Brain and Spine 3 (2023) 101778

Contents lists available at ScienceDirect

Brain and Spine

journal homepage: www.journals.elsevier.com/brain-and-spine

Surgical management of Aneurysmal Subarachnoid Haemorrhage in a resource-constrained region: A Nigerian regional experience

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ARTICLE INFO

Handling Editor: Dr W Peul

Keywords:
Aneurysmal subarachnoid haemorrhage
Clipping
Low income country
Nigeria

ABSTRACT

Background: Aneurysmal Subarachnoid Haemorrhage (aSAH) is a vascular injury with significantly high mortality, especially when poorly managed. This study seeks to outline the experiences in setting up a neurovascular service in Lagos, Nigeria.

Methods: A series of 45 patients were operated after aSAH over a period of 10 years. Patients consecutively were recruited following computed tomography angiography (CTA) diagnosis of aSAH. Clinical data were recorded on a predesigned form after obtaining informed consent; aSAH was classified using the WFNS classification, intraoperative findings were documented. Challenges in the management were analysed in a post-operative root cause analysis (RCA) review. Outcomes and factors responsible for the observed outcomes and actions taken were recorded.

Results: Forty-five patients were operated after aSAH was confirmed; there were 29 females and 16 males. (M:F 1:1.8), the age ranged from 14 to 76 years (mean 49.1±13.58). All the aneurysms were on the anterior circle of Willis, mainly on Anterior Communicating Artery aneurysm (18/48).

Thirty-eight patients (84.4%) survived and were discharged within an average of 10 days after surgery. Lower GCS at presentation was associated with poor prognosis ($p = 0.026$); however, data analysis demonstrated that other factors (financial issues, lack of appropriate instrumentation and equipment, experience of the surgeon) played a significant role in determining the outcome.

Conclusions: Aneurysmal Subarachnoid Haemorrhage (aSAH) is a challenging pathology and its management may be further burdened in resource constrained countries, as shown by the data analysed in this study from Lagos, Nigeria. Specialized and well-funded Neurovascular centres are needed to overcome the challenges faced and to improve care for aSAH patients in Nigeria.

1. Introduction

Aneurysmal SAH (aSAH) accounts for about 5–10% of all strokes globally diagnosed. (Schatlo et al., 2021)' (de Rooij et al., 2007). Its incidence ranges between 2 and 22 patients per 100,000 worldwide. (Rouanet and Silva, 2019)' (Steiner et al., 2013); incidence and prevalence of aSAH in Nigeria are unknown.

Aneurysmal SAH (aSAH) still remains a challenging pathology; mortality rate, including pre-hospital cases, is above 50%, with about a third of deaths happening prior to presentation at the emergency unit. (Steiner et al., 2013)' (van Gijn and Rinkel, 2001) Outcome is essentially dependent on the care received within the first few hours of ictus as some patients would die from the severity of SAH and possible re-bleed within the first few hours of ictus. Early and appropriate management play a significant role in securing the ruptured aneurysms and preventing complications of re-bleeding and death. These options include endovascular coiling and surgical clipping or wrapping of the aneurysms (Irie et al., 2022)' (Hutter et al., 1999). The overall mortality is documented to decrease when patients are managed in specialized Neurovascular units such as acute stroke units, Intensive Care Units (ICUs) and

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https://doi.org/10.1016/j.bas.2023.101778
Received 6 April 2023; Received in revised form 9 June 2023; Accepted 30 June 2023
Available online 17 July 2023

high-volume neurovascular surgery centres with experienced surgeons (Fugate and Rabinstein, 2012).

Vascular neurosurgery is just evolving in Nigeria. There are few Neurosurgeons with experience in the management of aSAH. Neurosurgical centres with appropriate facility for clipping of ruptured aneurysm are extremely few. In Nigeria, the health care system is categorised into Primary health centre, Secondary and tertiary. The tertiary centres are usually the Teaching Hospitals and some Federal Medical Centres. There are however few private hospitals that are well equipped. Patients with aSHA are typically seen at the peripheral heath centres before being referred to the bigger and more specialized centres. Unfortunately, there are few centres with facilities for aneurysm management. In many cases, such patients are managed conservatively by the internal medicine specialist without the involvement of Neurosurgeons. Also, in many cases due to poor facility and poverty, the diagnosis is hardly ever made. Few that get to appropriate facilities will be faced with challenges of investigation, diagnosis, standard neurovascular facilities and many others issues related to poor health care systems.

