



Effects of superficial temporal artery-middle cerebral artery bypass on hemodynamics and clinical outcomes in the patients with atherosclerotic stenosis in the intracranial segment of internal carotid artery and middle cerebral artery

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ABSTRACT

Objective: To observe the effects of superficial temporal artery-middle cerebral artery bypass (STA-MCA bypass) on hemodynamics and clinical outcomes in the patients with atherosclerotic stenosis in the intracranial segment of internal carotid artery and (or) middle cerebral artery.

Patients and methods: The data of 63 patients who had the symptoms of cerebral ischemia in recent 3 months, intracranial segment of internal carotid artery (ISICA) and (or) middle cerebral artery (MCA) stenoses or occlusion showed by digital subtraction angiography (DSA), and reduced cerebral perfusion displayed by CT perfusion (CTP) imaging were retrospectively collected in this study. According to the patient's choice of different treatment methods (STA-MCA bypass and drugs), these patients were allocated into two groups: Bypass group (30 cases) and Drug group (33 cases). Postoperative symptoms, anastomotic patency and hemodynamics were observed in the Bypass group. Post-treatment ischemic events and clinical outcomes were recorded in the two groups and were compared between the two groups.

Results: In the Bypass group, DSA all showed anastomotic patency in 28 patients (93.3%, 28/30), and the improvement rate of CTP was all significantly higher in the patients with stage-III CTP than in the patients with stage-II CTP at post-operative 3 days and 6 months (95% vs 60%). Post-treatment ischemic event incidence (13.3% vs 48.5%) and annual stroke rate (6.7% vs 25.6%) were significantly lower in the Bypass group than in the Drug group (All $P < 0.05$). Pre-treatment National Institutes of Health Stroke Scale (NIHSS) score and Modified Rankin Scale (MRS) score were not significantly different between the two groups, but the NIHSS (2.87 ± 0.19 and 2.4 ± 0.19 vs 4.03 ± 0.47 and 3.97 ± 0.49) and MRS (1.13 ± 0.09 and 1.0 ± 0.07 vs 1.55 ± 0.14 and 1.52 ± 0.15) all were significantly lower in the Bypass group than in the Drug group at post-treatment 6 and 24 months (all $P < 0.05$).

Conclusion: STA-MCA bypass can improve cerebral blood perfusion and reduce the incidence of stroke in the patients who have ISICA and (or) MCA-related symptoms, 70%-100% of stenosis, and above stage-ICTP. However, this conclusion remains to be further confirmed.

1. Introduction

Intracranial atherosclerotic stenosis (IAS) is a common cause of ischemic stroke. At present, the treatment of IAS is mainly conservative such as drug, and people usually pay a great deal of attention to the symptoms after ischemic stroke. Although the patients with IAS receive strict drug treatment, the death and disability rates of ischemic stroke are still high. For example, after two-year antiplatelet therapy, the

incidence of stroke was 13.2% in the control group (without antiplatelet therapy) and 10.7% in the antiplatelet group, suggesting that the effect of antiplatelet therapy on the incidence of stroke is not marked [1].

Extra-Intracranial bypass (EC-IC bypass) is a specific method to treat the IAS by introduction of extracranial blood flow into the brain, reducing the incidence of stroke. Although some RCT studies have indicated that EC-IC bypass is not superior to drug therapy in reducing

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the incidence of ischemic stroke [2,3], many neurosurgical centers are still trying to find out the patients who have the indications of EC-IC bypass. However, increasing evidence indicates that successful EC-IC bypass does introduce extracranial blood into ischemic brain tissue [4,5]. The aim of this study was to observe the efficacy of superficial temporal artery-middle cerebral artery bypass (STA-MCA bypass) on reducing the incidence of ischemic stroke in 30 patients with IAS by comparison of 33 patients with IAS receiving conservative treatment and explore the indications of EC-IC bypass.

2. Patients and methods

All study methods were approved by Institutional Review Board and Ethics Committee of the Third Affiliated Hospital, Sun Yat-Sen University. The patients reported in this study gave written informed consent to participate.

2.1. General data

The data of the patients who were treated in our hospital for ISICA and (or) MCA stenoses or occlusion between August 2014 and February 2017, were retrospectively collected. After admission, all patients received whole-brain angiography, computed tomography angiography (CTA) and computed tomography perfusion (CTP) imaging.

