



# Emergency Superficial Temporal Artery to Middle Cerebral Artery Bypass After Intravenous Administration of Tissue Plasminogen Activator for Stroke

## *İnme için Doku Plazminojen Aktivatörünün İntravenöz Uygulanmasından Sonra Acil Orta Serebral Arter - Süperfişiyal Temporal Arter Bypass*

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### ABSTRACT

Intravenous tissue plasminogen activator (IVtPA) is effective for the treatment of acute stroke. Although IVtPA is easily administered and is effective in many cases, the clinical condition of some patients can worsen after the initiation of thrombolytic therapy due to sustained cerebrovascular insufficiency. In such cases, several additional treatment options to re-establish cerebral perfusion are available, including superficial temporal artery to middle cerebral artery bypass. However, it is recommended that invasive procedures should be avoided soon after IVtPA administration because tPA is believed to exert prolonged fibrinolytic effects may continue for more than 24 hours. We described three cases of emergency superficial temporal artery to middle cerebral artery bypass performed within 24 hours of IVtPA administration, and discussed the safety of such procedures. We believe that superficial temporal artery to middle cerebral artery bypass can be safely performed even within 24 hours after IVtPA administration.

**KEYWORDS:** Emergency, Extra-intracranial bypass, Stroke, Tissue plasminogen activator

### ÖZ

İntravenöz doku plazminojen aktivatörü (IVtPA) akut inme tedavisinde etkilidir. IVtPA birçok olguda kolayca uygulanmasına ve etkili olmasına rağmen bazı hastaların klinik durumu uzun süreli serebrovasküler yetmezlik nedeniyle trombolitik tedavi başlatıldıktan sonra kötüye gidebilir. Bu gibi durumlarda, serebral perfüzyonu tekrar oluşturmak için yüzeysel temporal arter - orta serebral arter bypass dahil olmak üzere birkaç tedavi seçeneği vardır. Ancak IVtPA uygulanması sonrasında hemen invaziv işlemler yapılmasından kaçınılması önerilmektedir çünkü tPA'nın 24 saate kadar sürebilen uzun süreli fibrinolitik etkileri olduğuna inanılmaktadır. IVtPA uygulanmasından sonraki 24 saatte yapılan üç acil süperfişiyal temporal arter - orta serebral arter bypass işleminin IVtPA uygulamasından sonraki 24 saat içinde bile güvenle yapılabileceğine inanıyoruz.

**ANAHTAR SÖZCÜKLER:** Acil, Ekstra-intrakraniyal bypass, İnme, Doku plazminojen aktivatörü

### INTRODUCTION

Intravenous (IV) tissue plasminogen activator (tPA) has been shown to be effective for patients who experienced an acute stroke, and 0.6 mg/kg IVtPA is approved for the treatment of acute stroke within three hours of onset in Japan (7). Although IVtPA is easily administered and is effective in many cases, in certain cases, the condition of the patient can worsen after the initiation of thrombolytic therapy due to sustained cerebrovascular insufficiency.

In such cases, several additional treatment options to re-establish cerebral perfusion are available, including intraarterial additional tPA, angioplasty/stenting, thrombectomy, carotid endarterectomy (CEA) and superficial temporal artery to middle cerebral artery (STA-MCA) bypass (4). With regard to early invasive surgical procedures after IVtPA administration, a major concern is the potential for bleeding during or after surgery. However, little is known about the safety of emergency STA-MCA bypass soon after IVtPA administration.

We treated three patients who underwent emergency STA-MCA bypass within 24 hours after IVtPA administration, and

we herein present the cases of these patients and discuss the safety of such procedures.