This study documents the Authors' experience in the management of aSAH patients in Lagos, Southwest Nigeria, an area with an estimated population of over 20 million inhabitants with 2 major government neurological centres with 6 Neurosurgeons, not all of them with neurovascular expertise. It also focuses on the challenges encountered in the practice and on how to improve outcome using root cause analysis and critical self-audit.

2. Methods

The study includes all the patients surgically treated for aSAH by the authors in Lagos from January 2012 to December 2021.

The Authors reviewed demographic data, date/time of presentation, date/time of ictus and interval between ictus and presentation and surgery; a predesigned study form was used for the documentation.

Pre-operative data included GCS at presentation, clinical/neurological state at presentation as well as WFNS grade. Radiological data included site and side of the aneurysm and Fishers grading of the SAH from CTA/CT. Challenges in the pre and postop management such as ease of investigation in making diagnosis, reasons for delayed surgical intervention, financial capability to pay for surgery and secure ICU space were noted. Reasons for delays and reluctance for operative care were elicited from the patients or relations especially as it relates to apathy for surgery and inability to fund surgery or secure ICU space. Intraoperative findings were noted by the Surgeon at surgery. Outcomes of intervention were assessed by the Neurosurgeons after surgery and at outpatient clinic for a minimum of 6 months and documented.

The participants whose information were noted and analysed were made to sign a written informed consent form prior to recruitment. Comprehensive information on the study, its objectives, potential benefits, and risks was always provided to each participant or their primary care giver in patients that were unable to give consent; all potential participants were also informed about their rights.

The aneurysms were secured using standard microneurosurgical techniques. Pterional approach to the cranium was used and side was determined by the location of the aneurysm and in cases of Acom artery aneurysm, the side of the most prominent A1 was used. The head was fixed with a Mayfield head clamp and Microscope was used for all cases except one. Patients were recovered in ICU and monitored till safe to discharge to the ward and home.

For each case, a post-operative review of the surgery as root cause analysis (RCA) of the procedure was done by the medical team; details of the review were documented for the main purpose of identifying the challenges encountered in the case management and proffer ideas on how to overcome them. Postoperative hospitalization and possible complications were analysed; outcomes were measured using the Glasgow Outcome Scale (GOS). Previous cases were reviewed before the next surgery in order to improve subsequent cases.

Set outcome measures were survival without disabilities (excellent outcome), transient complications (Morbidity), permanent complications (severe morbidity) and mortality.

Data were then analysed using the IBM SPSS Statistics for Windows, Version 28.0 (Armonk, NY: IBM Corp), to elucidate the epidemiology and challenges involved in surgical management of aSAH with particular attention to findings at RCA as well as outcome.

3. Results

A total of 45 patients were operated after aSAH was confirmed with CTA. The series includes 48 aneurysms, as multiple aneurysms were detected in 3 patients. Female patients were slightly prevalent with a M: F ratio of 1:1.8 Age ranged from 14 to 76 years; the mean age (SD) of the patients in years was 49.1 (SD 13.58) years (Fig. 1).

On admission, 36 out of 45 patients scored between GCS 13 and 15; 5 patients had GCS 8 or below and necessitated intubation and ICU care prior to the surgical intervention, (Fig. 2).

26/45 patients presented in WFNS grade ll group. 4 of the 48 aneurysms were unruptured. Fishers grading of the aneurysm was as noted in Table 1. In this series, all the surgically treated patients had anterior circulation aneurysms; about 40% of all patients seen had ACOM aneurysm. The site of the aneurysms is reported in Fig. 3.

Microsurgical clipping was done in 45 aneurysms. Three aneurysms were wrapped; two aneurysms were fusiform and in the third case, a major vessel branched off the side of the aneurysm making it not suitable for clipping. In one patient with two aneurysms, one was clipped while the other was wrapped. The average time interval from ictus to surgery was 7 days (range: 0–21 days).

Intraoperative rupture of the aneurysm occurred in 4 patients. After clipping the aneurysm, papaverine would be instilled into the subarachnoid space before the final closure of the dura.

In the postoperative course, patients would be admitted to ICU or HDU before transfer to the ward.

Nimodipine 60 mg 4 hourly for 3 weeks and, when indicated, triple H therapy would be administered to patients suspected of vasospasms. Nevertheless, 4 patients developed significant vasospasm; in two of them there had been the intraoperative rupture of the aneurysm and hemiparesis.

Two patients developed hydrocephalus requiring a ventriculoperitoneal shunt, followed by favourable recovery; both patients had multiple bleeds before they eventually underwent surgery. None of the patients required external ventricular drain (EVD) insertion. No facility for intracranial pressure monitoring hence it was not done at all in any of the patients.

