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Surgical management of cerebrovascular disease in Africa: a systematic review of state

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Abstract

Background Surgical management is one of the mainstay management options for cerebrovascular diseases, which is not only curative but also preventive. However, there's a gap between the surgical management of cerebrovascular disease in Africa when compared to the developed parts of the world.

Methods A literature search was done on the state of Cerebrovascular surgery in Africa from databases such as Pubmed, Embase, and Google Scholar, articles we fetched and meticulously reviewed.

Results We found gaps in the surgical management of cerebrovascular diseases such as stroke in African countries when compared to developed countries. The challenges facing the surgical management of cerebrovascular disease in Africa include a low number of neurosurgeons and vascular surgeons trained in the surgical management of these diseases, a lack of adequate facilities for surgical management, and others. The burden of cerebrovascular diseases in Africa is great, and this warrants an improvement in the surgical management of the conditions, which includes primary prevention of such diseases through public health education on risk factors, improvement of health facilities to accommodate recent advances in the cerebrovascular surgeries, establishments of several neurosurgery training centers.

Conclusion The practice of surgical management of cerebrovascular disease in Africa needs to be optimized for it to be at the global standard and for better outcomes and management of patients.

Keywords Cerebrovascular diseases, Stroke, Neurosurgery, Vascular surgery, Carotid aneurysm

Introduction

Cerebrovascular disease is one of the leading causes of death globally with sub-Saharan Africa having the highest burden of the disease [1–3]. This is a disorder in which the brain or part of the brain is temporarily or permanently by ischemia or hemorrhage which could involve one or many cerebral vessels; cerebrovascular diseases include stroke, arterial stenosis or aneurysm of the brain, and vascular malformations [4–6]. Globally, stroke is the leading cause of disability, dementia, and mortality; with an average of 1 in 4 adults developing stroke in their lifetime [1, 7]. The annual incidence rate of stroke in Africa is 316 cases per 100,000 person-year while the prevalence rate is 1460 per 100,000 person-year [8]. Utilizing emergency clinic information, five examinations assessed stroke rough occurrence rates going from 31/100,000 every year in Harare, Zimbabwe in 1991 [9–11] to 149/100,000 every year in Maputo, Mozambique in 2006 [10, 12, 13]. In a meta-examination by Adeloye, the pooled gauge of 77.39/100,000 every year (95% CI = 51.31–103.48) from emergency clinic-based

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studies [13] was lower than from local area-based investigations. This might recommend that the accessible medical clinic-based African examinations underrated stroke occurrence because of prohibition of deadly or gentle cases who don't present in these medical clinics. There is a decline in the age-standardized mortality rate of stroke globally between the year 1990–2016, which could be a result of increased availability of acute stroke care, and improved surgical and inpatient management in developed countries; while there is a less steep decrease in age-standardized mortality rate recorded in Africa [2]. In the 2019 global statistics on stroke, an increased incidence of stroke was reported in low-income countries which including most African countries between 1971 and 2014, while 74% of all stroke death and 80% of all disabilities from stroke occurred in these low-income countries [3, 14]. Surgical management is an important management option for cerebrovascular disease, this is done to prevent stroke, or its reoccurrence, which comprises various procedures including simple and complex Intracranial bypass, craniotomy, hemispheric decompression, carotid endarterectomy for aneurysm and arteriovenous malformation, stereotactic radiosurgery, and endovascular surgery [15, 16]. The surgical option depends on the types of cerebrovascular disease, as ischemic or hemorrhagic stroke may require different surgical approaches [17]. Procedures such as mechanical thrombectomy aid rapid recanalization of the occluded cerebral vessel in ischemic stroke, leading increase perfusion to the ischemic penumbra; in all surgical management improves the outcome of cerebrovascular disease [18].

Methods

Search strategy

A literature search was done on the state of Cerebrovascular surgery in Africa from databases such as Pubmed, Embase, and Google Scholar, articles we fetched and meticulously reviewed. The search terms are "Cerebrovascular disease in Africa [MeSH Terms] OR Stroke surgery in Africa [MeSH Terms] OR Cerebrovascular surgery in Africa [MeSH Terms] OR Challenges of Cerebro* surgery in Africa [MeSH Terms] OR Endovascular disease in Africa [MeSH Terms] OR Surgical management of cerebro* in Africa [MeSH Terms]). Six research articles we collected and included in this review. The Prisma flow diagram was generated using PRISMA2020 reported in Fig. 1 below [19].

