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From Awake Carotid Occlusion to Saphenous-Vein High-Flow Bypass: Surgical Solutions for Complex Intracranial Aneurysms in a New

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Abstract

Background and Importance: The re-establishment of an on-site cerebrovascular fellowship in Cameroon enabled progressively more advanced open and hybrid treatments for complex intracranial aneurysms, including giant lesions and aneurysms associated with vasculopathy. In environments where endovascular resources are limited, extracranial-intracranial (EC-IC) bypass remains an essential technique to preserve or restore cerebral perfusion when parent-artery sacrifice or trapping is required. **Clinical Cases:** We report two illustrative cases in which EC-IC bypass was central to definitive management. Case 1: a 60-year-old woman with a symptomatic, giant cavernous internal carotid artery (ICA) aneurysm presenting with oculomotor palsy. The aneurysm was initially treated with distal ICA occlusion under awake anesthesia and appeared controlled; months later, the patient developed contralateral upper-extremity weakness and visual disturbance consistent with hypoperfusion. She subsequently underwent a high-flow CCA → saphenous-vein graft → M2 bypass with clinical improvement. Case 2: a 43-year-old man with subarachnoid hemorrhage from a wide-neck right M1-M2 aneurysm underwent a protective low-flow STA → M4 MCA bypass prior to definitive microsurgical clipping; trapping proved unnecessary and the patient recovered without neurologic deficit. **Conclusions and Implications:** EC-IC bypass techniques can be safely and effectively implemented in resource-limited cerebrovascular programs when teams are trained, basic microsurgical infrastructure is available, and perioperative systems are in place. These cases support strategic capacity-building—progressive skill development (STA-MCA → interposition grafts), targeted equipment investment, and rehabilitation pathways—to expand durable treatment options for complex aneurysms where endovascular solutions are unavailable or unsuitable.

Keywords

Bypass, Vascular Neurosurgery, Superficial Temporal Artery, Middle Cerebral Artery, Shunt, Low Cerebral Perfusion, Aneurysm, Interposition Graft

1. Introduction

Cerebral bypass surgery—once regarded by many as a historical curiosity—has re-emerged as an indispensable tool in contemporary cerebrovascular practice for a specific subset of complex lesions that are not amenable to standard endovascular or direct surgical clipping approaches. Modern indications include giant, fusiform, blister-type, or otherwise morphologically complex intracranial aneurysms; aneury- sms arising in the setting of unusual vasculopathies (for example, HIV-associated aneurysmal disease); and situations in which intentional parent-artery occlusion is planned and revascularization is required to preserve distal perfusion (*i.e.*, flow-replacement or flow-augmentation bypasses) [1]. Although endovascular techniques (including flow diversion and reconstructive coiling) have dramatically expanded therapeutic options for many aneurysm subtypes, there remain lesions for which bypass-assisted trapping or parent artery occlusion remains the most durable and safe strategy. High-flow interposition grafts (radial artery or saphenous vein) and low-flow pedicled bypasses (e.g., STA-MCA) are complementary techniques whose selective use depends on the aneurysm's anatomy, collateral circulatory reserve, and the local resources and surgical expertise available [2].

The role of extracranial-intracranial (EC-IC) bypass has been scrutinized by major randomized trials, principally in the context of ischemic cerebrovascular disease, where early large trials (EC/IC Bypass Study Group) and more recent efforts (the Carotid Occlusion Surgery Study, COSS) tempered enthusiasm for routine bypass to prevent ischemic stroke (showing no benefit in unselected populations of patients with atherosclerotic carotid disease) [3]. Importantly, these trials do not invalidate the carefully selected use of bypass in aneurysm surgery, skull-base tumour resection, or emergent revascularization for occlusive disease when hemodynamic compromise or complex surgical anatomy mandates revascularization. Contemporary series and technique papers emphasize that success in these complex neurovascular cases depends on meticulous patient selection, perioperative hemodynamic management, and microsurgical expertise [4].