No patient in the series developed wound infection nor post op seizure.

More than half (58.9%) had significant postoperative improvement, their course was uneventful and they were discharged within 10 days

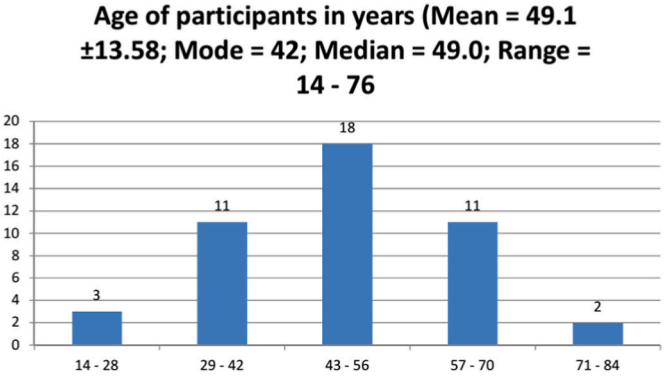

Fig. 1. Age distribution of patients with aSAH.

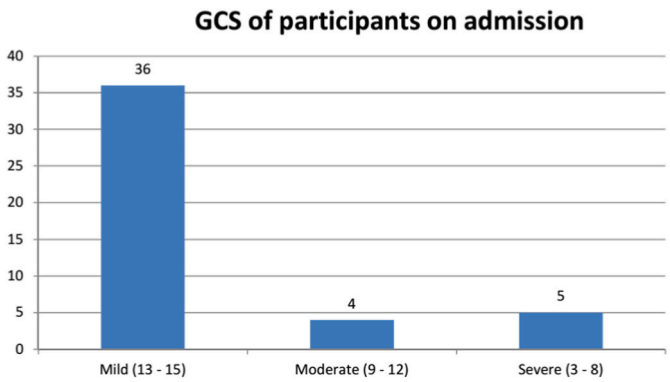

Fig. 2. GCS of patients on admission.

Table 1
Clinical Severity of patients with aSAH.

Variable	n (%)
WFNS Grade (n = 45)	
I	6 (13.3)
II	26 (57.8)
III	8 (17.7)
IV	4 (8.9)
V	1 (2.2)
Fishers Grade (n = 45)	
I	0 (0)
II	28 (62.2)
III	14 (31.1)
IV	3(6.7)

n(%): frequency (percentage); WFNS: World Federation of Neurological Surgeons.

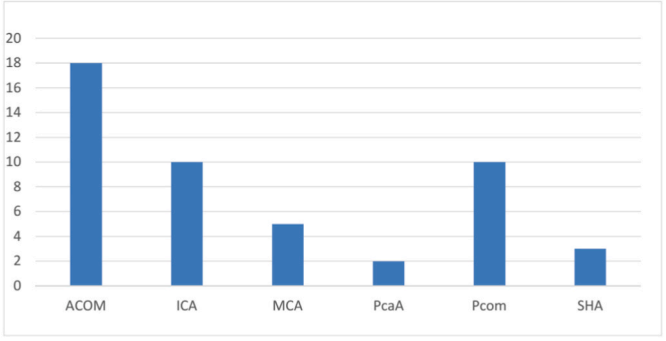

Fig. 3. Site of aneurysm.

after surgery.

Others had transient complications (retrograde amnesia, post-op ptosis and seizure) that resolved within a couple of days. (Table 3).

The gross mortality rate following surgery was 15.2%, (Fig. 4) with the mean interval between surgery and death being 4 weeks (range: 1 week to 8 weeks). Patients with aneurysm rebleed (3/45) while awaiting definitive management, as well as those with delayed presentation, had worse WFNS grades before surgery and that significantly affected the outcome.

Also, patients with poor GCS <8 (at presentation and before surgery), had poor prognosis when compared with others with less severe bleed (Table 2).

3.1. Root cause analysis

Root cause analysis (RCA) identified several factors that impacted on the outcome of patients. They could be grouped in 3 main cathegories.

