Abstract

Introduction: Doppler sonography of the cervical segment of the carotid arteries is becoming a popular tool for evaluating atherosclerosis of the carotid artery. We present the audit of findings on carotid ultrasound examination among patients with clinical suspicion and risks for cerebrovascular disease and possible correlates in Northern Nigeria. Materials and Methods: We performed carotid ultrasound examination on all patients referred for screening and clinical suspicion of cerebrovascular disease within the year 2017. The patients’ characteristics, risk factors, presence of atheroma and characteristic of the atheroma, degree of stenotic disease as well as the presence of incidental ultrasound findings were reviewed and documented. Results: Out of the 62 patients, 55 (88.7%) of them had various degrees and types of atheromatous plaques in different segments of the cervical carotid arteries, whereas 7 (11.3%) were normal. The predominant risk factor was smoking followed by diabetes mellitus, whereas the highest indication for the scan was transient ischemic attack. Incidental thyroid lesions such as nodules and cysts were encountered in 14 (22.6%) of the patients. There is a statistically significant difference between sex and age with the side of lesion, degree of stenosis, segment involved, and type of atheromatous plaque. Conclusion: There is a statistically significant difference between sex and age with the side of lesion, degree of stenosis, segment involved, and type of atheromatous plaque. About one-fifth of our patients had incidental thyroid lesions. Therefore, routine screening of population at risk is highly recommended.

Keywords: Atheroma, audit, carotid Doppler, stenosis, stroke
INTRODUCTION

Doppler sonography of the cervical segment of the carotid arteries is a noninvasive modality for the evaluation of the anatomy and hemodynamics of the carotid arteries. Carotid Doppler ultrasonography is becoming a popular tool for evaluating atherosclerosis of the carotid artery (CA).\(^1\)\(^2\) Its ability to measure intimal media thickness (IMT) and characterize the morphology of carotid atheroma makes it a reliable modality of determining the etiology and severity of stroke risk.\(^3\(^4\)) In addition, color Doppler ultrasonography and pulsed Doppler ultrasonography have been used for detecting CA stenosis.\(^1\)\(^4\)

Stroke is increasingly becoming a challenging public health issue in Africa, and the nonavailability of data has limited research output and consequently the response to this burden. Adeloye\(^5\) estimated that about 3483 new stroke cases among people aged 15 years or more were estimated in Africa in 2009, equivalent to 81.2 (13.2–94.9)/100,000 person-years. Despite the fact that it was recommended to be used as a baseline noninvasive method in the initial evaluation of either asymptomatic or symptomatic patients to define the possible stenosis on CA,\(^6\) the pattern of findings in the local setting remains so far, unknown. This report presents the audit of the spectrum of findings on carotid ultrasound examination among patients with suspected symptoms and risks for cerebrovascular disease and documented possible correlates. This is to generate a database that will benefit clinicians, researchers, industry, and policymakers in confronting the burden of cerebrovascular disease in Nigeria and other developing nations.

MATERIALS AND METHODS

All patients referred to vascular ultrasound clinic of screening and clinical suspicion of cerebrovascular disease within the year 2017 were included in the study. The following variables were recorded in the dedicated register:

1. Age
2. Gender
3. Indication for examination
4. Number of risk factors
5. Side and segment of the lesion
6. Presence or absence of the atheroma as well as the characteristic of the atheroma
7. Degree of stenotic disease if present
8. Presence or absence of the thyroid lesion and other incidental ultrasound findings.

Thereafter, the patients were scanned in supine position on the examination table. The patient’s head was turned away from the side and the neck a little extended. The examinations were carried out either from the patient’s side or sitting at the patient’s head. Coupling gel was applied on each side of the neck. The scan was performed in both transverse and longitudinal dimensions using the 7.5 MHz linear transducer of SONOSCAPE SSI–8000, 2014 digital color Doppler ultrasound system (Shenzhen, China). The transverse scan was performed first, which began from the level of the root of the neck up to the level of the angle of the mandible. The common carotid arteries as well as the level/orientation of bifurcation were located bilaterally. Major areas of abnormality were identified. Longitudinal scans were performed along with color and spectral Doppler interrogation.

