Case Report

Reconfiguration of the Carotid Artery after Angioplasty and Stenting: A Case Report and Review of the Literature

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Key Words

Angioplasty · Stenting · Artery reconstruction · Carotid occlusion · Stroke

Abstract

Severe carotid stenosis or occlusion may cause insufficient blood flow and lead to distal artery wall collapse and extensive lumen contraction. Whether this 'adaptive narrowing' can reconstitute after carotid recanalization is unclear. We report a patient with global ischemia due to occlusions of bilateral carotid and right vertebral arteries. The occluded left carotid was recanalized successfully with angioplasty and stenting. The adaptively narrowed distal carotid did not reconstitute immediately but regained its morphology 1 week after the procedure. Carotid adaptive narrow distal occlusion or stenosis may not regain its original morphology immediately but several days after recanalization. This knowledge is instructive for treating occlusive carotid diseases.

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Introduction

Carotid angioplasty and stenting for acute occlusion have been reported with high rates of recanalization and improved neurological functions [1]. Although reported anecdotally in selected patients, carotid angioplasty and stenting for chronic total or subtotal occlusions has encountered much controversy [2, 3]. One major concern has been the adaptive artery narrowing distal to occlusion [4]. Chronic carotid stenosis or occlusion may cause insufficient blood flow and low shear stress, which may lead to distal artery wall collapse and extensive

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Fig. 1. DSA of cervical arteries. **a** Bilateral internal carotid and right vertebral arteries were occluded. The left **(b)** and right **(c)** internal carotids were occluded at bifurcations. Severe stenosis in the left external carotid and mild stenosis in the right external carotid were also observed. **d** There was a mild stenosis in the origin of the left vertebral artery. The intracranial blood flow was mainly supplied by the left vertebral artery **(f)** and bilateral external carotids via extra-intracranial collaterals **(e)**.

lumen contraction [5]. Whether this ‘adaptive narrowing’ can reconstitute after carotid recanalization is unclear. Here, we report a patient with occlusions in bilateral carotid and right vertebral arteries. The patient experienced recurrent stroke, which was arrested successfully after recanalization of the chronically occluded left internal carotid with angioplasty and stenting. Notably, the adaptively narrowed artery did not regain its shape immediately but 1 week after the procedure. To our knowledge, this is the first case to show the restitution of adaptively narrowed carotid distal to chronic occlusion after recanalization.

Case Report

The patient was a 55-year-old male with a smoking history of more than 30 years. He initially presented with weakness in the left extremities. A magnetic resonance imaging scan in the local hospital revealed multiple infarctions in the right cerebral hemisphere. Ischemic stroke was diagnosed and 100 mg aspirin daily was prescribed. The patient maintained good condition until 1 year after the index stroke, when he abruptly developed weakness in right extremities and inarticulate speech. A magnetic resonance imaging scan at the local hospital revealed multiple novel infarctions in the left cerebral hemisphere. An ultrasound scan detected occlusions of the right vertebral artery and bilateral carotids. Due to the delay in transportation, the patient was beyond the time window for thrombolysis. Because this time he also experienced global cerebral ischemia manifested by progressive memory decline, daytime drowsiness, dysphasia and fluctuation of extremity strength, he was transferred to our hospital for further treatment.

A subsequent digital subtraction angiography (DSA) confirmed the occlusions of bilateral carotid and right vertebral arteries (fig. 1a–c). The intracranial blood flow was mainly supplied by the left vertebral artery (fig. 1f) and bilateral external carotids via extra-intracranial collaterals (fig. 1e). DSA also revealed

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Fig. 2. DSA and computed tomography angiography during and after the endovascular procedure. **a** A 0.014-inch guidewire was navigated, and it crossed the occlusion. **b** The occlusive segment was dilated with a small balloon. **c** A brain protection device was deployed at the C1 segment of the left internal carotid (arrow), and the occlusive segment was dilated once again with a bigger balloon. **d** An 8.0 × 40 mm stent was deployed. **e** Poststenting angiography demonstrated that the lumen was completely restored in the stent-covered segment, but the distal part of the artery remained compressed. A computed tomography angiography performed 1 week after the procedure demonstrated that the distal compressed carotid was restored satisfactorily (**f**), and there was no stenosis or thrombus in the stent (**g**, arrow). **h** DSA performed 1 year after the procedure indicated that the distal artery lumen was restored completely.

mild stenosis in the origin of the left vertebral artery (fig. 1d), severe stenosis (85%) in the left external carotid (fig. 1b) and mild stenosis in the right external carotid (fig. 1c). The neuroimaging results indicated that the global cerebral flow was insufficient. Considering the progression of the global ischemic symptoms and recurrent stroke despite the combined medical treatment, endovascular recanalization of the chronically occluded left carotid was recommended.

