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Hybrid surgery for symptomatic chronic complete occlusion of the internal carotid artery: A case report

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ABSTRACT

Currently, there are antiplatelet drugs, extracranial-intracranial (EC-IC) vascular bypass, carotid endarterectomy (CEA), endovascular intervention (EI), and other revascularization procedures for symptomatic chronic internal carotid artery occlusion (CICAO). In consulting the literature, we found that existing techniques for single treatments cannot achieve satisfactory results when there is a long segment occlusion with plaque attached to the intracranial segment and a short stump at the initial segment. We reported the case of a 50-year-old male patient with blurred vision, headache, and weakness in the right upper limb. After the exclusion of other neurological diseases, he was diagnosed with symptomatic CICAO; the occlusion segment was long and the stump was too short. We performed a novel hybrid surgery for the patient—a carotid endarterectomy combined with internal carotid artery stenting. After 6 months of follow-up, computed tomography angiography (CTA) confirmed that the left internal carotid artery was unobstructed, and the symptoms were relieved. A brief review of the literature is presented in addition to this report.

Introduction

Chronic internal carotid artery occlusion (CICAO) is different due to perfusion compensation, and its clinical manifestations vary greatly. If perfusion compensation is sufficient, it may be asymptomatic, and insufficient compensation may cause cerebral ischemic events such as stroke or transient ischemic attack (TIA).¹ Limb-shaking TIAs are a rare but characteristic clinical manifestation of CICAO²; unilateral visual impairment may also be a characteristic symptom of carotid disease.³ Non-specific clinical manifestations include headache and cognitive impairment. Headaches caused by CICAO are often chronic headaches with an unclear description, which may be related to the establishment of collateral circulation after chronic occlusion of the carotid artery. The long-term stroke rate of CICAO patients is 8 times that of normal people. Asymptomatic people have a low stroke recurrence rate, and the annual stroke rate is <2%. For patients with TIA or mild stroke, the annual risk of stroke recurrence is 5%–6%.⁴ If there is a hemodynamic disorder, the risk of stroke is twice that of TIA or mild stroke patients.^{5,6}

Currently, there are antiplatelet drugs, extracranial-intracranial (EC-IC) vascular bypass, and carotid endarterectomy (CEA), endovascular intervention (EI), and other revascularization procedures for symptomatic CICAO.^{7–9} For symptomatic CICAO patients with severe

hemodynamic disorders, EC-IC vascular bypass therapy may improve blood supply to the brain tissue and reduce the rate of stroke recurrence; however, its safety and effectiveness are still controversial. The Carotid Occlusion Surgery Study (COSS) prospective study confirmed that its effect is not significantly better than drug treatment.¹⁰ It is difficult to use only CEA surgery to open a long segmental occlusion that has obstructed the intracranial segment. With the development of interventional techniques, endoluminal technology offers the possibility of treating intracranial occlusion.

Despite this, the initial stump of the internal carotid artery is short, the long-segment occlusion thrombus load is large, and there is still a high risk of interventional opening. We reported the case of a 50-year-old male patient with blurred vision, headache, and weakness in the right upper limb. After the exclusion of other neurological diseases, he was diagnosed with symptomatic CICAO; the occlusion segment was long, and the stump was too short. We performed a novel hybrid surgery for the patient – CEA combined with internal carotid artery stenting (CAS). After 6 months of follow-up, computed tomography angiography (CTA) confirmed that the left internal carotid artery was unobstructed, and the symptoms were relieved. A brief review of the literature is presented in addition to this report.

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Case report

A 50-year-old male presented with left eye blurred vision, dizziness, and weakness of the right upper limb for 2 months. He had a past medical history of diabetes and hypertension for more than 10 years. Upon admission, physical examination found right upper limb weakness and blood pressure over 140/90 mmHg. Further examination using CTA revealed total occlusion above the internal carotid artery (Fig. 1). Magnetic resonance perfusion (MRP) images (Fig. 2) revealed an MR perfusion index that showed a large area with poor perfusion and delayed time-to-peak (TTP). After asking a neurologist to provide a consultation and rule out other neurological diseases, we decided to perform the hybrid surgery.

