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Original Research Article

Sonographic Findings of Carotid Artery Intima-Media Thickness in Adult Stroke Patients in Maiduguri, North-Eastern Nigeria

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Abstract

Background: Stroke is a leading cause of neurological disability and death in adults. Carotid atherosclerosis represents major aetiopathogenesis of stroke. Ultrasonography is affordable, safe and relatively available imaging modality. The aim of this study was to determine the intima-media thickness (IMT) of common carotid arteries (CCA) in adult stroke patients in Maiduguri, North-Eastern Nigeria. ***Materials and Methods:*** This was a cross-sectional prospective study carried out on 100 adult stroke patients that attended neurology clinic and wards at the University of Maiduguri Teaching Hospital (UMTH), Maiduguri, Nigeria. All patients had neuroimaging (Brain CT/MRI) for confirmation of diagnosis. The examination was performed using Logic P5 GE ultrasound scanner equipped with linear transducer. The IMT of CCA of the patients was measured using grey scale ultrasonography and was correlated with age and sex. ***Results:*** There were 62 males and 38 females aged 30-85 years (mean ± SD of 59.15 ± 4.20 years). Ischaemic stroke was the major subtype of stroke (73% of the study population). The overall mean CCA IMT was 1.03 ± 0.29 mm. Forty five percent (45%) of the stroke patients had increased CCA IMT (>1.0 mm). The relationship between increased CCA IMT with stroke was statistically significant (p = 0.02). There was significant correlation between increased CCA IMT with increasing age (p = 0.01). However, the IMT was higher in men than the women but their correlation was not statistically significant. ***Conclusion:*** Increased CIMT was significantly associated with stroke. There was positive correlation between increased CIMT with advancing age.
Keywords: Common Carotid Artery, Intima-Media Thickness, Stroke, Atherosclerosis, Ultrasound Scan, Nigeria.

INTRODUCTION

Stroke (also known as cerebrovascular disease) is recently defined as central nervous system (CNS) injury based on pathological, imaging or other objective evidence; or clinical evidence of CNS injury based on symptoms and signs persisting greater than or equal to 24 hours or until death with no cause other than of vascular origin [1]. It is mainly characterized as a neurological deficit attributed to an acute focal injury of the CNS by a vascular cause, including cerebral infarction, intracerebral haemorrhage (ICH), and subarachnoid haemorrhage (SAH), and is a major cause of disability and death worldwide [1]. However, transient ischaemic attack (TIA) is a transient episode of neurological dysfunction caused by focal brain, spinal cord, or retinal ischemia without acute infarction. It has no persistent neurological deficit [1].

Stroke is a leading cause of morbidity and mortality worldwide and majority of stroke morbidity are from developing countries. It was estimated that stroke accounted for about 5.5 million deaths world-wide, and two-thirds of these deaths occurred in people living in developing countries like Nigeria [2]. Danesi *et al.*, reported a study in South-Western Nigeria where they showed an overall crude prevalence rate of stroke as 1.14/ 1,000 persons, they also demonstrated increased prevalence with advancing age and male gender [3]. The burden of stroke in developing countries has been projected to be rising [3]. Many Previous studies have indicated that about 70-80% of strokes are due to cerebral infarction [2, 4]. The risk factors of stroke are; hypertension, diabetes, dyslipidaemia, cigarette smoking, obesity, advanced age, and male gender. Atherosclerotic disease of the carotid and cerebral arteries have long been recognized as the most common sources of emboli that travel to the brain causing infarct stroke [2].

Strong positive association between stroke and increased carotid artery intima-media thickness (CIMT) has been reported by previous studies in South-Western Nigeria [4-6]. Similar findings were also reported by many authors in Western countries [7-10] and Asian countries [11-14]. Significant positive correlation of increased CIMT and major risk factors of stroke like diabetes, hypertension, obesity and advancing age were also established by previous authors in Northern [15-17] and Southern [18-21] Nigeria. At present, to the best of our knowledge, there are few studies showing association between CIMT and stroke in Nigeria and Africa at large [4-6]. The thickening of the CIMT is a manifestation and surrogate marker of early atherosclerosis [10, 22] and also is a strong predictor of vascular events [10, 23]. The main cause of ischaemic stroke is atherosclerosis in carotid arteries seen commonly at carotid bulb and internal carotid artery [24]. Harris in Indonesia showed CCA IMT is strongly associated with stroke and is considered abnormal when greater than 1.00 mm [14]. Coll *et al.*, in a meta-analytic study showed that the measurement of CIMT ranges from 0.55-0.95 mm.