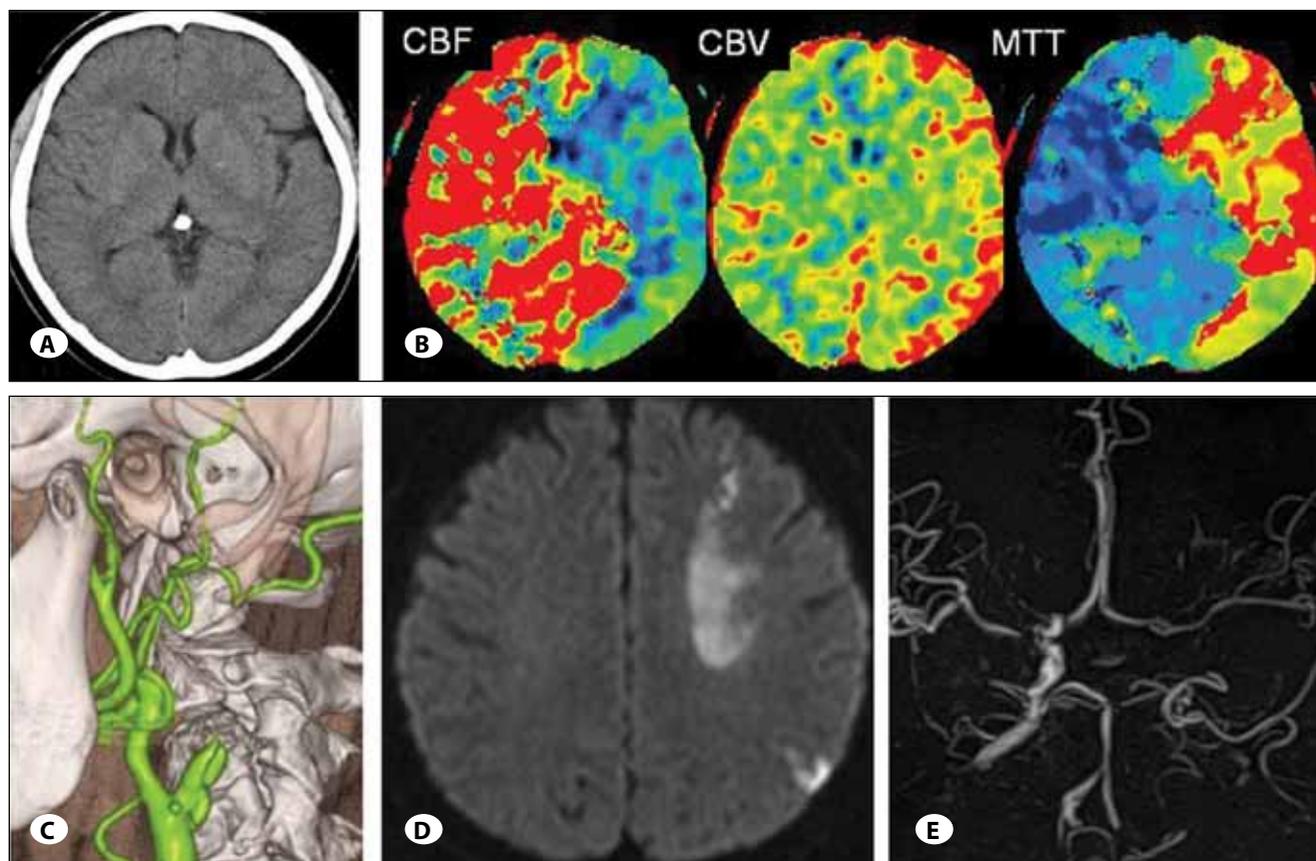
### CASE REPORTS

Emergency STA-MCA bypass is considered for patients with a symptomatic major artery occlusion, based on the following criteria: interval from the onset to surgery is 8 hours-72 hours; NIH stroke scale (NIHSS) score > 4; fluctuating or worsening of symptoms despite maximum medical treatment; (optional) diffusion-perfusion mismatch. However, surgery was performed after at least 4 hours after IVtPA.

