

# Treatment of hemodynamic insufficiency in chronic CCA occlusion using a short saphenous vein interposition graft: diagnostic and technical considerations

## An illustrative case report

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**Abstract** Extracranial–intracranial bypass surgery has been shown to reverse hemodynamic insufficiency on the basis of steno-occlusive disease of the internal carotid artery (ICA) or middle cerebral artery. In contrast, chronic occlusion of the common carotid artery (CCA) without extracranial donor vessels affords alternative revascularization procedures as well as a more elaborate preoperative workup. This case is intended to illustrate the specific diagnostic approach and considerations as well as a beneficial treatment modality in the setting of pronounced hemodynamic insufficiency as a consequence of a CCA occlusion, in conjunction with contralateral CCA and ICA stenoses. A 61-year-old man complaining of new onset aphasia underwent vascular imaging that revealed a proximal occlusion of the left CCA with a concomitant patent proximal ICA on ultrasound. Functional cerebral blood flow measurement

including Xenon-enhanced computer tomography showed corresponding chronic hemodynamic insufficiency of the left hemisphere. The patient received a modified revascularization procedure, where a saphenous vein was used as interposition graft between the subclavian artery and the left proximal ICA. Postoperatively, both clinical and morphological improvement were noted. Successful treatment of hemodynamic insufficiency because of chronic CCA occlusion necessitates a thorough preoperative workup and application of alternative revascularization strategies.

**Keywords** Hemodynamic insufficiency · CCA occlusion · Graft · Bypass · Xenon-CT · CTA

## Introduction

Recently, cerebral revascularization procedures regained considerable interest for their ability to restore adequate perfusion in the context of chronic hemodynamic insufficiency [7]. Classically, hemodynamic insufficiency is the result of a high-grade stenosis or occlusion of either the internal carotid artery (ICA) or middle cerebral artery (MCA), resulting in a compromise of cerebrovascular reserve capacity (CVRC). Routine workup includes cerebral angiography and magnetic resonance (MR) scanning, but functional imaging such as single photon emission computed tomography, positron emission tomography, or Xenon-enhanced computer tomography (XeCT) is mandatory to identify those patients who will eventually profit from a revascularization procedure [1, 8]. A compromise in CVRC is usually assumed if stimulated perfusion under acetazolamide (Diamox) increases less than 30% of

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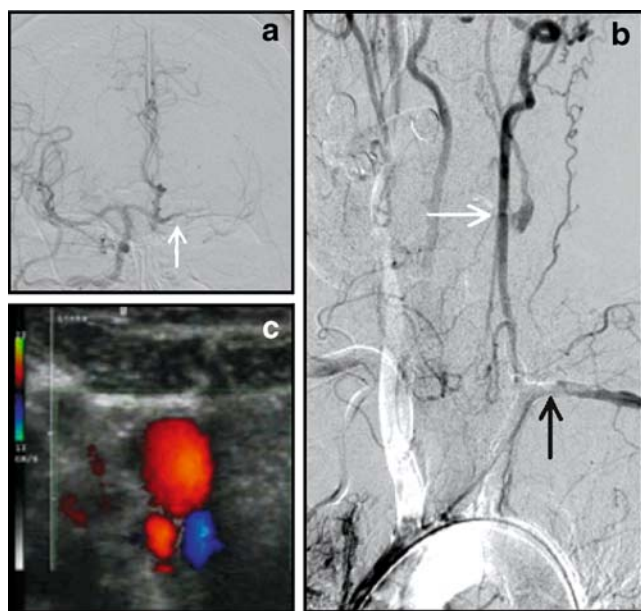
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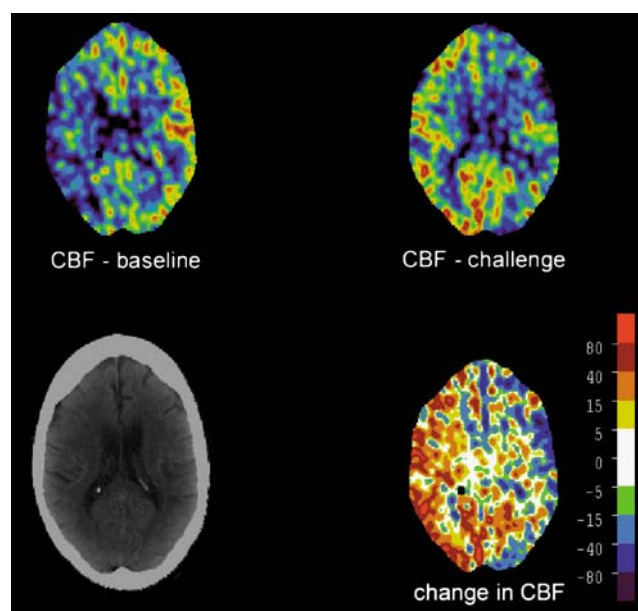
baseline value. In cases of isolated, unilateral ICA or MCA stenosis, standard extracranial–intracranial (EC/IC) bypass has been shown to sufficiently restore reserve capacity [3, 8]. However, when the vascular pathology is more complex, suitable alternative revascularization options have to be considered, such as in the rare case of common carotid artery (CCA) occlusion where donor vessels like the superficial temporal artery may not be available. In this paper, we report a case of chronic CCA occlusion and demonstrate how, after a thorough preoperative workup and application of alternative bypass techniques, a successful revascularization can be achieved.

