure after adjustment for the other risk factors. This supports the response-to-injury model of hypertension-induced atherosclerosis. Another explanation for the IMT thickening along with increased LDL cholesterol and triglyceride levels occurring in hypertensive was suggested to be adaptive thickening of the intima and the media [14]. Such 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 hypertensive group, in which endothelial damage is more likely to be sufficient to initiate atherogenesis. These findings were supported in the ACAPS study, where the effect of the lipid-lowering lovastatin intervention was larger in subgroup II patients than in the subgroup I patients [13, 14]. P Sharma *et al*., in their study also supported this study. The age of the study population ranged from 35 to 65 years. Mean IMT was significantly high in subgroup II patients compared to the subgroup I patients ($P<0.001$) [15].

Massimo Puato*et al*., also found that in grade II hypertensive subjects, both mean IMT and mean of maximum IMT were significantly higher compared with baseline values. Compared with grade I hypertensive subjects, both mean IMT and maximum IMT increased significantly (at least $P<0.01$) in each carotid artery segment. The increase in cumulative IMT was 3.4-fold for mean IMT and 3.2-fold for mean of maximum IMT [16].

The Plavnik*et al*., also showed intima media complex (IMC) of common carotid artery and femoral artery to be thicker in grade II hypertensive patients than in grade I subjects [17]. Similar results were obtained earlier by Jiang *et al*., [18] and Labrova*et al*., [19] in their studies. Mechanisms by which hypertension predisposes to atherosclerosis may include endothelial dysfunction, hyperinsulinemia, hemodynamic stress, and multiple metabolic alterations. Impaired production of endothelium-derived relaxing factors and increased activity of endothelium-derived contractile substances have been demonstrated in hypertensive patients, preceding overt atherosclerotic disease [20].

Vicenzini E *et al*., assessed CCA IMT, the CCA RI, and the presence of carotid plaques in 1655 consecutive patients and found that risk factors for atherosclerosis including hypertension were independently associated with higher

IMT values and an increase in the RI, which is similar to our findings. They further found that synergic action of risk factors might cause further deterioration of mechanical forces independent of carotid atherosclerosis [21].

Anna Skalska*et al*., in a multiple regression analysis study found that IMT-CCA was significantly influenced by age and SBP while RI was influenced by SBP and DBP [22]. In our study we found similar findings with IMT-CCA being significantly influenced by SBP whereas RI was influenced by SBP, DBP, MBP and Total cholesterol (TC).

## CONCLUSION

High frequency ultrasound and Color Doppler can be used as an effective tool to study Intima media thickness [IMT] and Resistive index [RI] of the common carotid artery in the evaluation of Atherosclerosis. Both the parameters (IMT and RI) are increased in hypertensive patients which showed a significant correlation with Systolic blood pressure (SBP) whereas RI alone showed a significant correlation with Diastolic blood pressure (DBP), Mean Blood Pressure (MBP) and Total Cholesterol (TC).

Early identification of atherosclerosis using these parameters should prompt early incorporation of lifestyle modification in these patients, which would definitely help in reducing the cardiovascular mortality.

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