Patients undergoing evaluation for acute stroke should have carotid imaging done, due to the large proportion of ischaemic stroke caused by increased CIMT and the non-invasive assessment of common CIMT appears to provide a promising imaging method to study atherosclerosis directly in the general population [7]. The B-mode ultrasonography used to evaluate the carotid artery which is relatively inexpensive, non-invasive, readily available, reproducible and safe imaging modality [10].

The aim of this study is to evaluate the CIMT in adult stroke patients in Maiduguri, North-eastern Nigeria and its correlation with age and sex.

MATERIALS AND METHODS

This was a cross-sectional prospective study carried out from June 2015 to December 2015, involving adult stroke patients. The study population consisted of 100 stroke patient attended neurology clinic and on admission in wards and who were referred to the Radiology department of UMTH, Maiduguri, Nigeria for neuro-imaging (CT/MRI scan). Only patients that met the inclusion criteria as listed below were recruited consecutively. Inclusion criteria were**:** Adult patients, who were diagnosed of stroke clinically and confirmed with CT/MRI scan. While, the exclusion criteria were: Unconscious patients, Stroke patients less than 18 years, Patients with incidental findings in the carotid arteries like arterial wall dissection and aneurysm, Pregnant women; because of physiological changes and accompanying dilatation of the CCA, and stroke mimics in neuro-imaging e.g. extra-axial haemorrhages, tumours, and abscess.

An informed written consent was obtained from the patients or their care givers before they were enlisted into the study. An ethical approval to carry out the study was obtained from the ethical and research committee of the University of Maiduguri Teaching Hospital. Each subject was informed of the safety of ultrasound scan and was also informed that he/she can withdraw from the study at any stage without consequences. The data collected from the participants were recorded and kept with strict confidentially. The examinations were explained to each patient and brief history was taken to ensure adequate compliance with the inclusion and the exclusion criteria. The bio-data which included age and sex were recorded for each patient. Stroke was diagnosed based on an updated definition of stroke for the 21st century by American Heart Association/American Stroke Association (AHA/ASA) Expert Consensus Document [1]. All the patients had neuroimaging (Brain CT or MRI) scan done. Images were obtained from 16 slice multidetectors General Electric Bright speed CT scanner or 0.2 Tesla Siemens Magnetom Concerto MRI Scanner. The sonographic examination of CCA was conducted using high resolution real-time ultrasound (US) scanner equipped with 7-12 MHz multi-frequency linear transducer (Logiq P5, General Electric). This provided excellent resolution for the superficially located common carotid arteries.

Patients were scanned in supine position with the shoulder placed on a pillow and neck extended, the head was turned about 45^0 away from the side being scanned. Ultrasound gel was applied to the neck to serve as acoustic coupling agent, the transducer was then placed transversely above the clavicle for the grey-scale examination. The CCA was located and the transducer was then turned about 90^0 to examine the artery in longitudinal view and then moved cephalad to the level of the carotid bifurcation for the right and left sides respectively. The study involved scanning of the far wall of the right and left CCA. The IMT was measured manually on a frozen magnified image of the CCA 1cm proximal to the carotid bulb, as the distance between the leading edge of the first bright line on the far wall (lumen-intima interface) and the leading edge of the second bright line (media-adventitia interface) [7, 13, 25] as shown in Figure 1. Areas of plaques were avoided, which are defined as focal thickening of 50% greater than the surrounding area or measurement greater than 1.5 mm [13]. All measurements were obtained at three different locations and the mean was derived to minimise intra-observer errors. To minimise inter-observer errors, the examinations were done by an experienced Radiologist. The IMT of the CCA of the patients were also correlated with age and sex.