Carotid IMT was measured as the distance between the leading edges of the two echogenic layers of the wall, using the posterior wall and also measurement, was obtained at the upper CA where the transducer was easily adjusted to make 90° angulation with the vessel wall for more accurate measurement. Magnification was also applied as much as possible to make measurement easier. The IMT measurements were also taken at the level of the carotid bifurcation and the internal CA (ICA). The identified atheromatous plaques were characterized and documented in to five types according to modified Gray-Weale classification as follows: Type 1 plaques were uniformly echolucent, Type 2 predominantly echolucent, Type 3 predominantly echogenic, Type 4 uniformly echogenic, and Type 5 consisted of plaques that could not be classified owing to heavy calcification and acoustic shadows.\(^7\) After capturing a transverse scan of the most stenotic segment of the CA on a B-mode or color Doppler, the original diameter (OD) and residual diameter (RD) were measured using electronic calipers. The RD was defined as the shortest diameter of the residual lumen at the most stenotic segment of CA, and OD was defined as the measured diameter from the outer media to the outer media of the diseased artery on the same plane and at the same direction with the RD. The percentage of carotid stenosis (CS%) grayscale ultrasound was calculated using the following equation: $\text{CS\%} = (1− \frac{\text{RD}}{\text{OD}}) \times 100\%$ based on the protocols of the European carotid surgery trial.\(^8\)

Color interrogation was used to identify areas of abnormal flow. Spectral Doppler mode was then activated, and measurements of velocimetric indices were done. At least five consistent waveforms were recorded on each segment.

Statistical analysis was performed using the Statistical Package for the Social Sciences Software, version 20.0 (SPSS, Inc., Chicago, Ill, USA). Descriptive statistics, including mean, median, standard deviation, frequency, and percentage, was used to describe demographic and clinical data. Pearson’s correlation coefficient was used to correlate the quantitative variables, whereas the Chi-squared test was used to test the possible association between categorical variables. A statistical difference was considered statistically significant when $P<0.05$.

RESULTS

A summary of the results generated from this audit of carotid Doppler ultrasound examination with their variables and frequencies is displayed in Table 1. Out of the 62 patients that had indications for the carotid Doppler scan, 55 (88.7%) of them had various degrees and types of atheromatous plaques in different segments of the cervical part of the carotid arteries, as exemplified in Figures 1 and 2, whereas 7 (11.3%) of them were
Ismail, et al.: Carotid Doppler sonography in Northwestern Nigeria

Table 1: Summary of Parameters/Variables/Frequencies

| Parameters                            | Variables (frequency)                        |
|---------------------------------------|---------------------------------------------|
| Age (yrs)                             | 19 - 84                                     |
| Sex                                   | Male(31), Female(31)                        |
| Risk factors for CVD                  | Hypertension(3), DM(19), Smoking(39), None(1) |
| Indication for scan                   | Screening(14), Headache(4), TIA(18), Paresis(4), Hernioplegia(9), Restroke(12), Other neuro-complains(1) |
| Side of Lesion                        | Right(13), Left (15), Bilateral(27), None(7) |
| Carotid artery Segment                | CCA(21), CB(9), ICA(5), Multiple Segments(20), None(7) |
| Type of Plaque                        | Type1(24), Type2(7), Type3(14), Type4(10), None(7) |
| Degree of stenosis (%)                | <40(24), 40-50(21), 50-60(6), >70(3), Total Occlusion(1), None(7) |
| No. of subjects with Plaque(s)        | None(7), One(35), Two(13), >Two(7)          |
| Intimal Media Thickness(IMT)           | Normal(14), Thickened(48)                   |
| Incidental Thyroid Lesions            | None(48), Nodule(9), Simple cyst (5)        |
| Other incidental findings             | None(58), Arrhythmia(4)                     |

CVD=Cerebrovascular Accident, DM=Diabetes Mellitus, TIA=Transient Ischaemic Attack, CCA=Common Carotid Artery, CB=Carotid Bulb, ICA=Internal Carotid Artery.

Table 2: Side of Lesions and Sex

| SEX     | RIGHT | LEFT | BILATERAL | NONE | TOTAL |
|---------|-------|------|-----------|------|-------|
| MALE    | 6     | 8    | 13        | 4    | 31    |
| FEMALE  | 7     | 7    | 14        | 3    | 31    |
| TOTAL   | 13    | 15   | 27        | 7    | 62    |

normal. The predominant risk factor was smoking, followed by diabetes mellitus (DM), whereas the highest indication for the scan was transient ischemic attack and then screening [Table 1].