#### Case 1

A 59-year-old female presented with right hemiparesis and motor aphasia. Her NIHSS score was 11 points. Computed tomography (CT) scans showed no early CT sign (Figure 1A). CT perfusion images demonstrated decreased cerebral blood flow (CBF), slightly increased cerebral blood volume (CBV), and a prolonged mean transit time (MTT) in the territory of the left MCA, suggesting misery perfusion (Figure 1B). CT angiography confirmed total occlusion of the cervical internal

carotid artery (ICA) (Figure 1C). She received IVtPA (0.6 mg/kg) 145 minutes after the onset of the stroke. However, her neurological symptoms did not improve, and her NIHSS score gradually deteriorated to 14 points by 12 hours after IV tPA administration. Diffusion-weighted magnetic resonance (MR) imaging showed high-intensity lesions mainly in the deep white matter of the left fronto-parietal lobe (Figure 1D) and MR angiography revealed no recanalization of the occluded left ICA (Figure 1E). To prevent the further progression of the ischemic lesion, emergency STA-MCA bypass was performed 15 hours after IVtPA. The estimated total blood loss was less than 30 ml. Intraoperatively, the procedure was uneventful, without any difficulty associated with hemostasis (Figure 2A). After surgery, there was no further neurological deterioration, and postoperative CT confirmed that there was no additional lesion (Figure 2B). CT angiography showed the good patency of the bypass grafts. CT perfusion images showed improvement in the CBF, CBV and MTT (Figure 2C). The postoperative course was also uneventful, and the patient was discharged with mild right hemiparesis. At the 6-year follow-up, her modified Rankin Scale (mRS) was grade 3.



**Figure 1: Case 1.** **A)** Initial computed tomography (CT) scan showing no early CT signs of stroke. **B)** Initial CT perfusion images showing decreased cerebral blood flow (CBF), slightly increased cerebral blood volume (CBV), and prolonged mean transit time (MTT) in the territory of the left middle cerebral artery (MCA). **C)** Initial CT angiogram showing total occlusion of the cervical internal carotid artery (ICA). **D)** Diffusion-weighted magnetic resonance (MR) image after intravenous tissue plasminogen activator (IV tPA) administration showing high-intensity lesions mainly in the left deep white matter. **E)** MR angiogram after IV tPA administration showing no recanalization of the occluded left ICA.

