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Original Article

Will improved neuroradiology facilities debunk the reported rarity of intracranial aneurysms in Sub-Saharan Africa?

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ABSTRACT

Background: Intracranial aneurysms (IAN) are rare in the Sub-Saharan Africa unlike other parts of the world. The debate is whether the low frequency might be apparent because of the scarcity of advanced neuroimaging services, or real. This study investigated if improved imaging facilities would debunk the rarity of IAN in our subregion.

Methods: This is a retrospective cohort study of prospectively recorded data of patients with subarachnoid hemorrhage (SAH) and IAN managed over 19 years (2003–2021), at the study center with a catchment population of over 47 million. The center witnessed progressive improvements in neuroimaging facilities: 2-Slice, 8-slice, and 64-slice computed tomography (CT) and 0.35T, 1.5T magnetic resonance imaging (MRI) during the period.

Results: There were 241 cases of SAH, but only 166 aneurysms were confirmed in 158 patients. Between 2003 and 2008, only 27 IAN patients (4.5 IAN/year) were diagnosed. After introduction of CT angiography/magnetic resonance angiography MRA using 8-slice CT/0.35T magnetic resonance imaging (MRI), between 2009 and 2014, the frequency of IAN increased to 8/year. Between 2015 and 2018 after installation of a 64-slice CT in 2014, the IAN remained the same (8/year). MRI 1.5T was added in 2018, the frequency doubled to 17 cases/year. The females were more (67.7%), the mean age was 46.3 years, but peak incidence was the sixth decade. Internal carotid artery aneurysms including posterior communicating artery were the most common (43%) followed by ACA with anterior communicating artery (24%) and middle cerebral artery (20%). Multiple aneurysms were seen in ten patients.

Conclusion: Improved neuroimaging between 2003 and 2021 did not debunk the rarity of IAN in our region.

Keywords: Africa, Geographical neurosurgery, Intracranial aneurysm epidemiology, Subarachnoid hemorrhage

INTRODUCTION

Sub-Saharan Africa has consistently recorded low intracranial aneurysm (IAN) frequencies prompting some reporters to argue that IAN are rare.[24,29,34] The debate is whether the observed differences are apparent or real. Some neurosurgeons have suggested that the burden of cerebral aneurysms in Africa might be underestimated due to underreporting. It has been argued that the limitations in diagnostic facilities, neurosurgical workforce and health awareness in African populations could explain the low frequencies.[5] However, these factors have improved in recent years and this ought to reverse the low incidence figures of IAN from some parts of Africa.

Mortality and morbidity from aneurysmal subarachnoid hemorrhage (aSAH) remain high despite immense research work and improvements in diagnostic and therapeutic capabilities. Each year, approximately 1 in 10,000 North Americans suffer aSAH, and despite recent advances, morbidity and mortality remain high as about 50% of aSAH patients die from the first hemorrhage or later complications.[13] In addition, patients with permanent brain damage raise severe consequences to 70%. The economic cost of caring for the victims is considerable in addition to the loss of quality of life for both the patient and the family. Given the magnitude of this problem, the search for ways to mitigate the consequences has become urgent and epidemiological studies could provide the clues.

There is documented geographical variation in the incidence and frequency of IANs. The incidence rate of aneurysmal SAH in developed countries varies from 1% to 5% of the population. A low incidence has been reported from some parts of Asia and Africa.[5,30,11,13,19,22,26,29,31-33] High incidence has been reported from Japan,[8,9] Finland,[10] Greenlandic Eskimos,[15] and in Maoris of New Zealand.[18]

Studies such as ours are important and needed to better understand the epidemiologic, clinical, and economic burden of cerebral aneurysms in Africa at national and regional levels. The study of the epidemiology of IANs may identify populations with a high or low risk of developing IANs and therefore facilitate the identification of genetic or acquired factors that might be responsible and thus drive prevention strategies.

The aim of this study was to review the annual frequency of IANs seen at a major referral neurosciences hospital in South-Eastern Nigeria over a 19-year period (2003–2021) that included a period of progressive upgrade of diagnostic facilities. Have the improved diagnostic facilities and awareness led to increase in the frequency of diagnosed IANs in the center?

