



Surgical Aneurysm Repair of Aneurysmal Subarachnoid Hemorrhage in Sub-Saharan Africa: The State of Training and Management

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■ **BACKGROUND:** In a resource-limited setting such as sub-Saharan African countries, neurosurgeons need training and fellowship for surgical repair of aneurysmal subarachnoid hemorrhage (aSAH). Surgical repair of ruptured aneurysms costs less and requires less instrumentation compared with endovascular procedures. The purpose of this study is to evaluate the state of training and management of aSAH in sub-Saharan Africa training centers.

■ **METHODS:** An e-survey was sent as a Google Form to neurosurgeons and neurosurgical trainees in neurosurgery training centers in sub-Saharan Africa; responses were accepted from September 9 to October 23, 2022. Statistical analysis was performed using Microsoft Excel and JAMOVI 3.2.

■ **RESULTS:** All 44 centers from 17 countries responded. Most of the respondents were neurosurgery residents ($n = 30$; 68.18%). The level of training on clipping was basic after completing the residency program ($n = 18$; 40.91%). Twenty respondents (45.45%) identified that fellowships on aneurysmal clipping and endovascular treatment are offered abroad. Thirteen participants (29.55%) indicated that endovascular treatment is available at their institutions. The most common challenges with lack of training for neurosurgical aneurysm clipping were scarce scholarship and collaboration with training centers from

high-income countries ($n = 33$; 75%). The availability of intensive care unit beds also contributed to the presence of neurosurgical training of aneurysm clipping (12.1 ± 3.67 vs. 9.29 ± 5.82 ; $P = 0.05$).

■ **CONCLUSIONS:** In sub-Saharan African countries, the lack of collaborations with high-income countries for training through fellowships of young neurosurgeons for aneurysm repair seems to be the most important challenge that should be overcome.

INTRODUCTION

Aneurysmal subarachnoid hemorrhage (aSAH) is managed by either clipping or coiling of the ruptured aneurysm. Clipping the aneurysm requires more training and technical skills compared with endovascular coiling. In resource-limited settings such as sub-Saharan African countries, neurosurgeons should be encouraged to undergo training toward surgical repair of aSAH, because this condition is more frequent at the anterior circulation and is a good indication for clipping aneurysm.¹

Although neurosurgical development has been rapid and impressive in high-income country (HIC) settings, low- and middle-income countries (LMICs) have lagged behind. According to the Lancet Commission and World Bank report in 2015, there is

Key words

- Aneurysmal subarachnoid hemorrhage
- Fellowship
- Sub-Saharan Africa
- Surgical aneurysm repair
- Training

Abbreviations and Acronyms

- aSAH:** Aneurysmal subarachnoid hemorrhage
CAANS: Continental Association of African Neurosurgical Societies
HIC: High-income country
ICU: Intensive care unit
INR: Interventional neuroradiologists
LMIC: Low- and middle-income country

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a shortage of essential surgical care for 5–6 billion people worldwide.¹ In those countries, half of the patients die within 1 month of the hemorrhage, and of the patients who survive longer than 1 month, 40% remain debilitated. Because of the poor outcome after the hemorrhage and the young age at which it occurs, the loss of productive life years from SAH is as large as that from ischemic stroke, which is the most common subset of stroke in developed countries.² We argue that this burden of aSAH is more important in low-income countries of sub-Saharan Africa.

