

Spontaneous obliteration of brain arteriovenous malformations: illustrative cases

Kevin Agyemang, FRCS(SN),^{1,2} Anna Rose, MRCS,² Olatomiwa Olukoya, MBChB,² Jennifer Brown, FRCSC,¹ and Edward Jerome St George, FRCS(SN)^{1,2}

¹Neurosurgical Department, Institute of Neurological Sciences, Queen Elizabeth University Hospital, Glasgow, United Kingdom; and ²School of Medicine, University of Glasgow, Scotland, United Kingdom

BACKGROUND Spontaneous angiographic obliteration of a brain arteriovenous malformation (AVM) is considered a rare outcome, with most cases in the literature related to prior hemorrhage in small brain AVMs. The authors present a prospective, single center, consecutive case series. The clinical course and radiographic features of four cases with spontaneous obliteration of brain AVM were analyzed.

OBSERVATIONS The median age of patients in this series was 47.6 years, with an equal gender split. The median maximum brain AVM diameter was 2 cm. The median time to spontaneous obliteration was 26 months, with hemorrhage preceding this in three out of four cases and a prolonged latency in the only case with a nidus size larger than 3 cm and no hemorrhage.

LESSONS The present study provides additional information to allow clinicians to counsel patients about the rare outcomes of conservative management. This work extends our understanding of when this phenomenon can occur by reporting on the differences associated with spontaneous obliteration of larger AVMs.

<https://thejns.org/doi/abs/10.3171/CASE22309>

KEYWORDS brain; arteriovenous malformation; AVM; spontaneous; obliteration; thrombosis

Brain arteriovenous malformations (AVMs) are lesions in which blood is shunted directly from a single or multiple feeding arteries into one or more draining veins through a nidus, with no intervening capillaries.¹ Brain AVMs were previously considered to be congenital malformation with a stable size and risk of hemorrhage.

In the pediatric population, recurrence of angiographically confirmed, resected, or obliterated AVMs (5% to 14%) has pointed to a more dynamic nature of these lesions.^{2,3} Recurrence appears to occur more frequently in diffuse AVMs, in which small satellite AVM vessels are likely to be missed.³ Some authors have suggested that residual abnormal vasculature may stimulate proliferation of new abnormal blood vessels, leading to recurrence.⁴

Brain AVMs are currently best thought of as arising from a complex interplay between a developmental anomaly, predominantly of the venous cerebrovascular system, and the resulting cerebral hemodynamics over

time. The vessels within this system remodel, leading to changes in size, risk of hemorrhage, and, rarely, obliteration observed in clinical practice.⁵⁻⁷

Spontaneous angiographic obliteration of an AVM (SpOAVM) is considered a rare outcome, with less than 100 case reports in the English-language literature. To our knowledge, all of these cases have involved AVMs with a nidus less than 6 cm in maximum diameter. A recent institutional study reported an incidence of 0.014 per 100 patient-years.⁸ Compression of the nidus by a hematoma and thrombosis of a prominent draining vein have been described as two suggested mechanisms.^{5,8,9}

The management goals of AVM focus on preventing primary hemorrhage and the subsequent sequelae of disabling stroke or death. Previous reports on spontaneous obliteration have been mostly restricted to small AVMs after hemorrhage. We discuss the clinical and angiographic features of four cases of spontaneous obliteration of

ABBREVIATIONS ARUBA = A Randomized trial of Unruptured Brain Arteriovenous malformation; AVM = arteriovenous malformation; IQR = interquartile range; MDT = multidisciplinary team; MRI = magnetic resonance imaging; SIVMS = Scottish Intracranial Vascular Malformation Study; SpOAVM = spontaneous angiographic obliteration of an AVM; SRS = stereotactic radiosurgery.

INCLUDE WHEN CITING Published November 21, 2022; DOI: 10.3171/CASE22309.

SUBMITTED July 27, 2022. **ACCEPTED** September 6, 2022.

© 2022 The authors, CC BY-NC-ND 4.0 (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

AVM observed over the last 15 years at a single institution and compare our series to the reported literature.