Management of cavernous and giant internal carotid artery (ICA) aneurysms illustrates the continuing relevance of bypass techniques. Giant cavernous ICA aneurysms may produce mass effect (for example, cranial neuropathies) and often prove refractory to conservative or endovascular approaches when parent vessel sacrifice is required; in such circumstances, high-flow bypass with planned parent artery occlusion remains a well-established, effective strategy for definitive treatment and symptom relief, albeit one that requires specialized graft material, microsurgical skill, and perioperative support [5].

Beyond anatomic complexity, the evolving epidemiology of aneurysmal disease includes presentations linked to systemic vasculopathies. HIV-associated intracranial aneurysmal vasculopathy is increasingly recognized, with diffuse fusiform and multiplicative aneurysm phenotypes described across age groups; these lesions can be friable, anatomically complex, and poorly suited to simple endovascular reconstruction, sometimes necessitating bypass-based strategies as part of a staged or combined approach [6].

Performing bypass surgery in resource-limited settings raises practical and systems challenges that go beyond technical skill: reliable graft harvest and preservation (e.g., saphenous vein or radial artery), appropriate microinstruments and microscopes, intraoperative flow assessment, and an experienced multidisciplinary team (anesthesia, neurocritical care, rehabilitation) are all prerequisites for safe practice. Nonetheless, case series and instructional reports indicate that with targeted capacity building and adaptation of techniques (including staged procedures, protective low-flow bypasses before high-flow grafting, and careful use of antiplatelet/anticoagulant regimens), centres in low-and middle-income countries can adopt bypass techniques and expand the local armamentarium for complex cerebrovascular disease [7]-[9].

Here we report two illustrative cases from a newly established cerebrovascular fellowship program in Cameroon in which bypass surgery (an STA-MCA low-flow bypass and a later high-flow common carotid-SVG-MCA bypass) was used to treat complex intracranial aneurysms—one a symptomatic giant cavernous ICA aneurysm and the other an M1-M2 aneurysm at risk for trapping. Through these cases and an accompanying focused literature review, we aim to 1) demonstrate the technical feasibility and clinical rationale for EC-IC bypass in resource-limited environments, 2) discuss strategic choices between low-flow pedicled bypasses and high-flow interposition grafts, and 3) propose practical recommendations for training, equipment prioritization, and system investments that can make bypass surgery a safe, sustainable option in similar settings.

2. Clinical Presentation

Case 1

Presentation and initial investigation. A 60-year-old woman presented with progressive, severe headaches and binocular diplopia. In the days preceding admission, her headache intensified, and the frequency increased and was associated with nausea and vomiting; simple analgesia provided no relief. Computed tomography angiography (CTA) identified a giant (≈3.0 cm) aneurysm of the left cavernous internal carotid artery (ICA) (**Figure 1**).

Initial management and course. Awake parent-artery occlusion was selected based on the symptomatic cavernous ICA aneurysm (oculomotor palsy) with presumed adequate collateral circulation. This was performed at the level of the cervical internal carotid artery, just distal to the carotid bifurcation, through a standard neck approach. However, formal balloon test occlusion or perfusion studies were not available. Therefore, clinical tolerance to temporary occlusion under awake conditions, with continuous neurological monitoring, was used as a surrogate to assess collateral sufficiency. The immediate postoperative period was notable for the absence of new neurologic deficits. Several months after the procedure, the patient developed new right-sided hemiparesis that occurred in the setting of transient systemic hypotensive episodes, likely related to blood pressure fluctuations during routine activities, resulting in insufficient collateral perfusion. Neurologic examination on readmission demonstrated decreased visual acuity (subjective complaint), right-sided hemiparesis with hyperreflexia, and otherwise intact cognition and cranial nerve function. Non-contrast CT showed no established infarction, but clinical features were consistent with hypoperfusion of the left carotid territory.