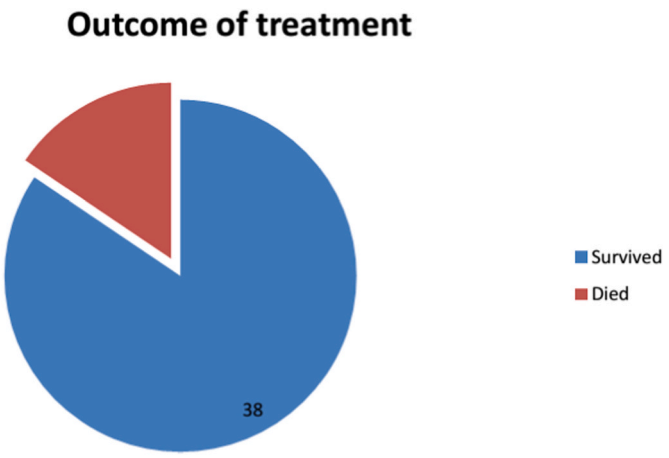

Fig. 4. Outcome of patients with aSAH.

Table 2
Association between GCS on admission, re-bleeding, and outcome
A statistically significant correlation between the GCS on admission (p = 0.026) and outcome was found. The association between GCS on admission showed a 91.7% survival for mild GCS, whereas moderate and severe GCS had respectively a mortality of 50% and 40%
This demonstrated that high GCS on admission is associated with favourable prognosis.

Variables	Outcome		X (de Rooij et al., 2007)	df	p-value
	Survived	Died			
GCS at presentation					
Mild (13–15)	33 (91.7)	3 (8.3)	7.317	2	**0.026**
Moderate (9–12)	2 (50.0)	2 (50.0)			
Severe (3–8)	3 (60.0)	2 (40.0)			
Re-bleed					
Yes	3 (75.0)	1 (25.0)	0.298	1	0.505
No	35 (85.4)	6 (14.6)			

Table 3
Clinical Complications of aSAH.

Variable (n = 19)	n (%)
Residual Hemiparesis	3 (15.8)
Transient Retrograde Amnesia	1 (5.3)
Multiple Bleed	1 (5.3)
Rebleeding	4 (21.1)
Ruptured IO	4 (21.1)
Vasospasms	3 (15.8)
Seizures	1 (5.3)
Hydrocephalus	2(10.6)

1) Financial restrictions
2) Treatment delay
3) Technical challenges due to lack of equipment and inexperience of the treating neurosurgeon.

Table 4 lists the challenges encountered in clinical and surgical management of these patients as well as the solutions identified to overcome the issue.

4. Discussion

In high income countries, the acute onset of severe thunderclap headache is considered an emergency that requires immediate transfer to the nearest emergency department (ED). At the onset of symptoms, the patient themselves or someone next to them may easily call the

Table 4
RCA of clinical care of patients with aSAH.

S/N	Challenges	Decision
1	Inappropriate sizes of clips (2/45)	Full range of clips set
2	Insufficient experience with complex aneurysm (2/45)	Training and courses
3	Poor illumination (1/45)	Mandatory use of operating microscope for subsequent surgeries.
4	Vasospasm after surgery (1/45)	ICU care for the first 48 h
5	Finance to image (2/45)	Benevolent Radiodiagnosis centre to give concessions for indigent patients
6	Late presentation (5/45)	Increase awareness of aSAH among other healthcare workers and availability of aneurysm clipping
7	Apathy for Vascular surgery (4/45)	Raise Awareness and demystifying belief of universally poor prognosis
8	Delays in getting theatre space (6/45)	Policy to operate within 24–48 h. Get theatre staff to give priority to Aneurysm cases
9	Finance for surgery (3/45)	Approach foundations to finance surgery
10	Poor team coordination (2/45)	Team work and pre-op briefings

ambulance service. Within few minutes from the call, paramedical and medical staff assess the patient on arrival and transfer them without delay to the closest neurosurgical hub for treatment; if needed, some basic resuscitative measures would be done en route. In countries like the UK or Italy, the national healthcare system provides treatment at no cost for the patient. In countries with insurance-based healthcare systems, billing would be sorted out when the patient is stabilized; when aSAH, is suspected, the patient is promptly investigated and indication for treatment given after the diagnostic assessment is complete. Awareness of the severity of aSAH is common among the first responders, ED specialists and perhaps even among many patients.

The above described scenario does not occur in the setting of this study. No ambulance service exists in many states of the Nigerian federation; they are often not readily available even in the biggest cities. However, even when available, usually in urban areas, ambulance services have to be paid out of pocket and they are usually way too expensive for the average citizen. This situation and outcomes are similar in other sub Saharan African countries with poor infrastructure and lack of neurovascular surgeons. In similar review in Senegal West Africa, there are very few Neurovascular surgeons, poor infrastructure and lack of health insurance. Poor outcome was recorded in over 20% of cases with mortality of 12.7% in the Senegal review against 15% in this series (Thioub et al., 2018).