The procedure was performed under local anesthesia with lidocaine and full heparinization with activated clotting time around 300 s. After an 8-Fr guiding catheter was placed in left common carotid, a 0.014-inch PT Choice guidewire (Boston Scientific, Miami, Fla., USA) was navigated across the occlusive lesion without strong resistance (fig. 2a). Under the roadmap, a small over-the-wire Maverick balloon (2.0 × 15 mm; Boston Scientific) was advanced gently across the occlusive lesion, which was then dilated at a maximal pressure of 5 atmospheres. Postdilation angiography indicated that the artery lumen was partly restored, but the blood flow remained very limited (fig. 2b). After removing the balloon, a FilterWire brain protection device (Boston Scientific) was advanced into the C1 segment of the left internal carotid and deployed (fig. 2c). The occlusion site was then dilated once again with a larger Ultrasoft balloon (6.0 × 20 mm; Boston Scientific). The postdilation angiography indicated that the lumen was enlarged considerably (fig. 2c). A Precise stent (8.0 × 40 mm; Cordis, Miami, Fla., USA) was then located at the site of occlusion and deployed successfully. The poststenting angiography demonstrated that the lumen was restored completely in the stent-covered segment, but the proximal artery lumen remained compressed (fig. 2d, e).

A computed tomography angiography scan performed 1 week after the procedure demonstrated that the compressed distal carotid was restored satisfactorily (fig. 2f, g). Follow-up DSA performed 1 year after the procedure indicated complete recovery of the distal artery lumen (fig. 2h). The patient improved progressively, and no further TIA or stroke was observed during the following 12 months.

Discussion and Literature Review

It is widely recognized that patients with chronically occluded carotid cannot benefit from recanalization. However, if multiple cervical arteries are involved, global ischemia may be the result [6]. This patient had severe hemodynamic impairment because 3 of 4 cervical arteries, bilateral carotid and right vertebral, were occluded. Severe stenosis in the left external carotid and mild stenoses in the right external carotid were also observed. These pathologies endangered the whole cerebral blood flow and resulted in global cerebral ischemia and recurrent stroke.

Hemodynamic studies have confirmed that severe stenosis can cause critical flow and wall mechanical conditions, which may lead to distal artery compression [7]. This low-shear-associated artery contraction has been referred to as 'adaptive narrowing'. In this case, the lumen of the occlusion segment was restored satisfactorily, but the distal adaptive narrowing did not reconstitute immediately after angioplasty and stenting. The follow-up angiographic results revealed that chronically collapsed artery reconstituted 1 week after the recanalization.

This case indicated that angioplasty and stenting might provide a feasible treatment option for severe cerebral hypoperfusion related to multiple cervical artery stenosis or occlusions. Carotid adaptive narrow distal occlusion or stenosis may not regain its original morphology immediately but several days after recanalization. This knowledge is instructive for treating occlusive carotid disease.

Gradually and chronically changed blood flow through large arteries can modulate artery lumen [8]. Remarkably decreased blood flow can lead to arterial reduction [9], while significantly increased blood flow can lead to arterial dilation [10]. Evidence from animal studies indicated that these adaptive responses of artery morphologies to changes in blood flow tend to maintain a constant wall shear stress [11]. This equilibrium is maintained by pressure sensation and signal transduction systems. Langille and O'Donnell [12] showed that a 70% reduction in blood flow through the common carotid artery caused a 21% decrease in the artery diameter within 2 weeks. Using smooth muscle relaxant papaverine did not reconstitute the artery lumen; the authors concluded that the reduction of artery diameter in response to decreased blood flow may reflect a structural modification of the arterial wall rather than sustained contraction of smooth muscle. The hypothesis was confirmed by a further study, which indicated that arterial restriction after reduced blood flow was abolished when the endothelium was removed from the vessels [12]. In an animal model, the morphological changes of the artery associated with local stenosis could be restored after eliminating the stenosis [13].

The endothelium can sense the changes in luminal shear stress [14], which can trigger a cascade of signal transduction toward the structural reformation of the artery wall [15–17]. These adaptive effects have been observed in resistance arteries [18] and in large arteries [19, 20]. Whether and when the dilated or constricted artery associated with changed intraluminal shear stress may be restored has not been studied. This case provides *in vivo* evidence that constricted artery lumen distal to severe local stenosis may be restored in less than 1 week following treatment of stenosis with stenting.

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Disclosure Statement

The authors have no conflict of interest to disclose.

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