Strict anti-platelet aggregation therapy was started 5–7 days before the start of surgery, and the patient was given clopidogrel hydrogen sulfate 75 mg/d and aspirin 100 mg/d. After general anesthesia, the anterior incision of the sternocleidomastoid muscle was performed, and the common carotid artery, internal carotid artery, and external carotid artery were separated after the carotid sheath was exposed. It was observed that the beginning of the left internal carotid artery was significantly hardened, and distal pulsation had disappeared. After

systemic heparinization (5000 IU), the thyroid superior artery, the external carotid artery, and the common carotid artery were sequentially blocked with non-invasive vascular clamps, but the internal carotid artery was not blocked. After blocking, transcranial Doppler (TCD) ultrasonography detected the average flow velocity of the middle cerebral artery as <50% of the baseline value. While performing the longitudinal incision of the common carotid artery and internal carotid artery wall, with an incision length of approximately 3 cm, the mixed plaque filling in the lumen of vessel could be seen. We completely removed the intima of the internal carotid artery initial segment and removed the carotid atherosclerotic plaque, which was about 7 cm long (Fig. 3). Saline was used to rinse repeatedly until no plaque debris remained and no blood reflux was found. Finally, the vessel wall was continuously sutured using a 5-0 pleuro line. Along the common carotid artery puncture (Fig. 4), a 6 F arterial sheath was introduced. The Transend 0.014-inch microguidewire and Excelsior XT-27 150 cm × 6 cm microcatheter were introduced through the sheath, and repeated attempts were made to successfully select the middle cerebral artery. The angiography clearly showed that the middle cerebral artery was in good condition (Fig. 5). The Boston Scientific Gateway 2.5 mm × 15 mm balloon was introduced through the guidewire to expand the intracranial occlusion of the left

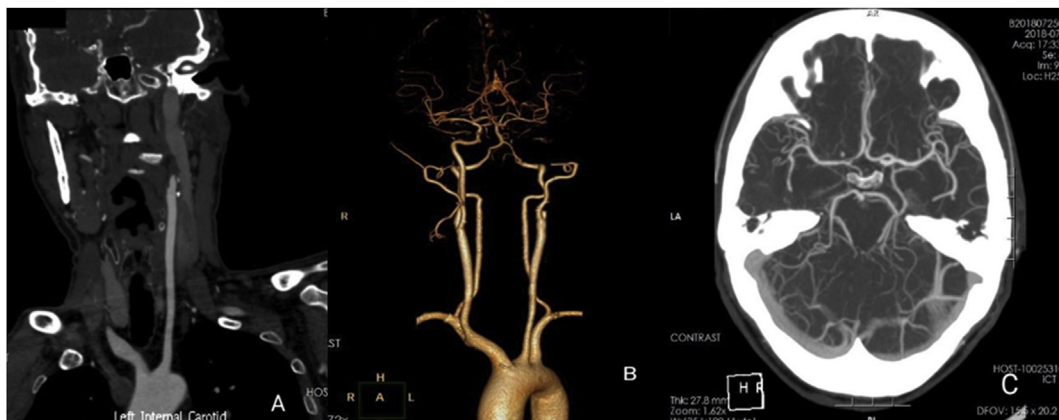


Fig. 1. Preoperative 2-dimensional reconstructive computed tomography angiography (CTA) (A and C) and preoperative 3-dimensional reconstructive CTA (B) reveal total occlusion above the internal carotid artery.