There were nine patients with incidental thyroid nodules, whereas five had simple cysts, as exemplified in Figure 3. Other findings such as arrhythmia were encountered in two patients. However, these incidental lesions do not show evidence of extrinsic indentation on the carotids.

The carotid atheromatous lesions were seen mostly bilaterally in both genders (27, 43.5%) and then more on the left side [Tables 1 and 2].

More patients had <40% and 40%–50% of stenosis [Table 3], involving multiple segments and the common CA [Table 4] of Type 1 and Type 3 atheromatous plaque [Table 5].

A male patient in the age group of 60–69 years [Table 6] had total occlusion of the right ICA in the Type 4 atheromatous plaque category [Tables 7-9]. More patients were generally seen in the age of 50 years and above with a higher degree of stenosis in these age groups.

There is a statistically significant difference between sex and age with the measured parameters – side of lesion, degree of stenosis, segment involved, and type of atheromatous plaque ($P < 0.05$).

**Discussions**

During the period under review, a total of 62 patients were scanned, with equal distribution of males and females. Their ages ranged from 19 to 84 years with a mean of 61.7 years (+14.5 years). This is in agreement with the practice guidelines developed by the American Institute of Ultrasound in Medicine in collaboration with the American College of Radiology, the Society for Pediatric Radiology, and the Society of Radiologists in Ultrasound,[9] which is also similar to that of Japan Society for Ultrasonics in...
In our study, smokers are the highest risk group (62.9%) of those with plaque. They had plaque(s) mostly at multiple segments and the common CA which also constituted an important independent risk for the development of atheromatous plaque ($P < 0.005$). This is similar to the findings of Dempsey et al.\textsuperscript{[11]} who studied 790 patients with a history of smoking and concluded that smoking was a statistically significant independent predictor of CA plaque thickness. However, hypertension (1.61%) and DM (24.19%) scored low, even though hypertension as reported by several researchers\textsuperscript{[12,13]} is a known independent risk for plaque formation and stroke. Joakimsen et al.\textsuperscript{[14]} found more plaques in the walls of the common carotid artery (CCA) bifurcation, followed by the ICA when they studied 3016 men and 3404 women and found that 55.4% of men and 45.8% of women had plaques, with men having more echolucent type of plaque. These findings are similar to our study, which also showed more males with echolucent plaques and more females with predominantly echogenic type. There were more patients with plaques in the CCA and in multiple segments of the CA than other segments of the CA.

Regarding the type of carotid atheroma, Type-1 and 2 plaques were seen in 50% of our study population. However, a larger sample size study by Casadei et al.\textsuperscript{[15]} found Type 1 and Type 2 plaques in 160 (21.4%) of the 747 patients they examined. Apart from differences in sample size, the severity of risk factors may also differ between the two study environments.

Compared to the findings of Johnson et al.\textsuperscript{[16]} our findings showed that the association between smoking burden and carotid plaque presence was stronger in males than in females. Increasing carotid IMT additionally was associated with male sex. The study also showed that there are more males (19.4%) with a high degree of stenosis or increasing severity of plaque formation than females (12.9%). Furthermore, the severity increased with increasing age, from the age group of 50–59 years and above with a significant positive relationship between increasing age with the severity of carotid atherosclerosis and degree of stenosis ($P < 0.005$). These findings also agree with those of Yin et al.\textsuperscript{[17]} from the eastern part of China, showing that the prevalence of carotid atheroma and carotid plaque increased gradually with age. These conditions were more prevalent in men than in women.

In the course of data collection, we encountered 14 cases of incidental thyroid lesion, constituting 22.6% of the study population. Steele et al.\textsuperscript{[18]} found a lower rate of incidental thyroid lesion (9.4% of 188 retrospective carotid ultrasound

### Table 3: Degree of Stenosis and Sex

| Sex   | < 40 | 40 - 50 | 50 - 60 | >70 | Total Occlusion | None | Total |
|-------|------|---------|---------|-----|-----------------|------|-------|
| Male  | 15   | 6       | 3       | 2   | 1               | 4    | 31    |
| Female| 9    | 15      | 3       | 1   | 3               | 3    | 31    |
| Total | 24   | 21      | 6       | 3   | 1               | 7    | 62    |