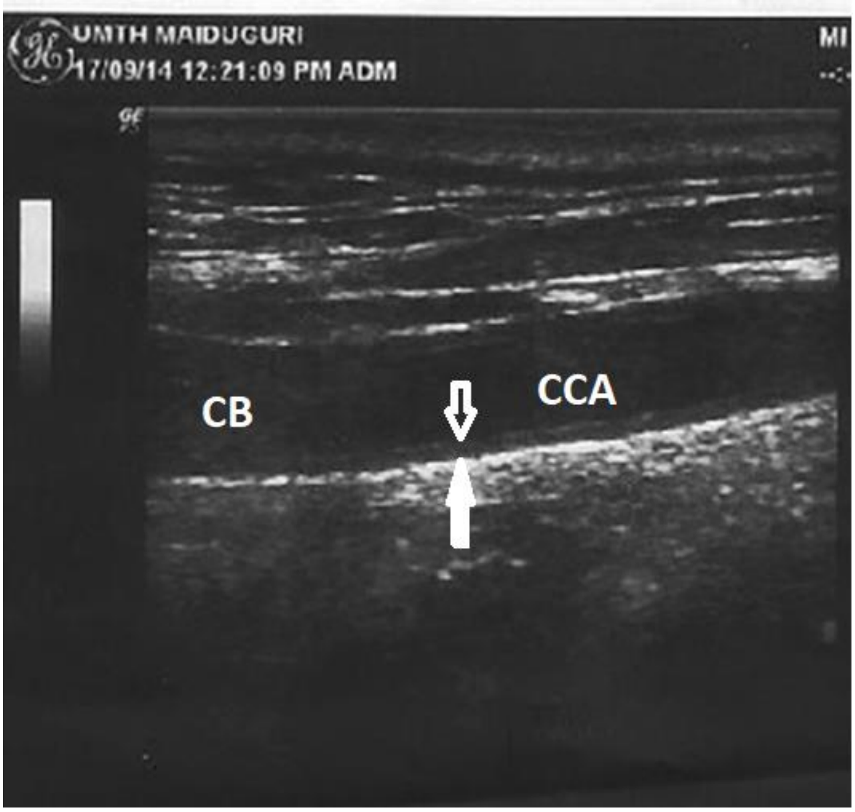

Fig-1: Longitudinal view ultrasound image of CCA showing measurement of IMT
IMT = distance between open and closed arrows in mm, IMT = Intima-Media Thickness, CCA = Common Carotid Artery, CB = Carotid Bulb

The data obtained from the structured data sheet were entered into a computer system and statistical analysis was performed using Statistical Package for Social Sciences (SPSS) for Windows® version 16.0 software (SPSS Inc. IL, USA). Descriptive statistics which include range, ratio, mean and standard deviation were used to describe the findings. The inferential statistics for the significant test, Analysis of Variance (ANOVA) and Student's t-test were used to determine the relationship of CCA IMT with sex and age. The level of statistical significance was set as $p < 0.05$ with 95% confidence level.

Results

The study was carried out on 100 consented adult stroke patients, 62 patients (62% of the study population) were males and 38% were females with the male to female ratio of 1.6:1. The age of the patients ranged from 30-85 years and a mean ± SD of 59.15 ± 4.20 years. While, the peak age group for the study population was 50-59 years. All patients with clinical features of stroke were confirmed with either Brain CT or MRI scan. The frequency of stroke subtypes of the study population showed 73% of the study population had ischaemic stroke, while the remaining 27% had haemorrhagic stroke.

The overall mean ± SD of CCA IMT was 1.03 ± 0.29 mm. While, the mean of the CCA IMT on the right and left sides were as shown in Table 1. However, there was no statistically significant difference between the right and left sides ($p = 0.07$). The overall mean of CCA IMT was 1.15 mm in patients with ischaemic stroke, while that of haemorrhagic stroke was 0.89 mm. The abnormal increased (> 1.00 mm) IMT of CCA was observed in 45% of the study population. However, it was noted in 59% of ischaemic stroke patients. The overall mean ± SD of CCA IMT of males and females were 1.07 ± 0.29 mm and 1.00 ± 0.30 mm respectively (p value = 0.08). The CCA IMT was found to be slightly higher in men than in women; however, the relationship was not statistically significant.

