Original Article

Cranial tomographic angiographic evaluation of suspected intracranial vascular abnormalities among a Nigerian cohort

Ademola Joseph Adekanmi, James Ayotunde Balogun[1], Peter Taiwo Adenigba[2]

Departments of Radiology and [1]Neurosurgical Sciences, College of Medicine, University of Ibadan, [2]Department of Radiology, University College Hospital, Ibadan, Nigeria

Abstract

Background: Lately, there has been an increased utilization of computed tomography angiography (CTA) as the preferred first-line modality for the evaluation and diagnosis of most cerebral vascular lesions.

Objective: The objective of this study was to evaluate suspected intracranial vascular cases, using CTA at a major referral tertiary hospital in South West Nigeria.

Materials and Methods: This was a hospital-based retrospective study of suspected intracranial vascular cases in all ages and both sexes that had CTA from January 2011 to December 2018. Data were analyzed with IBM SPSS version 23.0, and $P < 0.005$ was considered statistically significant.

Results: A total of 128 patients were studied, the mean age was 44.1 ± 17.7 years, and male: female ratio was 1:1.06. The leading clinical diagnoses were as follows: intracranial aneurysms (34/128), subarachnoid hemorrhage (27/128), intracranial vascular tumors (26/128), brain hemorrhage from vascular abnormality (19/128), and arteriovenous malformations (AVMs) (10/128). At CTA, 61 patients had vascular abnormalities: intracranial aneurysm was seen in 63.9% with a peak age range of 41–60 years, and the leading location of aneurysms was posterior cerebral artery (18.8%), followed by posterior communicating artery (16.7%) and the cavernous segment of the internal carotid artery (16.7%). AVMs were more common in patients aged 40 years and below (91.7%) in males (66.7%) and in the parietal lobe. Intracranial aneurysms were 3.25 times as common as brain AVMs.

Conclusion: Intracranial aneurysms are the predominant vascular lesions, occurring mostly in the older age group. AVMs occurred mostly in younger people, more in males, and predominantly in the parietal lobes. The hospital incidence of aneurysms to AVMs was 3.25:1.

Keywords: Aneurysm, arteriovenous malformation, subarachnoid hemorrhage, vascular lesions

Address for correspondence: Dr. Ademola Joseph Adekanmi, Department of Radiology, College of Medicine, University of Ibadan, Ibadan, Nigeria.
E-mail: kanmiademola@gmail.com

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INTRODUCTION

Computed tomography angiography (CTA) has emerged as the main tool for the evaluation of intracranial vascular diseases, instead of the previously well-established catheter-based arterial angiographic studies.[1] The recent advancements in computed tomography (CT) scanner technology, greatly improved image resolution, its non-invasiveness, and lack of complications associated with catheter angiography, have made CTA, the first-line, and in most cases a sufficient modality for the evaluation of

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vascular lesion of the brain. CTA has emerged as the preferred imaging modality not only for the vascular lesions of the brain, but also to assess any pathological changes in the surrounding brain tissue for diagnosis, determination of treatment options, pre-surgical planning, and follow-up of treatment.[1-3]

Most intracranial vascular lesions are supratentorial, affecting the cerebral hemispheres, the thalamus and basal ganglia regions. Supratentorial vascular diseases are associated with adverse vascular events with high morbidity and mortality. Although cerebrovascular diseases, which account for the majority of the intracranial lesions, are frequently asymptomatic.[4-6] The symptomatic cases, however, present with seizures, stroke, or dementia.[7-9] Feigin *et al*. in 2010 listed stroke as the second leading cause of death globally, with over two-thirds of these deaths occurring in the developing regions of the world, such as sub-Saharan Africa[10] with significant sequelae documented by researchers.[11,12] Previous researchers have further identified racial differences as a factor affecting the distribution of cerebrovascular lesions.[13-15]

Infratentorial vascular anomalies, however, may arise from vertebrobasilar artery atresia, stenosis, a complete absence of arteries, fenestrations, duplication, and hypoplasia.[16]

In Nigeria, there are no data regarding the overall incidence of intracranial vascular lesions; however, studies have reported an increase in hypertension,[17] diabetes mellitus,[18] hyperlipidemia, and aging population. These conditions are risk factors for intracranial vascular diseases. The increasing prevalence of the aforementioned risk factors[17,18] may suggest an increase in intracranial vascular lesions among our people.

