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Case Report

STA-Distal ACA Bypass Using a Contralateral STA Interposition Graft for Symptomatic ACA Stenosis

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Intracranial arterial stenosis usually occurs due to atherosclerosis and is considered the most common cause of stroke worldwide. Although the effectiveness of bypass surgery for ischemic stroke is controversial, the superficial temporal artery to the middle cerebral artery bypass for ischemic stroke is a common procedure. In our report, a 50-year-old man presented with sudden-onset left side weakness and dysarthria. An angiogram showed significant stenosis in the junction of the right cavernous-supraclinoid internal carotid artery and right pericallosal artery. Symptoms altered between improvement and deterioration. Magnetic resonance imaging showed a repeated progression of anterior cerebral artery (ACA) infarction despite maximal medical therapy. We performed a STA-ACA bypass with contralateral STA interposition. Postoperative course was uneventful with no further progression of symptoms. Thus, bypass surgery may be considered in patients with symptomatic stenosis or occlusion of the ACA, especially when patients present progressive symptoms despite maximal medical therapy.

Keywords Anterior cerebral artery, Cerebral revascularization, Infarction, Temporal arteries

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INTRODUCTION

Intracranial arterial stenosis (IAS) is usually attributable to atherosclerosis and corresponds to the most common cause of stroke worldwide.[5] Sánchez-Sánchez et al.[17] have found that the anterior cerebral artery (ACA) involvement occurs in 5% of the cases with symptomatic IAS and cerebral infarction in only the ACA territory are not frequent.[4][17] Moreover stenosis or occlusion of ACA is often asymptomatic due to ample collateral blood supply. Therefore, symptomatic solitary stenosis or occlusion of ACA is a very rare entity.

Although the effectiveness of bypass surgery for ischemic stroke has remained controversial in previous reports,[2][15] the superficial temporal artery (STA) to the middle cerebral artery (MCA) bypass for ischemic stroke is a common procedure, especially when recurrent transient ischemic attack (TIA) or infarction is present despite maximal medical treatment. Several cases of revascularization for symptomatic stenosis or occlusion of ACA have been previously described, yet the effectiveness of ACA revascularization procedures for prevention of strokes is still in question because symptomatic ACA territory infarction due to ACA stenosis or occlusion is a rare clinical situation.[7][8][12][15]

In this article, we report our experience of STA to distal ACA bypass with a contralateral STA interposition graft for recurrent progressive symptomatic infarction of ACA territory with stenosis at the A2-A3 junction.

CASE REPORT

A 50-year-old man with diabetes presented to our emergency room with left homonymous hemianopsia. Brain magnetic resonance imaging (MRI) showed an acute infarction in the territory of the right posterior cerebral artery (PCA) (Fig. 1A). Brain magnetic resonance angiography (MRA) showed stenosis of the right cavernous to the supraclinoid internal carotid artery (ICA) and the right pericallosal artery. A transthoracic echocardiogram and Holter monitoring were performed, but there was no suspicion of cardiogenic embolization. Dual antiplatelet agent was started, and he was discharged without any major neurological deficit.

One month later, he revisited our emergency room, presenting with a tingling sensation in the left arm and decrease of sensation in the left arm and leg. The symptoms started the day before and disappeared immediately after intravenous hydration. MRI showed recent infarctions in the right occipital lobe, right thalamus, and right medial frontal lobe (Fig. 1B). Digital subtraction cerebral angiography (DSA) showed significant stenosis of the right supraclinoid segment of ICA and the right distal ACA (Fig. 1C). Phosphodiesterase inhibitor (cilostazol) was added with dual antiplatelet