The demography of the patients in the series are similar to documented series in the literature. Mean age of about 50 years is documented in this series which is about a decade younger than stroke patients and with slight female preponderance (de Rooij et al., 2007)' (van Gijn and Rinkel, 2001) (Thioub et al., 2018)' (van Gijn et al., 2007).

National insurance is yet to be well established in the region. Therefore, patients with signs and symptoms of aSAH usually wait until the headache subsides (if at all), take themselves if possible or relations will drive them in their cars to any nearby hospital even if there are no specialists; Nigeria has less than 100 neurosurgeons for a population of over 200 million and only very few centres provide neurovascular service in the whole country.

When patients cannot afford surgery or the centre/region has no neurovascular services, their fate is grim. Financial limitations prevent them to access diagnostic workup and, consequently, treatment; early re-bleeding and even death or survival burdened by disease complication may be their destiny. When the patient survives the acute stage, they are usually conservatively managed (or not at all if no money for care) until they can afford to seek the services of a specialist; this will take few days in many cases.

This article illustrated the Authors' experience in surgical management of aSAH. Although the study period covered a ten-year span, the series only includes 45 patients, whose data were collected from Lagos, Nigeria. The small number of patients obviously does not mirror the real incidence of aSAH in Lagos, home to more than 20 million inhabitants simply because most of them were not even referred for neurosurgical consultation. Others that presented with classical signs and symptoms of aSAH were not able to afford the necessary investigations and their diagnosis could not be confirmed. It is also important to note that there are other facilities where the patients might have been referred outside the centre of this study.

Treatment of aSAH encompasses clipping or endovascular coiling. Coiling is a treatment option is currently not available in the region; moreover, it is even more expensive than open surgery, thus not easy to implement in a setting where the cost of care is borne out of pocket and usually out of reach for the patient population we attend to. Therefore, surgery remains the only option. Unfortunately, many patients would refuse surgical management due to collective misconceptions aneurysmal brain surgery is not worth the risk as it is related to high post-operative mortality. However, as more cases were done with good outcome in our series, there were clinical and public health presentations in the region to create awareness for surgical management of aSAH and the result was seen in more patients being referred to the centre and submitting for surgical management. This is reflected in more cases done from 2018 onward.

Regarding the patients who were surgically treated, most patients in the study presented with WFNS grades 1 (6/45) and 2 (26/45) and GCS of or over 13 (38/45). This would suggest that most patients were still admitted in good neurological conditions and might have good chances for successful surgical intervention. However, the outcome in many cases eventually resulted less favourable than expected as many challenges were encountered and several factors impacted on the course of the patients.

A major issue was represented by treatment delay. There were many reasons responsible for the average ictus to surgery time of 7 days. These ranged from late presentation, delay to secure funding for surgery, patients/relations need for assurance that surgery was the only definitive treatment and also lack of theatre time. RCA identified delays in getting theatre space for patients who were given indication for surgery even if the neurosurgeon had tried to schedule the procedure within the first 24–48 h to prevent re-bleeding; the lack of available operating theatres delayed the procedure as other surgical emergency cases also queued up for the operating room. Differently from high income settings, in resource challenged countries, having dedicated neurosurgery suite is often extremely difficult. Advocating for early surgeries and policy change by the theatre staff would certainly reduce the possibility of early re-bleeds and improve outcomes.

All the patients were submitted to craniotomy with clipping or wrapping of the aneurysm. In the early cases, inexperience with complex cases were identified during RCA and the lead surgeon had to go for more training and courses at a high-volume centre. The effect was directly noticeable in subsequent cases with significant drop in morbidity and mortality from the third patients onwards (Fig. 5).

Regarding the 3 patients who underwent wrapping as the morphology of the aneurysm had contraindicated clipping. Stenting would have been indicated, yet unfortunately interventional neuroradiology is not yet available in our region. Three of the unruptured aneurysms co-existed with ruptured aneurysms in patients with multiple aneurysms.