Aneurysms, arteriovenous malformations (AVMs), dural arteriovenous fistulas, cavernous angiomas, venous angiomas, atherosclerotic vascular lesions, and capillary telangiectasias are the major intracranial vascular diseases. However, most of the intracranial vascular lesions are aneurysms, a situation where the arterial size reaches a one-half increase of the original arterial size,[19] with a prevalence of about 3.2% worldwide,[20] and a prevalence range of 5%–10% among the population in a study conducted by Caranci *et al*.[21] in Italy with 10%–30% of this number having multiple aneurysms.[22] Although most unruptured aneurysms are asymptomatic. Subarachnoid hemorrhage (SAH) is the most common presentation of aneurysmal rupture in about 80%–90% of nontraumatic SAHs, with a peak age incidence of SAH occurring in those aged 55–60 years.[23,24]

AVMs, the second most common intracranial vascular disease, are vascular abnormalities consisting of tangles of abnormal blood vessels (nidus) in which the feeding arteries directly connect to a venous drainage network without the interposition of a capillary bed.[25] AVMs are mostly supratentorial (90% of brain AVMs) and the remainder found in the posterior fossa. With regard to incidence and adverse cerebrovascular events, intracranial AVMs occur in about 0.1% of the population.[26] Brain AVMs are responsible for 1–2% of all strokes, 3% of strokes in young adults,[27] and 9%–10% of all SAHs.[25,28]

Another group of intracranial vascular lesions is the venous angiomas. These are persistent primitive medullary veins from abnormal embryological venous development.[29] Venous angiomas are the most detected incidental vascular malformations radiologically and at autopsy.[30] Other important but less common intracranial vascular disorders are the capillary telangiectasia and cavernoma, which are abnormal capillaries with enlarged areas similar to cavernoma. They are low-pressure vascular structures, mostly asymptomatic, rarely bleed, and require no treatment in most cases.[21,31,32]

Cerebral malaria, tuberculous meningitis, neurosyphilis, cysticercosis, Chagas disease, brucellosis, viral hemorrhagic fever, sickle cell disease, Takayasu disease, Behcet disease, and moyamoya are other causes of intracranial vascular diseases, peculiar to the tropics.[33]

Radiological investigations, particularly CT angiographies, are crucial for intracranial vascular disease diagnosis, management planning, and follow-up posttreatment/intervention and the efficacy of CTA in the diagnosis of intracranial vascular lesions validated.[34-37] In Nigeria, few studies have shown the use of CTA in the diagnosis of intracranial vascular lesions.[37-39]

In this study, we evaluated the CTA features and the distribution of intracranial vascular lesions among patients with suspected intracranial vascular lesions referred for cranial CT examination at a major referral tertiary hospital in Nigeria.

MATERIALS AND METHODS

Study design

This was a retrospective descriptive study among all patients referred for cranial CTA during an 8-year period (January 2011–December 2018) at the University College Hospital, Ibadan, Nigeria. There were, however, periods of machine downtime, which varied from weeks to a few months.

All patients that had cerebral CT angiography scans over the 8-year study period from February 2011 to December 2018 for suspected intracranial vascular lesions were enrolled. The study setting was the Radiology Department of a major tertiary and referral hospital in south west Nigeria. We retrieved the hospital records of all patients that had a cranial CTA for suspected intracranial vascular disease during the study period from the departmental records. The age, sex, and clinical information, including the clinical diagnosis and other relevant information, were extracted and documented. CTA scan images of patients were also analyzed. The inclusion criteria for this study were all individuals of all ages and both sexes referred for CTA from various units in our hospital during the study period.

Patients with detailed demographics, clinical information, and images of diagnostic value, devoid of artifacts, were included in this study. Data of patients with scanty demographic and clinical information, as well as nondiagnostic images, were excluded. Although secondary data were employed, the confidentiality of patients was preserved by assigning numbers to each eligible patient in place of real names, and the data kept strictly confidential and safe, in line with the principles of the Helsinki Declaration (Helsinki, 1978).