Objectives of study

This study is aimed at:

- Reviewing the current state of cerebrovascular surgery in Africa
- Reviewing the gaps and challenges of cerebrovascular surgery in Africa.

Eligibility criteria

For an article to be included it must meet the following criteria:

- Must not be a narrative review
- Must be done in Africa

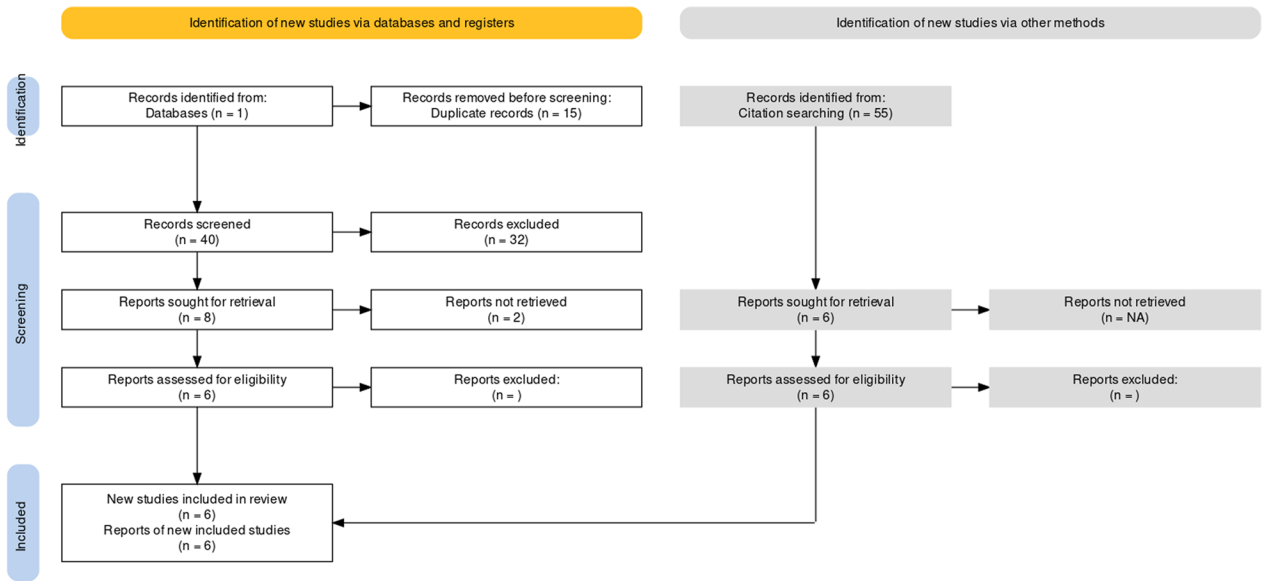

Fig. 1 Prisma chat [19]

- Articles that evaluate the state of cerebrovascular surgeries
- Must be written in the English language

Data extraction

Duplicates were excluded in Mendeley (Elsevier, London, UK). The abstracts were screened independently by eight of the authors using Rayyan software. The abstracts were divided into three groups, and each group of abstracts was reviewed by a pair of authors, with a third author (KA) adjudicating any discrepancies. Full texts of potentially relevant studies were assessed for eligibility. Disagreements were resolved through discussion between the reviewers until mutual agreement was reached.

The following data were extracted from the included articles: author names, year of publications, country(ies) included in the article, study design, study's population, cerebrovascular condition, diagnostic tools, intervention, and outcome. The summary of these data is reported in Table 1, some articles reported the state of surgical management of some cerebrovascular conditions, and the inference made from these articles is reported under outcome in Table 1.

Data analysis

We will conduct a narrative synthesis describing the present state and the gap in the practice of cerebrovascular surgery in selected studies. The quality assessment of selected articles was assessed by two independent reviewers using the Newcastle–Ottawa scale (NOS) criteria. Studies with NOS scores 0–3, 4–6, and 7–9 were considered low, moderate, and high quality, respectively.