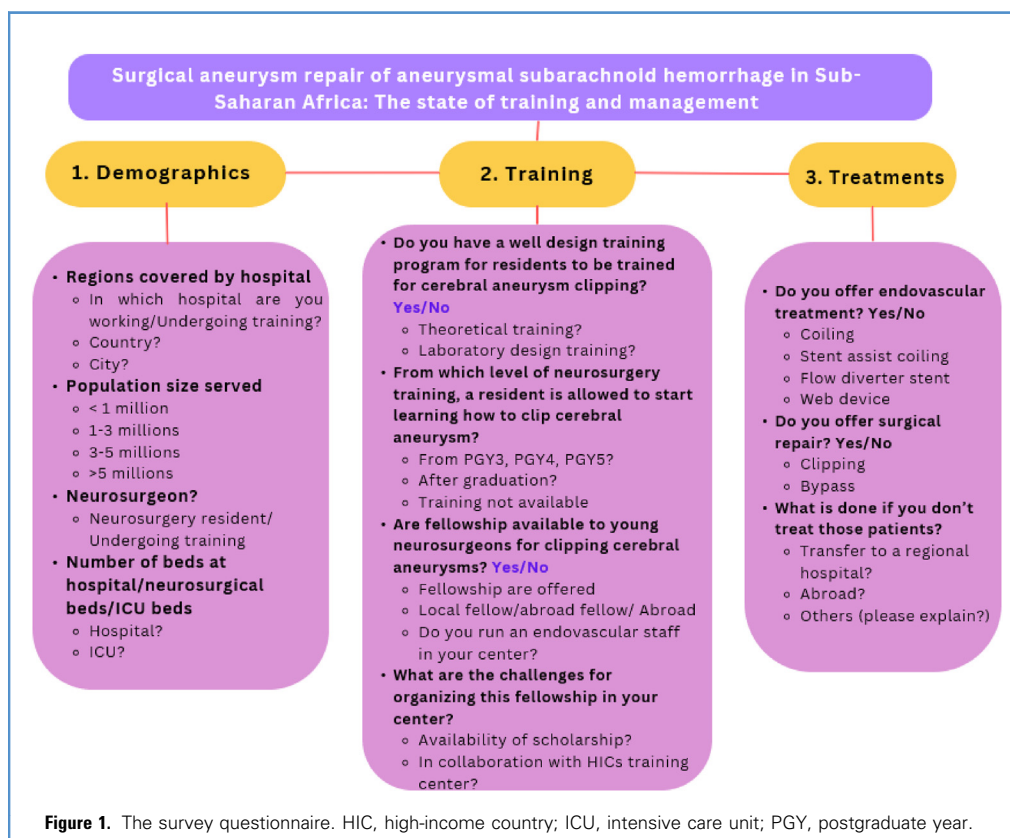
The standard way to prevent recurrent hemorrhage from aneurysm rupture is neurosurgical clipping. With the introduction of detachable coils to treat the aneurysm, endovascular coiling has become increasingly common. In many institutes, endovascular coiling has replaced neurosurgical clipping as the treatment of choice, if coiling is technically feasible. Furthermore, coiling is widely believed to be the preferred option in patients in poor clinical condition, but there is no high-quality evidence comparing the risks and benefits of clipping versus coiling in patients with high-grade aSAH. Thus, it remains unclear whether clipping or coiling is the better treatment option in such patients.³ Molyneux et al.⁴ found in their study that the annual risk of the treated aneurysm rebleeding is higher in patients treated with coiling compared with those treated with clipping; the risk remains low and is at a similar level to the risk of further SAH from another source, either a preexisting aneurysm or a newly formed

aneurysm.⁵ On the other hand, ISAT (International Subarachnoid Aneurysm Trial) suggested that, for ruptured intracranial aneurysms that are eligible for both neurosurgical surgery and endovascular intervention, the clinical outcome at 1 year was better in patients treated with endovascular coiling. However, because of the high cost of implanted devices, including flow diverters, stents, and coils, endovascular coiling was universally considered to be more expensive than clipping in resource-limited settings in sub-Saharan African countries.^{6–9}

The purpose of this study is to evaluate the state of training and management of aSAH in sub-Saharan Africa by mapping the availability and accessibility of training programs for young neurosurgeons via a fellowship across sub-Saharan Africa, accessibility of surgical treatment of cerebral aneurysms, and challenges of training pathways toward aneurysm clipping.

