Sonographic assessment of the carotid intima-media thickness on B-mode ultrasonography in a Nigerian population

Oluwagbemiga Oluwole Ayoola, Mayomi A. Onuwaje, Anthony O. Akintomide

INTRODUCTION

Essential hypertension is a genetic disease characterized by consistently elevated blood pressure (BP). It is a well-recognized risk factor for early degenerative lesions in the arterial tree. Epidemiological studies have shown that high BP levels are correlated with increased prevalence and incidence of coronary and cerebrovascular disease. The clinical relevance of hypertension arises from its associated predisposition to cardiovascular morbidity and mortality. The induction of atherosclerosis is probably the most important mechanism by which hypertension acts as a cardiovascular risk factor.

In a study by Ikek and Ikeh, the prevalence of hypertension in Nigeria is 10–20%. Arterial wall changes occur during a long subclinical lag phase of endothelial damage and gradual diffuse intimal thickening. The intimal thickening can be studied by two-dimensional B-mode ultrasonography. Carotid intima-media thickness (CIMT) is a marker of early atherosclerosis, its anatomic extent and progression. Increase in CIMT shown to be an independent risk factor for stroke.

Address for correspondence:
Dr. Oluwagbemiga Oluwole Ayoola,
Department of Radiology, Obafemi Awolowo University, Ile-Ife, Osun, Nigeria.
E-mail: oluyoola@gmail.com

ABSTRACT

Background: Hypertension is a common health problem and a major risk factor of cardiovascular disease. The most important mechanism by which hypertension acts as a cardiovascular risk factor is the induction of atherosclerosis. The early phase of atherosclerosis before its clinical manifestation can be studied using B-mode ultrasonography. Aims and Objectives: This study evaluated the intima-media thickness of the common carotid artery (CCA), carotid intima-media thickness (CIMT) of subjects with essential hypertension as a way of detecting these early changes of atherosclerosis. Subjects and Methods: The study was performed on 200 subjects with newly diagnosed hypertension and 100 apparently normal controls that were consecutively recruited by a cardiologist. An ultrasound examination of both CCA were done to obtain the CIMT. Data were analyzed using the SPSS data analysis software. Results: The CIMT of males were greater in the hypertensive group compared to the controls (0.10 ± 0.02 cm vs. 0.077 ± 0.02 cm [P < 0.0001] and 0.10 ± 0.02 cm vs. 0.078 ± 0.02 cm [P < 0.0001] for the right and left sides, respectively). The female group showed a similar pattern of results (0.09 ± 0.02 cm vs. 0.072 ± 0.02 cm [P < 0.0001] and 0.1 ± 0.02 cm vs. 0.076 ± 0.02 cm [P < 0.0001] for the right and left sides respectively). Conclusion: A statistically significant increase in CIMT was noted in both male and female hypertensives in comparison to a normal population.

Key words: Carotid, hypertension, ultrasound

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SUBJECTS AND METHODS

This is a prospective case-controlled nonrandomized study carried out at the Radiology Department between December 2008 and June 2010. Approval for the study was obtained from the local Ethical and Research Committee.

Newly diagnosed hypertensives, above 40 years of age, along with age- and sex-matched apparently healthy controls who consented to participate in the study were recruited from the cardiology clinic from where they were referred to a radiologist to have an ultrasound done. All subjects, who were required to fast on the day of examination, had their weight and height taken and also blood samples taken to assess their fasting blood and fasting lipid profile via a capillary tube. Their body mass index (BMI) was subsequently calculated from their heights and weights using the formula below:

\[ \text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m)}^2} \]

A single radiologist carried out all carotid examinations and was blinded to the status of all subjects. Subjects with clinical evidence of target organ damage by arterial hypertension (stroke, coronary heart disease, heart failure, and renal impairment) were excluded from the study by use of renal function tests and electrocardiogram. This information was obtained through a review of medical documentation for each study subject. Subjects with liver cirrhosis, chronic lung disease, adrenal gland disease or renal disease, smokers, patients with dyslipidemia (total cholesterol >6.2 mmol/L, low density lipoprotein (LDL) >4.1 mmol/L and/or high density lipoprotein (HDL) <1 mmol/L),7 diabetics (fasting blood sugar [FBS] ≥7 mmol/L), pregnant or lactating mothers were also excluded. The subject population was stratified with both sexes having equal number examined for both study groups.

A mind ray ultrasound machine (DC-6) with 7.5–10 MHz variable frequency linear probe was used for the study. The examination was carried out with each subject lying supine, neck slightly extended and turned contralaterally to the carotid artery being examined; continuous scans were done in the longitudinal and transverse planes after the application of ultrasound gel. All measurements of the intima-media thickness were made in the longitudinal plane at the point of maximum thickness of the far wall of the common carotid artery (CCA) along a 1 cm section of the artery proximal to the carotid bulb. The position of the carotid bulb was defined as the point where the far wall deviated from the parallel plane of the distal CCA. The CIMT was defined as the distance between the inner echogenic line representing the adventitia-media junction. After freezing the image, the measurement was made with electronic calipers [Figure 1].