### Table 4: Segment of carotid artery involved and Sex

| Sex   | CCA  | CB   | ICA  | Multiple Segments | None | Total |
|-------|------|------|------|-------------------|------|-------|
| Male  | 12   | 3    | 2    | 10                | 4    | 31    |
| Female| 9    | 6    | 3    | 10                | 3    | 31    |
| Total | 21   | 9    | 5    | 20                | 7    | 62    |

### Table 5: Type of Atheromatous plaque and Sex

| Sex   | Type 1 | Type 2 | Type 3 | Type 4 | None | Total |
|-------|--------|--------|--------|--------|------|-------|
| Male  | 13     | 5      | 6      | 3      | 4    | 31    |
| Female| 11     | 2      | 8      | 7      | 3    | 31    |
| Total | 24     | 7      | 14     | 10     | 7    | 62    |

Figure 3: Axial grayscale sonogram of the common carotid arteries at the middle of the neck, showing incidental complex left lobe thyroid cyst, measuring 14.75 mm × 10.96 mm in widest axial dimensions. It showed an eccentric echogenic peripheral solid element.
Table 6: Degree of Stenosis and Age

| Age(years) | Degree of Stenosis | Total Occlusion | None |
|------------|-------------------|----------------|------|
|            | < 40              | 40 - 50        | 50 - 60 | >70 |
| 19-29      | 3                 | 3              |        |     |
| 30-39      | 1                 |                |        |     |
| 40-49      | 2                 | 3              |        |     |
| 50-59      | 5                 | 4              | 1      |     |
| 60-69      | 9                 | 5              | 2      | 1   |
| 70-79      | 6                 | 6              | 1      | 1   |
| 80-89      | 2                 | 2              | 3      | 1   |
| Total      | 24                | 21             | 6      | 3   |

Table 7: Segment of carotid artery involved and Degree of Stenosis.

| Segment of the Carotid Artery Involved | Degree of Stenosis | Total Occlusion | None |
|---------------------------------------|-------------------|----------------|------|
|                                       | < 40              | 40 - 50        | 50 - 60 | >70 |
| CCA                                   | 11                | 9              | 1      |     |
| CB                                    | 6                 | 3              |        |     |
| ICA                                   | 3                 | 1              |        |     |
| Multiple Segments                      | 7                 | 6              | 5      | 2   |
| Normal                                | 7                 |                |        |     |
| Total                                 | 24                | 21             | 6      | 3   |

Table 8: Type of Atheromatous plaque and Degree of Stenosis

| Atheromatous Plaque | Degree of Stenosis | Total Occlusion | None |
|---------------------|-------------------|----------------|------|
|                     | < 40              | 40 - 50        | 50 - 60 | >70 |
| Type 1              | 16                | 7              | 1      |     |
| Type 2              | 5                 | 2              |        |     |
| Type 3              | 3                 | 7              | 3      | 1   |
| Type 4              | 5                 | 2              | 2      | 1   |
| Normal              |                   |                |        |     |
| Total               | 24                | 21             | 6      | 3   |

Table 9: Segment of carotid artery involved and type of Atheromatous plaque

| Segment of the Carotid Artery Involved | Atheromatous Plaque | Total |
|---------------------------------------|---------------------|-------|
|                                       | Type 1 | Type 2 | Type 3 | Type 4 | None |
| CCA                                   | 10     | 3      | 4      | 4      | 21   |
| CB                                    | 6      | 1      | 2      |        | 9    |
| ICA                                   | 1      | 2      | 2      |        | 5    |
| Multiple Segments                      | 7      | 3      | 6      | 4      | 20   |
| Normal                                |        |        |        |        | 7    |
| Total                                 | 24     | 7      | 14     | 10     | 73   |

examinations). However, an Iranian study showed a higher prevalence of thyroid incidentals of 51.2% among 410 patients, who were referred for the evaluation of carotid arteries and other neck examinations.[19]

**Conclusion**

This study shows that cigarette smoking is the most important risk factor to correlate with carotid intimal thickness, a strong indicator for the development of stroke. There is a statistically significant difference between sex and age with the side of lesion, degree of stenosis, segment involved, and type of atheromatous plaque. About one-fifth of our patients had incidental thyroid lesions.