Result

In our initial search, we found a total of 56 articles. Ten articles were removed due to duplicates, abstract selection using selection criteria reduced the number of articles to 8, and full-text review reduced the articles to 6 [20–25] (Fig. 1). All articles were written in English. Using the Newcastle–Ottawa scale, all the 6 included studies had a score of >6/10, and were considered high-quality. All studies had ethical approval. The date of publication was between 2010 and April 2023. One article was written in South Africa, Senegal, Tanzania, and Egypt, respectively, while the remaining two articles covers 17 African countries.

Study designs of included articles

Two of the studies were case-series [20, 21], one retrospective case-control [22], two multinational cross-sectional studies [23, 25], and a comparative study [24]. The cross-sectional studies were carried out through an e-survey; the comparative study was done between northern Europe and northern Africa.

Diagnosis of cerebrovascular disease

The majority of diagnoses of cerebrovascular disease are made through computed tomography angiography, magnetic resonance angiography, and arteriography [20–22]. 81% of neurosurgical centers in Africa have access to computed tomography angiography, 47% of the center could obtain computed tomography angiography within 2 h [25].

The outcome of cerebrovascular disease management

Watereyn et al. reported 62.5% mortality among patients managed non-surgically [22], and Thioub et al. reported 1% mortality in all patients managed. Non-surgical management account for about 99% of the mortalities reported in this review, while surgical and endovascular management are associated with nearly 100% survival.

State of surgical aneurysmal clipping and carotid endarterectomy

Most of the patients are managed by surgical clipping 70% and 64% in Thioub et al. [21] and Waterkeyn et al. [22] respectively. About 18.2% of all patients reported in Waterkeyn et al. [22], were able to be operated on within the first 4 h of presentation, Dokponu et al. reported only 40.91% of all neurosurgeons in sub-Saharan Africa having basic level training in surgical aneurysmal clipping [23]. 61% of all neurological centers in Africa were reported to provide surgical clipping of intracranial aneurysm [25]. When compared to Northern Europe, the unmet need for carotid endarterectomy is 98.5% in Northern Africa and 0% in Northern Europe [24].

State of endovascular surgery

The three cases were managed with endovascular surgery in South Africa and were associated with 100% survival [20]. Only 1% of the cases were with endovascular surgery in Senegal [21], while Waterkeyn et al. reported unavailability of endovascular surgery in the whole of Tanzania [22]. Dokponu et al. reported that none of the neurosurgeons in sub-Saharan Africa had any level of training in endovascular surgery [23]. It was reported that just 22% of neurosurgical centers in Africa perform endovascular surgery while 64% of centers don't have an endovascular specialist [25].

Discussion

As it applies globally over the last three decades, there is a trend of increasing incidence and prevalence of cerebrovascular diseases in Africa, although patterns of the pathology vary with small vessel disease being a

Table 1 Characteristics of studies table

Author	Year	Country	Study design	Population	Conditions	Diagnostic tool	Interventions	Outcome
Omotosho et al. [20]	2021	South Africa	Case series	3 Adults	Vertebrobasilar junction fenestration	Computed tomography angiography	Endovascular	0% mortality
Thioub et al. [21]	2018	Senegal	Case series	10 Pediatrics	Intracranial aneurysm	Computed tomography angiography, arteriography, magnetic resonance angiography	Surgical—7 Endovascular—1 Non-surgical—2	1% mortality
Waterkeyn et al. [22]	2023	Tanzania	Retrospective case–control	22 Adults	Intracranial aneurysm	CT angiography, MR angiography	Surgical clippings—14 Non-surgical—8 Endovascular not available in the country 4 operated within 72 h of presentation	62.5% mortality in the non-surgical group
Dokponu et al. [23]	2023	17 Sub-Saharan African countries	Cross-sectional	44 Neurosurgeon	–	–	Assessment of aneurysmal clipping and endovascular treatment of an aneurysm	40.91% of neurosurgeons have a basic level of training in aneurysmal clipping. None have training in endovascular treatment
Taha et al. [24]	2010	Egypt versus Finland and England	Comparative studies	–	Stroke, transient ischemic attack	–	Carotid Endarterectomy	Provision of CEA to needs in England & Finland is 100% while in Egypt is 1.5%
Dokponu et al. [25]	2021	16 African countries	Cross-sectional	36 Neurosurgical center	Aneurysmal Subarachnoid hemorrhage	–	Access to diagnostic tools and endovascular management	81% of the center has access to CT angiography 47% of centers could obtain CT within 2 h 61% of centers provide clipping of Intracranial aneurysm 22% of centers could provide endovascular treatment 64% of Centers don't have endovascular specialist