METHODS

An electronic survey questionnaire was designed and shared as a Google Form (Google LLC, Mountain View, California, USA) to neurosurgeons and neurosurgical trainees across sub-Saharan Africa. Responses were accepted from September 9 to October 23, 2022 (Figure 1) via social media (Telegram, WhatsApp). A reminder to fill in the survey was sent every week. The survey was sent to contacts in each country. When a center did not provide data after 1 week, the first author (Y.C.H.D.) contacted local neurosurgeons/residents via



WhatsApp for reminders. When these contacts failed to respond, the first author (Y.C.H.D.) contacted the local neurosurgeon/residents a second time (a week later) and then a third time (another week later). If the local neurosurgeon did not respond after 3 attempts, a second contact was identified. The participants were identified through neurosurgical societies such as the Association of Future African Neurosurgeons (AFAN), Young African Neurosurgeons Forum (Young CAANS [Continental Association of African Neurosurgical Societies]), and Sub-Saharan African Future Neurosurgeons Association (SAFNA). Through the social media of these societies and associations, we sent the survey to 44 neurosurgery training centers from the West African College of Surgeons (WACS) and from the College of Surgeons of East, Central, and Southern Africa (COSECSA) in sub-Saharan Africa headed by 40 training programs in 17 of 46 countries of the region. We analyzed demographics, neurosurgical training, and management of patients with aSAH in sub-Saharan Africa. Eleven responses (20%) were duplicates from the same centers. Duplicate data were removed by considering the seniority of the respondent, time in the current role, and the amount of data fields completed in the survey.

The results were tabulated in a Microsoft Excel spreadsheet (Microsoft, Redmond, Washington, USA). Statistical analysis was

performed by Microsoft Excel and JAMOVI 3.2 (<https://www.jamovi.org>). The Levene test was used to test the homogeneity of variance and the Q-Q plot as a graphic method to test the assumption of normality. We conducted a 1-way analysis of variance between neurosurgery training programs that can clip aneurysms and programs that cannot.

RESULTS

Characteristics of Respondents and Their Institutions

Fifty-five responses were recorded from 17 of 46 sub-Saharan African countries (37%); more than half of the sub-Saharan African countries do not have a neurosurgical training center. After the removal of duplicate responses, we included 44 responses from different neurosurgical training centers in 17 countries. Most of the respondents were neurosurgery residents (n = 30; 68.18%) from Nigeria (n = 13; 29.55%) and lived in a city of more than 5 million people (n = 27; 61.36%). Their institutions had a median of 32 (95% confidence interval, 25–50) neurosurgical beds and 10 (95% confidence interval, 9.26–12.28) intensive care unit (ICU) beds. Figure 2 gives more details on cities in which respondents are trained or work. There was no fellowship available in Central