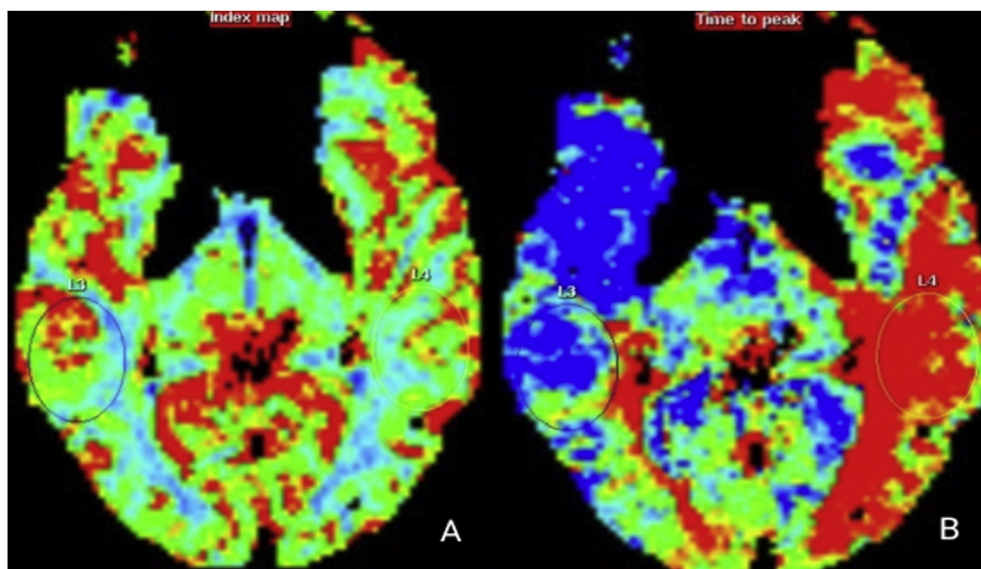


Fig. 2. Preoperative magnetic resonance perfusion (MRP) images reveal a preoperative MR perfusion index showing a large area with poor perfusion (A) and delayed time-to-peak (TTP) (B).

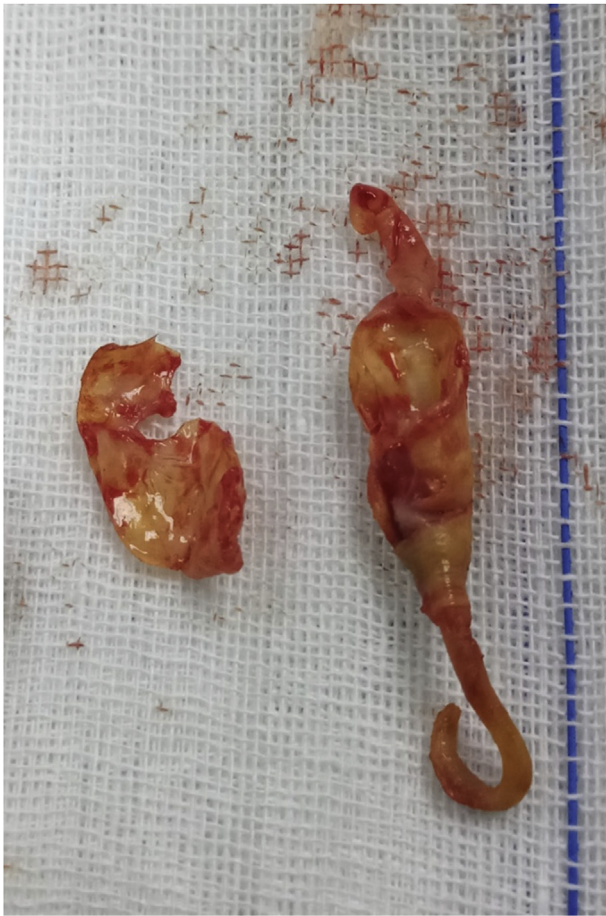


Fig. 3. Excised carotid atherosclerotic plaque, about 7 cm long.