MATERIALS AND METHODS

This is a retrospective analysis of prospectively recorded data of patients with the diagnosis of IAN seen between January 1, 2003, and December 31, 2021, at the study center. Information was obtained from clinic records, radiology (angiography, computed tomography [CT], and magnetic resonance imaging [MRI]), inpatient and operating theater database of the hospital.

The study was carried out in a private tertiary hospital established in August 2002. It was the only hospital that provided surgical management of IAN cases in the sub-region during most of the period of the study. The center had 8 consultant neurosurgeons and 30 Senior Neurosurgical Residents over the period of the study. Although located in a city with a population of about 723,000 (2006 National Census), the hospital also served as a referral center for many states, providing cerebral angiography (CA), CT angiography (CTA) and MRA services. The catchment population of mixed socio-economic status is over 47 million [Table 1].

Diagnosis of aSAH was based on history, examination, lumbar puncture, carotid angiography, CTA, and/or MRA. The protocol of the hospital for aSAH included repeating the CTA 2 weeks after a negative initial angiogram. Autopsy search for IAN was not performed because of religious and cultural impediments. The demographic data, age, sex, clinical features, and anatomical location of aneurysm were recorded for analysis. Annual frequencies were calculated and matched with the growth of diagnostic facilities and specialists. The findings were compared to earlier local, regional, and international experiences. The study was not concerned with management or outcome.

Data were entered into spreadsheet and descriptive statistics estimated temporal trends. Frequency tables of variables were generated. Figures and tables were used to illustrate relevant findings.

RESULTS

There were 241 SAH patients of which aneurysms were responsible for 158 (65.56%), and AVM in 24 (10%), while for the rest, the cause of SAH could not be confirmed [Table 2].

There was no aneurysm diagnosed in the first decade of age as the youngest patient was 13 years while the oldest was 78-years-old. The mean age was 48.23 years, the peak incidence was sixth decade, but 37.5% of the patients were 40 years or younger.

There were 166 aneurysms diagnosed in the 158 patients because of multiple aneurysms in some patients. The internal carotid artery (ICA) was the most frequent location (43%), while others were anterior communicating artery (ACoA) (23%), middle cerebral artery (MCA) (20%), and Vertebro-Basilar (VBA) (14%). Multiple aneurysms were seen in 10 patients (6.3%) [Table 3].

The annual frequency of patients with IAN fluctuated [Figure 1], dipping to zero in 2008, only one IAN in 2003 and 2011, and three in 2014 and 2015, respectively, with

Table 1: Catchment population and aneurysm frequency.

	Periodic data				
Variables	2003–08	2009–14	2015–18	2019–21	Total
Aneurysms (Average/yr)	27 (4.5)	48 (8)	32 (8)	51 (17)	158 (8.3)
NS consultants	2	3	4	7	
NS residents	1	3	6	10	
New patients (Average/yr)	3397 (566)	9773 (1629)	10,258 (2564.5)	10012 (3,337)	33440 (1,760)
Population	2006		2016	2021	
Enugu city	543,000		697,000	795,000	
South-East and South-South	35.0 m		47.5 m	50.4 m	

NS: neurosurgery, yr: Year

Table 2: Aneurysm characteristics.

Variables	No.
SAH patients	241
Aneurysm patients	158
No. of aneurysms	166
Multiple IAN Pts	10
Sex distribution	F 107; M 51
Sex ratio	F: M=2:1
Age range	13–78 yrs
Mean age	Mean 46.3 yrs
AVM patients	24

IAN: Intracranial aneurysm, SAH: Subarachnoid haemorrhage, AVM: Arteriovenous malformation

Table 3: Location of aneurysms.