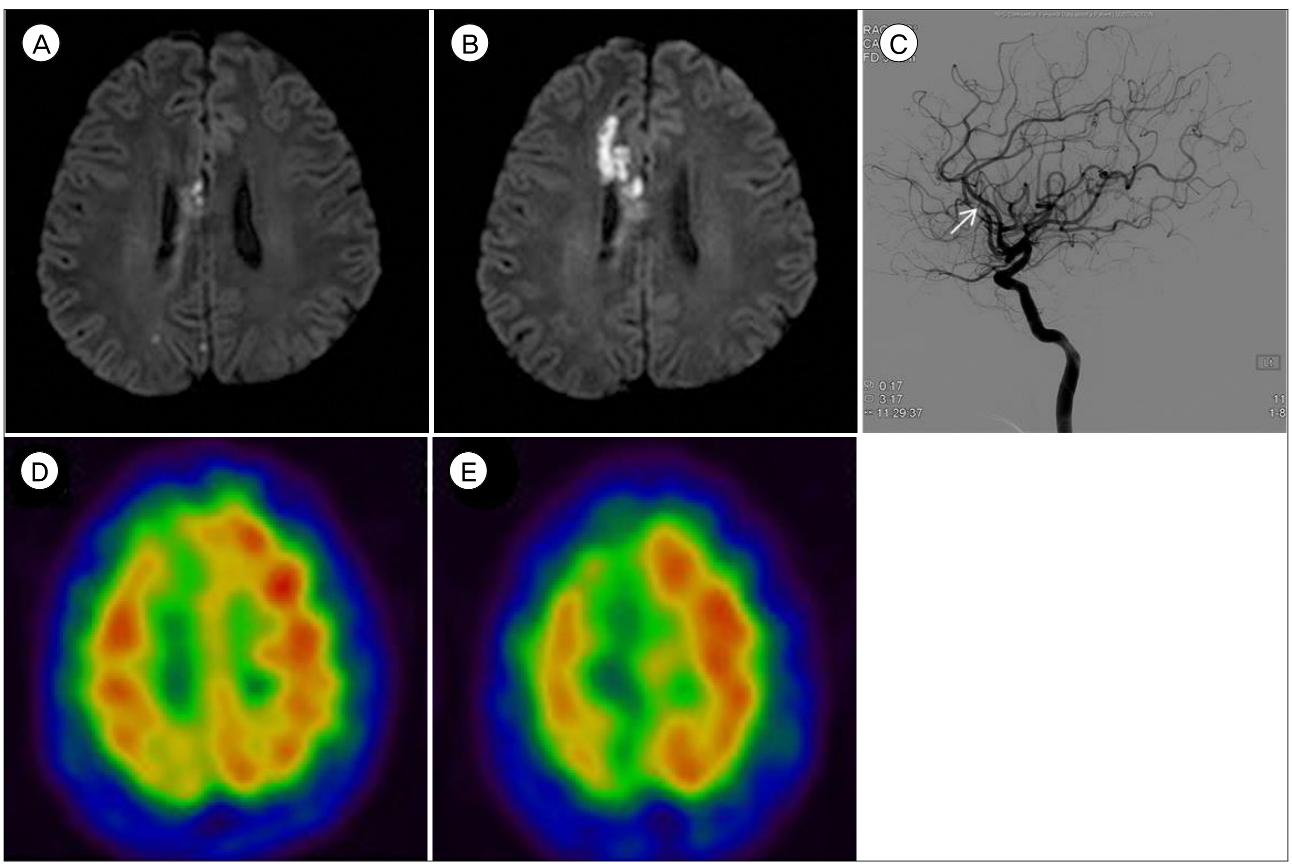

Fig. 1. Preoperative MRI, cerebral angiography, and SPECT. (A) Initial MRI shows acute infarction on the territory of right ACA. (B) 1-month follow up MRI shows further progression of the ACA infarction. (C) Cerebral angiography reveals right supraclinoid cavernous stenosis and right distal ACA (white arrow). (D) Basal and (E) Diamox SPECT shows decreased vascular reserve function in the ACA territory. MRI = magnetic resonance imaging; SPECT = single-photon emission computed tomography; ACA = anterior cerebral artery.

therapy. Two weeks after discharge, he returned to the emergency room with grade 4 left leg weakness. Diffusion MRI revealed a new infarction of the ACA territory. Symptoms showed repeated improvement and deterioration. MRI performed one week later showed a progression of the ACA infarction. Symptoms were not improved medically; hence, surgical treatment was considered. Single-photon emission computed tomography (SPECT) was performed for preoperative evaluation. Diamox-stressed SPECT showed hypoperfusion at the right ACA, PCA territory with increased perfusion asymmetry, suggesting inadequate vascular reserve function, especially in the ACA territory (Fig. 1D, E).