All CTA images were acquired by 64-slice Toshiba Aquilion CT. All patients were either fasted overnight or for 4–6 h before the study. After each patient/caregiver had signed an informed consent form, patients had cannulation of upper limb peripheral vein in readiness for intravenous contrast administration. Patients were positioned supine for CTA. Contrast dose and rate were calculated based on the patient's weight. The cranial CT angiography protocol was selected, and the Hounsfield unit value was set on the desired artery. The auto-triggering technique was instituted for the CTA scans. After completion of the scan, the volume rendered 3D, maximum intensity projection, and multiplanar reconstructed images from the native axial images with the inbuilt vessel software. All reconstructed 3D and native images were saved on the hospital server for archiving. We used the Statistical package for social sciences (SPSS) version 23.0 (IBM SPSS, Chicago, IL, USA) for analysis, while data were displayed with tables of case frequencies, percentages, and bar charts. Test of association was done as appropriate. $P < 0.05$ was considered statistically significant.

RESULTS

A total of 128 patients referred for cranial CTA at the CT unit of the Department of Radiology of our institution were included in this study. The mean age of the patients was 44.1 ± 17.7 years, range: 1–87 years. About half of the patients (48.4%) were male. There were more males among patients aged ≤20 years of age (63.6%), as shown in Table 1.

The presenting complaint varied among the study cohort. Most of the patients (60.9%) had recurrent headaches, blurred vision, vomiting, and seizure disorder, followed by patients with loss of consciousness, sudden collapse, hypertension, and recurrent dizziness (23.4%). The least presenting complaints were puffy face/inability to make urine in 1.6% of the cases each [Table 2].

Table 3 shows the top clinical diagnosis. The leading diagnosis was suspected intracranial aneurysm in 34/128 (26.6%) of patients, followed by a SAH in 27/18 (21.1%) cases and intracranial vascular masses in 26/128 (20.3%) of cases. The least clinical diagnoses and reasons for referral for CTA were other minor vascular lesions: vasculitis, venous angioma, and cavernous angioma (2.3%).

Out of 128 patients referred for cranial CTA, 79.7% had abnormal CTA findings. Vascular abnormalities alone or in association with nonvascular findings were seen in 47.7% of the study population, while nonvascular pathologies were recorded in 32%. Out of the total number of those with vascular pathologies, 63.9% were aneurysms and 19.7% cases of AVM. Vaso-occlusive

Table 1: Age group and sex distribution of the study population

Age group (years)	Gender		Total (%)
	Male (%)	Female (%)	
20 or less	7 (63.6)	4 (36.4)	11 (8.6)
21-40	22 (48.9)	23 (51.1)	45 (35.2)
41-60	22 (46.8)	25 (53.2)	47 (36.7)
Above 60	11 (44.0)	14 (56.0)	25 (19.5)

Table 2: Presenting complaint among the study population

Presenting complaints	Case frequency (%)
Recurrent headache, blurring of vision, vomiting, seizure disorder	78 (60.9)
Loss of consciousness, sudden collapse, hypertension, recurrent dizziness	29 (22.7)
Tinnitus/hearing loss/auricular and periauricular mass	3 (2.3)
Abnormal eye bulging	3 (2.3)
Limb weakness/inability to move limbs	3 (2.3)
Neck stiffness	3 (2.3)
Orbital swelling/drooping eyelid	3 (2.3)
Facial asymmetry/deviation	2 (1.6)
Puffy face/inability to make urine	2 (1.6)
Others	2 (1.6)

Others: Previous head trauma and sickle cell disease crisis

Table 3: Clinical diagnosis of the study cohort

Clinical diagnosis	Case frequency (%)
Intracranial aneurysm	34 (26.6)
Subarachnoid hemorrhage	27 (21.1)
Intracranial vascular SOL	26 (20.3)
Hemorrhagic CVD	19 (14.8)
AVM brain	10 (7.8)
Minor vascular lesions	3 (2.3)
Others	9 (7.1)