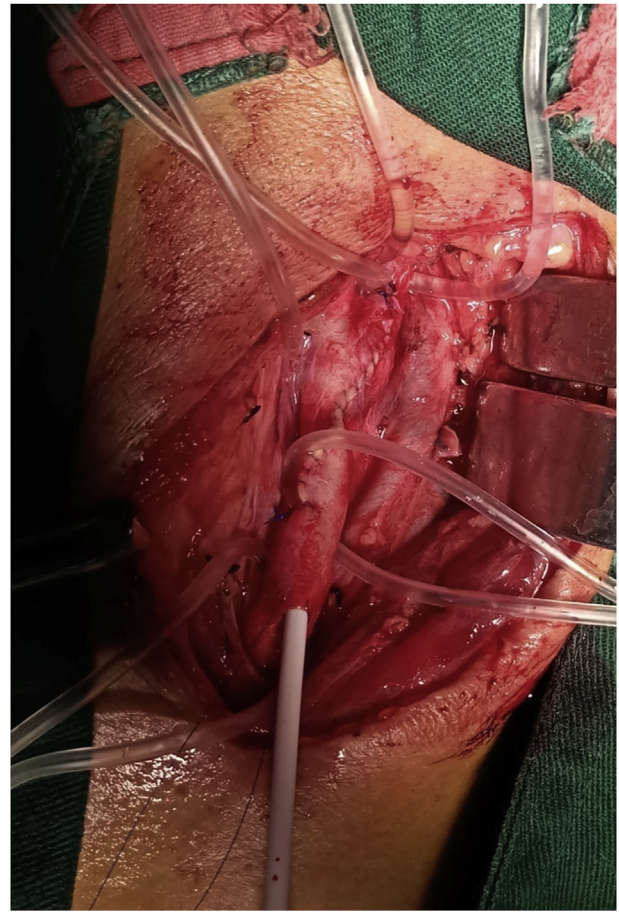


Fig. 4. Puncture along the common carotid artery.

internal carotid artery. The angiography showed patency in the left internal carotid artery from the initial segment to the whole process, but multiple severe stenosis remained locally. Therefore, the Neuroform EZ 4–30, 4.5–30, 4.5 × 15 mm stents were placed with the aid of the road map (Fig. 6). Performing a digital subtraction angiography again (Fig. 7) showed that the left internal carotid artery appeared to be in good condition from the initial segment to the middle cerebral artery without residual stenosis. TCD showed a significant improvement in blood flow velocity in the middle cerebral artery, with an average flow rate of 112% of the baseline value. A soluble hemostatic gauze was locally placed into the drainage tube to completely stop bleeding, and the incision was sutured layer by layer. We naturally neutralized heparin after surgery and gave a subcutaneous injection of low molecular weight heparin 5000 U (1 time/12 h), anti-coagulant therapy 3 d, and at the same time, clopidogrel hydrogen sulfate 75 mg/d and aspirin 100 mg/d for anti-platelet treatment. Blood pressure was strictly controlled to prevent high perfusion risk.

Before treatment, the patient complained that his right hand was weak, but this symptom improved, although it was not an accurate quantitative evaluation of cerebral perfusion. CTA and MRP were repeated again, and the CTA showed that the left internal carotid artery had been opened, but some stent artifacts were present (Fig. 8). The postoperative MR perfusion index showed improved perfusion, and the left cerebral hemisphere TTP was similar to the right side (Fig. 9).

The Modified Rankin Scale (mRS) was reduced from 3 points before surgery to 1 point. The patient was discharged on the tenth day after surgery and continued to take dual antiplatelet drugs. No cerebral ischemic events were observed during the 6-month follow-up period. CTA was repeated again (Fig. 10), showing patency in the left internal carotid artery, but some stent artifacts were still present.

Discussion

CICAO is different due to perfusion compensation, and its clinical manifestations vary greatly. If perfusion compensation is sufficient, it may be asymptomatic, and insufficient compensation may cause cerebral ischemic events such as stroke or TIA.¹ Unilateral visual impairment may be a characteristic symptom of carotid disease, and non-specific clinical manifestations include headache and cognitive impairment. Headaches caused by CICAO are often chronic headaches with an unclear description, which may be related to the establishment of collateral circulation after chronic occlusion of the carotid artery and abnormal pulsation of the external carotid artery. In this report, the patient's first symptoms were blurred vision, right limb weakness, and headache.