CT = Computed tomography, MR = magnetic resonance, CEA = carotid endarterectomy

commoner cause in Africa [6, 26, 27]. Increasing exposure to risk factors especially high systolic blood pressure accounts for emerging cases of cerebrovascular diseases in Africa's young adult population. And there are indications that current estimations may be understated [6, 26]. African nations bear a great portion of the global stroke burden [28]. Fatality rates from stroke in Africa are very high [27]. Stroke is also responsible for significant morbidity including depression, cognitive impairment, and disability, with low- and middle-income countries generally accounting for 3.7 times the rate in high-income countries. [6, 26, 27]

Stroke treatment is quite expensive with patients suffering from stroke paying more than the average patient [29]. Length of stay in the hospital remains the most important determinant of cost [30]. In South Africa determined 1.6–3% of entire health expenditure is gulped by stroke management, and this is consistent with findings in developed countries [31]. In 2012, the cost of treating stroke varied between $600 and $4860 in Nigeria and is said to be unaffordable. Juxtaposing those values with current inflation rates yields a problem compounded by increased DALY from the unavailability of rehabilitative care services [32]. The burden is similar in other African countries where sufferers can't afford emergency care for cerebrovascular diseases nor subsequent specialist neurological care [33].

Essential neurosurgical care includes surgery for Traumatic brain injury (burr holes, craniotomy/craniectomy, etc.) accounts for 45%, cerebrovascular accidents for 20%, hydrocephalus for 7%, and brain tumors for 5% of the regional neurosurgical need. In the African region, with a population of 990 million, 488 neurosurgeons were identified [34]. The greatest total neurosurgical capacity exists in the Western Pacific region, where more than 22,000 neurosurgeons are capable of performing nearly 5 million essential neurosurgical cases annually. In contrast, the nearly 500 neurosurgeons in Africa can be expected to perform approximately 110,000 neurosurgical operations [34].

To meet regional demand in Africa, where more than 1.8 million cases are not being addressed by capable neurosurgeons, the surgical workforce must increase by more than 1700%. Independent of other geographical, social, or financial barriers, the vast majority of Africa's population lacks access to a neurosurgeon [35]. Despite accounting for 15% of global neurosurgical disease volume, African hospitals and healthcare networks have access to less than 1% of the neurosurgical community. To adequately address essential neurosurgical disease worldwide, an estimated 23,300 additional surgeons are required in low- and middle-income countries—approximately 11,300 in Southeast Asia and 8400 in Africa [34].

Population-based health education programs and appropriate public health policy must be developed, this will largely improve poor awareness. The emphasis should be on preventing the development of risk factors in the first place. There should be better health funding by the government as declared in the 'Abuja target' [36]. Better funding will translate to more hospitals, better infrastructure, and more training of neurosurgeons and other health personnel. The net effect will be optimal stroke care. Countries in Africa should embrace health insurance either provided by the government, community, or faith-based organizations. There is a need for more specialized trained neurosurgeons and vascular surgeons, and the provision of diagnostic equipment for the management of stroke.

Conclusions

Cerebrovascular diseases such as stroke are among the leading cause of mortality and morbidity globally which are most times best managed surgically. Surgical management of cerebrovascular diseases in Africa is faced with some challenges such as highlighted in the results section, only some of the neurosurgeons and neurosurgical trainees in Africa have basic training in surgical aneurysmal clipping, only few centers have facility for or specialist in endovascular surgery; some countries don't have endovascular services available, and great unmet needs for cerebral endarterectomy. It'll be preferable to consider primary prevention of such a condition to lessen the burden on the available resources. Also, medical practitioners and students should be encouraged to consider having their specialty training in cerebrovascular neurosurgery, the creation of more training centers, and the provision of equipment that aids in the early and easy diagnosis of cerebrovascular diseases, neurosurgical trainees and neurosurgeons should be trained on surgical aneurysmal clipping and endovascular surgery through alliance with developed countries, and endovascular equipment should made available in every neurosurgical centers.