Minor vascular lesions: Vasculitis, venous angioma, and cavernous angioma; Others – caroticocavernous fistula, venous infarcts, cerebral artery atherosclerosis, and venous sinus thrombosis. AVM – Arteriovenous malformation; SOL – Space occupying lesion; CVD – Cerebrovascular disease

Table 4a: Computed tomography angiography findings among the study cohort

Cranial CTA findings	Frequency (n=128), n (%)
Normal findings	26 (20.3)
Abnormalities found (102)	
Nonvascular abnormalities alone	41 (32.0)
Vascular abnormalities alone	40 (31.3)
Combined vascular and nonvascular abnormalities	21 (16.4)

CTA – Computed tomography angiography

Table 4b: Vascular abnormalities detected on computed tomography angiography among the study cohort

Vascular abnormalities	Frequency (n=61), n (%)
Aneurysms	39 (63.9)
AVM	12 (19.7)
Other abnormal CTA abnormalities	13 (21.3)
Encased vessels	2 (3.3)
Vaso-occlusive disease/atherosclerotic disease	2 (3.2)

Other abnormal CTA abnormalities; caroticocavernous fistula, hypoplasia of various parts of the cerebral arteries, absent left PCA, and vasculitis. CTA – Computed tomography angiography; AVM – Arteriovenous malformation; PCA – Posterior cerebral artery

disease/atherosclerotic disease occurred in about 3.3% of the patients [Table 4a and b]. Some of the intracranial vascular abnormalities on CTA are shown in Figures 1-3.

Most of the patients with vascular abnormalities on CTA (78.7%) were within the age group of 21–60 years. Among patients with intracranial aneurysm, almost half (48.7%) were within the age group of 41–60 years, $P = 0.001$, while most of the patients with AVM (91.7%) were ≤40 years $P = 0.001$ [Figure 4]. Again, more than half of the patients with vascular abnormalities on CTA (59.0%) were female. There were more women with intracranial aneurysms (76.9%), $P < 0.001$, and more males (66.7%) among patients with AVMs, although not statistically significant, $P = 0.056$ [Figure 5].

With regard to the site of an aneurysm in the circle of Willis, posterior cerebral artery (PCA) was the leading location (18.4%), followed by the middle cerebral artery, posterior communicating artery, and the cavernous

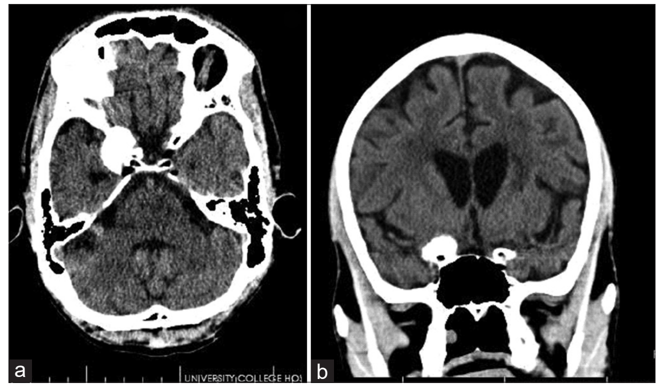

Figure 1: Axial (a) and coronal reformatted (b) computed tomography angiography showing aneurysmal dilatation of the right internal carotid artery. Background cerebral atrophy, as evidenced by prominent sulci and Sylvian fissures, is also noted

segment of the internal carotid artery, each accounting for 16.3% [Table 5].

The most affected location among patients with AVM was the right parietal lobe, occurring in 41.7% of the cases [Table 6].

Other CTA findings in this study are caroticocavernous fistula, arteriovenous fistula, hypoplastic anterior cerebral artery (ACA), absent right posterior cerebral artery (PCA), left middle cerebral artery (MCA) stenosis, and hypoplastic PCA. Also observed in this study are normal variants of the circle of Willis, including hypoplasia of the proximal segment of the right PCA, the proximal segment of left PCA, right ACA, and the vertebral artery.