Aneurysm location	No.	%
Internal carotid artery (including posterior communicating artery)	71	43
Ant cerebral and anterior communicating artery	39	23
Middle cerebral artery	33	20
Vertebro-basilar	23	14
Total	166	100
Multiple locations	10 patients	

no obvious cause for the trend [Table 1]. Further analysis revealed that between 2003 and 2008, there were only 27 IAN patients (4.5 IAN/annum). With the introduction of CT angiography (CTA) using 8-slice CT in 2009, the annual frequency increased to 8, between 2009 and 2014, but remained the same between 2015 and 2018 after the installation of a 64-slice CT in 2014. After 1.5T MRI was installed in 2018, the frequency doubled to 17 cases/year. There was also significant growth in the catchment population, the hospital's patient volume and diagnostic facilities [Table 1].

The females were more (67.7%), the mean age was 46.3 years, but peak incidence was in the sixth decade.

During the period of the study, 24 cases of AVM were diagnosed giving AVM to IAN ratio of 1:6.6. Two of the patients with AVM also had multiple aneurysms, with one of them harboring four aneurysms.

The clinical presentations of IAN were diverse, but SAH predominated in 65%. Other findings were headaches (92%), 3rd nerve palsy (32), seizures (5), suspected meningitis (2), and sudden blindness (2). Two patients had polycystic kidney disease but there were no cases of Sickle cell disease, HIV, or family history of IAN in the series.

DISCUSSION

Does the study suggest low frequency of Aneurysms in Enugu?

Between 2003 and 2008, the study center depended exclusively on non-digital carotid angiography as there were no facilities for CTA or MRA. The annual frequency of IAN detected ranged from 1 to 8. The introduction of CTA and MRA in 2009 using 8-slice CT and 0.35T MRI did not increase the numbers significantly [Figure 1].

The quality of our diagnostic services improved in 2014 with the installation of a 64-slice CT scanner that provided a high standard CTA, but this did not significantly increase the IAN volumes in the subsequent 3 years as was expected. In 2018, the hospital installed 1.5T MRI that improved MRA quality from the earlier 0.35T machine. Over the 3-year period (2019–2021) there were 51 IAN cases giving an annual frequency of 17 compared to the preceding periods. There was increase in IAN numbers, but considering the large catchment population of the hospital and the fact that it was the referral center for SAH and IAN cases, the results suggest that the frequency of IAN in the sub-region is still low in comparison with international data [Table 4].

Experiences in other parts of Nigeria and Africa seem to support this view. A study in Abuja, Nigeria,[34] reported that across a 4-year period, 57 patients presented with aSAH but only 25 were confirmed to harbor 27 aneurysms while 47% could not afford the cost of confirmation investigations, thus giving an annual

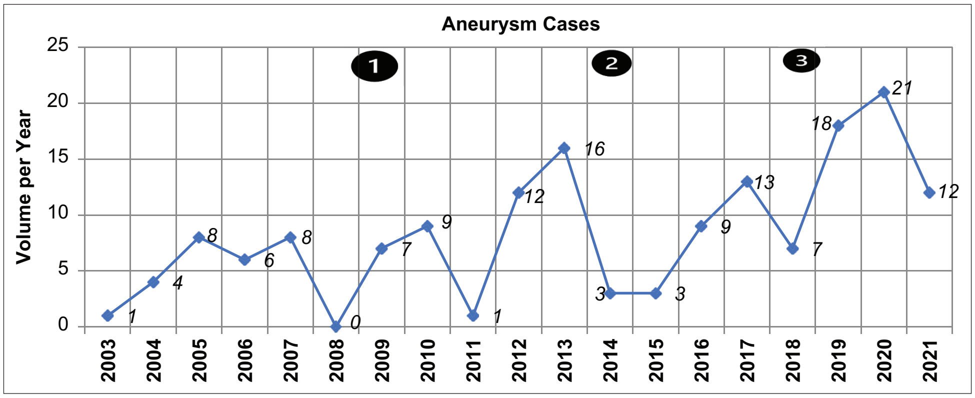

Figure 1: Annual frequency of intracranial aneurysms. ❶: 0.35T magnetic resonance imaging (MRI) and 8-slice computed tomography (CT) introduced in the hospital [2009]. ❷: 64-slice CT introduced in the hospital [2014]. ❸: 1.5T MRI introduced in the hospital [2018].