Data processing and statistical analysis was carried out using the statistical software package SPSS version 14 (IBM Corp. Released 2005. IBM SPSS Statistics for Windows, Armonk, NY). The student t-test was used to compare continuous variables and the Chi-square test for categorical variables. A P < 0.05 was considered statistically significant.

RESULTS

A total of 200 subjects, 100 males and 100 females aged between 40 and 86 years (mean 58.8 ± 11.6 years) were in the hypertensive group, whereas 100 subjects, 50 males and 50 females aged between 41 and 86 years (mean 54.9 ± 10.9 years) were in the control group.

The mean BMI [Table 1] of the hypertensive group of 25.8 ± 8.2 kg/m² was higher than the mean BMI of the control group 21.4 ± 10.1 kg/m² (P < 0.001).

The mean systolic and diastolic BP [Table 1] of the hypertensive group 167.5 ± 24 mmHg and 98.4 ± 16.7 mmHg, respectively, were higher than the mean systolic and diastolic BP of the control group, which were 123.6 ± 14.4 mmHg and 78.1 ± 8.7 mmHg, respectively (P < 0.001 for both indices).

The mean total cholesterol level in the hypertensive group at 4.24 ± 0.79 mmol/L was significantly higher than the control group, which was 3.97 ± 0.74 mmol/L (P < 0.05). The other
Table 1: Demographic characteristics and sonographic parameters of the study population

|                           | Hypertensive (n=200) | Control (n=100) | P     |
|---------------------------|----------------------|----------------|-------|
| BMI (kg/m²)               | 25.8 ± 8.2           | 21.4 ± 10.1    | < 0.001 |
| Systolic blood pressure (mmHg) | 167.5 ± 124          | 122.6 ± 14.4   | < 0.001 |
| TC (mmol/L)               | 4.2 ± 0.79           | 3.97 ± 0.74    | < 0.05  |
| HDL (mmol/L)              | 0.97 ± 0.4           | 0.92 ± 0.22    | > 0.05  |
| TG (mmol/L)               | 0.96 ± 0.53          | 0.73 ± 0.4     | < 0.001 |
| LDL (mmol/L)              | 2.87 ± 0.72          | 2.8 ± 0.7      | > 0.05  |
| Diastolic blood pressure (mmHg) | 98.4 ± 16.7          | 78.1 ± 8.7     | < 0.001 |
| Left CIMT (cm)            | 0.10 ± 0.05          | 0.08 ± 0.02    | < 0.05  |
| Right CIMT (cm)           | 0.09 ± 0.02          | 0.07 ± 0.01    | < 0.001 |

BMI = Body mass index; TC = Total cholesterol; HDL = High density lipoprotein; TG = Triglyceride; LDL = Low density lipoprotein; CIMT = Carotid intima-media thickness

cholesterol index that was significantly higher ($P < 0.0001$) in the hypertensive (mean of 0.96 ± 0.53 mmol/L) when compared to the control population (mean of 0.73 ± 0.4 mmol/L) was the triglyceride. All the other indices namely HDL, LDL along with FBS are illustrated in Table 1.

In the hypertensive group, the mean CIMT [Table 1] on the right and left were 0.09 ± 0.02 cm and 0.10 ± 0.05 cm, respectively, and this was higher than the mean intima-media thickness for the control group, which were 0.07 ± 0.01 cm and 0.08 ± 0.02 cm on the right and left, respectively ($P < 0.001$ on both sides).

A significant positive correlation was found between age and intima-media thickness in both the hypertensive and control groups with an $r$ value of 0.42 ($P < 0.05$) and 0.15 ($P > 0.05$) for the right and left CIMT, respectively, in the hypertensive group; 0.262 and 0.469 ($P < 0.05$ in both) for the right and left CIMT, respectively, in the control group.

The BMI did not reveal any significant correlation with the CIMT in both sides ($P > 0.05$). All correlations in both groups were positive except one. In the control group, the $r$ values were 0.168 and 0.026 on the left and right, respectively, whereas in the hypertensive group, the values were 0.032 and −0.045 in the left and right, respectively.

In the hypertensive group, the CIMT of males was 0.10 ± 0.02 cm and 0.10 ± 0.02 cm for the right and left sides, respectively, were higher than that of females, only on the right, with a mean CIMT of 0.09 ± 0.02 cm and 0.1 ± 0.02 cm for the right and left arteries ($P > 0.05$ on both sides).

In the control group, the mean CIMT in males on the right with value of 0.077 ± 0.02 cm and left of 0.078 ± 0.02 cm was slightly higher than the mean CIMT in the female with value of 0.072 ± 0.02 cm and 0.076 ± 0.02 cm for the left carotid, respectively ($P > 0.05$ on both sides).

No significant difference was noted between CIMT values on the left and right side in either of the study groups. In the hypertensive group, the mean value in left CIMT was 0.10 ± 0.05 cm while that of the right was 0.10 ± 0.02 cm; whereas in the control group, the left and right side both gave a value of 0.07 ± 0.02 cm.