Illustrative Cases

Study Design, Setting, and Time Frames

A consecutive, single-center case series of brain arteriovenous malformations with atypical behavior or findings was prospectively captured from the neurovascular multidisciplinary team (MDT) meeting of a regional neurosurgical department. The institution is a teaching hospital that provides neurosurgical care for the west of Scotland, a population of approximately 2.7 million people. Patients were captured between June 2005 and June 2020. We adhered to the definitions outlined in "Reporting Terminology for Brain Arteriovenous Malformation Clinical and Radiographic Features for Use in Clinical Trials"¹⁰ and the preferred reporting of CasESeries in surgery (PROCESS).¹¹

Participants

Four consecutive patients who had undergone spontaneous obliteration of AVM were identified and reviewed. Patients who had undergone any form of prior intervention were excluded. All patient identifiers and digital imaging and communications in medicine (DICOM) annotations were removed from radiological images.

Preintervention Optimization

One patient was prescribed antiepileptic medication to manage presenting seizures. Smoking cessation was recommended in one patient unsuccessfully. No other optimization was used.

Intervention

Patients underwent a digital subtraction angiogram (DSA) to evaluate the angioarchitecture of the AVM. No interventions or attempted interventions were performed.

Quality Control

Angiographic findings were discussed at an MDT meeting to ensure consistency in the reporting of findings. An independent consultant neuroradiologist was in attendance during this review.

Follow-Up

Clinical review at a neurosurgery or neuroradiology clinic was scheduled at 6-month intervals in the first year and annually thereafter for 5 years. Time-of-flight magnetic resonance angiography radiological surveillance was offered to patients who achieved obliteration. Spontaneous obliteration was defined as complete resolution of the AVM in the absence of intervention, as interpreted on digital subtraction angiography, by a certified neuroradiologist. No specific long-term surveillance was instituted after discharge, but patients were followed by their primary care doctor.

Results

Participants

Approximately 525 new patients with an AVM were discussed in the neurovascular MDT over this period; 20% underwent stereotactic radiosurgery (SRS), and 35% underwent surgery or embolization. An average delay of 18 months was usual between the diagnosis and referral for SRS, surgery, or embolization and treatment, yielding 300 person-years of untreated follow-up. Conservatively managed patients were followed up for an average of 5 years, yielding 717 person-years of follow-up.

The median age at diagnosis of AVM was 47.6 years (interquartile range [IQR] 27.3–56.7), and there was a 1:1 male:female divide. The median maximum AVM diameter was 2 cm (IQR 1.3–5.3).

Outcomes and Follow-Up

Four patients (2 declined treatment, 2 were discovered at planned intervention) underwent spontaneous obliteration, leading to an incidence of 0.39 per 100 untreated patient-years. The median time to spontaneous obliteration was 26 months (IQR 7–90), with hemorrhage preceding this in three of four cases. No AVM-related factors were found to be significantly associated with a latency to SpOAVM occurring before 2 years. The latency was longest in the patient with the largest AVM (>6 cm), which was also the only case without evidence of prior hemorrhage. Table 1 summarizes the association between various factors and short latency to obliteration (<2 years).

Cases

Case 1. A man in his 20s presented with a generalized seizure. Imaging demonstrated a large, unruptured, right temporal AVM (6.4 cm, Spetzler-Martin grade 4; Fig. 1). The patient declined treatment and presented 6 years later with headaches. Spontaneous obliteration was seen on magnetic resonance imaging (MRI) 1 year later and was confirmed on angiography 9 years after presentation.

Case 2. A woman in her 30s who presented with headaches and left homonymous hemianopia was found to have a small (1-cm) occipital AVM associated with hemorrhage. She underwent spontaneous obliteration 4 months later. The imaging is summarized in Fig. 2.

No recanalization or clinically significant events were observed after confirmation of SpOAVM in all cases.

Discussion

Observations

We report on a small consecutive series of four cases of AVM that underwent spontaneous obliteration. Most (75%) patients had a lobar AVM, with multiple feeders, a maximum nidus diameter smaller than 30 mm, and associated hemorrhage at presentation. A prolonged latency to obliteration (9 years) was observed in the only patient with a large AVM (64 mm).

Lessons: Results in the Context of the Relevant Literature

Hemorrhage at presentation, a small nidus size, and absence of multiple draining veins or feeding arteries have all been identified as strongly associated with SpOAVM in previous series.^{12–14} The mean duration between diagnosis and spontaneous obliteration of an AVM cited in the literature is 50.9 months.¹⁵ The mean time to spontaneous obliteration for the four cases in our series was 41 months. Most (3/4) of these cases underwent early (<51 months) obliteration following diagnosis. In these cases, a small AVM diameter (<3 cm) along with hemorrhage at presentation was observed. Surprisingly, most of our cases also had multiple arterial supply, and two patients had multiple deep draining veins.