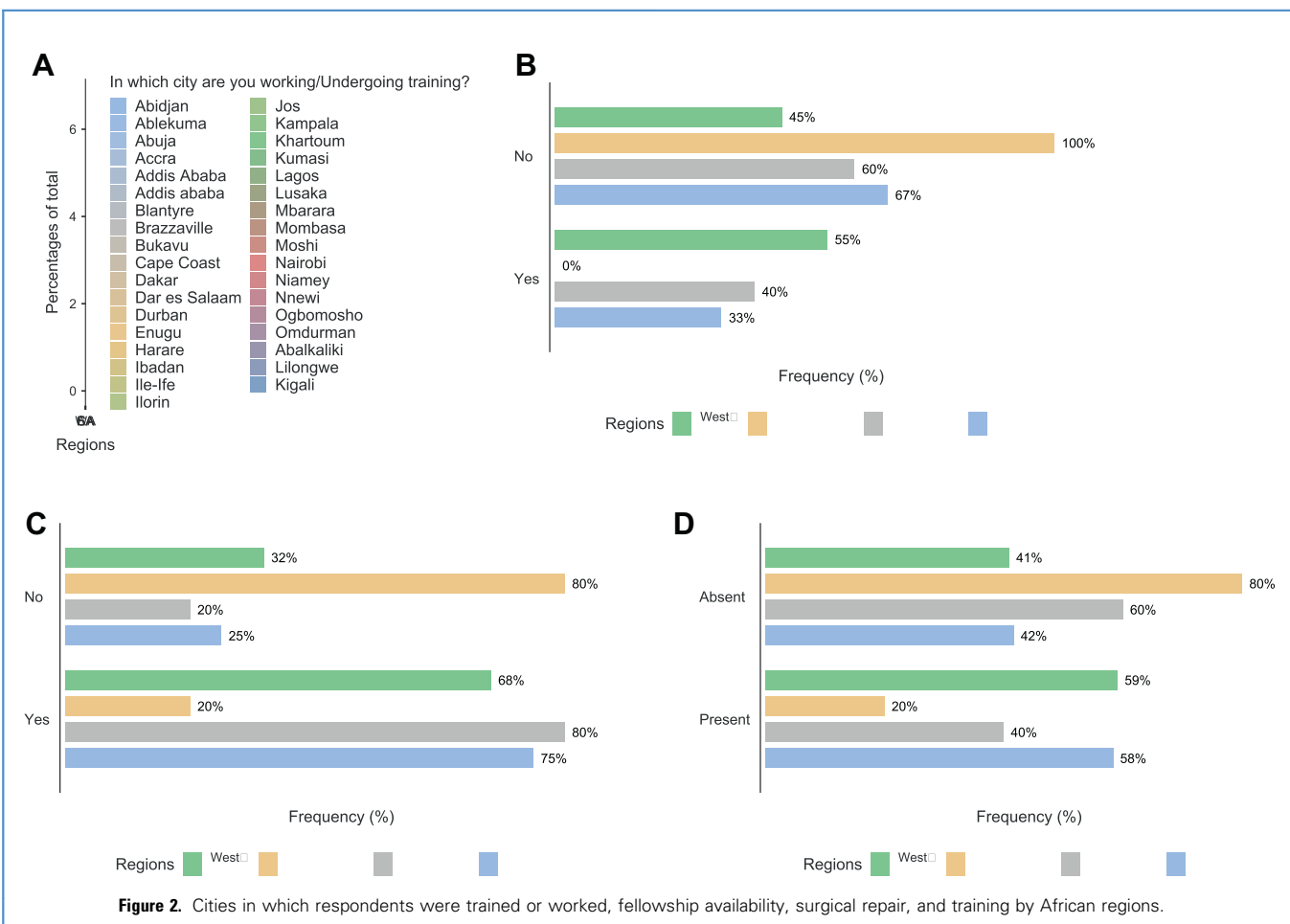


Figure 2. Cities in which respondents were trained or worked, fellowship availability, surgical repair, and training by African regions.

Africa and none of the training centers of respondents offered training or neurosurgical treatment of aneurysms. However, in West Africa, 55% of responders reported the availability of fellowships; 68% offer neurosurgical repair of aneurysm and 59% have neurosurgical training centers for aneurysm clipping.

Cerebral Aneurysm Repair and Training

Twenty-three responders (52.27%) reported that neurosurgical training was available and 37 (84.09%) reported that theoretic training was available. However, clinical fellowships ($n = 26$; 59.09%) and research training ($n = 39$; 88.64%) were lacking. The basic level of training in clipping was after completing the residency program ($n = 18$; 40.91%) followed by the third year of postgraduate training ($n = 16$; 36.36%). Twenty respondents (45.45%) identified that the fellowships of aneurysmal clipping and endovascular treatment are offered abroad, whereas 29 (65.91%) reported the absence of a neuroradiologist within the neurovascular staff at their center. **Figure 3** highlights the availability of aneurysm surgical repair through clipping or endovascular treatment according to the available neurosurgery department and training centers in each sub-Saharan African country. Twenty-nine respondents (65.91%) affirmed that aneurysm surgical repair could be performed at their institutions and the frequent modality included clipping ($n = 30$; 68.18%). A few participants ($n = 13$; 29.55%) indicated the availability of endovascular treatment at their institution. Coiling was in the same proportion ($n = 13$; 29.55%) as the most available endovascular treatment followed by stent-assisted coiling ($n = 12$; 27.27%) and flow-diverting stent ($n = 5$; 11.36%). Moreover, 5 of the 13

respondents who reported the availability of endovascular treatment at their institution confirmed the availability of these 3 modalities. When asked whether there were challenges of fellowship availability and access, 43 of the respondents (97.72%) reported that the most common challenges for training included lack of scholarship and no collaboration with training centers from HICs ($n = 33$; 75%) (**Figure 4**). When unable to perform surgical repair or endovascular treatment, respondents transferred patients abroad ($n = 29$; 65.91%) or to a regional or a private hospital ($n = 13$; 29.55%) able to manage cerebral aneurysms (**Table 1**). As can be seen from **Table 2**, there is a gap between the median number of neurosurgeons as well as neuroradiologists per capita across sub-Saharan African countries.