Surgical procedures

In the supine position with slight neck flexion, surgical exposure was achieved by a bicoronal incision for the bypass procedure. The bilateral parietal branches of STA were marked with Doppler flowmeter. The left parietal branch of STA was harvested about 7 cm in length for use as interposition graft, and then the right STA was dissected from proximal to distal. After the harvest and donor STA preparation, a right frontal paramedian craniotomy was performed. We identified the appropriate recipient branch of distal ACA in the medial cortex of the frontal hemisphere. Firstly, contralateral STA to ipsilateral STA end to end fashioned anastomosis was done with 10-0 nylon, and then distal ACA to STA bypass end to side fashioned anastomosis was performed. The patency was checked with indocyanine green angiography and Doppler flowmeter (Fig. 2).

Postoperative course

Postoperative course was uneventful with no further progression of symptoms. Postoperative angiograms 4 days after the bypass surgery demonstrated patent STA-STA-ACA anastomosis with perfusion to the right ACA region in the right external carotid artery angiography. The right MCA territory blood supply was observed through the anterior communicating (ACOM) artery and the right posterior communicating (PCOM) artery showed on the left ICA angiography (Fig. 3A, B). Diamox SPECT images obtained at 7 days after surgery showed improved resting perfusion, vascular reserve function of the right ACA territory and no decrease in perfusion in the left ACA territory (Fig. 3C, D). MRI images obtained 6 months later showed no further restriction of diffusion in the brain parenchyma and normal cerebral blood flow in the ACA territory. In addition, the time-to-peak delay was improved compared to previous perfusion images. The patient's clinical symptoms improved, and there was no evidence of symptom recurrence with medication.

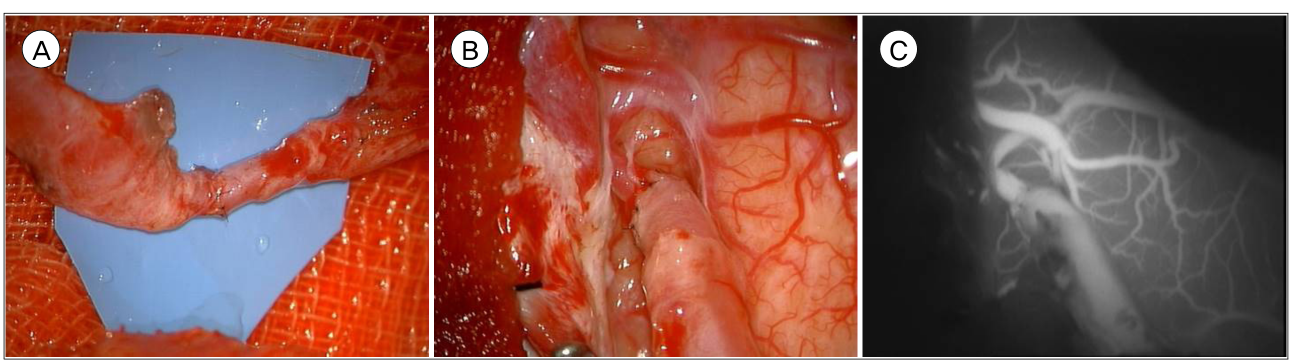

Fig. 2. Intraoperative photograph and ICG angiography. (A) Contralateral STA to ipsilateral STA end to end fashioned anastomosis and (B) distal ACA to STA bypass end to side fashioned anastomosis were performed. (C) Intraoperative ICG angiography. ICG = indocyanine green; STA = superficial temporal artery; ACA = anterior cerebral artery.

