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Case Report

Dynamic changes in blood flow of a bypassed superficial temporal artery with unstable internal carotid artery stenosis

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Abstract

Background: There are limited indications for superficial temporal artery to middle cerebral artery (STA–MCA) bypass in the treatment of cerebral atherosclerotic disease. However, recent reports emphasize that STA–MCA bypass may be beneficial for select patients. In this report, we describe a case in which a flow-dependent STA–MCA bypass was achieved in a patient with unstable internal carotid artery (ICA) stenosis.

Case Description: A 51-year-old woman presented with left ICA occlusion. A severely elongated mean transit time (MTT) indicated misery perfusion. STA–MCA bypass was performed immediately and blood flow through the graft appeared excellent on magnetic resonance angiography (MRA). Two weeks later, MRA revealed normal anterograde ICA blood flow and the bypass graft was not visible. Three years later, the left ICA stenosis again became severe and the patient developed contralateral hemiparesis. She underwent endovascular surgery and the ipsilateral MCA became occluded during the procedure. The STA–MCA bypass graft appeared immediately after the MCA occlusion and became a major provider of blood flow to the ipsilateral MCA area. She recovered with almost no deficit.

Conclusion: This is a rare case which shows that dynamic flow changes through an STA–MCA bypass can occur with variable ICA blood flow. STA–MCA bypass can be beneficial for the treatment of unstable ICA stenosis.

Key Words: Flow-dependent bypass, superficial temporal artery to middle cerebral artery bypass, unstable internal carotid artery stenosis

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INTRODUCTION

The superficial temporal artery to middle cerebral artery (STA–MCA) bypass is an extracranial–intracranial (EC–IC) bypass technique used to treat intracranial atherosclerotic disease and cerebral vasospasm. However, the discouraging results of the first randomized EC–IC bypass trial[10] and the development of endovascular techniques such as angioplasty have resulted in limited indications for its use. Recently, the utility of this procedure has been reassessed, and recent reports emphasize that STA–MCA bypass may be beneficial for a select group of patients. Here, we report a rare case in which dynamic changes in blood flow through an STA–MCA bypass presumably occur in a flow-dependent manner relative to anterograde flow through an unstable internal carotid artery (ICA) stenosis. Interestingly, although the bypass graft appeared occluded in postoperative imaging studies, it was actually patent and in a "dormant condition" until the stenosis recurred.

CASE REPORT

A 51-year-old woman with a history of left ICA terminal stenosis came to our hospital complaining of transient right hemiplegia. On presentation, her level of consciousness was normal and she had no neurological deficits. She had a history of hypertension, but was negative for diabetes mellitus and hyperlipidemia. Her family history was remarkable in that her father had died of a subarachnoid hemorrhage at a young age. Magnetic resonance angiography (MRA) showed severely impaired blood flow in the left ICA [Figure 1] and scattered regions of high intensity around the left Rolandic fissure [Figure 1]. Digital subtraction angiography (DSA) was immediately performed and revealed that the left ICA was occluded distal to the ophthalmic artery [Figure 1] and that collateral blood flow was coming from the left posterior communicating (p-com) artery. Perfusion weighted imaging (PWI) showed a severely prolonged mean transit time (MTT) in the distribution of the left ICA and right anterior cerebral artery (ACA), whose flow is also dependent on the left ICA [Figure 1].

Because of the patient's imminent risk of whole brain ischemia, immediate STA–MCA bypass was performed. The frontal and parietal branches of the STA were bypassed to different recipient branches of the MCA. Postoperative MRA showed excellent blood flow through the STA–MCA bypass; however, anterograde ICA blood flow became normal 2 weeks later [Figure 1]. PWI performed at the same time showed much better perfusion than before the operation and almost no laterality [Figure 1]. The STA branches used for the bypass were not visible on MRA 1 year later, and remained undetectable on repeat MRA [Figure 1]. Following surgery, the patient had occasional right paresthesia, but otherwise recovered well.

Three years later, she re-presented to our hospital complaining of right hand weakness. MRA showed a recurrence of severe stenosis of the ICA [Figure 2]. At this time, the bypass graft was not visible and PWI showed no laterality of perfusion [Figure 2]. Immediate angiography confirmed the severity of the ICA stenosis [Figure 2]. The stenosis was very severe and the bypass graft appeared to be occluded. Even though the patient had been treated with antithrombotics since she was first diagnosed with ICA stenosis, transient ischemia occurred repeatedly and she experienced a recurrence of severe stenosis [Figure 2]. At that time, her relative MTT was normal and anterograde ICA blood flow was relatively good. However, the recurrence of symptoms was