Comparing CTA findings with the physician's diagnosis, only 47.1% of the patients clinically diagnosed with an intracranial aneurysm or aneurysmal SAH had an aneurysm on CTA. Furthermore, 20.0% of the patients clinically diagnosed with AVM had an AVM on CTA. About 68.4% of the patients clinically diagnosed with hemorrhagic cerebrovascular disease (CVD) had coexisting pathology identified by CT.

In screening for an aneurysm, the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of clinician's diagnosis when compared with CTA were 41.0%, 79.8%, 47.1%, and 75.5%, respectively. While clinician's diagnosis for brain AVM, when compared with CTA, had a sensitivity of 16.7%, a specificity of 93.1%, PPV, and NPV of 20.0% and 91.5%, respectively.

DISCUSSION

Indications for cranial CT examination are numerous. In this study, the most frequent indications for patients

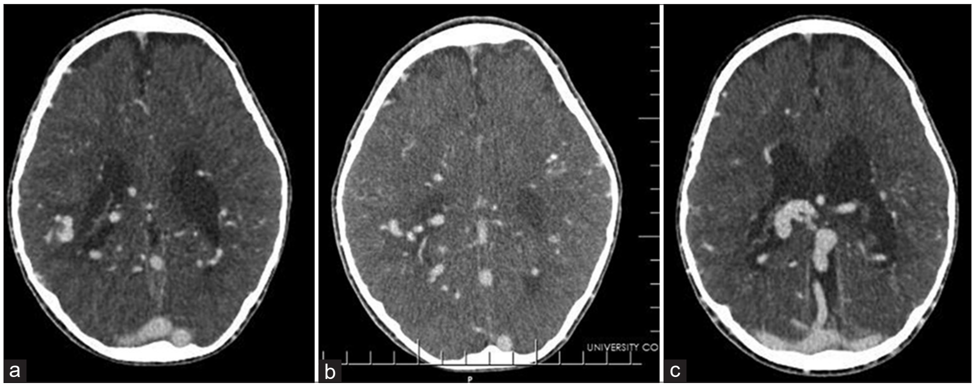

Figure 2: (a-c) Axial computed contrast-enhanced images showing dilated tortuous cerebral arteries in the parietal lobe adjacent to the posterior horn of the right lateral ventricle (a and b), early filling of the straight sinus, the transverse sinus in the arterial phase (c), in keeping with arteriovenous malformation

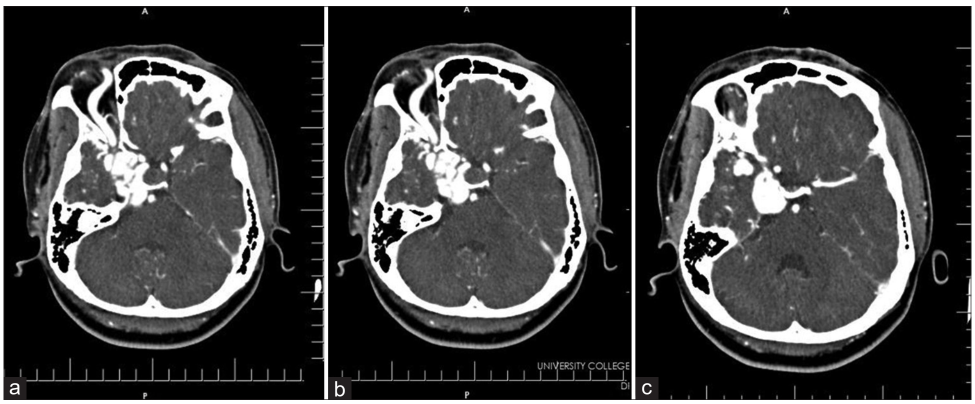

Figure 3: (a-c) Axial computed contrast-enhanced images showing dilated tortuous cavernous ICA and dilated right cavernous sinus and ophthalmic vein, in keeping with caroticocavernous fistula