Comparison of Variances

The assumption of homogeneity of variance was assessed using the Levene test, which found a high P value ($P = 0.49$). We compared the availability of ICU beds in centers running a program for aneurysm clipping with those that do not. The mean of the number of ICU beds was 12.1 ± 3.67 for the first group and 9.29 ± 5.82 for the second. The availability of ICU beds was more important in training centers running a program for aneurysm clipping than in those centers that did not have such a program (12.1 ± 3.67 vs. 9.29 ± 5.82 ; $P = 0.05$) (**Figure 5**).

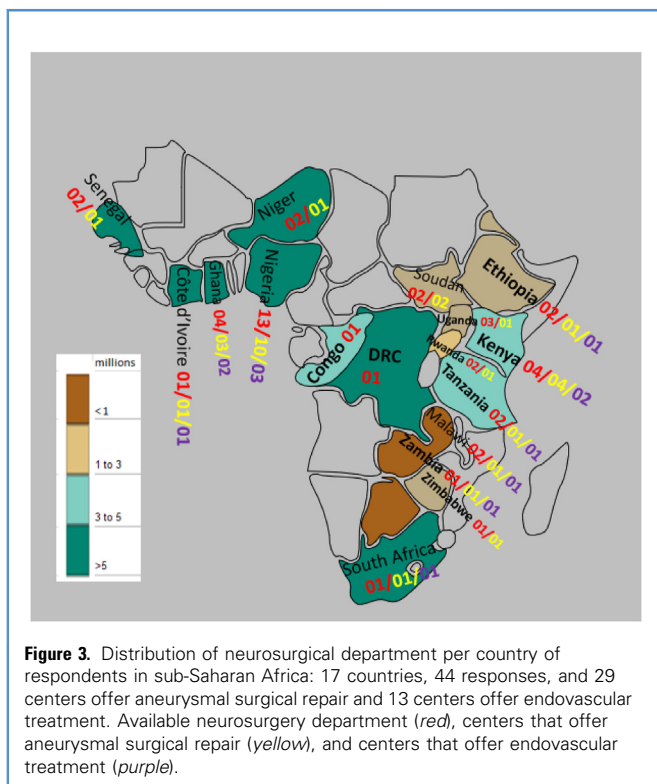
DISCUSSION

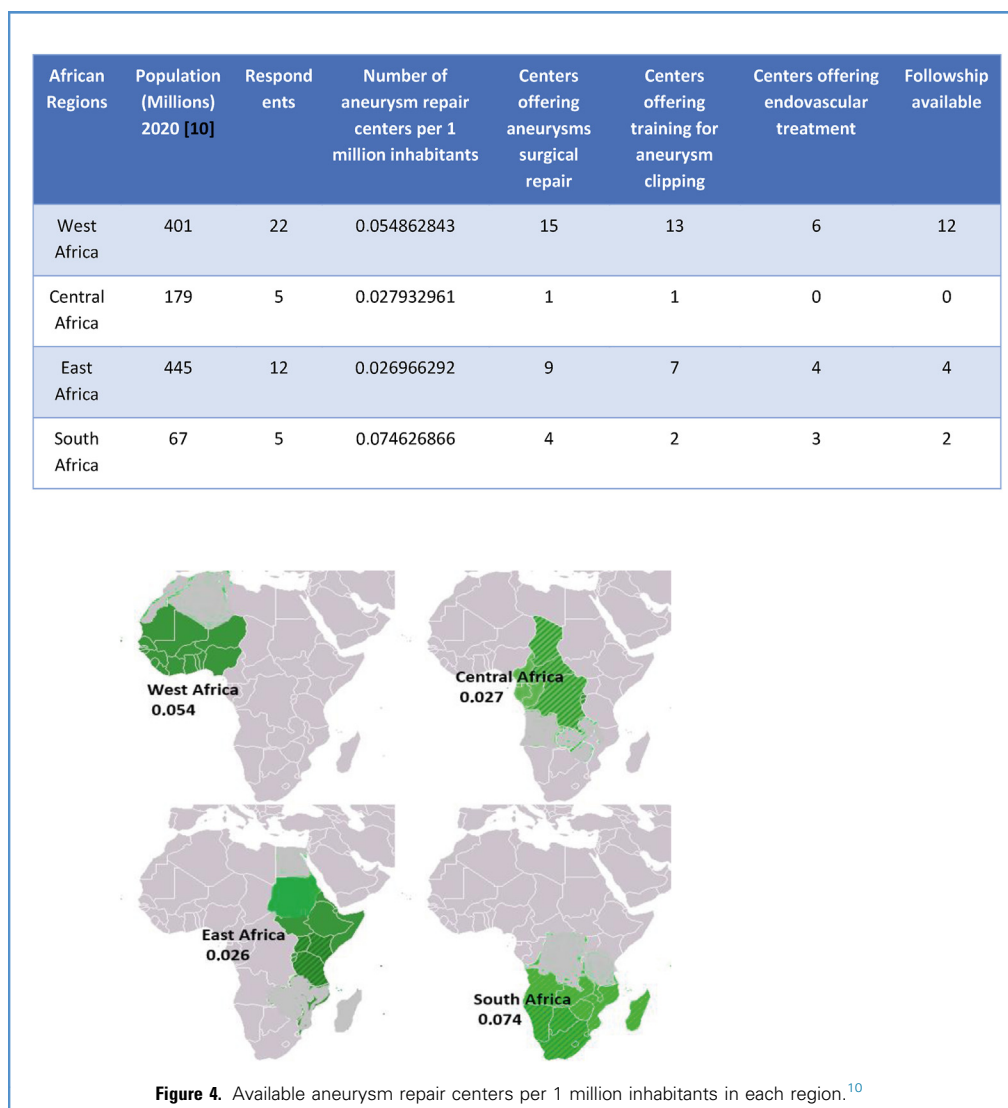
Key Findings

In this e-survey, we mapped 44 different neurosurgical training centers in 17 sub-Saharan African countries and the lack of basic training, fellowships, and endovascular means for young neurosurgeons, which included a lack of funding and lack of collaboration with HICs. Clipping practice training programs for residents were available in 52.27% of the programs, whereas theoretic training was available in 84%. The basic level of training on clipping was after completing the residency program ($n = 18$; 40.91%) followed by the third year of postgraduate training ($n = 16$; 36.36%). Fellowships of aneurysmal clipping and endovascular treatment are offered abroad ($n = 20$; 45.45%). However, 29 respondents (65.91%) affirmed that aneurysm surgical repair could be performed at their institutions, with clipping as the most common modality ($n = 30$; 68.18%). Endovascular treatment was reported as available by 13 respondents (29.55%). Availability of ICU beds also contributed to the presence of training programs for aneurysm clipping.