### Case 2

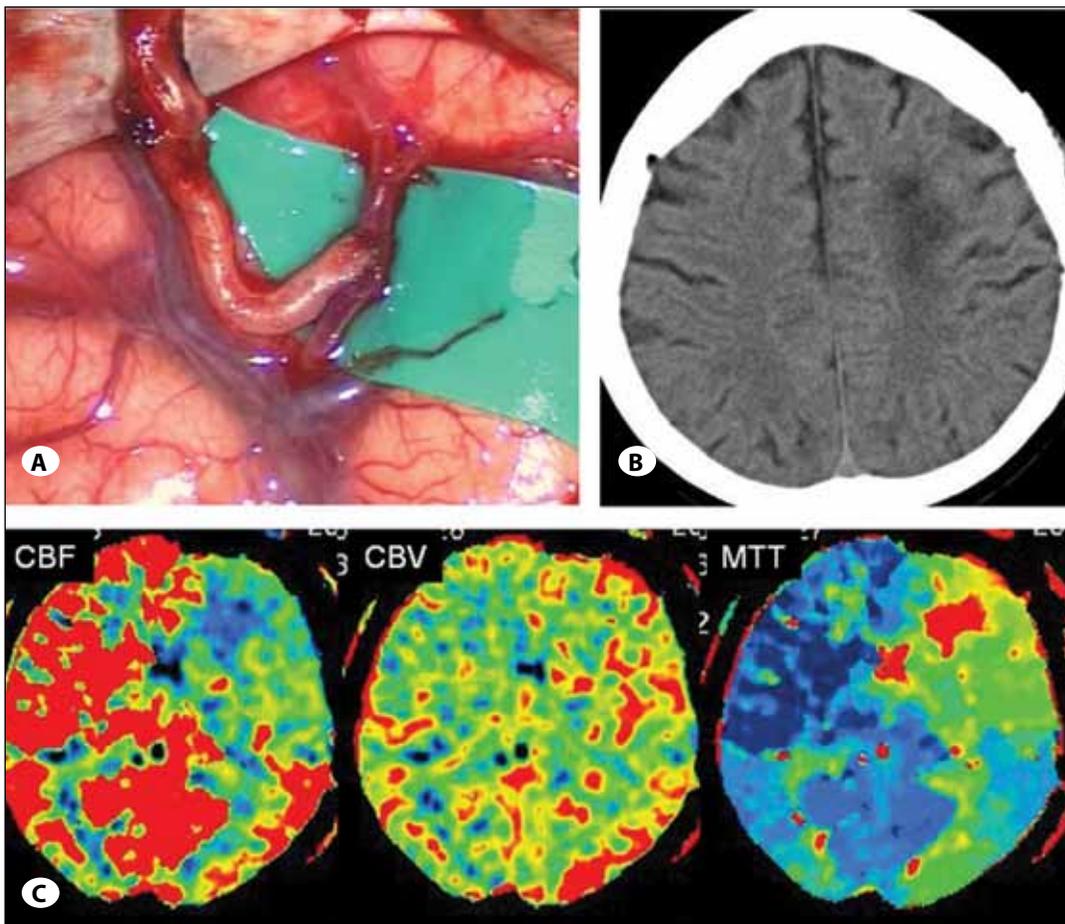
A 78-year-old male presented with left hemiparesis. His NIHSS score was 28 points. A CT scan showed no early CT sign. CT perfusion images demonstrated decreased CBF, spotty decreased CBV, and a prolonged MTT in the territory of the right MCA (Figure 3A). CT angiography confirmed occlusion of the right MCA. He received IVtPA (0.6 mg/kg) 150 minutes after the onset of the symptoms. After IVtPA, his symptoms fluctuated (25-30 points of NIHSS score). Diffusion-weighted MR imaging showed high-intensity lesions in the right basal ganglia and deep white matter (Figure 3B), and MR angiography revealed no recanalization of the occluded right MCA (Figure 3C). An emergency STA-MCA bypass was performed 14 hours after IVtPA. The estimated total blood loss was less than 30 ml. Intraoperatively, the procedure was uneventful, without any difficulty associated with hemostasis (Figure 3D). After surgery, there was no further neurological deterioration, and postoperative CT confirmed that there was no additional lesion. CT angiography showed the good patency of the bypass grafts (Figure 3E). CT perfusion images showed improvement in the CBF, CBV and MTT in the right frontal lobe (Figure 3F). His postoperative course was also uneventful, and he was discharged with severe left hemiparesis, disturbance of consciousness, and dysphagia. After the 3-year follow-up, his mRS was grade 5.