The highest IMT mean value (1.35 ± 0.25 mm) was observed in the CCA of age group of 80-89 years. While, the least IMT mean value (0.64 ± 0.65 mm) was noted in age group of 30-39 years. There was progressive increased of the CCA IMT with increasing age as shown in Table-2. Hence, there was positive linear correlation between IMT of CCA with age group and the p value was statistically significant.

Table-1: The Mean ± SD, Range and p-value of CCA IMT

Variables	N	Range	Mean ± SD	p-value
CCA IMT (mm)				
RCCA	100	0.62-1.50	1.04 ± 0.31	p = 0.02
LCCA	100	0.65-1.47	1.02 ± 0.27	

N = Study population, SD = Standard deviation, IMT = Intima-media thickness, RCCA = Right common carotid artery, LCCA = Left common carotid artery

Table-2: Correlation of CCA IMT with Age Groups

Age group (years)	N		Mean ± SD of the IMT (mm)	
		RCCA		LCCA
30-39	5	0.65 ± 0.08		0.64 ± 0.35
40-49	14	0.94 ± 0.35		0.91± 0.24
50-59	36	0.99 ± 0.25		0.97 ± 0.19
60-69	32	1.08 ± 0.29		1.12 ± 0.47
70-79	7	1.20 ± 0.25		1.19 ± 0.13
80-89	6	1.36 ± 0.46		1.33 ± 0.70
Total	**100**	**1.04 ± 0.31**		**1.02 ± 0.27**
		P = 0.01		

N = Study population, SD = Standard deviation, IMT = Intima-media thickness, RCCA = Right common carotid artery, LCCA = Left common carotid artery

DISCUSSION

Carotid atherosclerosis is a well-known risk factor and independent marker of stroke. Carotid US scan is a non-invasive, readily available, affordable and reproducible imaging modality for evaluation of CCA especially in stroke patients. . In this study infarct was the commonest stroke subtype accounting for about 73% and this agreed with many previous studies [2, 6, 14, 24]. Magaji in Maiduguri, North-eastern Nigeria in his work on measurement of CCA IMT in normal subjects reported the mean CCA IMT as 0.73 mm [26]. Almost similar findings were observed by some authors in Nigeria ranging from 0.61 to 0.73 mm [27-29]. Similar finding was reported by Paul *et al* in a study conducted in India [30] but lower value was recorded by Lim *et al* in UK of 0.53 ± 0.07 mm [31].

Agunloye *et al.*, in a study in Ibadan, South-western Nigeria recorded mean CCA IMT of 0.94 ± 0.38mm on right and 1.00 ± 0.42 mm on left in hypertensive patients with stroke [4]. This finding was slightly lower than our index study. In another study conducted by Owolabi *et al* in Ibadan, Nigeria observed mean CCA IMT of 0.91 ± 0.38 mm in stroke patients [6]. The finding was significantly higher than the hypertensive control subjects but it was slightly lower than our finding. The association between CIMT and stroke in Nigerians and sub-Saharan Africans was reported by only a few researchers [4-6].

Bots *et al.*, conducted a case-control study in Netherlands and reported increasing common CIMT increased stroke risk and is also associated with future cerebrovascular and cardiovascular events [7]. Touboul *et al* in France observed increased CCA IMT of ischaemic stroke patients as 0.80 ± 0.06 mm compared to normal control and also showed the risk of brain infarction increased with increasing CCA IMT [8]. Chambless *et al* in a cohort study conducted in USA reported mean common CIMT of 0.73 mm and established an association between CIMT with incidence of ischaemic stroke [9]. They also found that having mean CIMT of greater than 1.00 mm was associated with three- to four-fold more risk of subsequent ischaemic stroke [9]. Ellul *et al.*, in Greece measured CIMT of ischaemic stroke patients and observed mean of 0.79 ± 0.16 mm. The CIMT was strongly correlated with conventional vascular risk factors which is independent and is an early marker of generalized atherosclerosis [32]. However, these values were significantly lower than our findings.