Limitations

This systematic review is limited due to small number of articles that were reviewed and analyzed which is due limited number of researches available on surgical management of cerebrovascular diseases in Africa, also some countries of Africa were not covered in this review making inference quite difficult. We suggest that more multinational surveys on the state of cerebrovascular surgeries in Africa should be done.

Abbreviations

CT Computed tomography

MR	Magnetic resonance
MRI	Magnetic resonance imaging
CEA	Cerebral endarterectomy
MeSH	Medical subject headings
NOS	Newcastle–Ottawa Scale

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Author contributions
KA contributed to the study's conception and design. Abstract/title screening, data extraction, and risk of bias assessment were performed by all the authors. Data analysis was performed by KA and all authors contributed to the interpretation of the results. The first draft of the paper was written by all authors, and all authors commented on the subsequent versions of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
Extracted data from the studies included in this review are presented in the Cost Table.

Declarations

Ethical approval and consent to participate
Not applicable.

Consent for publication
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Competing interests
The authors declare that they have no competing interests.

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References

1. GBD 2016 Lifetime Risk of Stroke Collaborators, Feigin VL, Nguyen G, Cercy K, Johnson CO, Alam T, Parmar PG, Abajobir AA, Abate KH, Abd-Allah F, Abejie AN, Abyu GY, Ademi Z, Agarwal G, Ahmed MB, Akinyemi RO, Al-Raddadi R, Aminde LN, Amlie-Lefond C, Ansari H, et al. Global, regional, and country-specific lifetime risks of stroke, 1990 and 2016. N Engl J Med. 2018; 379(25):2429–37. https://doi.org/10.1056/NEJMoa1804492.
2. GBD 2016 Stroke Collaborators. Global, regional, and national burden of stroke, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet Neurol. 2019;18(5):439–58. https://doi.org/10.1016/S1474-4422(19)30034-1.
3. Owolabi MO, Akarolo-Anthony S, Akinyemi R, Arnett D, Gebregziabher M, Jenkins C, Tiwari H, Arulogun O, Akpalu A, Sarfo FS, Obiako R, Owolabi L, Sagoe K, Melikam S, Adeoye AM, Lackland D, Ovbiagele B, Members of the H3Africa Consortium. The burden of stroke in Africa: a glance at the present and a glimpse into the future. Cardiovasc J Africa. 2015;26(2 Suppl 1):S27–S38. https://doi.org/10.5830/CVJA-2015-038.
4. Osuntokun BO, Odeku EL, Adeloye RB. Cerebrovascular accidents in Nigerians: a study of 348 patients. West Afr Med J Niger Pract. 1969;18(5):160–73.
5. GBD 2016 Neurology Collaborators. Global, regional, and national burden of neurological disorders, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet Neurol. 2019;18(5):459–80. https://doi.org/10.1016/S1474-4422(18)30499-X.
6. Akinyemi RO, Owolabi MO, Ihara M, Damasceno A, Ogunniyi A, Dotchin C, Paddick SM, Ogeng'o J, Walker R, Kalaria RN. Stroke, cerebrovascular diseases and vascular cognitive impairment in Africa. Brain Res Bull. 2019;145:97–108. https://doi.org/10.1016/j.brainresbull.2018.05.018.
7. Akinyemi RO, Ovbiagele B, Adeniji OA, Sarfo FS, Abd-Allah F, Adoukonou T, Ogah OS, Naidoo P, Damasceno A, Walker RW, Ogunniyi A, Kalaria RN, Owolabi MO. Stroke in Africa: profile, progress, prospects and priorities. Nat Rev Neurol. 2021;17(10):634–56. https://doi.org/10.1038/s41582-021-00542-4.
8. Akinyemi RO, Ovbiagele B, Adeniji OA, et al. Stroke in Africa: profile, progress, prospects and priorities. Nat Rev Neurol. 2021;17:634–56. https://doi.org/10.1038/s41582-021-00542-4.