### Case 3

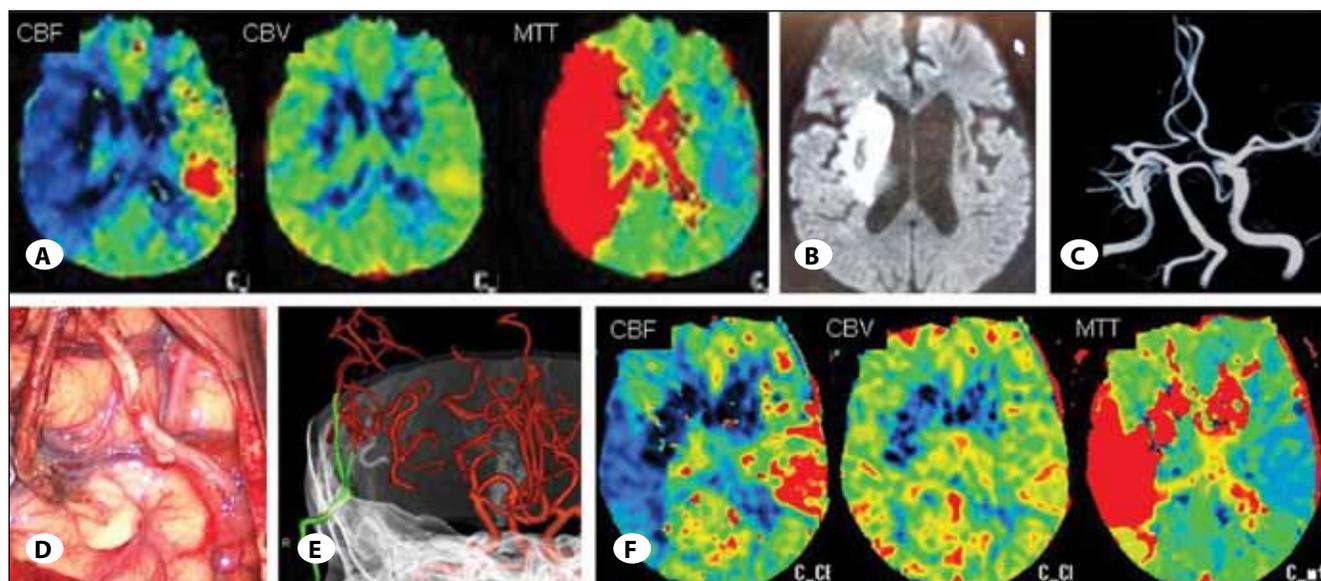
A 75-year-old male presented with left hemiparesis. His NIHSS score was 12 points. CT scans showed no early CT sign. Diffusion-weighted MR imaging showed high-intensity lesions in the right basal ganglia and deep white matter (Figure 4A). MR angiography confirmed total occlusion of the right ICA. He received IVtPA (0.6 mg/kg) 157 minutes after the onset of the stroke. However, his NIHSS score gradually worsened to 14 points. Follow-up MR angiography revealed no recanalization of the occluded right ICA (Figure 4B). An emergency STA-MCA bypass was performed 24 hours after IVtPA. The estimated total blood loss was less than 30 ml. Intraoperatively, the procedure was uneventful, without any difficulty associated with hemostasis (Figure 4C). After surgery, there was no further neurological deterioration, and postoperative CT confirmed that there was no additional lesion (Figure 4D). CT angiography showed the good patency of the bypass grafts (Figure 4E). His postoperative course was also uneventful, and he was discharged with mild left hemiparesis. After the 1.5-year follow-up, his mRS was grade 2.