Fifty (25%) hypertensives had carotid intimal plaques compared to only 4% in the controls ($P < 0.05$).

**DISCUSSION**

Essential hypertension is a modifiable risk factor for cardiovascular disease. There is a strong positive correlation between BP and the risk of cardiovascular disease (stroke, myocardial infarction, and renal disease) and mortality. The diagnosis of hypertension is made when an average of two or more diastolic BP measurement on at least two visits is ≥90 mmHg or when the average multiple systolic BP reading on two or more subsequent visits is consistently ≥140 mmHg. Essential hypertension is defined as high BP in which secondary causes such as renovascular disease, renal failure, pheochromocytoma, aldosteronism, or other causes of secondary hypertension are not present. Essential hypertension accounts for 95% of all causes of hypertension. Factors such as obesity and aging have been documented to lead to hypertension.

The first clinical manifestation of cardiovascular disease often arises in well-advanced atherosclerosis although changes in the arterial wall occur during a long subclinical lag phase of endothelial damage. The early changes in the arterial wall can be studied using B-mode ultrasound to measure the intima-media thickness of the peripheral vessels especially the common carotid and the femoral artery. However, the carotid artery is mostly suitable because of the superficial location, size, and limited movement.

The intima-media complex which consists of endothelial cells, connective tissue, and smooth muscle, is defined as a double line pattern visualized in both walls of the carotid artery in a longitudinal image. Epidemiological studies and intervention trials have established that CIMT, as measured by ultrasound, is a good marker of atherosclerosis. Moreover, ultrasound measurement of CIMT has repeatedly been shown to predict the occurrence of both stroke and myocardial infarction in the general population, and as such increased CIMT has been considered by some to be a marker subclinical atherosclerosis.

Age-related increase in CIMT is said to represent a thickening in intimal layers that results from arteriosclerosis. This is probably the case in individuals with major risk factors such as hypertension who demonstrate a marked increase in intima-media thickness. However, there is growing evidence that this may also be an adaptive response in healthy individuals. This fact is supported by some of the results obtained in our study.
which showed an $r = 0.42$ ($P < 0.05$) and 0.15 ($P > 0.05$) for the right and left carotid artery, respectively, in the hypertensive group; 0.262 and 0.469 ($P < 0.05$ in both) for the right and left carotid artery, respectively, in the control group. Only values obtained in the left CIMT for the hypertensive group showed a weak, insignificant positive correlation. These findings are in agreement with those done Takato et al.\(^6\) in which a longitudinal study was done in the elderly over a 6-year time frame. A significant positive correlation between baseline age and CIMT ($r = 0.11, P < 0.05$).

In this study, gender was not noted to have any significant effect on CIMT as in other studies done by Gariepy et al.,\(^7\) in which they found that CIMT was significantly lower in women in both arteries ($P < 0.001$). The values obtained were essentially the same except for values in the right CIMT, which showed thinner CIMT of 0.09 ± 0.02 cm in women compared to that of the men, which measured 0.1 ± 0.02 cm ($P > 0.05$). The reason for this may be attributed to the fact that the effect of gender is more pronounced in the elderly as noted in a study done by Takato et al., whereas subjects in their fourth decade were recruited into this study.\(^6\)

Unlike in Rosfors et al.,\(^8\) study, which showed a higher CIMT on the left as compared to the right CCA, no significant difference was noted between the left and right CCA in either study group. In the control group, mean values of 0.07 ± 0.02 cm were obtained on both sides whereas the values in the hypertensive group were 0.1 ± 0.05 cm for the left and 0.1 ± 0.02 cm for the right. The difference noted in both sides has been attributed to hemodynamic stress on the left side related to the specific anatomy of the carotid vessels. Whereas the right CCA from the brachiocephalic trunk (generally at right angles to the flow of the innominate artery), the left seems to stem directly from the aortic arch and runs more from an even line with the ascending aorta.\(^9\)

BMI was shown to have a weak positive correlation on both sides of the carotid artery in both groups except in the right carotid artery of the hypertensive groups, which gave an $r = -0.045$. This agrees with a study done by Kotsis et al.\(^10\)

In a 5-year follow-up study carried out by Puato et al.,\(^11\) 97 subjects with Grade I hypertension, who were left untreated, the prevalence of raised CIMT was significantly higher in hypertensive subjects than in control subjects at baseline, as well as at follow-up: 10.3% in hypertensive subjects versus 3.7% in control subjects ($P < 0.001$) and 16.2% in hypertensive subjects versus 5.0% in control subjects ($P < 0.001$), respectively. Although a follow-up study was not done in our study, but comparison between the CIMT in both sides [Table 1] showed significant values in the hypertensives as compared to the control group.

**CONCLUSION**

This study has shown that the CIMT in hypertensive patients is significantly higher than that of normotensives. Age is an important predictor of CIMT with the relationship between age and intima-media thickness been strong in the presence of concomitant hypertension and other risk factors such as obesity.

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**Conflicts of interest**

There are no conflicts of interest.

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