In a review by Buis et al.,¹⁵ SpOAVM was a clinically silent event in most cases. Neurological deficits were observed at the time of obliteration in 12% of reported cases. Headaches or seizures heralded spontaneous obliteration in equal measure in another 12% of cases reports included in their review. In 4% of cases, resolution was immediately preceded by hemorrhage.¹⁵ Two of the four cases discussed here had clinically silent SpOAVM. In one patient, obliteration was heralded by headaches but not hemorrhage; the other patient had headaches and hemorrhage.

TABLE 1. Potential factors associated with spontaneous obliteration of brain arteriovenous malformations within 2 years of diagnosis

Factor	Case 1	Case 2	Case 3	Case 4	Percentage w/ SpOAVM \leq 2 yrs
Demographics					
Age <40 yrs	Yes	Yes	No	No	50
Female sex	No	Yes	Yes	No	50
AVM characteristics					
Max nidus diameter <30 mm	No	Yes	Yes	Yes	67
Lobar location	Yes	Yes	No	Yes	67
Arterial feeders >1, n (%)	Yes	Yes	Yes	No	33
Single draining vein	No	Yes	No	Yes	100
Deep drainage	Yes	No	Yes	No	0
Clinical presentation at obliteration					
Headaches	Yes	Yes	Yes	Yes	50
Seizures	No	No	No	Yes	0
Focal neurological deficit	No	Yes	No	No	100
Hemorrhage at presentation	No	Yes	Yes	Yes	67
Latency to obliteration \leq 2 yrs	No	Yes	No	Yes	N/A

Compression of the venous outflow or thrombosis has been proposed as a probable mechanism of spontaneous obliteration.

The incidence of death or sustained disability, reported in the first 4 years of conservative management of unruptured AVMs in

the Scottish Intracranial Vascular Malformation Study (SIVMS), was 9 per 100 patient-years.¹⁶ Compared with the spontaneous obliteration rate of 1.4% quoted by Liew et al.,⁸ death or severe disability was more than 600 times more likely to occur during the first 4 years of