Operative technique (high-flow bypass). Given the clinical and radiologic evidence of impaired cerebral perfusion and the lack of infarction, we elected to perform a high-flow extracranial-intracranial bypass. Under general anesthesia, approximately 30 cm of saphenous vein was harvested from the left lower limb. The left common carotid artery (CCA) was exposed (≈3 cm segment to the bifurcation with 1 cm of ICA/ECA mobilized), and an end-to-side anastomosis from the saphenous vein graft to the CCA was created. The graft was tunneled subcutaneously to the left pterional craniotomy. The superior M2 branch was dissected for ≈1 cm and an end-to-side anastomosis from the saphenous vein graft to the M2 segment was completed (Figure 2). Intraoperative assessment of graft function was based on direct visualization of graft filling and clinical parameters, as microvascular Doppler, indocyanine green (ICG) angiography, and intraoperative angiography were not available.

Postoperative course and outcome. The patient's hemiparesis improved from Medical Research Council (MRC) grade 3/5 to 4/5 and her visual complaints showed subjective improvement. She was transferred to inpatient rehabilitation and was discharged on postoperative day 10 to continue rehabilitative care. Postoperative vascular imaging could not be obtained due to patient refusal; therefore, graft patency was inferred from clinical improvement. At six months follow-up, assessed through clinical consultation, the patient was functionally independent with no residual neurological deficit, corresponding to a modified Rankin Scale (mRS) score of 1.

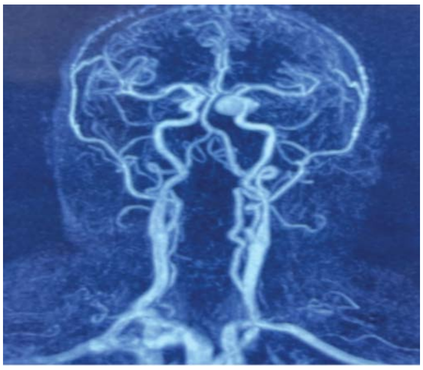

Figure 1. Intracavernous left giant ICA aneurysm.

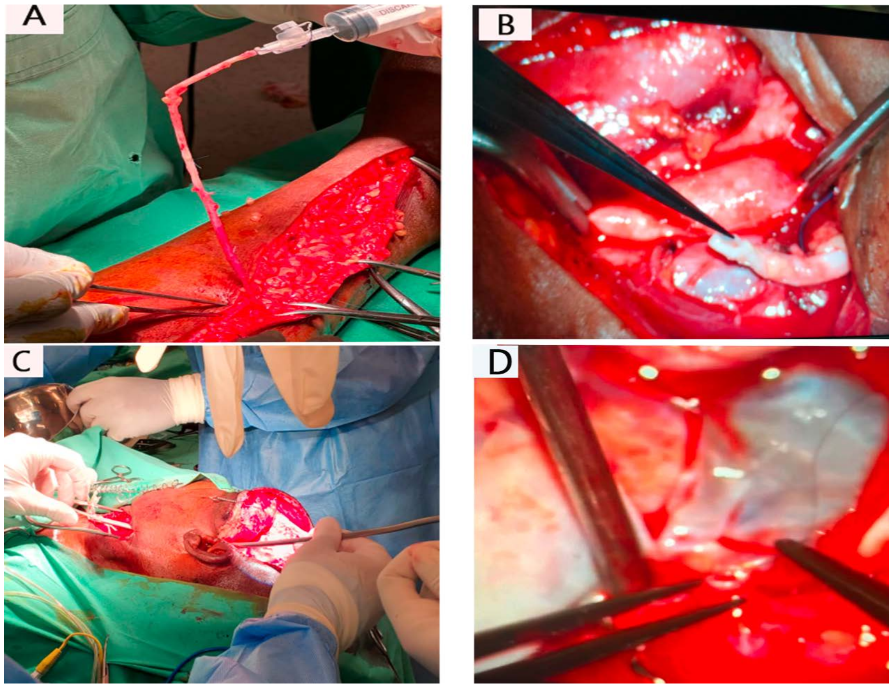

Figure 2. (A) Harvest of the external saphenous vein of left lower limb. (B) End-to-side anastomosis of the left common carotid artery to saphenous. (C) Passage of the saphenous vein through the neck. (D) End-to-side anastomosis of the left common carotid artery to left M2 MCA using saphenous interposition graft.