Previously, patients with chronic internal carotid artery occlusion were believed to have established collateral circulation, and no further surgical intervention was recommended. However, recent studies have found that patients with subacute and chronic internal carotid artery occlusion have a higher risk of recurrent stroke despite active medical treatment.¹¹ In addition, animal studies have found that cerebral hypoperfusion caused by occlusion of chronic cerebral blood vessels can cause neuronal death and cognitive dysfunction through various signal transduction pathways.^{12,13} Therefore, the reopening of the occluded blood vessels is theoretically beneficial for improving local hemodynamics, thereby improving the prognosis and cognitive function of the patient, while preventing stroke recurrence.^{14,15}

Currently, the surgical treatment of carotid occlusion mainly includes carotid endarterectomy, EC-IC vascular bypass, interventional therapy, and hybrid surgery. Hafner et al.⁹ reported that the total recanalization rate of 47 patients with carotid endarterectomy was 68%, which was related to the duration of carotid occlusion. The recanalization rate of

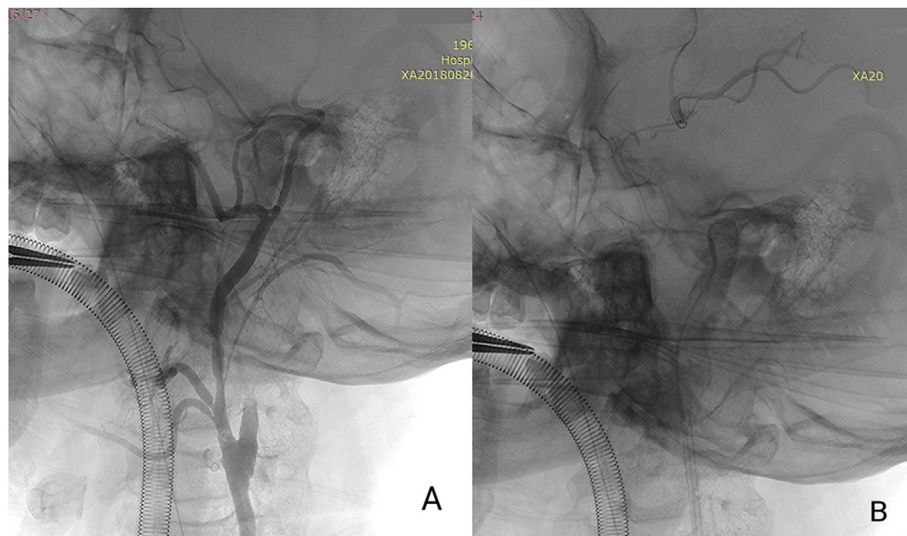


Fig. 5. Stump angiography created by CEA surgery shows a good condition (A). The middle cerebral artery is visible on the angiography (B).



Fig. 6. Under the guidance of the guidewire (A), insert the Neuroform EZ 4–30, 4.5–30, 4.5 × 15 mm stent with the aid of the road map (B).

patients with occlusion times ≤ 7 d was 100%, and that of patients with occlusion times ≤ 1 month was 50%. Therefore, patients with chronic carotid occlusion have a lower success rate of carotid endarterectomy. The Carotid Occlusion Surgery Study (COSS) randomized high-risk patients with carotid occlusion and cerebral hemisphere ipsilateral and contralateral oxygen uptake scores (OEF) > 1.13 ; however, in the middle of the study, there was no statistically significant difference between the 2-year recurrence rates of stroke in the surgery group and the drug group, so the study was terminated early due to more complications after surgery.¹⁰