## Case report

We present the case of a right-handed 61-year-old man developing acute onset of aphasia as well as intermittent paresthesias of his right arm and leg; no further neurological deficits were noted. Initial workup with MR scanning demonstrated left-sided borderzone ischemia. Cerebral angiography showed a proximal left CCA occlusion at its origin from the aortic arch, with an insufficient collateralization via the anterior communicating artery (Fig. 1a); injection of the left vertebral artery revealed minor filling of the left external carotid artery (ECA), the carotid bulb, and the ICA in a retrograde fashion (Fig. 1b), a circumstance

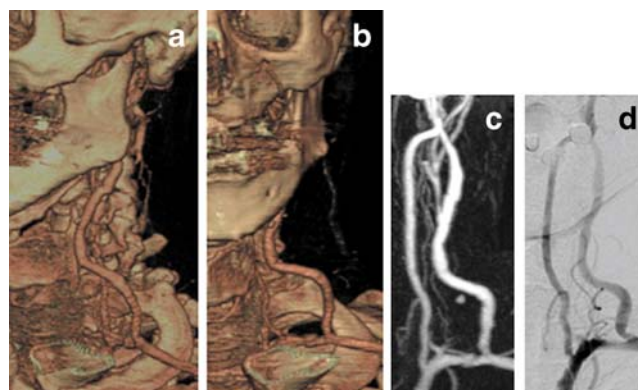


**Fig. 1** **a** Collateral filling of the left hemisphere via anterior communicating artery (white arrow); **b** complete occlusion of the left common carotid artery at the aortic arch (black arrow), retrograde filling of the internal carotid artery via the external carotid artery (white arrow) in the delayed arteriographic phase; **c** verification of retrograde flow pattern in patent distal vessels with Doppler sonography (red: inverse flow within the external carotid artery; blue: antegrade flow within the internal carotid artery)



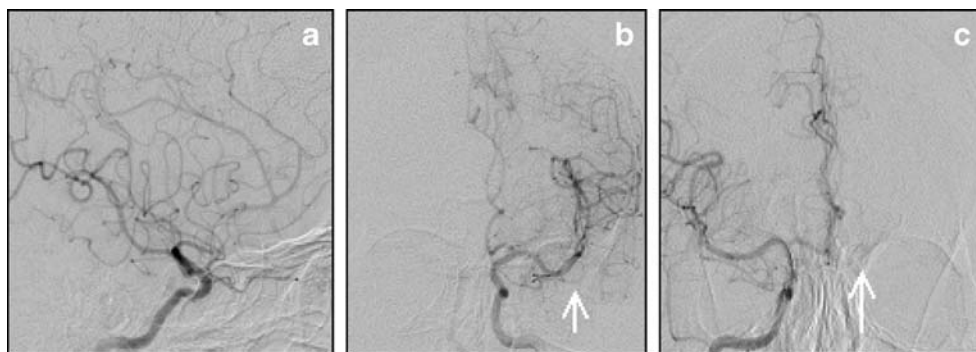
**Fig. 2** XeCT baseline CBF measurement showed grossly preserved perfusion of the left hemisphere with reduced levels on the right (upper left); when challenged with acetazolamide, perfusion increased appropriately on the right, while severe steal phenomenon was observed for the left hemisphere (upper right, lower right)

that has been observed before [2] and in this case could also be appreciated with Doppler sonography confirming patency of the ICA (Fig. 1c). Functional imaging with XeCT revealed grossly preserved baseline perfusion of the left hemisphere (Fig. 2). However, a pronounced steal phenomenon was observed under diamox challenge: Not only did perfusion fail to increase appropriately, but a dramatic fall of up to 30% from baseline value was noted for the entire hemisphere. It is interesting to note that decreased baseline perfusion was recorded on the right hemisphere, most likely because of an additional CCA and ICA stenosis on the right, but challenge with Diamox was appropriate. In conclusion, cerebral blood flow measurements were in good accordance with the neurological symptoms and reflected a situation of severely disturbed perfusion with a



**Fig. 3** Postoperative comparative CTA (**a**, **b**), MRA (**c**), and angiography (**d**) demonstrate filling of the bypass