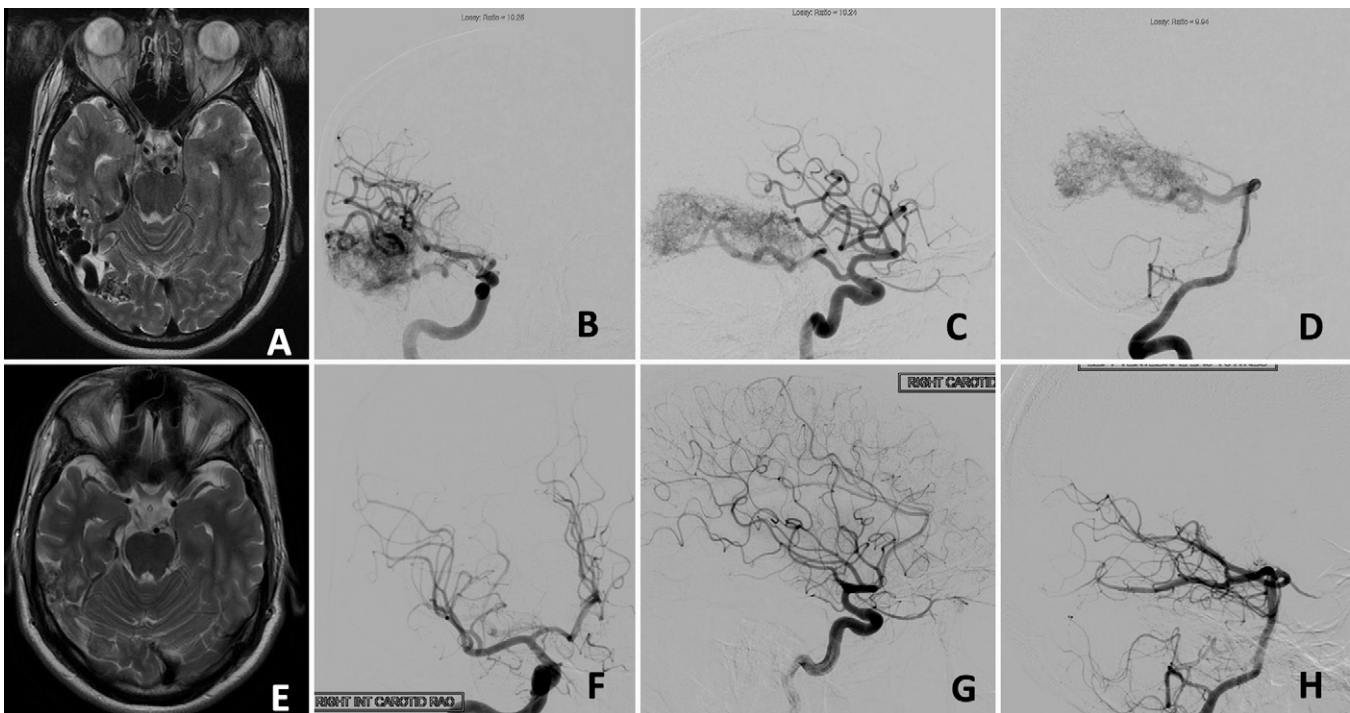


FIG. 1. Case 1. Axial T2-weighted MRI (A) showed large flow voids of the right temporoparietal occipital region AVM. Anteroposterior right internal carotid artery (ICA) angiogram (B). Preobliteration lateral ICA projection (C) showed the AVM supply from an enlarged prominent right posterior communicating artery. The A1 segment was not identified due to the high flow of retrograde unopacified blood from the left. Left lateral vertebral angiogram (D) showed the left posterior cerebral artery (PCA), which supplied the AVM. Drainage was to both the transverse sinus near the torcula and anteriorly to a region at the level of the cribriform plate and hence down to the skull base via a petrosal vein. Further supply from the right PCA is not shown. No associated aneurysm, venous varices, or stenosis appear. Axial T2-weighted MRI at obliteration (E) showed thrombosed vessels with associated perilesional edema and no evidence of hemorrhage. Postobliteration anteroposterior (F) and lateral (G) right carotid artery angiograms showing absence of abnormal AV shunting. Normalization of the caliber of the posterior communicating artery. Flow across the anterior cerebral artery (ACA) normalized. Left vertebral artery angiogram (H) showing no AV shunt.

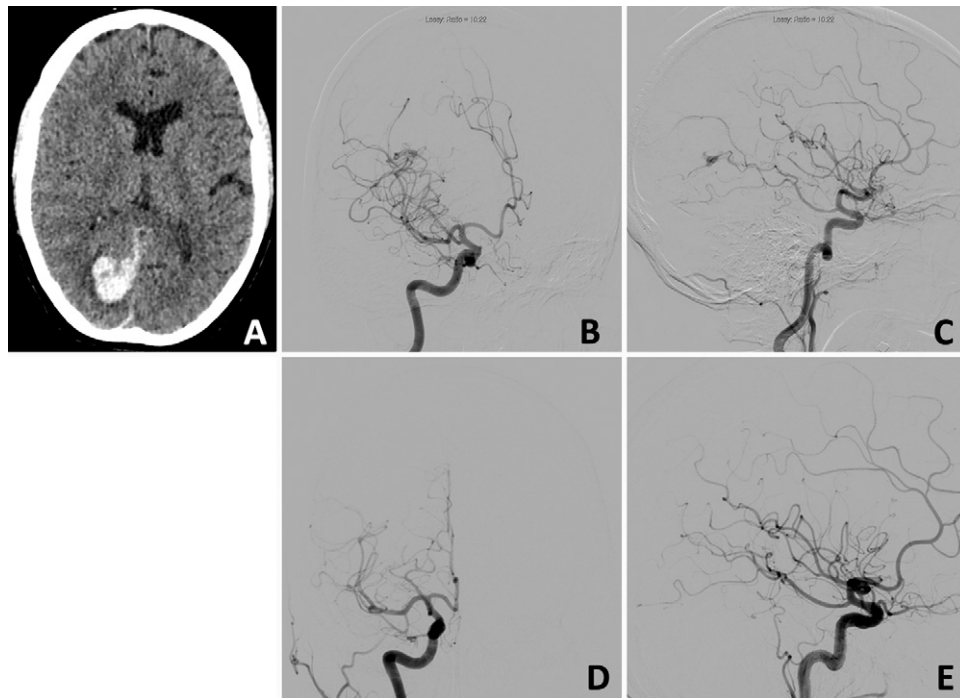


FIG. 2. Case 2. Brain CT (A) showing right occipital hemorrhage secondary to a 1-cm AVM (Spetzler-Martin grade 2). Preobliteration right ICA angiograms, anteroposterior (B) and lateral (C) projections, showing arterial supply from the right fetal posterior communicating artery, no associated aneurysms, and superficial drainage to the torcular and transverse sinuses (D). Postobliteration right carotid angiogram, anteroposterior (D) and lateral (E) projections, obtained at the planned embolization 4 months later, showing obliteration of the AV shunt.