Case 2

Presentation and initial investigation. A 43-year-old man with hypertension and diabetes presented to a referring hospital with a thunderclap headache accompanied by nausea, vomiting and blurred vision; he remained alert without impaired consciousness. Magnetic resonance angiography demonstrated subarachnoid hemorrhage (Fisher grade 2) and a ruptured saccular wide-neck aneurysm of the right M1 segment adjacent to the MCA bifurcation (dome-to-neck ratio < 2).

Preoperative strategy and rationale. Because of the aneurysm's wide neck and the potential need for parent-artery sacrifice during definitive treatment, we planned a protective low-flow extracranial-intracranial bypass prior to clip occlusion to preserve distal perfusion if trapping became necessary.

Operative technique (protective STA-MCA bypass and clipping). A superficial temporal artery (STA) to M4-MCA (cortical branch) low-flow end-to-side bypass was performed as the first step. Following confirmation of graft patency, the aneurysm was dissected and successfully clip-occluded; trapping of the M1 segment was ultimately unnecessary (Figure 3). Graft patency was assessed intraoperatively by visual inspection and bleeding from the recipient vessel. No adjunctive flow measurement tools (Doppler or ICG) were available.

Postoperative course and outcome. The patient was extubated immediately after surgery and transferred to the intensive care unit, where he remained for 10 days for close neurologic and hemodynamic monitoring. He subsequently recovered in the ward and was discharged without neurological deficit, corresponding to a modified Rankin Scale (mRS) score of 0. Because of financial limitations, the patient was discharged without further diagnostic work-up and long-term follow-up data were not available as the patient was lost to follow-up.

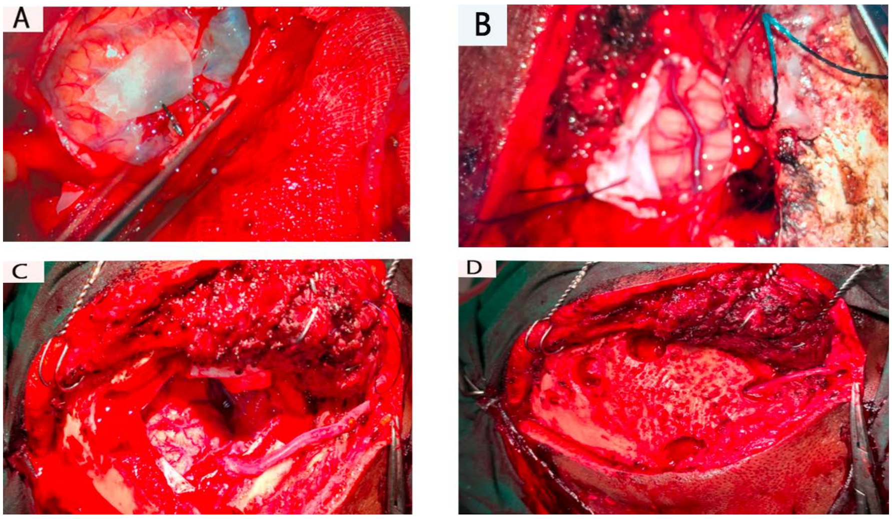

Figure 3. (A) Durotomy. (B) Placement of M4 vascular lakes and clipping. (C) End-to-side anastomosis between M4 MCA and superficial temporal artery. (D) Placement of bone flap.

Perioperative management. This included systemic heparinization during vascular anastomosis. Postoperatively, antiplatelet therapy was initiated to maintain graft patency. Blood pressure was carefully maintained in the high-normal range to optimize cerebral perfusion and reduce the risk of ischemia. These protocols were adapted to local resource availability.