Management of Aneurysm Practice and Training

Previously, Kanmounye et al.¹¹ reported the evolution in neurosurgical practice in Africa over the past 2 decades, but neurosurgeons and residents face a myriad of difficulties in their day-to-day practice and education. Furthermore, cerebrovascular surgery was more popular among fellows than among residents or consultants ($n = 52.4$ vs. 46.2 vs. 20.5% , respectively; $P = 0.02$). Our results were consistent with the conclusion such that, in sub-Saharan African, training programs for aneurysmal clipping and endovascular treatment are offered abroad in 45.45% as a fellowship.





Furthermore, Tetinou et al.¹² reported in a recent scoping review regarding aneurysm management in Africa that the mean time from diagnosis to treatment was higher in Africa (12.1 days) than in Western countries (26.7 hours),¹³ and this delay between diagnosis and treatment, which constitutes a significant barrier and affects patient outcome,^{14,15} is probably biased by sub-Saharan African countries (excluding South Africa), where neurosurgeons face more barriers to service delivery.¹⁶

In addition, in sub-Saharan Africa, open surgery (clipping) represented the main treatment modality for the management of cerebral aneurysms, followed by the second type of management, being the natural history of the disease.¹⁷⁻²⁰ In our current survey, respondents affirmed that aneurysm surgical repair could be performed at their institutions, with clipping as the most common modality ($n = 30$; 68.18%), and, thus, we agree that surgical repair aneurysm might be the priority in sub-Saharan Africa countries; endovascular treatment could be provided in only 22% of centers in