conservative management than spontaneous obliteration.⁸ Similarly, SpOAVM was 242 times less likely to occur than death or symptomatic stroke, an outcome that was observed after 3.39 per 100 patient-years in the medical arm of the A Randomized trial of Unruptured Brain Arteriovenous malformation (ARUBA) trial.¹⁷

The extremely low likelihood of spontaneous resolution of a brain AVM explains why most clinicians are unaware of this outcome and, anecdotally, why fewer are likely to discuss it with patients.

Most clinicians treating AVMs accept that the ARUBA and SIVMS studies have not established medical therapy as a superior management stance for unruptured AVMs. A pragmatic interpretation by some commentators is that patients can be afforded ample time and opportunity to explore treatment options given the safety of conservative management in the short term.¹⁸

The annual rate of hemorrhage increases from 2.2 to 4.5 per 100 patient-years following rupture of an AVM.¹⁹ The significant association between hemorrhage and spontaneous obliteration would suggest that for patients who survive an initial bleed, the odds of this rare outcome are also increased. In the first year following rupture of an AVM, when the risk of rehemorrhage is highest (6%–15.8%),^{20,21} the balance of risks would naturally favor intervention. The likelihood of spontaneous obliteration is too low to advocate as a strategy, but patients who opt for conservative management should be made aware of this rare outcome.

In reviewing these four cases, we asked if it is also reasonable to support patients who delay recommended treatment in anticipation of spontaneous obliteration of an unruptured AVM in the short term. For a small number of patients, this outcome occurs after opting

against advice for treatment, at interval angiography, or ahead of planned intervention. The outcome is likely to adversely impact patient confidence in the treating team where SpOAVM was not previously discussed.

Strengths and Weaknesses

All patients were captured from a single data source, a regional MDT meeting, that covered patients from a stable geographical population. Clinical follow-up continued for all patients through their general practitioner.

Radiological surveillance was limited to MRA after SpOAVM, which limits the series and means it is unable to comment on recanalization. All patients remain alive with no clinical concerns at the time of submission.

Future Research

An observational study in clinical settings with latency to definitive treatment of AVM of 12 months or more is likely to provide more robust information on the true incidence of spontaneous resolution.

Lessons

The cases presented here are consistent with the literature that spontaneous resolution remains a rare outcome that occurs most commonly following hemorrhage. Large unruptured brain AVMs may also undergo spontaneous obliteration, albeit after a longer latency than smaller AVMs.

We recommend that clinicians update angiographic studies ahead of planned intervention after significant delay and in conservatively

managed patients who report new symptoms. The anatomical location, angiographic features, and chances of successful treatment remain the most important factors when counseling patients about expected outcomes following diagnosis of an AVM.

Our series is a reminder of this rare phenomenon; however, larger cohort studies are required to improve our understanding of AVMs that spontaneously obliterate. Familiarity with this unusual outcome within the treating team would help to demonstrate fluency and inspire confidence in patients.

Acknowledgments

We would like to thank all neuroradiologists at the Queen Elizabeth University Hospital for their contributions.