Table 4: Comparative global IANs frequency.

Reference study	Town, country	Study period	Total IAN	Annual frequency
Index study	Enugu, Nigeria	2003–2021	158	8.3
Shokunbi *et al.*[29]	Ibadan Nigeria	1988–1999	17	1.6
Ohaegbulam[24]	Enugu, Nigeria	1974–1977	5	1.7
Ugwuanyi *et al.*[34]	Abuja Nigeria	2016–2020	27	6.7
Tokpa *et al.*[33]	Abidjan Corte Ivoire	2012–2018	128	18.3
Thioub *et al.*[32]	Dakar Senegal	2013–2016	129	36.8
Ogengaʼo *et al.*[22]	Nairobi Kenya	1998–2007	56	6.2
Nabaweesi-Batuka *et al.*[19]	Nairobi, Kenya	2010–2014	121	30
El Khamlichi *et al.*[5]	Rabat Morocco	1983–1999	200	11.7
Khan *et al.*[12]	Quarter	2007–2016	323	32.3
Ramnarayan *et al.*[26]	Kozhikode, India	1998–2003	182	36.4
Law *et al.*[16]	Hong Kong	2002–2006	135	33.75
van Munster *et al.*[35]	Kuopulo Finland	1986–2005	1786	94
van Munster *et al.*[35]	Utrecht, Netherlands	1986–2005	1788	94
Korja *et al.*[14]	Helsinki, Finland	1995–2009	1993	142.4

IAN: Intracranial aneurysm

frequency of 6.25. Assuming all the 57 patients were confirmed to have IAN, this could have raised the annual frequency to 14.25. However, this finding that 47% of the SAH patients could not afford the cost of a CTA or MRA in the Federal Capital Territory that has one of the highest populations of affluent and middle-class citizens in Nigeria and Africa obviously suggests that this could be a serious factor in the scarcity of IANs.

A recent scoping review of aneurysmal SAH in Africa revealed the scanty publications on this important subject that dominates neurosurgical literature.[30] Interestingly, most of the publications emanated from North African countries. The publications from sub-Saharan Africa on aneurysms were insignificant in contrast to other neurosurgical topics. A retrospective study from Senegal, reported 129 aneurysms over 3.7 years giving an annual frequency of about 35.2 which is one of the highest figures to come from Africa.[32] However, considering that the population of Dakar metropolitan is about 3.9 million while Senegal has over 17 million people, it can be concluded that the frequency of IAN in that country is relatively low. Aneurysm frequency in Nairobi increased from 5.6 per year in 2009 to 30 in 2016[19,22] however, that multiethnic city of over 6 million people, has a mix of Kenyan ethnic groups, Asians, Somalians and Europeans, which could account for the IAN larger volume, although for the size of the population it is still considered low.

Interestingly, over a period of 4 years, 82 patients with spontaneous SAH were managed at hospital in Austria, serving 360,000 inhabitants, giving SAH incidence of 5.7/100,000/year. In 70 of the 82 patients (85.4%), cerebral aneurysms were detected by CTA.[28] The index study was conducted in a hospital that serves a much larger population [Table 1] yet managed fewer aneurysms per year.

Autopsy studies have provided information on the incidence of IAs although there may be concerns about the accuracy of the results. In an autopsy study of 1000 brains in India, IANs were found in 10 (1%).[11] An autopsy study of 10,259, at Montefiore Medical Center covering 1951–1987 reported 84 patients with 102 aneurysms giving a prevalence of 0.8%.[7] In Accra, Ghana, an autopsy study in 1985 reported 41 aneurysms from 310 adults giving an extraordinarily high frequency of 13.2%.[2] This is yet to be replicated or validated either in regular clinical practice or another postmortem study for nearly 40 years since that publication. A recent publication from Ibadan, Nigeria found only 9 aneurysms in 2,277 autopsies (0.4%).[5] Autopsy search for aneurysms might have helped to establish the true frequency in the population we serve. Unfortunately, this has not been possible because of refusal by families on grounds of tradition. A possible alternative is non-invasive MRA screening,[36] but cost considerations would make it difficult to recruit sufficient numbers with only about 5% enrolment in health insurance in the country.