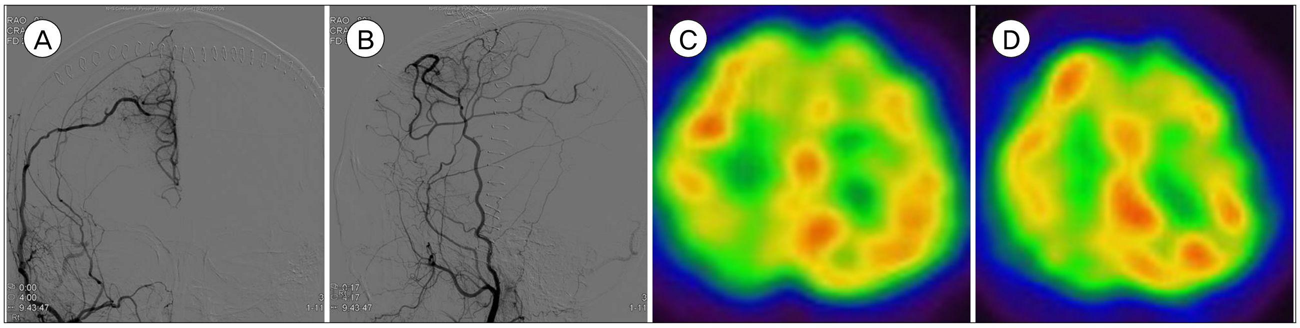

Fig. 3. Cerebral angiography obtained 4 days after surgery and perfusion MRI at 6 months after surgery. (A, B) Blood flows to the right ACA region from right ECA. (C) Basal and (D) Diamox SPECT show improved perfusion status, compared to previous SPECT. MRI = magnetic resonance imaging; ACA = anterior cerebral artery; SPECT = single-photon emission computed tomography.

DISCUSSION

The first STA-MCA bypass for treatment of occlusive cerebrovascular disease was performed by Yasargil[21] in 1967, and bypass surgery gained popularity as treatment of ischemic stroke. However, since the Extracranial-Intracranial (EC-IC) Bypass Study Group in 1985 failed to prove any benefit of bypass surgery in symptomatic steno-occlusive disease in the MCA or ICA,[2] EC-IC bypass as a treatment for intracranial stenosis had rapidly declined.

On the assumption that EC-IC bypass surgery prevents further ischemic stroke in high-risk subgroups of patients with symptomatic major cerebral arterial occlusive diseases, the Japanese EC-IC bypass trial (JET study) was conducted as a prospective randomized multicenter study and demonstrated the effect of EC-IC bypass surgery in preventing subsequent cerebral ischemia in highly selected patients.[5] To find evidence of bypass surgery, several modalities were used to evaluate hemodynamic high-risk patients and described hemodynamic changes after bypass surgery. In 1998, a randomized study reported that stage 2 hemodynamic failure (increased oxygen extraction) measured by positron emission tomography) with symptomatic carotid occlusion is an independent prognostic factor for high risk of subsequent stroke despite medical treatment.[6] However, discordant with the cerebral hemodynamic evidence in the EC-IC bypass group, EC-IC bypass surgery did not show a decrease in the subsequent stroke rate in The Carotid Occlusion Surgery Study, and previous results failed to be proven in clinical trial.[16]

There are different opinions on the interpretation of this result, and the argument that a subgroup of patients with medically refractory symptoms may benefit from bypass surgery has gained support from surgeons.[1)3] Currently, bypass surgery is performed for progressive TIA or infarction despite maximal medical therapy. As evidence supporting bypass surgery, several modalities are used to evaluate patients with hemodynamic high risk, and hemodynamic changes are described after bypass surgery. In addition, several studies have followed demonstrating the usefulness of bypass surgery for ischemic stroke.[7)12]

The incidence of an ACA territory infarction is reported at 1.1-3% in all cases of strokes.[19] Due to the scarcity of the incidence, etiology, mechanism of stroke, and treatment strategy were not clearly defined compared to the infarction of the MCA or PCA territory. Kang et al.[11] reported 100 patients with ACA infarction where clinical, MRI, and angiographic findings were evaluated. ACA atherosclerosis was the most frequent etiology of stroke (61%), and among them, in situ thrombo-occlusion or stenosis was the etiology in 20 out of 100 patients (20%).[20]

Only a few cases of EC-IC or in situ bypasses for symptomatic occlusion of the ACA have been reported, and established treatments concerning the effectiveness of bypass technique for the prevention of infarctions remains controversial because of its rarity. The previously reported cases of ACA bypass for ischemic steno-occlusion of ACA are listed and described in Table 1.