### DISCUSSION

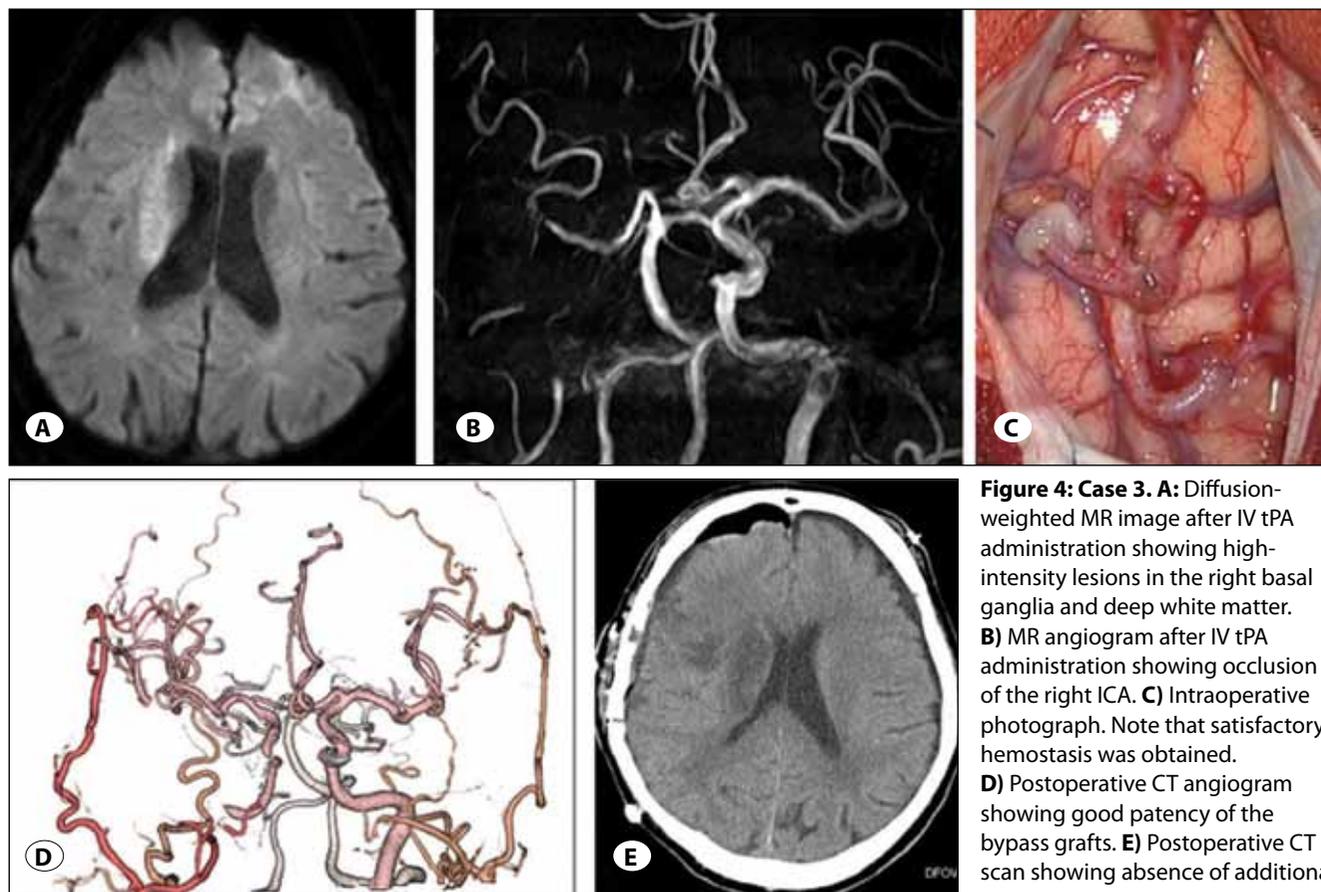
A number of studies suggest that tPA exerts prolonged fibrinolytic effects (6). With regard to the pharmacokinetics



**Figure 2: Case 1.**  
**A)** Intraoperative photograph. Note that satisfactory hemostasis was obtained.  
**B)** Postoperative CT scan showing no additional lesion.  
**C)** Postoperative CT perfusion images showing improvement in the CBF, CBV, and MTT.



**Figure 3: Case 2.** A: Initial CT perfusion images showing decreased CBF, spotty decreased CBV, and prolonged MTT in the territory of the right MCA. B) Diffusion-weighted MR image after IV tPA administration showing high-intensity lesions in the right basal ganglia and deep white matter. C) MR angiogram after IV tPA administration showing occlusion of the right MCA. D) Intraoperative photograph. Note that satisfactory hemostasis was obtained. E) Postoperative CT angiogram showing good patency of the bypass grafts. F) Postoperative CT perfusion images showing improvement in the CBF, CBV, and MTT in the right frontal lobe.



**Figure 4: Case 3.** A: Diffusion-weighted MR image after IV tPA administration showing high-intensity lesions in the right basal ganglia and deep white matter. B) MR angiogram after IV tPA administration showing occlusion of the right ICA. C) Intraoperative photograph. Note that satisfactory hemostasis was obtained. D) Postoperative CT angiogram showing good patency of the bypass grafts. E) Postoperative CT scan showing absence of additional lesions.

of tPA, it has been suggested that the fibrinolytic effects may peak at 4 h after IVtPA administration, but that the effects may continue for more than 24 h despite its short half-life (4-6 min) (6). Therefore, it is recommended that invasive procedures should be avoided within 24 hours after IVtPA administration.