9. Matenga J. Stroke incidence rates among black residents of Harare—a prospective community-based study. S Afr Med J. 1997;87(5):606–9.
10. Adeloye D, Basquill C. Estimating the prevalence and awareness rates of hypertension in Africa: a systematic analysis. PLOS ONE. 2014;9(8):e104300. https://doi.org/10.1371/journal.pone.0104300.
11. Damasceno A, Gomes J, Azevedo A, Carrilho C, Lobo V, Lopes H, Madede T, Pravinrai P, Silva-Matos C, Jalla S, Stewart S, Lunet N. An epidemiological study of stroke hospitalizations in Maputo, Mozambique: a high burden of disease in a resource-poor country. Stroke. 2010;41(11):2463–9. https://doi.org/10.1161/STROKEAHA.110.594275.
12. Osuntokun BO, Bademosi O, Akinkugbe OO, Oyediran AB, Carlisle R. Incidence of stroke in an African City: results from the Stroke Registry at Ibadan, Nigeria, 1973–1975. Stroke. 1979;10(2):205–7. https://doi.org/10.1161/01.str.10.2.205.
13. Adeloye D. An estimate of the incidence and prevalence of stroke in Africa: a systematic review and meta-analysis. PLOS ONE. 2014;9(6):e100724. https://doi.org/10.1371/journal.pone.0100724.
14. Kim J, Thayabaranathan T, Donnan GA, Howard G, Howard VJ, Rothwell PM, Feigin V, Norrving B, Owolabi M, Pandian J, Liu L, Cadilhac DA, Thrift AG. Global Stroke Statistics 2019. Int J Stroke. 2020;15(8):819–38. https://doi.org/10.1177/1747493020909545.
15. Crowell RM. Surgical management of cerebrovascular disease. Nurs Clin North Am. 1986;21(2):297–308.
16. Hoff JT. Surgical management of cerebrovascular disease. JAMA. 1984;251(17):2275–6. https://doi.org/10.1001/jama.1984.03340410077047.
17. Salmenkivi K. Iskeemisten aivoverenkiertöhäiriöiden verisuonikirurginen hoito [Surgical treatment of ischemic cerebrovascular disorders]. Duodecim; laaketieteellinen aikakauskirja. 1973;89(5):386–9.
18. Zhang J. Advances in surgical treatment of ischemic cerebrovascular disease. Zhejiang Da Xue Xue Bao Yi Xue Ban. 2019;48(3):233–40. https://doi.org/10.3785/j.issn.1008-9292.2019.06.01.
19. Haddaway NR, Page MJ, Pritchard CC, McGuinness LA. PRISMA2020: an R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and Open Synthesis. Campbell Syst Rev. 2022;18:e1230. https://doi.org/10.1002/cl2.1230.
20. Omotoso BR, Harrichandparsad R, Moodley IG, Satyapal KS, Lazarus L. Fenestration of the vertebrobasilar junction detected with multidetector computed tomography angiography. Folia Morphol. 2022;81(2):510–4. https://doi.org/10.5603/FM.a2021.0028.
21. Thioub M, Mbaye M, Thiam AB, Mutomb S, Sy C, Faye M, Ba MC, Badiane SB. Pediatric intracranial aneurysms in Senegal: a series of 10 cases treated in unfavorable socio-economic conditions. Child's Nervous Syst ChNS. 2019;35(1):165–8. https://doi.org/10.1007/s00381-018-3943-2.
22. Waterkeyn F, Lohkamp LN, Ikwuegbuenyi CA, Mchome LL, Rutabasibwa NB, Shabani HK, Härtl R, Petr O. Current treatment management of aneurysmal subarachnoid hemorrhage with prevailing trends and results in Tanzania: a single-center experience at Muhimbili orthopedic and neurosurgery institute. World Neurosurg. 2023;170:e256–63. https://doi.org/10.1016/j.wneu.2022.11.003.
23. Dokponou YCH, Alihonou T, Adjiou DKFP, Obame FLO, Nyalundja AD, Dossou MW, Murhega RB, Lawson LD, Badirou OBA, Kpègnon NA, Bankole NDA. Surgical aneurysm repair of aneurysmal subarachnoid hemorrhage in sub-Saharan Africa: the state of training and management. World Neurosurg. 2023. https://doi.org/10.1016/j.wneu.2023.05.085.
24. Taha AG, Vikatmaa P, Soinne L, Thabet BA, Lepäntalo M. A comparison of carotid surgery in northern Europe and northern Africa. World J Surg. 2010;34(2):362–7. https://doi.org/10.1007/s00268-009-0270-5.