The inclusion criteria were as follows: ① ISICA and (or) MCA stenoses [degree of stenosis: 70–100% based on the Warfarin-Aspirin Symptomatic Intracranial Disease standard [6] confirmed by digital subtraction angiography (DSA) and caused by atherosclerosis; ② onset of ischemic stroke or transient ischaemic attack within 3 months after at least 6-month strict drug treatment and combined with or without mild neurologic impairment; ③ reduced cerebral blood perfusion (stage II–III; the staging of cerebral blood perfusion is shown in Table 1) displayed by CTP; and ④ According to whether patients and their families agreed with surgery, these patients were divided into the Bypass group (30 cases) and Drug group (33 cases).

The exclusion criteria were as follows: ① intracranial artery stenoses caused by moyamoya disease, moyamoya syndrome, cerebral arteritis, fibromuscular dysplasia, cerebral artery fenestration, radiation damage, or arterial dissection; ② intracerebral haemorrhage or haemorrhagic cerebral infarction within recent 6 weeks, or a > 5-cm diameter cerebral infarction in the stenosis-related area, or severe stroke [National Institute of Health stroke scale (NIHSS) ≥ 9 scores or Modified Rankin Scale (MRS) > 3 scores]; ③ presence of intracranial tumor, aneurysm, and cerebral arteriovenous malformation; ④ the patients who could not receive aspirin and clopidogrel treatment; ⑤ positive pregnancy test in the women with reproductive age; ⑥ contraindication to surgery including severe heart, lung, liver, and kidney dysfunctions; and ⑦ age > 80 years or poor general condition, or an expected survival time of less than 3 years; ⑧ the follow-up period less than 24 months.

A total of 63 patients were in line with the above inclusion and exclusion criteria. According to the patient's choice of different treatment methods (STA-MCA bypass and drugs), these patients were allocated into two groups: Bypass group and Drug group. In the Bypass

Table 1
Staging of cerebral blood flow perfusion in CTP.

Stages	Conditions
Stage 0	Normal
Stage I (compensatory stage)	CPP decreases, but CBF and the rate of brain metabolism are normal by compensation of vasodilatation, CBV increases, MTT and TTP are normal or increase
Stage II (decompensated stage)	CPP further decreases, CBF decreases, CBV is normal or increases, MTT and TTP extend, brain metabolism is normal by compensation of increased oxygen uptake
Stage III (ischemic stage)	CPP decreases below critical point, CBF and CBV decrease, MTT and TTP extend, brain metabolism decreases

Notes: CTP: computed tomography perfusion; CPP: cerebral perfusion pressure; CBF: cerebral blood flow; CBV: cerebral blood volume; MTT : mean transit time; TTP: time to peak.

Table 2
General data of the patients in the two groups.

Items	Bypass group	Drug group	P values
Case (n)	30	33	
Age (year)	53.6 \pm 3.3	51.3 \pm 3.7	0.663 ^a
Sex [n (%)]			0.749 ^b
Male	22(73.3%)	23(69.7%)	
Female	8(26.7%)	10(30.3%)	
Types of stroke [n (%)]			0.917 ^b
TIA	7(23.3%)	7(21.2%)	
RIND	6(20%)	8(24.2%)	
PS	17(56.7%)	18(54.6%)	
Symptoms at admission [n (%)]			0.924 ^c
Paresis	17(56.7%)	19(57.6%)	
Dizziness	13(43.3%)	11(33.3%)	
Slurred speech	9(30%)	10(30.3%)	
Slow response	4(13.3%)	3(9.1%)	
Preoperative NIHSS [n (%)]	2(6.7%)	4(12.1%)	0.758 ^c
0-1	11(60%)	11(33.3%)	
2-4	17(33.3%)	18(54.6%)	
5-8			0.987 ^b
Preoperative MRS [n (%)]			
1	12(40%)	13(39.4%)	
2	13(43.3%)	14(42.4%)	
3	5(16.7%)	6(18.2%)	
Stenosed arteries (responsible vessels) [n (%)]			0.928 ^b
Internal carotid artery occlusion	6(20%)	8(24.2%)	
Internal carotid artery stenosis (stenosis degree of 70%-99%)	8(26.7%)	10(30.3%)	
Middle cerebral artery occlusion	10(33.3%)	10(30.3%)	
Middle cerebral artery stenosis (stenosis degree of 70%-99%)	6(20%)	5(15.2%)	
Side [n (%)]			0.498 ^b
Left	12(40%)	16(48.5%)	
Right	18(60%)	17(51.5%)	
Risk factors [n (%)]			0.953 ^b
Hypertension	18(60%)	20(60.6%)	
Hyperlipemia	17(56.7%)	21(63.6%)	
Diabetes	11(36.7%)	13(39.4%)	
Coronary disease	8(26.7%)	7(21.2%)	
CTP [n (%)]			0.458 ^b
Stage II	10(33.3%)	14(42.4%)	
Stage III	20(66.7%)	19(57.6%)	