LMICs in Africa because of a lack of equipment and trained personnel for efficient treatment of aSAH with endovascular procedures.²⁰ However, the lack of specialist interventional neuroradiologists (INRs) is not a barrier that is limited to Africa and LMICs; HICs such as the United Kingdom face similar barriers.^{4,20} We found that in our current survey, the availability of clipping practice training programs for residents was 52.27%, whereas theoretic training was reported in 84% of the programs. This availability could be improved by changing the priority to providing surgical intervention for aneurysms across the African continent. We believe that one of the best solutions is the practice training of senior residents and young neurosurgeons for neurosurgical aneurysm repair.

Comparison with HICs

Our results are in agreement with previous survey research that found no HIC standard-equipped centers for aSAH repair in sub-

Table 1. Availability and Challenges of Cerebral Aneurysm Training and Management in Respondent Countries

Features	Number (%)
Challenges for endovascular training program	
Availability of scholarship	43 (97.72)
Need collaboration with high-income country training center	33 (75)
Funding	1(2.27)
Equipment	1 (2.27)
Lack of personnel	1 (2.27)
Delivery of aneurysmal surgical repair	29 (65.91)
Aneurysmal surgical treatment available	
Clipping and bypass	4 (9.09)
Clipping	30 (68.18)
Bypass	3 (6.82)
Not available	6 (13.64)
Delivery of endovascular treatment	13 (29.55)
Endovascular treatment available	
Coiling	13 (29.55)
Stent-assisted coiling	12 (27.27)
Flow-diverter stent	5 (11.36)
Destination if unable to treat patients	
Transfer to a regional or private hospital	13 (29.55)
Transfer aboard	29 (65.91)

Saharan Africa. For example, in 2019, a Provider Profiling Questionnaire was sent to 230 Neurocritical Care Research Network (NCRN)-affiliated sites worldwide to recruit participants for the INSIDER (International Subarachnoid Hemorrhage Comparative Effectiveness Research Alliance) study, and from 145 centers across 5 continents that responded, no center with such a profile was found in sub-Saharan Africa.²¹ In 2020, the results of a questionnaire survey of management of patients with aneurysmal subarachnoid hemorrhage in Poland carried out by Hofman et al.²² reported 45 centers performing neurointerventional radiology procedures and neurocritical care. Thus, for 38 million inhabitants in Poland, >45 neurocritical centers were available for aSAH repair, whereas there were only 44 centers for 1.092 billion inhabitants in sub-Saharan Africa. In addition, in 2021, there were 42 INR centers for 68 million inhabitants in France, whereas there were only 13 INR centers for 1.092 billion inhabitants in sub-Saharan Africa.²³ This situation has been long neglected and this study will surely raise awareness and call for immediate action from both LMICs and HICs to fill this gap.

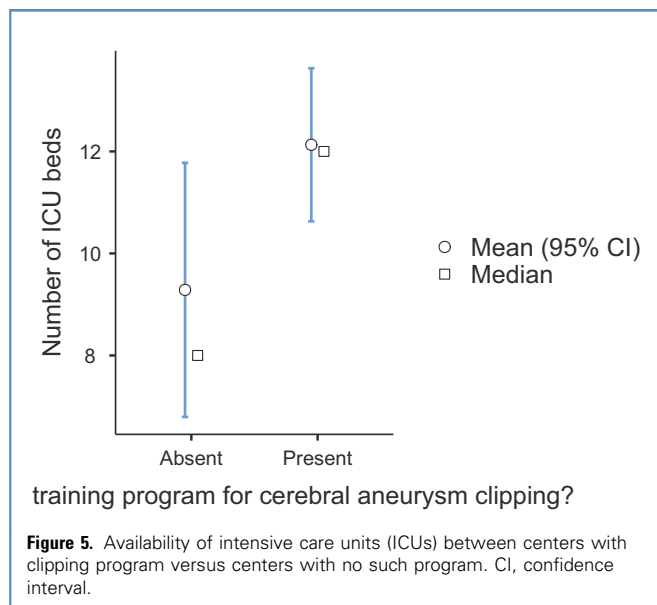
Proposed Solutions

In LMICs such as those in sub-Saharan Africa, with local training programs and basic neurosurgery activity, short surgical