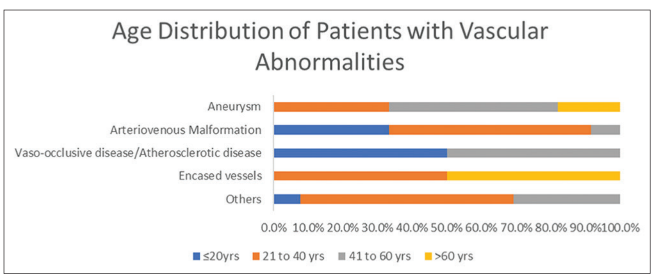

Figure 4: Computed tomography angiography findings, according to age group distribution

referred for cranial CT were recurrent headache, blurred vision, vomiting, seizure disorder, loss of consciousness, sudden collapse, hypertension, and recurrent dizziness. Our findings are in agreement with the previous study by Patel *et al.*[11]. Thomas *et al.* 2010 and Gupta *et al.*[6,8] reported that chronic headache alone, as an indication for CT, has a low yield, with 82% of the patients found to have no abnormality on cranial CT scans. However, when a headache is associated with other complaints such as dizziness, tinnitus, vomiting, focal weakness, or any neurological signs, there was a twofold probability of finding an abnormality on CT scan.[6] This was also corroborated by the United States headache consortium recommendation of neuroimaging for patients who have a nonacute headache associated with abnormal findings on neurological examination.[7] On the other hand, a CT scan has a high diagnostic yield in patients with seizure disorders alone.[9,11,40] In 2016, Ndubuisi *et al.*,[5] in a study of pediatric patients referred for CT and magnetic resonance imaging for seizure disorders in Enugu, Nigeria, reported that seizures alone accounted for over 21% of the patients referred for neuroimaging with as high as 53% of the imaging findings showing a structural abnormality.

Several studies have demonstrated the use of CTA in neuroimaging.[12,34-37] In this study, we identified vascular etiology in 36.8% of the patients with intracerebral bleed. Our findings agree with the findings from previous conventional angiography studies.[30,31] However, in a survey by Delgado-Almandoz *et al.*,[41] vascular causes were identified in 14.8% of the patients with intracerebral bleed. The older patient population (mean age, 65 years), compared with the mean age of 43 years in this current patient population, may explain the observed differences. Among patients with vascular abnormalities, cerebral

Table 5: Vascular distribution of cerebral aneurysms on computed tomography angiography evaluation

Location of aneurysm	Frequency (%)
Posterior cerebral artery	9 (18.4)
Posterior communicating artery	8 (16.3)
Internal carotid artery	8 (16.3)
Middle cerebral artery	8 (16.3)
Anterior cerebral artery	7 (14.3)
Anterior communicating artery	2 (4.1)
Basilar artery	2 (4.1)
Superior cerebellar artery	2 (4.1)
Others	3 (6.3)

Multiple cerebral aneurysms were present in some patients. Anterior circulation aneurysms=25 (51.0%); Posterior circulation aneurysms=21 (42.9%)

Table 6: Location of cerebral aneurysms on computed tomography angiography

Location of AVM	Frequency (%)
Right parietal lobe	5 (41.7)
Thalamic region	2 (16.6)
Right frontal lobe	1 (8.3)
Left parietal lobe	1 (8.3)
Pineal region	1 (8.3)
Suprasellar region	1 (8.3)
Periventricular and subependymal aspect of left frontal horn	1 (8.3)

Multiple AVMs were present in some patients. AVMs – Arteriovenous malformations

aneurysms were the most frequent (63.9% of the cases) with a ratio of the intracranial cerebral aneurysm to AVM of 1:3.25 recorded in this study, similar to a ratio of 1–3, reported by Adeloye *et al*.[13] This finding is at variance with the study of Ogbole *et al*.,[14] in which a ratio of 2:1 was reported. This difference may be due to the longer duration and larger sample size in our study, which is more representative.