STA-MCA bypass was developed to prevent subsequent stroke by improving the hemodynamics distal to the occluded artery. A recent randomized study, the Carotid Occlusion Surgery Study (COSS), concluded that STA-MCA bypass for ICA occlusion did not provide an overall benefit regarding ipsilateral 2-year stroke recurrence (5). However, in the COSS, the patients underwent surgery during the relatively chronic stage (mean interval between entry event and randomization, 72 days), and therefore, it remained inconclusive whether STA-MCA bypass in the acute stage can have any beneficial effects on the outcomes of patients with strokes. Some authors have reported that emergency STA-MCA bypass is safe and effective procedures (4). However, the optimal timing for emergency STA-MCA bypass after IVtPA administration remained unknown.

Ishishita et al. reported a case of emergency STA-MCA bypass that was performed nine hours after IVtPA administration (0.6 mg/kg), without any complications during or after surgery (3). In the present patients, the interval from IVtPA to surgery ranged from 14-24 hours. Although a major concern was the potential for bleeding during or after surgery, it was relatively easy to achieve satisfactory hemostasis for the procedures in each patient, and none developed intra- or postoperative hemorrhagic complications, in accordance with the case reported by Ishishita, et al. Therefore, we believe that intentionally waiting until the disappearance of the fibrinolytic effects may not outweigh the benefits of emergency STA-MCA bypass.

Carotid reconstruction surgery, including CEA or carotid artery stenting, can cause a rapid increase in cerebral blood flow in the chronic ischemic brain, resulting in complications such as cerebral hyperperfusion syndrome (CHS). In contrast to CHS after CEA or carotid artery stenting, CHS after STA-MCA bypass is thought to be rare, since the anastomosis usually provides low-flow revascularization (2). Furthermore, previous reports have shown that emergency STA-MCA bypass caused no CHS [2, 4]. We also encountered no CHS in the present patients.

Gross et al. has described the detailed methods about STA-MCA bypass as follows (1). The risk of perioperative stroke/graft occlusion is mitigated by the administration of an antiplatelet agent, hydration, avoidance of hypotension, and maintenance of normocapnea. The intraoperative usage of heparinized saline flushes and ICG angiography can limit the risk of graft occlusion. Dissection of a generous STA segment limits tension on the graft, and suturing should be performed from STA to MCA to avoid potential tearing of the more fragile MCA vessel. After discharge, patients are advised to avoid dehydration and local pressure on the graft site.

The present study has several limitations. Its major limitations are its retrospective nature, and the lack of a control group. The present study is composed of a small series of patients. Neurosurgeons must be able to perform bypass quickly and with low enough complication rates to benefit patients, whereas facility with STA-MCA bypass at the present time is limited, and this may limit the applicability of our results to those centers where bypass is still performed with some frequency. The dose of IVtPA used in our patients was 0.6 mg/kg (7), the approved dose in Japan, which differs from the 0.9 mg/kg typically used in other countries. Therefore, we consider that the same may not necessarily apply to the patients who receive IVtPA at a dose of 0.9 mg/kg. Further larger studies will be required to confirm the safety and the optimal time point to perform emergency STA-MCA bypass after IVtPA administration.

## CONCLUSION

We believe that it is safe to perform emergency STA-MCA bypass even within 24 hours after IVtPA administration at a dose of 0.6 mg/kg, and this procedure may help improve the patient outcome after a stroke. Further larger studies, including the patients who receive IVtPA at a dose of 0.9 mg/kg, are required to confirm the safety and the optimal time point to perform emergency STA-MCA bypass after IVtPA administration.

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