References

- McCormick WF, Wilson CB, Stein BM. Pathology of vascular malformations of the brain. In: *Intracranial Arteriovenous Malformations*. Williams and Wilkins; 1984:44–63.
- Andaluz N, Myseros JS, Sathi S, Crone KR, Tew JM Jr, Jackson RJ. Recurrence of cerebral arteriovenous malformations in children: report of two cases and review of the literature. *Surg Neurol*. 2004; 62(4):324–330, discussion 330–331.
- Lang SS, Beslow LA, Bailey RL, et al. Follow-up imaging to detect recurrence of surgically treated pediatric arteriovenous malformations. *J Neurosurg Pediatr*. 2012;9(5):497–504.
- Krayenbühl HA. Angiographic contribution to the problem of enlargement of cerebral arteriovenous malformations. *Acta Neurochir (Wien)*. 1977;36(3-4):215–242.
- Moftakhar P, Hauptman JS, Malkasian D, Martin NA. Cerebral arteriovenous malformations. Part 2: physiology. *Neurosurg Focus*. 2009;26(5):E11.
- Norris JS, Valiante TA, Wallace MC, et al. A simple relationship between radiological arteriovenous malformation hemodynamics and clinical presentation: a prospective, blinded analysis of 31 cases. *J Neurosurg*. 1999;90(4):673–679.
- Spetzler RF, Hargraves RW, McCormick PW, Zabramski JM, Flom RA, Zimmerman RS. Relationship of perfusion pressure and size to risk of hemorrhage from arteriovenous malformations. *J Neurosurg*. 1992;76(6):918–923.
- Liew JA, Yang W, Mashouf LA, et al. Incidence of spontaneous obliteration in untreated brain arteriovenous malformations. *Neurosurgery*. 2020;86(1):139–149.
- Schwartz ED, Hurst RW, Sinson G, Bagley LJ. Complete regression of intracranial arteriovenous malformations. *Surg Neurol*. 2002;58(2):139–147.
- Atkinson RP, Awad IA, Batjer HH, et al. Reporting terminology for brain arteriovenous malformation clinical and radiographic features for use in clinical trials. *Stroke*. 2001;32(6):1430–1442.
- Agha RA, Sohrabi C, Mathew G, Franchi T, Kerwan A, O'Neill N. The PROCESS 2020 guideline: updating consensus preferred reporting of CasESeries in surgery (PROCESS) guidelines. *Int J Surg*. 2020;84:231–235.
- Abdulrauf SI, Malik GM, Awad IA. Spontaneous angiographic obliteration of cerebral arteriovenous malformations. *Neurosurgery*. 1999;44(2):280–288.
- Panciani PP, Fontanella M, Carlino C, Bergui M, Ducati A. Progressive spontaneous occlusion of a cerebellar AVM: pathogenetic hypothesis and review of literature. *Clin Neurol Neurosurg*. 2008; 110(5):502–510.
- Patel MC, Hodgson TJ, Kemeny AA, Forster DM. Spontaneous obliteration of pial arteriovenous malformations: a review of 27 cases. *AJNR Am J Neuroradiol*. 2001;22(3):531–536.
- Buis DR, van den Berg R, Lycklama G, van der Worp HB, Dirven CM, Vandertop WP. Spontaneous regression of brain arteriovenous malformations: a clinical study and a systematic review of the literature. *J Neurol*. 2004;251(11):1375–1382.
- Al-Shahi SR, White P, Counsell C, et al. Outcome after conservative management or intervention for unruptured brain arteriovenous malformations. *JAMA*. 2014;311(16):1661–1669.
- Mohr JP, Overbey JR, Hartmann A, et al. Medical management with interventional therapy versus medical management alone for unruptured brain arteriovenous malformations (ARUBA): final follow-up of a multicentre, non-blinded, randomised controlled trial. *Lancet Neurol*. 2020;19(7):573–581.
- Teo M, St George J, Lawton MT. Time for BARBADOS after ARUBA trial. *Br J Neurosurg*. 2015;29(5):635–636.
- Gross BA, Du R. Natural history of cerebral arteriovenous malformations: a meta-analysis. *J Neurosurg*. 2013;118(2):437–443.
- Graf CJ, Perret GE, Torner JC. Bleeding from cerebral arteriovenous malformations as part of their natural history. *J Neurosurg*. 1983;58(3):331–337.
- Yamada S, Takagi Y, Nozaki K, Kikuta K, Hashimoto N. Risk factors for subsequent hemorrhage in patients with cerebral arteriovenous malformations. *J Neurosurg*. 2007;107(5):965–972.

Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Agyemang, Olukoya, St George. Acquisition of data: Agyemang, Olukoya, St George. Analysis and interpretation of data: all authors. Drafting the article: Agyemang, Olukoya, St George. Critically revising the article: Agyemang, Olukoya, Brown, St George. Reviewed submitted version of manuscript: Agyemang, Olukoya, Brown, St George. Approved the final version of the manuscript on behalf of all authors: Agyemang. Statistical analysis: Agyemang. Administrative/technical/material support: Agyemang, Rose. Study supervision: St George.

Supplemental Information

Previous Presentations

The abstract was published in the Proceedings of the Autumn 2020 and Spring 2021 meetings of the Society of British Neurological Surgeons.

Correspondence

Kevin Agyemang: Queen Elizabeth University Hospital, Glasgow, United Kingdom. kevin.owusu-agyemang@glasgow.ac.uk.