Bypass options

A3-A3 side to side in situ bypass technique has been widely used for revascularization of complex ACA aneurysms in the literature.[8] Ikeda et al.[8] reported two cases where inter-ACA anastomoses were performed for symptomatic occlusion of ACA with poor collateral. Another report[10] described an A3-A3 in situ bypass which was performed for unilateral ACA stenosis or occlusion. The A3-A3 bypass has the advantage of not requiring graft harvesting and additional surgical incision. However, deep sutures are needed which require technical expertise, and the most problematic issue of the A3-A3 in-situ bypass is nearly always the decreased flow of the normal side due to the steal phenomenon.[8] In our case, the steal phenomenon was expected if ACA flow was increased with the bypass, since pre-operative angiogram showed right supraclinoid-cavernous segment stenosis, and blood flow to the right MCA territory was supplied from the left ICA through the ACOM and PCOM artery.

As the other bypass option, EC-IC (STA-ACA) bypass has been used to flow augmentation. The ipsilateral parietal branch of STA to cortical ACA bypass in unilateral ACA symptomatic stenosis was reported by Lee et al.[13] However, the length and caliber of the parietal branch of the STA were not sufficient for direct ACA to STA anastomosis in many cases. Therefore, radial artery,[12] occipital artery,[14] cephalic vein,[9] and contralateral STA14) free grafts were used for interposition graft. Horiuchi et al.[7] reported on the STA-STA-ACA bypass combined with A3-A3 bypass which was performed in patients with bilateral stenosis or occlusion of the ACA which was done to reduce the risk of watershed zone infarction and steal phenomenon. In our case, we thought that caliber and length of the parietal branch of STA in preoperative extracranial angiography was not enough for aug-

Table 1. The previously reported cases of ACA bypass for ischemic steno-occlusion of ACA

Study	Sex/age	Stenosis location	Clinical presentation	Bypass vessles	Anatomosis	Craniotomy	Graft
Ishii et al[9] (1983)	F/30	A1	Left arm weakness	STA-Cephalic vein-A4 (callosomarginal)	End to end End to side	Bifrontal and right temporoparietal craniotomy	Cephalic vein
Ikeda et al[8] (1985)	M/50	A2	Right leg weakness	A3 to A4	Side to side	paramedian craniotomy	
	M/52	Right ICA ACOM	Left side weakness	1. STA-MCA 2. PIFA-PIFA	- Side to side		
Terasaka et al[18] (1997)	M/38	A2-A3 junction	Left leg weakness	A2-STA-A3	Side to end End to side	Bifrontal craniotomy	STA
Lee et al[13] (2013)	M/69	A2	Left leg weakness	STA-distal ACA	End to Side	Paramedian craniotomy	
Kiyofuji et al[12] (2014)	F/74	A2	Left side weakness	A3-A3-RA-STA	Side to side Side to end End to end	Bicoronal	Radial artery
	F/73	A2	Left leg weakness	As above	As above	As above	As above
Nagm et al[14] (2016)	F/71	A2	Right leg weakness	STA-OA-PIFA	End to end End to side	Medial frontal craniotomy	OA
Horiuchi et al[7] (2018)	F/71	A2	Left side weakness	ACA-OA-STA	-	-	OA
	M/50	A2	Left side weakness	A3-A3	-	-	
	F/70	A1	Right leg weakness	A3-A3-STA-STA	Side to side Side to end End to end	Paramedian craniotomy	STA

ACA = anterior cerebral artery; F = female; STA = superficial temporal artery; M = male; ICA = internal carotid artery; ACOM = anterior communicating artery; MCA = middle cerebral artery; PIFA = posterior internal frontal artery; RA = radial artery; OA = occipital artery.

mentation of ACA flow. In addition, STA-ACA interposition graft procedure does not require the additional remote surgical graft harvesting procedure which also may cause related complications, such as numbness, pain and other problems in the graft site. Since our case is a unilateral lesion with the possibility of steal phenomenon, we concluded that interposition graft using contralateral STA free graft without additional A3-A3 in situ bypass was the optimal procedure for the patient.

CONCLUSION

Bypass surgery may be considered for patients with symptomatic stenosis or occlusion of the ACA, especially in patients with progressive symptoms despite maximal medical therapy. Contralateral STA interposition graft can be used as a good surgical option when the length of the STA and the caliber of the donor artery is not enough.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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