In recent years, with the development of endovascular interventional techniques, interventional recanalization for acute ischemic stroke caused by acute carotid occlusion has been recommended as Class I evidence by several European and American professional societies.^{16,17} However, there are relatively few reports of interventional recanalization for chronic carotid occlusion. Terada et al.¹⁸ first reported interventional recanalization in 2005 for patients with chronic carotid occlusion. Lin et al.¹⁹ analyzed the complications of intravascular recanalization for

chronic carotid occlusion. The study included 54 patients with major clinical manifestations of recurrent neurological deficits or focal occlusive ischemic symptoms. The time from occlusion to treatment was 56–1424 days. The results showed that the revascularization success rate was 65% (35/54). After the passage of the guidewire through the occlusion segment, 73% (27/37) of patients used brain protection, and a cumulative stroke or mortality rate for 3 months postoperatively was 4%. There were 3 cases of vascular complications: 1) 1 case had a pseudoaneurysm 3 months after recanalization; 2) 1 case was a recanalized carotid cavernous fistula; and 3) 1 case had a small amount of extravasation of carotid bifurcation after recanalization failure. No significant clinical complications were observed during follow-up. The Park et al.²⁰ study mainly focused on the interventional recanalization of a long-segmental occlusion of the internal carotid artery, and it defined the occlusion of the internal carotid artery to the cavernous sinus as an “S-type occlusion.” He defined the onset time of 6–48 h as the acute phase and 48 h to 14 days as the subacute phase. Of the 14 patients included in his study (8 cases were in the acute phase and 6 were in the subacute phase), 8 cases had



Fig. 7. Postoperative digital subtraction angiography (DSA) examination. The left internal carotid artery shows favorably on the angiography from the initial segment to the middle cerebral artery without residual stenosis.

progressive symptoms, 3 cases had recurrent attacks, 2 cases had transient ischemic attacks, and 1 cases had a stable condition. The results showed that the success rate of recanalization was 92.8% (13/14), with 3 cases of perioperative embolic events and 1 case of carotid cavernous fistula. The rate of favorable prognosis after the long-term follow-up of 2–66 months was 92.8%.

In 2013, Shih et al.²¹ first reported the use of hybrid surgery (carotid endarterectomy combined with endovascular stenting) in the treatment of 3 patients with chronic internal carotid artery occlusion, which reduced the difficulty and uncertainty of intravascular intervention and theoretically reduced the incidence of surgery-related complications such as distal embolization. However, the surgical procedure in our case is still

different from that study, as we punctured the common carotid artery, which was safer to puncture under direct vision. We then successfully performed balloon dilation and stent implantation. In addition, the patient’s occlusion segment was longer, and prior to carotid endarterectomy, there was no blood backflow after the tourniquet was loosened on the distal ICA.

Recently, a newly reported CICA classification provided guidance for the technical feasibility and safety of intravascular recanalization for symptomatic CICA and assessed the success of this classification in predicting the potential efficacy of intravascular recanalization.²² According to Hasan et al.,²² types C and D occlusions have the highest risk of complications and the lowest success rates, compared with types A and B. Taking all factors into account, including the drug treatment’s inability to alleviate the patient’s symptoms, we conducted a multidisciplinary assessment and decided to use a hybrid surgery. The patient first underwent open surgery (carotid endarterectomy) to create a small flow through the ICA and create a stump that would make subsequent angioplasty safer and less technically difficult.

According to the results of the MATCH study,²³ the incidence of stroke after 18 months of dual-antiplatelet therapy was not significantly different from that of clopidogrel alone. Therefore, we recommend that patients have dual antiplatelet therapy for 3 months followed by antiplatelet drug use alone. According to Lei Zhang et al.,²⁴ patients with long-term occlusion of the internal carotid artery have a high risk of perfusion syndrome after the surgery. Therefore, blood pressure should be actively controlled after surgery to prevent postoperative hyperperfusion syndrome. Fortunately, this patient did not have a high perfusion event after surgery.

In conclusion, hybrid surgery for symptomatic internal carotid artery occlusion is a feasible surgical procedure. Further studies and long-term follow-up care may provide more reliable evidence in support of this approach.

Ethical approval statement

As a retrospective study, formal consent is not required.

Informed consent statement

Informed consent was not obtained as no patient identifiable data has been submitted.

Declaration of competing interest

We have no conflicts of interests to declare.



Fig. 8. Postoperative 2-dimensional reconstructive computed tomography angiography (CTA) (B and C) and postoperative 3-dimensional reconstructive CTA (A) reveal the left internal carotid artery is unobstructed, but some stent artifacts remain.