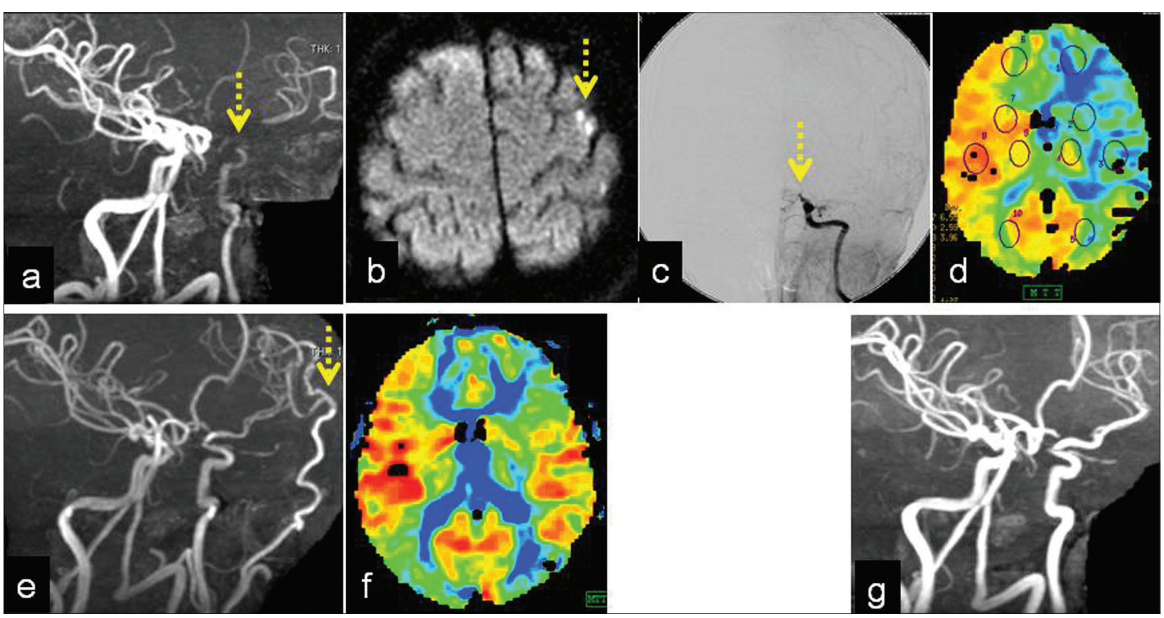

Figure 1: (a) Occlusion of the left internal carotid artery (ICA) near its terminal end (arrow). (b) Diffusion-weighted imaging showed scattered areas of high intensity around the left Rolandic fissure (arrow). (c) Digital subtraction angiography showed occlusion of the left ICA distal to the ophthalmic artery (arrow). (d) Perfusion weighted imaging (PWI) showed severely elongated MTT of the distribution of the left ICA and right ACA. (e) Magnetic resonance angiography (MRA) showed excellent flow through the STA–MCA bypass (arrow). (f) PWI study at the same time as (e) showed much better perfusion than before the operation. (g) The STA–MCA bypass is not visible on MRA 1 year later