**Fig. 4** Bypass facilitates precipitous filling of the left ACA and MCA territory (a, b); no further collateralization is noted from the right ICA (c)



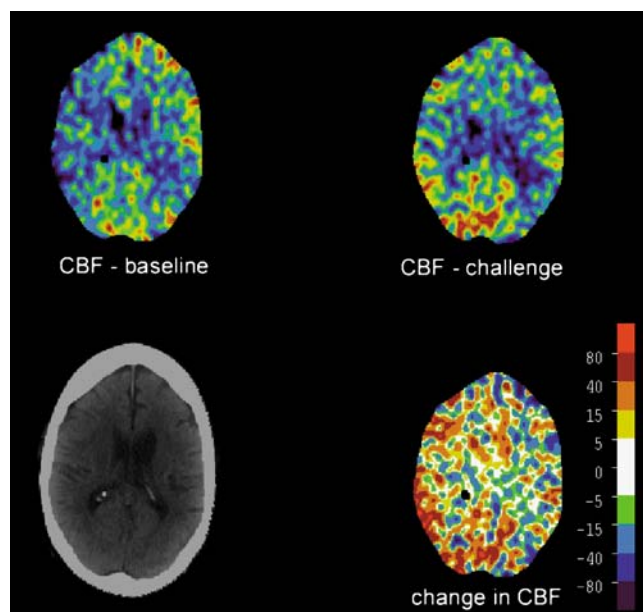
marked left hemispheric steal on the basis of a CCA occlusion and contralateral CCA and ICA stenoses. On the basis of these findings and the patient's progressive neurological deficits, the indication for surgical revascularization was given. However, because of the occlusion of the CCA and inadequate perfusion of the ECA, a technique alternative to superficial temporal artery (STA)–MCA bypass surgery had to be employed.

As angiography and Doppler sonography had revealed a patent ICA, it was then decided to utilize a saphenous vein graft connected to the left subclavian artery with an end-to-side anastomosis, which could then in turn be anastomosed to the proximal end of the ICA after its separation from the bifurcation. Surgery was performed under local anesthesia, and the perioperative course was uneventful. Under continuous anticoagulation with aspirin, the patient recovered rapidly, and at his 6-month follow-up, his aphasia had improved substantially, while no further paresthesias of arms or legs had occurred. Computed

tomography angiography (CTA), MR angiography (MRA), and conventional angiography (Fig. 3) at that time demonstrated bypass patency with perspicuous filling of the left ICA territory (Fig. 4). Furthermore, crossflow from the right-sided ICA was now absent (Fig. 4c), with the steal phenomenon under Diamox challenge gradually improving (Fig. 5).

## Discussion

The treatment of patients with cerebrovascular occlusive disease remains a multidisciplinary challenge. Patients with hemodynamic compromise because of carotid occlusion are at increased risk for developing stroke and need to be characterized correctly to tailor the appropriate therapy. In our institution, XeCT remains the diagnostic procedure of choice to determine cerebral blood flow as well as CVRC. In cases of progressive neurological worsening with a decrease in CVRC, surgical revascularization should be considered. With a single vessel occlusion or stenosis of the ICA or MCA, direct standard EC/IC bypass with end-to-side anastomosis of the distal end of the STA to a cortical MCA branch is usually sufficient to restore adequate perfusion. Only rarely alternative revascularization strategies, such as STA-M2, occipital artery-M3, or large caliber interposition grafts are indicated [4]. In this case, the patient developed neurological symptoms, attributable to an occlusion of the proximal left CCA with a patent ICA because of retrograde filling via the ECA. The angiographic patency of the ICA with an occluded CCA, though quite uncommon, has been described before [2, 6], but it can be easily missed, and it was essential to characterize exact flow patterns via ultrasound. Due to the occlusion of the CCA, standard EC/IC-bypass surgery would not be an option for the obvious lack of an adequate donor vessel, i.e. the STA. Therefore, interposition of a short saphenous vein graft, connecting the subclavian artery to the proximal end of the ICA, was used to ensure supplementary blood flow to the left hemisphere. The potential risk of temporary occlusion of the ICA was



**Fig. 5** XeCT revealed slight increase in right sided baseline perfusion when compared to preoperative levels, while moderate recovery of reserve capacity (*lower right*) was also noted



expected to be low because of minor filling via the ECA; nevertheless, the surgery was performed under local anesthesia, and no symptomatic changes of the patient were observed. The operative alternative—connecting the bypass graft to a M2 or M3 segment—would have brought about a considerably higher perioperative risk with the need of a longer bypass conduit, an additional craniotomy, and the technical difficulties encountered with vessels of different caliber. Significant clinical improvement was noted postoperatively, and at 6-month follow-up, bypass patency was verified via angiography, duplex sonography, CTA, and MRA. In this patient, where several compromised vessels had led to severe disruption of baseline flow and reserve capacity, XeCT showed gradual recovery of the left hemispheric hemodynamic insufficiency and even improvement of contralateral baseline perfusion.