Table 2. Characteristics of the respondents

Variables	Values
Characteristics of respondents	
Neurosurgeon	14 (31.82)
Neurosurgery resident	30 (68.18)
Population size served by respondent institution	
>5 million	27 (61.36)
3–5 million	7 (15.91)
<3 million	10 (22.73)
Number of neurosurgical beds, mean (range)	32 (10–165)
Number of intensive care unit beds, mean (range)	10 (2–30)
Availability of a cerebral aneurysm clipping training program for residents	23 (52.27)
Availability of a theoretic training program for cerebral aneurysm clipping	37 (84.09)
Availability of a laboratory design training program for cerebral aneurysm clipping	5 (11.36)
Basic level of training on clipping a cerebral aneurysm	
After completing the residency program	18 (40.91)
PGY5	4 (9.09)
PGY4	6 (13.64)
PGY3	16 (36.36)
Availability of clinical fellowship to young neurosurgeons for clipping cerebral aneurysms	18 (40.91)
Place where clinical fellowships are offered	
Local and abroad	11 (25.00)
Abroad	20 (45.45)
Local	13 (29.55)
Existence of an interventional neuroradiologist on the neurovascular staff of your center	15 (34.09)
Values are number (%) except where indicated otherwise. PGY, postgraduate year.	

missions and short-term fellowships in HICs for young neurosurgeons are essential to improve neurosurgical standards and to develop new neurosurgical techniques locally and implement neurosurgical subspecialties such as neurovascular surgery in those neurosurgical departments that are in need. For this reason, Ahanogbe et al.²⁴ concluded in 2016 that hospital equipment and neurosurgeon training would be needed to improve the management of aSAH. Therefore, collaboration with HICs centers is essential to establish mentorship and to organize short surgical missions and boot camps in departments in sub-Saharan African countries to teach and implement new techniques and subspecialties in neurosurgical facilities, such as neurovascular surgery for aneurysm repair.²⁵



Limitations

One limitation of this study is that it may have missed many young neurosurgeons and trainees, because some of them do not have reliable Internet, electronic devices, and e-mail. Also, our use of nonrandomized sampling methods reduces the external validity of our survey findings. Nonetheless, our survey is the first to specifically assess aneurysm repair training of young African neurosurgeons in sub-Saharan African countries, and with representatives from 17/30 sub-Saharan African countries, we believe that our findings are representative of the status quo.

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Furthermore, to minimize the effect of nonresponse bias, we increased the data collection period and the number of survey dissemination modes. We believe that these data will be informative for governments, World Federation of Neurosurgical Societies, CAANS, and their partners to determine solutions to enhance the training and the service delivery care regarding neurovascular conditions such as aneurysms in sub-Saharan African countries.

CONCLUSIONS

Surgical repair of cerebral aneurysms in sub-Saharan Africa presents many challenges. Organized neurosurgical training is available at only a few centers in sub-Saharan Africa and few of these have a cerebral aneurysm clipping program. Endovascular repair is still not widely applied in sub-Saharan Africa. Aneurysm repair requires well-trained personnel and adequate equipment.

Although neurosurgery residents receive theoretic training, the repair of cerebral aneurysms requires additional training. Financial support and educational collaboration with HICs are necessary to improve training quality for treatment of cerebral aneurysms.

CRedit AUTHORSHIP CONTRIBUTION STATEMENT

Methodology, F.L.O.O., Y.C.H.D., N.D.A.B., and N.A.K.; Data Curation, Y.C.H.D., F.L.O.O., and N.D.A.B.; Writing — Original Draft, Y.C.H.D., N.D.A.B., W.D., and R.B.; Writing — Review & Editing, Y.C.H.D., N.D.A.B., A.D.N., O.B., and T.A.; Supervision, N.D.A.B.; Project Administration, Y.C.H.D. and F.D.P.A.

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