3. Discussion

Summary of key findings

We report two illustrative cases from a newly established cerebrovascular fellowship program in Cameroon in which extracranial-intracranial (EC-IC) bypass techniques were used to 1) restore cerebral perfusion after intentional carotid occlusion for a giant cavernous ICA aneurysm and 2) protect distal flow prior to definitive clipping of a wide-neck M1-M2 aneurysm. The first case required a staged high-flow bypass using a saphenous-vein interposition graft from the common carotid artery (CCA-SVG-M2) after delayed hypoperfusion, and the second used a prophylactic low-flow STA-MCA bypass to enable safe clipping of a ruptured wide-neck aneurysm. These vignettes demonstrate that, even in a resource-limited environment, both low- and high-flow revascularization strategies can be successfully applied when indications are thoughtfully adjudicated and technical prerequisites are met.

Indications and clinical rationale for bypass in modern practice

Bypass surgery remains a critical tool for selected cerebrovascular lesions that are not suitable for reconstructive endovascular therapy or primary clipping—

classically giant, fusiform, blister, or otherwise complex aneurysms, and lesions associated with vasculopathy (for example, HIV-associated dysplastic aneurysms) where vessel integrity is compromised and parent-artery sacrifice may be required. In such circumstances, flow-replacement (high-flow interposition graft) or flow-augmentation/protection (low-flow STA-MCA) bypasses enable durable occlusion of the diseased segment while preserving distal perfusion. Contemporary case series and technique reports continue to emphasize this role of bypass as complementary to endovascular advances rather than as anachronism [6]. Recent large series confirm that, despite advances in endovascular therapy, EC-IC bypass remains indispensable for a subset of complex aneurysms not amenable to reconstruction, with good functional outcomes reported in the majority of patients [10].

Technical considerations—choosing low-flow vs high-flow approaches

Selecting between a pedicled low-flow donor (e.g., STA) and a high-flow interposition graft (radial artery or great saphenous vein) depends on the intended flow requirement, anatomic reach, and donor/recipient vessel size mismatch. Low-flow STA-MCA bypasses are elegant, relatively low-morbidity solutions that are well suited to cortical revascularization and protective strategies when only modest flow is needed or when a short-term protective bypass is desirable prior to reconstructive clipping. High-flow bypasses (CCA-SVG-M2 or CCA-RA-MCA) provide larger flow capacity and are preferred when reconstructive trapping or permanent parent-artery sacrifice is planned for larger territory coverage; however, they require conduit harvesting, longer tunnelling, and a more demanding anastomotic technique. Our staged approach—an awake carotid occlusion followed by high-flow bypass when hypoperfusion manifests—illustrates both the physiologic variability that can occur after parent-artery sacrifice and the capacity of staged revascularization to salvage at-risk territories. The literature supports this spectrum of techniques and emphasizes that intraoperative flow assessment and meticulous anastomotic technique are paramount for durable outcomes [7] [11]. Evidence from recent meta-analyses also supports the safety of EC-IC bypass in anterior circulation aneurysms, with low rates of ischemic and haemorrhagic complications, reinforcing its role as a reliable revascularization strategy when tailored to patient-specific hemodynamic needs [12].

Outcomes, complications and durability: what evidence shows

Available case series and systematic reviews indicate that EC-IC bypass—whether with radial artery or saphenous-vein grafts—can be performed with acceptable perioperative risk in experienced hands and can provide durable protection against ischemia after parent-artery occlusion, or permit definitive treatment of complex aneurysms that are otherwise untreatable. Complications specific to high-flow grafts include graft stenosis/occlusion, graft aneurysm formation, and donor-site morbidity; these risks underscore the importance of careful graft selection, gentle handling, and long-term surveillance. Conversely, protective low-flow bypasses are associated with lower conduit morbidity but can be insufficient if the perfusion deficit is global or large in territory. Our first case—clinical hypoperfusion without infarction successfully reversed by CCA-SVG-M2 bypass—aligns with prior reports that staged or delayed high-flow revascularization can restore function when performed before irreversible ischemic injury [13]. Recent systematic reviews demonstrate high graft patency rates (up to 96%) and favourable clinical outcomes in more than 80% of patients undergoing EC-IC bypass for complex aneurysms, although complication rates remain non-negligible and emphasize the need for careful patient selection [14].