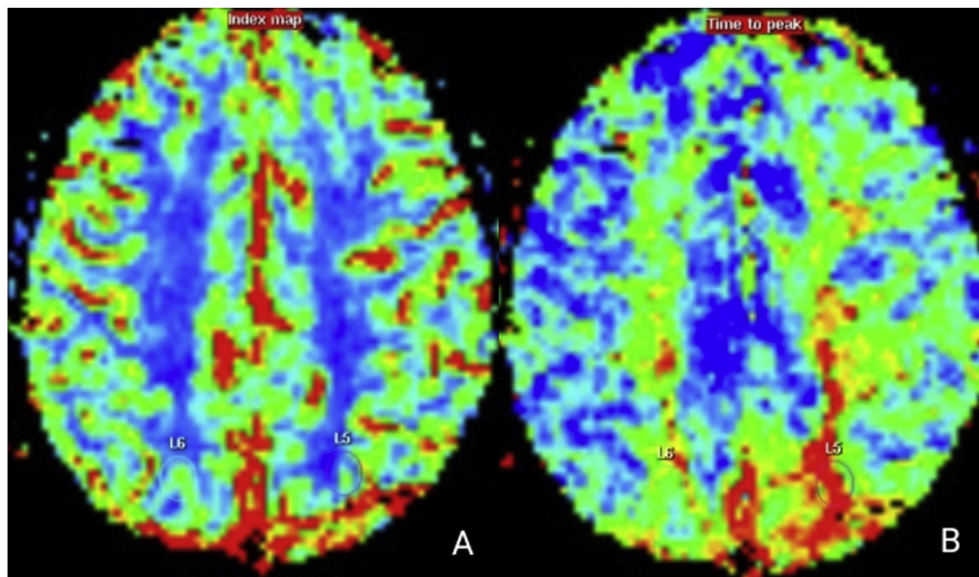


Fig. 9. Postoperative MR perfusion images reveal a postoperative MR perfusion index showing improved perfusion (A), and the left cerebral hemisphere time-to-peak (TTP) is similar to the right side (B).

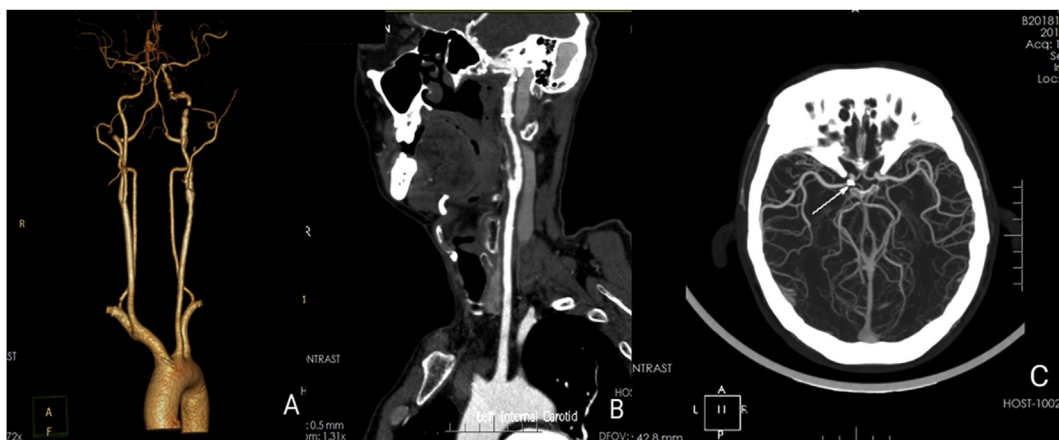


Fig. 10. Upon re-examination 6 months after surgery, 2-dimensional reconstructive computed tomography angiography (CTA) (B and C) and 3-dimensional reconstructive CTA (A) reveal the left internal carotid artery is patent, but some stent artifacts still remain.

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Informed consent has been obtained from the patient (or patient's guardian) for publication of the case report and accompanying images.

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