Few groups have reported a small number of cases with a similar reconstructive vascular approach, using the subclavian or axillary artery as the inflow vessel for a bypass to the carotid bulb [5, 6]; however, blind exploration was required in the majority of patients as preoperative angiography was found to be insensitive to document patent distal vessels. Belkin et al. published a series of six patients, where color-enhanced duplex sonography was found to be sensitive to identify the perfusion state of the ICA; although favorable clinical follow-up was presented in this series, hemodynamic assessment postoperatively only consisted of baseline transcranial Doppler studies.

Although successful treatment of an “isolated” carotid bifurcation has been described before [9], this case illustration is of interest because it nicely highlights the essential diagnostic workup and strategic considerations mandatory when treating this complex cerebrovascular pathology.

## Conclusion

This multidisciplinary case report aims to illustrate the diagnostic challenges met in selected stroke patients presenting with complex neurovascular pathologies. A successful alternative operative treatment option is presented on the basis of a specifically tailored pre- and postoperative workup, which effectively enlarges the range of revascularization options.

## References

1. The EC/IC Bypass Study Group (1985) Failure of extracranial–intracranial arterial bypass to reduce the risk of ischemic stroke. Results of an international randomized trial. *N Engl J Med* 313:1191–1200
2. Belkin M, Mackey WC, Pessin MS, Caplan LR, O'Donnell TF (1993) Common carotid artery occlusion with patent internal and external carotid arteries: diagnosis and surgical management. *J Vasc Surg* 17:1019–1027 discussion 1027–1018
3. Jinnouchi J, Toyoda K, Inoue T, Fujimoto S, Gotoh S, Yasumori K, Ibayashi S, Iida M, Okada Y (2006) Changes in brain volume 2 years after extracranial–intracranial bypass surgery: a preliminary sub-analysis of the Japanese EC-IC trial. *Cerebrovasc Dis* 22:177–182
4. Langer DJ, Vajkoczy P (2005) ELANA: excimer laser-assisted nonocclusive anastomosis for extracranial-to-intracranial and intracranial-to-intracranial bypass: a review. *Skull Base* 15:191–205
5. Podore PC, Rob CG, DeWeese JA, Green RM (1981) Chronic common carotid occlusion. *Stroke* 12:98–100
6. Riles TS, Imparato AM, Posner MP, Eikelboom BC (1984) Common carotid occlusion. Assessment of the distal vessels. *Ann Surg* 199:363–366
7. Schmiedek P (1989) EC-IC bypass in hemodynamic cerebrovascular disease. *J Neurosurg* 71:464–466
8. Schmiedek P, Piepgras A, Leinsinger G, Kirsch CM, Einhüpl K (1994) Improvement of cerebrovascular reserve capacity by EC-IC arterial bypass surgery in patients with ICA occlusion and hemodynamic cerebral ischemia. *J Neurosurg.* 81:236–244
9. Sullivan TM (1996) Subclavian-carotid bypass to an “isolated” carotid bifurcation: a retrospective analysis. *Ann Vasc Surg* 10:283–289

## Comments

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One should be innovative in thinking like the authors and not be satisfied with ‘routine’ bypass methods when there still would be a need for one. After the EC/IC bypass study, there were only a few centers in the world that continued with bypass surgery. Now, there is a growing demand for bypasses, and the number of centers performing them is increasing. This study also addresses nicely the importance of dedicated neurovascular centers with multidisciplinary teams in taking care of the more and more demanding cases left for open micro-neurosurgery. This encourages young vascular neurosurgeons first to go to the lab to learn the techniques, then to travel to see the masters before starting their own practice.

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The authors nicely illustrate a creative surgical management strategy in a patient presenting with common carotid occlusion manifesting clinical evidence of hemispheric hypoperfusion. The patient was found to maintain a patent ICA distal to the occlusion filling from the extra- and intracranial collaterals. The selection of an entirely extracranial revascularization strategy permitted flow augmentation to be established without exposing the patient to the risk of general anesthesia and craniotomy. This novel approach resulted in apparently excellent clinical outcome and reflects the importance of a comprehensive radiographic workup, which includes four-vessel angiography and hemispheric perfusion studies before consideration of surgery can be made. The authors utilize XeCT to determine hemispheric blood flow and CVRC. We additionally use VasSol MR imaging Noninvasive Optimal Vessel Analysis (NOVA) to non-invasively quantify volumetric blood flow rate in individual vessels. NOVA gives information regarding individual quantitative vessel blood flow and direction, allowing greater sophistication in understanding cerebral blood flow preoperatively.

The authors should be commended for designing an operative strategy that allowed a high likelihood of revascularization with the lowest possible perioperative risk.