25. Dokponou YCH, Kotecha J, Bandyopadhyay S, Erhabor J, Ooi SZY, Egiz A, Boutarbouch M, Dalle DU, Higginbotham G, Thioub M, Sichimba D, Bankole NDA, Kanmounye US. Continental survey of access to diagnostic tools and endovascular management of aneurysmal subarachnoid hemorrhage in Africa. Front Surg. 2021;8:690714. https://doi.org/10.3389/fsurg.2021.690714.
26. GBD 2019 Stroke Collaborators. Global, regional, and national burden of stroke and its risk factors, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet Neurol. 2021;20(10):795–820. https://doi.org/10.1016/S1474-4422(21)00252-0.
27. Walker R. Osuntokun award lecture 2021: challenges of measuring the burden of stroke in Africa. J Stroke Cerebrovasc Dis. 2022;31(4):106386. https://doi.org/10.1016/j.jstrokecerebrovasdis.2022.106386.
28. Krishnamurthi RV, Ikeda T, Feigin VL. Global, regional and country-specific burden of ischaemic stroke, intracerebral haemorrhage and subarachnoid haemorrhage: a systematic analysis of the Global Burden of Disease Study 2017. Neuroepidemiology. 2020;54(2):171–9. https://doi.org/10.1159/000506396.
29. Guinhouya KM, Tall A, Kombate D, Kumako V, Apetse K, Belo M, Balogou AK, Grunitzky KE. Coût des accidents vasculaires cérébraux à Lomé (Togo) [Cost of stroke in Lomé (Togo).]. Sante (Montrouge, France) 2010. https://doi.org/10.1684/san.2010.0192.
30. Rochmah TN, Rahmawati IT, Dahlui M, Budiarto W, Bilqis N. Economic burden of stroke disease: a systematic review. Int J Environ Res Public Health. 2021;18(14):7552. https://doi.org/10.3390/ijerph18147552.
31. Maredza M, Chola L. Economic burden of stroke in a rural South African setting. Eneurologicalsci. 2016;3:26–32. https://doi.org/10.1016/j.ensci.2016.01.001.
32. Birabi BN, Oke KI, Dienye PO, Okafor UC. Cost burden of post stroke condition in Nigeria: a pilot study. Glob J Health Sci. 2012;4(6):17–22. https://doi.org/10.5539/gjhs.v4n6p17.
33. Gombet TR, Ellenga-Mbolla BF, Ikama MS, Ekoba J, Kimbally-Kaky G. Coût financier de la prise en charge des urgences cardiovasculaires au Centre Hospitalier et Universitaire de Brazzaville (Congo) [Cost of emergency cardiovascular care at the University Hospital Center in Brazzaville, Congo]. Medecine tropicale: revue du Corps de sante colonial. 2009;69(1):45–7.
34. Dewan MC, Rattani A, Fieggen G, Arraez MA, Servadei F, Boop FA, Johnson WD, Warf BC, Park KB. Global neurosurgery: the current capacity and deficit in the provision of essential neurosurgical care. Executive summary of the global neurosurgery initiative at the program in global surgery and social change. J Neurosurg. 2018;130(4):1055–64.
35. Punchak M, Mukhopadhyay S, Sachdev S, Hung YC, Peeters S, Rattani A, et al. Neurosurgical care: availability and access in low-income and middle-income countries. World Neurosurg. 2018;112:e240–54.
36. World Health Organization. Abuja declaration: ten years on. Geneva: WHO; 2010.

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