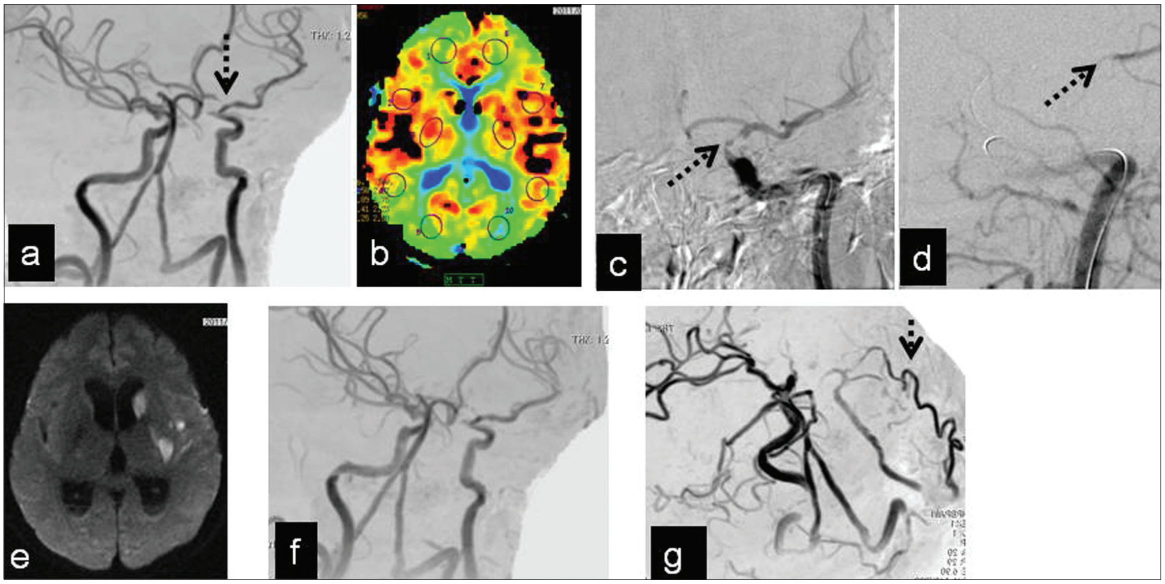

Figure 2: (a) Left ICA terminal stenosis was severe again (arrow) when the patient re-presented for mild right hemiparesis. (b) Perfusion weighted imaging at the time of re-presentation showed no laterality. (c) Angiography demonstrated severe stenosis near the terminal end of the left ICA (arrow). (d) Flow through the superficial temporal artery to middle cerebral artery (STA–MCA) bypass was visualized when the left MCA became occluded (arrow). (e) DWI the day after angioplasty showed limited infarction. (f) Magnetic resonance angiography (MRA) showed the ICA stenosis was improved after the angioplasty and the bypass was no longer visible. (g) One week later, left ICA flow was reduced and the STA–MCA bypass was dominant source of blood flow (arrow)

distressing to the patient, and she and her family strongly pleaded with us to perform an interventional treatment and not only the medical therapy. Endovascular angioplasty was the only option to stabilize the stenosis. Recent SAMMPRIS study showed that in patients with intracranial arterial stenosis, aggressive medical management was superior to percutaneous transluminal angioplasty and stenting.[3] However, at that time, it was still controversial and we decided to do the angioplasty. A 6F guiding catheter (Guider™ Softip XF; Stryker Neurovascular, Fremont, CA, USA) was inserted into the left ICA. An over-the-wire type balloon microcatheter (Gateway™ over-the-wire PTA dilator catheter, 2.0 × 9 mm; Stryker) was advanced past the stenotic lesion with difficulty, and the balloon was inflated to a pressure of 0.5 atm. Unexpectedly, the patient's left MCA occluded and the patient's consciousness deteriorated while her right hemiparesis worsened. Flow from the STA–MCA bypass appeared when MCA occlusion occurred [Figure 2]. The parent catheter had entered the common carotid artery, which enabled us to see the STA flow. The balloon was immediately exchanged with a Tangent™ microcatheter (Stryker), and 120,000 units of urokinase were injected from the distal MCA to the termination of the ICA. The stenosis improved and anterograde MCA flow was recovered, leading to simultaneous retrograde flow through the graft. The patient's status improved as the procedure finished. Diffusion-weighted imaging (DWI) the next day showed limited cerebral infarction [Figure 2] and her consciousness and right hemiparesis gradually improved. MRA revealed that the ICA stenosis was reduced following the angioplasty and the bypass graft was no longer visible [Figure 2]. However, 1 week later, left ICA flow reduced and STA–MCA bypass flow again became dominant [Figure 2]. One month later, the patient was discharged from the hospital with almost no neurological deficits.

DISCUSSION

This is a case report which clearly shows that dynamic flow changes through an STA–MCA bypass occurred in a flow-dependent manner in a patient with unstable intracranial ICA stenosis. A previous randomized, multi-center trial failed to demonstrate that EC–IC bypass could prevent further cerebral ischemia in patients with atherosclerotic ICA or MCA disease, and after publication of that study, enthusiasm for cerebral revascularization waned rapidly.[10] However, a greater understanding of the importance of assessing cerebral hemodynamic factors in patients with ICA or MCA atherosclerosis has led to a resurgence of interest in the EC–IC bypass procedure.[6,7] Today, through the use of advanced imaging techniques, we are able to understand the mechanisms underlying symptom development and to select candidates likely to benefit from urgent reperfusion. Hwang *et al*. indicated that the STA–MCA bypass may be beneficial to patients suffering from acute stroke or stroke in progress.[4] They used MR PWI to evaluate diffusion–perfusion mismatch and performed STA–MCA bypass within 24 hours of symptom onset.[4] Similarly in our case, the MTT of the left ICA area and right ACA area was greatly prolonged [Figure 1] because her azygous ACA stemmed from the left ICA. A large area of ischemia was strongly suspected and we performed STA–MCA bypass immediately. The result of the recently closed COSS trial showed that despite the use of advanced imaging modalities, no benefit of STA–MCA bypass was found in the management of atherosclerotic carotid occlusion.[8] With this result, it became difficult to recommend and perform this procedure. In our case, STA–MCA bypass was done before the COSS result came out. Moreover, the patient did not have any permanent stroke even though she had occasional right paresthesia, which indicated that the unstable ICA stenosis caused lack of anterograde flow but was helped by the bypassed graft flow.