Are IAN characteristics different?

The age distribution in our cohort showed mean age was 48.23 years but the peak incidence was in the 6th decade which is similar to global experience. Females outnumbered males by 2:1 which also is similar to reports from most studies with a few exceptions like a study from Qatar which reported a preponderance of males (68.7%).[12]

The anatomical distribution of aneurysms showed that ICA which included posterior communicating artery accounted for about 43%, while ACA/ACoA contributed 23% and MCA 20%. This distribution pattern was also recorded in other African studies and in Black Americans unlike Caucasian IAN patients that show dominance of MCA aneurysms,[20,23] whereas in Japan, the proportions of the sites of aneurysm rupture were 40% for the ACA, including ACoA and distal ACA, 25% for the ICA, 25% for the MCA, and 10% for the VBA.[8]

Racial and geographical differences in frequency of IANs

Racial differences have been reported between Māori and European populations of New Zealand in aneurysmal SAH. It was found that the incidence per 100,000 of the population for all aneurysms was 14.3 for Europeans but 25.7 for Maoris.[18] Racial differences have also been reported from Denmark, where Caucasians have a lower incidence than Eskimos,[15] from Saudi Arabia, where Arabs have lower incidence than non-Saudis[1] and from USA, where Blacks have lower incidence than Caucasians,[23] Geographical differences have been reported in Finland where regional differences exist in the incidence of aSAH.[10,27,35]

Other explanations for these differences include genetic predilection and connective tissue disorders. Connective tissue defects may play a significant role in the development of IAN. Multi organ connective tissue disorders may, therefore, indicate a risk of IAN development.[3]

The major risk factors for IANs are hypertension, tobacco abuse and female sex.[4,6,16,21] Prevention of aSAH can be achieved by reducing risk factors, which include those for aneurysm formation and aneurysm rupture. Age, cigarette smoking, multiple aneurysms, and aneurysm site appear to be related to the size of ruptured aneurysms.[14]

The uneven sex distribution of IANs suggests possible physiologic or pathologic factors in the intracranial arteries. The female preponderance is usually explained by systemic factors such as hormonal influences and intrinsic wall weakness.[17]

Despite massive efforts, progress so far has been modest in isolating the genetic determinants for IAN. More detailed epidemiology data might be essential for successful genome-wide association study.

Modern aneurysm management requires heavy investments in financial and human resources to equip specialist centers. Such centers must provide facilities for CTA, MRA, digital subtraction angiography, operating microscopes, vascular C-Arms, endovascular armamentarium, modern intensive care unit, high-dependency unit, and aneurysm clipping tools. The question then arises as how neurosurgical units in countries with low IAN volumes could justify such heavy investments when the healthcare budget is inadequate to even cater for more common diseases. Are the IAN numbers sufficient to produce vascular neurosurgeons? Perhaps the best option might be to identify centers with higher volumes and encourage other centers to refer their cases to those centers. High-volume hospitals have more favorable outcomes than low-volume hospitals. This effect is substantial, even for hospitals conventionally classified as high volume.[25]

Limitations

Out of pocket payment for healthcare prevents many patients from seeking help. The absence of digital subtraction angiography (DSA) facilities might have led to missing small aneurysms. The COVID-19 pandemic might have prevented some patients from seeking healthcare. Catchment population was based on national census of 2006 and 2016 and for a hospital is not precise.

CONCLUSION

There was an increase in the number of IANs diagnosed in the study center with increasing awareness of the availability of neuroimaging facilities.

Improved diagnostic facilities led to detection of more IANs in the study center. However, the frequency rate was still far less than would be expected for the catchment population of this study, strongly suggesting that improved diagnostic neuroradiology has not debunked rarity of IANs in our subregion.

Declaration of patient consent

Patients' consent not required as patients' identities were not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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