In concordance with previous studies, intracranial aneurysms were common among the older population, with a peak age of 41–60 years. There was also a preponderance of females with intracranial aneurysm, compared to males in this current study, which corroborate findings from previous studies.[16,17] Juvela *et al*.[16] reported that women might have an odd ratio as high as 4 for the risk of aneurysm formation compared to men. Another group of researchers, Badr *et al*.,[15] in a retrospective analysis of 50 patients who had both multislice CT angiography and catheter-based angiography to evaluate cerebral arterial aneurysm and AVM noted that cerebral arterial aneurysm develops in all ages and is more prevalent among adults aged 30–60 years, in agreement with the findings of the current study. AVM in this present study was common among the younger population (91.7% of the patients aged 40 years and below), similar to the findings reported by Badr *et al*.[15] in which AVM appeared more in individuals

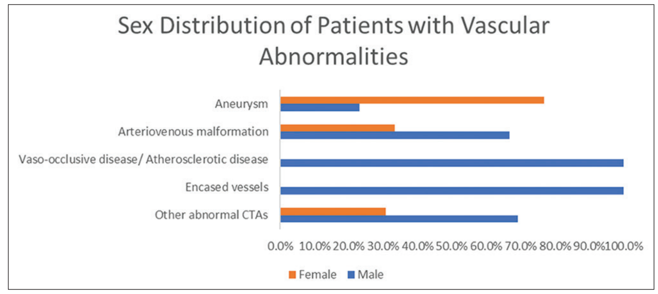

Figure 5: Computed tomography angiography findings versus sex of the study population

who were 10–30 years old. Previous studies have shown that gender does not affect the formation of an AVM.[18,42] Although, in this current study, there was no significant association between gender and AVM ($P = 0.056$), about 67% of the patients with AVM were male. AVMs may be common among young male Nigerians. Further studies will, however, be necessary to validate this finding in the future.

Apart from the fact that intracranial aneurysm size is a primary determinant of rupture probability,[20] location of the aneurysm also had an independent effect on the risk of rupture, with aneurysms in the posterior circulation, particularly having a higher risk of rupture.[23]

In previous studies, the middle cerebral artery, anterior communicating artery, and posterior communicating artery were the most common sites of aneurysms.[25,26,28,29] In this current study, the most frequent locations of intracranial aneurysms were the posterior cerebral arteries, middle cerebral arteries, the posterior communicating artery as well as the cavernous segment of the internal carotid arteries. We at this moment postulate that distinctive causes, risk factors, diet, and exposure to infective organisms may be responsible for the differences in intracranial aneurysm location and may vary from one geographical area to another, in addition to the known racial differences being a factor in intracranial vascular lesions.[13-15] Although PCA aneurysm represents approximately 1% of all intracranial aneurysms, the high proportion of PCA in our study may be due to the relatively younger population, in which PCA aneurysms are relatively more common.[33]

The result of this current study also showed that about 58.3% of AVM are in the lobar region; this is consistent with a previous study by Stapf *et al*.[34]

Several studies have shown the efficacy of CTA in the diagnosis and management of intracerebral vascular lesions.[12,36,37] Westerlaan *et al*.[38] in a meta-analysis of CT angiography for detecting aneurysms in patients with SAH reported an overall pooled sensitivity of 98% (95% CI:

97%, 99%) and a pooled specificity of 100% (95% CI: 97%, 100%) from 42 studies which used either a 4-, 16-, or 64-detector row CT scanner. Furthermore, Kovač *et al*.[43] demonstrated the diversity of intracranial arterial variations in a prospective review of CTA examinations. The overall frequency of CTA abnormalities (76%) in this study was similar to the findings of previous radiological report.[44] Result from our study after comparing clinician diagnosis to CTA findings showed that CTA was able to provide additional or new information on the pathology among a substantial number of cases. The result also showed low sensitivity of clinician diagnosis of intracranial aneurysm and AVM compared to CTA radiological diagnosis. These further buttressed the importance of CTA and agree with previous studies of CTA being a first-line diagnostic modality for intracranial vascular imaging.[12,30,45]

The repeated downtime of the CT scanner is one limitation of this study. Some cases would have been missed during such periods.

CONCLUSION

Intracranial aneurysms were the predominant vascular lesions, occurring mostly in the older age group. AVMs occurred mostly in younger people, particularly in males and in the parietal lobes predominantly. The hospital incidence of aneurysms to AVMs was 3.25:1.

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Conflicts of interest
There are no conflicts of interest.

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