Bypass in disease-specific contexts: fusiform, giant, and HIV-associated lesions

Fusiform and serpentine aneurysms, and aneurysms arising in settings of arteriopathy (including HIV-associated vasculopathy), often lack a defined neck and have fragile walls that are poor substrates for coiling or flow diversion alone. Literature on HIV-related aneurysms highlights their diffuse, sometimes multilobar nature and increased risk for recurrence after endovascular treatment—scenarios in which bypass-assisted trapping or flow-replacing strategies may be preferable. Our cases—including a complex cavernous ICA aneurysm in an environment where reconstructive endovascular technology may be limited—illustrate the continued relevance of bypass for these pathology subtypes [5].

Practical constraints and risk mitigation in resource-limited settings

Performing bypass surgery safely requires more than microsurgical skill: it requires appropriate instruments (microinstruments and high-quality operating microscope), reliable graft procurement and preservation protocols, intraoperative heparinization and flow monitoring, and postoperative neurocritical care and rehabilitation. Resource limitations complicate each of these domains. However, case series and experience reports show that targeted capacity building—focused training of local teams, procurement of a basic but adequate microsurgical set, partnerships for mentoring (tele-mentoring or visiting fellowships), and incremental adoption of techniques (beginning with STA-MCA and progressing to interposition grafts)—can yield reproducible outcomes. Documenting these cases in a fellowship setting can accelerate local learning curves and create sustainable skill transfer [15].

Comparison with contemporary literature (LMICs and HICs)

In high-income settings, advanced endovascular options (flow diverters, remodeling stents) have reduced the proportion of aneurysms requiring open bypass, yet complex lesions persist for which open revascularization yields the most durable solution. In LMICs, by contrast, limited access to advanced endovascular devices and constrained critical-care capacity often push the treatment balance back toward tailored open solutions when expertise exists locally. Reports from dedicated centers show acceptable outcomes with carefully selected bypass strategies, but also emphasize higher variability in postoperative surveillance and rehabilitation support in LMICs compared with HIC cohorts. Our experience parallels these findings: bypass enabled definitive management and symptom improvement, but its safe implementation demanded adaptations to local logistics and vigilant postoperative care [16].

Capacity building, training and system-level implications

These cases argue for deliberate investment in cerebrovascular capacity as a component of national surgical planning in LMICs. Practical priorities include 1) incorporation of microsurgical cerebrovascular modules into local fellowship curricula, 2) procurement of essential microvascular instruments and microscopes, 3) development of standardized protocols for conduit harvest and graft preservation, 4) establishment of tele-mentoring links with high-volume centers for intraoperative guidance, and 5) strengthening perioperative neurocritical and rehabilitative pathways to preserve gains made in the operating room. Incremental skill building—starting with STA-MCA bypass and progressing to interposition grafting—can build durable local capacity while mitigating early complication risks [17].

4. Limitations

This report is intrinsically limited by its case-report design. Also, the absence of intraoperative flow measurement tools and postoperative angiographic follow-up represents a limitation, reflecting the resource constraints of our setting. Case series cannot substitute for prospective comparative evidence about the relative merits of endovascular versus bypass strategies in complex lesions, but they remain essential to document feasibility, technical nuances, and context-specific outcomes—particularly when local resources constrain otherwise standard treatment options.

5. Conclusion and Future Directions

EC-IC bypass—both low-flow STA-MCA and high-flow CCA-SVG-M2 reconstructions—remains a vital component of the cerebrovascular armamentarium for selected complex aneurysms. Our two cases demonstrate that these techniques can be successfully and safely performed in a newly established fellowship program in a resource-limited setting when appropriate planning, technique, and perioperative care are present. Future efforts should focus on systematic outcome tracking, multi-center registries in LMICs, and structured implementation studies that evaluate training models, cost-effectiveness, and long-term graft durability. These data will help refine indications and guide investments so that bypass surgery becomes a sustainable, high-quality option in a broader range of health systems.

Ethics Approval and Consent to Participate

Written informed consent was obtained from both patients for participation and publication of their clinical data.

The study was conducted in accordance with the ethical standards of the Helsinki Declaration.

Conflicts of Interest

The authors declare no competing interests.

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