DM is the second most common risk for the development of carotid intimal thickness found in our study. This finding can influence the consideration of lifestyle measures in
the prevention of cerebrovascular disease. In view of the limitations of this study by small number and other unanswered questions, further prospective studies involving larger patient population and other unexamined risk factors will be needed to validate our findings. Furthermore, routine screening of population at risk is strongly recommended.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References
1. Lee W. General principles of carotid Doppler ultrasonography. Ultrasonography 2014;33:11-7.
2. Tahmasebpour HR, Buckley AR, Cooperberg PL, Fix CH. Sonographic examination of the carotid arteries. Radiographics 2005;25:1561-75.
3. Blaser T, Hofmann K, Buerger T, Effenberger O, Wallesch CW, Goertler M. Risk of stroke, transient ischemic attack, and vessel occlusion before endarterectomy in patients with symptomatic severe carotid stenosis. Stroke 2002;33:1057-62.
4. Alagoz AN, Acar BA, Acar T, Karacan A, Demiryürek BE. Relationship between carotid stenosis and infarct volume in ischemic stroke patients. Med Sci Monit 2016;22:4954-9.
5. Adeloye D. An estimate of the incidence and prevalence of stroke in Africa: A systematic review and meta-analysis. PLoS One 2014;9:e100724.
6. Léránt B, Csiba L. The role of extracranial ultrasound in the prevention of stroke based on the new guidelines. Perspect Med 2012;1:94-9.
7. Geroulakos G, Ramaswami G, Nicolaides A, James K, Labropoulos N, Belcaro G, et al. Characterization of symptomatic and asymptomatic carotid plaques using high-resolution real-time ultrasonography. Br J Surg 1993;80:1274-7.
8. European Carotid Surgery Trialists’ Collaborative Group. MRC European Carotid Surgery Trial: Interim results for symptomatic patients with severe (70-99%) or with mild (0-29%) carotid stenosis. Lancet 1991;337:1235-43.
9. The American Institute of Ultrasound in Medicine (AIUM). AIUM practice parameter for the performance of an ultrasound examination of the extracranial cerebrovascular system. J Ultrasound Med 2016;35:1-1.
10. Terminology and Diagnostic Criteria Committee, Japan Society of Ultrasonics in Medicine. Standard method for ultrasound evaluation of carotid artery lesions. J Med Ultrason (2001) 2009;36:219-26.
11. Dempsey RJ, Moore RW. Amount of smoking independently predicts carotid artery atherosclerosis severity. Stroke 1992;23:693-6.
12. Liu A, Yu Z, Wang N, Wang W. Carotid atherosclerosis is associated with hypertension in a hospital-based retrospective cohort. Int J Clin Exp Med 2015;8:21932-8.
13. Su TC, Jeng JS, Chien KL, Sung FC, Hsu HC, Lee YT. Hypertension status is the major determinant of carotid atherosclerosis: A community-based study in Taiwan. Stroke 2001;32:2265-71.
14. Joakimsen O, Bonaa KH, Stensland-Bugge E, Jacobsen BK. Age and sex differences in the distribution and ultrasound morphology of carotid atherosclerosis: The Tromso Study. Arterioscler Thromb Vasc Biol 1999;19:3007-13.
15. Casadei A, Floreani M, Catalini R, Serra C, Assanti AP, Conci P. Sonographic characteristics of carotid artery plaques: Implications for follow-up planning? J Ultrasound 2012;15:151-7.
16. Johnson HM, Piper ME, Jorenby DE, Fiore MC, Baker TB, Stein JH. Risk factors for subclinical carotid atherosclerosis among current smokers. Prev Cardiol 2010;13:166-71.
17. Yin JH, Song ZY, Shan PF, Xu J, Ye ZM, Xu XH, et al. Age- and gender-specific prevalence of carotid atherosclerosis and its association with metabolic syndrome in Hangzhou, China. Clin Endocrinol (Oxf) 2012;76:802-9.
18. Steele SR, Martin MJ, Mullenix PS, Azarow KS, Andersen CA. The significance of incidental thyroid abnormalities identified during carotid duplex ultrasonography. Arch Surg 2005;140:981-5.
19. Taheri MS, Hemadi H, Haghighatkhah HR, Kamyar K, Jalali AH, Shakiba M. Prevalence of incidental thyroid nodules diagnosed by ultrasound in an Iranian population. Iran J Radiol 2008;5:19-23.