Lorenz *et al.*, in a meta-analysis review summarized that increased in CIMT led to increased risk of having stroke of 13 to 18% and CIMT is the most preferred technique to assess atherosclerosis burden in most clinical studies and strongly recommended standard protocol for future studies [23]. Coll *et al.*, in a review article reported that CIMT is the most studied and validated marker of atherosclerosis and is directly correlated with its pathology. The CIMT is used to detect and monitor early atherosclerosis and CCA is the preferred part of carotid artery measurement [22]. Similarly, O’leary *et al.*, documented that, there is significant association between CIMT and atherosclerosis with stroke and its risk factors. Thickness of CIMT varies with age, sex and ethnicity, increased CIMT with increasing age and generally thicker in men than women and stronger association of CCA IMT with stroke than internal carotid artery IMT [33]. Previous authors also reported almost similar findings [10, 34].

Sahoo *et al.*, did a study in India on ischaemic stroke patients and reported the mean CCA IMT of 0.80

mm. They also documented significant association between increased CIMT with advancing age but no significant difference in sex [13]. Similarly, many studies conducted in Asia reported mean CIMT ranging from 0.75-0.98 mm [12, 24, 35-37]. These values were lower than those found in our study. Harris in Indonesia also reported significant correlation between CCA IMT and stroke [14]. However, Sawaraq *et al.,* in India recorded CIMT value of 1.3 mm in stroke patients and it was significantly associated with age and major risk factors of stroke [11]. The CIMT values found by these researchers were higher than ours. The differences may be due to the differences in race/ethnicity, dietary habits of our patients with theirs, and the methodology used in our study. Previous studies on CIMT and major risk factors for stroke like: hypertension, diabetes mellitus, obesity and hyperlipidaemia have shown that there is significant positive correlation in Nigeria [15-21], Asian [12, 14, 36, 37] and Western [25, 38, 39] countries.

In this study, 45% of the stroke patients have increased IMT of CCA and was noted in 59% of ischaemic stroke patients. Also, the patients with ischaemic stroke had more increased CCA IMT compared to haemorrhagic stroke patients. The IMT is considered abnormal if the thickness was greater than 1mm [14] and is indicative of atherosclerosis and increased risk of cardiovascular disease [36]. Harris in Indonesia reported abnormal CIMT of 99% in stroke patients [14]. Saha *et al.,* in India showed thickened CIMT in 71% of ischaemic stroke patients [24]. These findings were significantly higher than our finding.

Our study revealed that the CIMT on the right side was slightly higher than the left but not statistically significant. Similar observation was made by Magaji [26] in his study, which was conducted on normal subjects in Maiduguri Nigeria. Similar findings were also reported by other authors [15, 19]. However, previous studies found no significant difference of CIMT on both sides [12] while others reported slightly higher CIMT on the left side [4, 6].

In our study, the CIMT of the male patients was higher than the ones found in the females but it was not statistically significant. Some authors also recorded almost similar findings as found in our study [12, 13, 19, 21]. However, other authors differed with our finding and showed significant correlation with sex: higher in men [15, 19, 25, 27, 29, 30, 33, 39] while one author observed higher among women [20].

In this study, increased CCA IMT was observed in all the elderly patients and had increased progressively with increasing age. Many authors agreed with our finding [11, 13, 19, 21, 24-27, 29, 30, 32, 33, 35, 39] but few authors differed from our findings [12, 31, 36].

Conclusion

Carotid ultrasound scan is a useful diagnostic tool in evaluation of early carotid atherosclerosis in stroke patients. It is readily available, affordable, reproducible and safe imaging modality. Our study showed that increased CCA IMT was significantly related to stroke. The increased CCA IMT was also significantly correlated with increased age in stroke patients. Multi-centered studies are recommended to further enhanced knowledge of the correlation of CIMT and stroke especially in sub-Saharan Africa, in order to emphasize the routinely evaluation of the carotid arteries, especially the CIMT, in stroke patients.

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