Besides the inexperience of the neurosurgeon, another major problem was represented by the lack of basic equipment and consumables due to recent implementation of aneurysm surgery in our centres. For example, a wide variety of clips i.e sizes and shapes were not initially available, consequently affecting the outcomes of the first two cases. When a full set of aneurysm clips with variations in sizes and

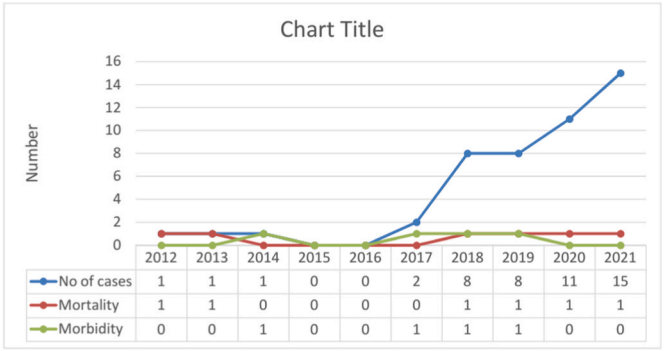

Fig. 5. Graph comparing volume with outcome.

configuration (e.g fenestrations) were eventually sourced, outcome subsequently improved.

Illumination and magnification were also identified as factors impacting on the outcome; sparing the perforators while clipping aneurysm without magnification and the appropriate illumination provided by the operating microscope is extremely difficult. (Hutter et al., 1999)· (Rutledge et al., 2022)· (Kuytu et al., 2022) Currently the use of the operating microscope during vascular surgeries has been made a unit policy.

Specialized neurovascular care and ICU care in the postoperative course are basic requirements for improving the outcome of aSAH patients. One patient died from vasospasm mainly because of financial exhaustion and inability to secure ICU after the surgery. We then changed protocol to ensure all patients had at least 48 h of ICU care to improve outcomes. The change made included pre-surgery counselling for the need for mandatory ICU care post-op (Fugate and Rabinstein, 2012).

Other possible complications of aSAH include hydrocephalus, seizures and wound infection (Fugate and Rabinstein, 2012)· (Bhattacharjee et al., 2021).[13131212121111]The overall mortality rate of patients operated in this study was 15.6% but when appropriately controlled by excluding patients with poor prognosis at presentation from rebleed or unstable clinical status, delayed presentation and GCS less than 8 at presentation, the adjusted mortality dropped to 10%. Bivariate analysis showed pre-op GCS lower than 8 is associated with poor prognosis and mortality. This is statistically significant at p-value of 0.026. Also, the outcome improved with higher volume of cases and progression of the learning curve related to intra-op and post-op management.

We would like to highlight the significant role of RCA in improving the outcome of patients in neurosurgical practice[141413131312]. At the RCA meetings, representatives of all health workers involved in the management of each case are involved and encouraged to discuss freely the challenges of the case with emphasis on what to do to improve the outcome of the subsequent cases. This has helped over the years as the number of cases progressed in our practice, especially in aneurysmal surgery. Issues noted were addressed critically and ensured never to have a repeat occurrence as much as possible. (Table 4). The progressive improvement in outcome was a result of climbing the learning curve quicker. Intraoperative rupture in the first few cases were associated either directly or indirectly with worse outcome unlike intraoperative rupture much later in the series in which the patients still had excellent outcomes. In some instances, as the experience got better, perforators had to be teased away from the aneurysmal dome under adequate illumination and magnification and sometimes with a controlled compromise of the aneurysmal sac without any detriment to the patients. This would be regarded as the importance of experience and learning curve already mastered.

Finally, it is to note that a major setback is the lack of patients' consent for surgical management, due to the widely diffused distrust and misconceptions on aneurysmal surgery in the Nigerian population. The unit has been able to create awareness via clinical presentations at local conferences and media talks showcasing the potential good outcomes of early and appropriate care. This has been able to help others make a decision for surgical options.

4.1. Limitations of the study

Late presentation, delay in surgical intervention and lack of financial strength to afford ICU and post operative CTA are recognised limitations of the study.

5. Conclusion

Neurovascular surgery may be extremely challenging in resource constrained settings. Regarding Nigeria, the lack of enough neurosurgeons who can guarantee access to appropriate treatment all over the country is indeed a major problem. However, the major factor affecting the mortality and morbidity of aSAH patients was lack of adequate funding for the surgery or financial exhaustion in the post-op ICU care. Unfortunately, the issue of health care funding remains largely unresolved in our environment and calls for an urgent solution, highlighting the responsibility of government institutions.

Declaration of competing interest

We hereby declare that we have no disclosures nor conflict of interest in connection with this work, and this manuscript has neither been previously published in part nor in whole in any journal and has not been submitted elsewhere for review.

Acknowledgement

The authors wish to acknowledge the contribution of Dr Debora Garozzo of Department of Neurosurgery, Mediclinic Parkview Hospital, Dubai, UAE.

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