There have been several reports of long-term follow-up of patients who underwent STA–MCA bypass. A single center with a mean follow-up period of 34 months for patients who underwent STA–MCA bypass reported that 15% of the patients experienced stroke recurrence, resulting in an annual stroke risk of 5%, and improved cerebral hemodynamics were documented in 81% of the revascularized cerebral hemispheres.[5] However, Schick *et al.* concluded that the functioning of the STA–MCA bypass worsens over time, suggesting a role for surgery predominantly in the first year of ischemic events due to an insufficient collateral supply.[9]

In this case, the degree of ICA stenosis was quite variable. The ICA was occluded when STA–MCA was performed, but anterograde ICA blood flow became normal 2 weeks later [Figure 1]. Over the following 3 years, the patient experienced occasional right paresthesia and transient ischemia that was likely due to ICA flow instability. Three years later, she re-presented with right hand weakness and MRA study revealed severe recurrence of the stenosis [Figure 2]. The underlying cause of the ICA stenosis was not clear in this case. Unstable ICA stenosis may be caused by fragile atherosclerosis, thrombosis, dissection or, very rarely, vasospasm.[11] It has been reported that recanalization followed by subsequent recurrence of stenosis is not uncommon for cervical artery dissection.[2] The patient has no cardiac factor causing thrombosis, or cervical ICA stenosis causing artery to artery embolization. Repeated stenosis that occurred at the same part suggests that thrombosis was not likely. If it was atherosclerosis, recanalization was not likely. Dissection was the most likely since manipulation of the microguidewire and microcatheter was not smooth during endovascular angioplasty. However, it is difficult to prove it. Regardless of the etiology, the ICA stenosis was so variable that it likely impaired the development of collateral blood flow. The relative MTT was severely prolonged at the time of the first ICA occlusion and ipsilateral perfusion seemed highly dependent on the

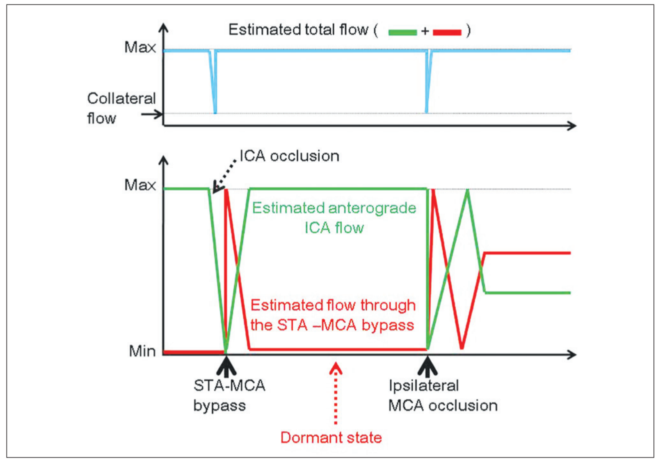

Figure 3: Schematic graphs of anterograde internal carotid artery (ICA) flow, flow through the superficial temporal artery to middle cerebral artery (STA–MCA) bypass, and the sum of these as "estimated total flow." The graph at the bottom of the figure shows the estimated anterograde ICA flow (green) and estimated flow through the STA–MCA bypass (red).These are assumed to be inversely proportional.The graph at the top of the figure shows the estimated total flow in the left MCA area, which is approximately the sum of the estimated anterograde ICA flow plus the estimated flow through the STA–MCA bypass. The graph shows that severe flow reduction occurred twice, as indicated by the black arrows. Except for these two occurrences, the total flow is thought to have been sufficient to maintain cerebral perfusion, and therefore little infarction occurred

anterograde ICA flow.MRA showed that the flow through the STA–MCA bypass seemed to vary inversely with the anterograde blood flow through the ICA [Figure 3]. For this reason, we approximate total blood flow as the sum of anterograde ICA flow and flow through the STA–MCA bypass and minimal collateral flow [Figure 3]. The estimated total flow was consistent with the MR perfusion studies [Figures 1 and 2]. Because of the limited time period of impaired total flow, the infarcted area was minimal [Figures 1 and 2]. Amin-Hanjani *et al*. showed a similar case where a bypassed STA flow diminished as a previously occluded ICA recanalized 6 months later.[1] They also suggested that STA graft flow changes depending on anterograde filling.[1] Our case strongly supports the reciprocal relationship between anterograde flow in a stenotic ICA compared to a distally placed surgical bypass. We could also show the resurgence of the bypass flow simultaneously with the anterograde filling shut down. It is a particularly compelling example of the reciprocal relationship.

This case suggests that blood flow through an STA–MCA bypass can change on an "as needed" basis in an anterograde blood flow-dependent manner. Even though the bypass may seem to be occluded if anterograde blood flow through the bypassed vessel is sufficient, the bypass graft itself may still be patent and in a "dormant condition" [Figure 3].

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