Notes: TIA : transient ischemic attack; RIND : reversible ischemic neurologic deficit; PS : progressive stroke; NIHSS: National Institute of Health Stroke Scale; MRS: Modified Rankin Scale; CTP: computer tomography perfusion; a: Unpaired t test; b: Pearson's chi-square test; and c: Fisher's exact test.

group, there were 30 patients including 22 male and 8 female with a mean age of 53.6 years (range 24–78). In the Drug group, there were 33 patients including 23 male and 10 female with a mean age of 51.3 years (range 30–76). The general data of the two groups are shown in Table 2.

2.2. Pharmacotherapy

After admission, all patients in the two groups received aspirin 100 mg qd, Lipitor 20 mg qn until discharge. After discharge, all patients were told to take aspirin 100 mg qd for a lifetime and to pay

attention to controlling blood glucose (fasting blood glucose < 11.1 mmol/ L), blood pressure (< 140/90 mmHg) and blood lipid (low density lipoprotein < 2.6 mmol/ L).

2.3. Surgical procedures

STA-MCA bypass was performed in all patients of the Bypass group 3 days after admission. A small tongue-shaped incision was made around the parietal branch of the superficial temporal artery (STA). Then, the skin flap was separated and monopolar electrocautery was used to separate along the sides of the parietal branch until the STA bifurcation. If the parietal branch was small or missing, then the frontal branch was separated. After exposing the brain tissue, a long and straight artery with as few branches as possible was selected as a recipient vessel. Continuous suture was performed in the 30 patients.

2.4. Follow-up

The patients were followed for 24–42 months (mean: 30) in the Bypass group and for 24–36 months (mean: 27) in the Drug group. Ischemic events occurring from the admission to the end of follow-up were recorded in all patients. The annual stroke rates of the two groups were calculated according to the following formula.

$$\text{Annual stroke rate} = \frac{\text{Number of ischemic events}}{\text{Case(n)} \times \text{follow-up period(year)}} \times 100\%$$

In the Bypass group, all patients received the re-examinations including clinical outcomes, whole-brain DSA and head CTP at postoperative 3 days and 6 months, as well as received the re-examinations of clinical outcomes alone at postoperative 24 months. In the Drug group, all patients received the re-examinations of clinical outcomes at postoperative 6 and 24 months.

Neurological evaluations were performed by two senior neurologists and imaging evaluations by two senior radiologists in all patients.

2.5. Statistical analysis

Statistical analysis was performed using statistical product and service solutions (SPSS) 19.0 software. Measurement data were expressed as mean \pm standard deviation and were analyzed with *t* test. Numeration data were expressed as the number of cases or rate, and were analyzed with Pearson's chi-square test and Fisher's exact test. Statistical significance was established as $P < 0.05$.

3. Results

3.1. Surgical complications and anastomotic patency

STA-MCA bypass was successfully performed in the 30 patients. Decreased muscle strength of the contralateral upper limb occurred in one patient after surgery and automatically recovered after one week. Five patients had subcutaneous hydrops which was cured by puncture aspiration and pressure bandaging. No haemorrhagic complications occurred. DSA indicated that anastomotic stoma was patent in 28 patients (93.3%) and was not patent in 2 patients (6.7%) at both postoperative 3 days and 6 months (Fig. 1).

3.2. Ischemic events, NIHSS and MRS

From discharge to the end of follow-up, a total of 5 ischemic events occurred in 4 patients, including 3 transient ischemic attacks (TIA) and 2 reversible ischemic neurologic deficits (RIND) in the Bypass group; while in the Drug group, a total of 19 ischemic events occurred in 16 patients, including 8 TIAs, 6 RINDs and 5 progressive strokes (PS). No death occurred in the patients of the two groups (Table 3).

In the Bypass group, NIHSS was (4.83 ± 0.38) before surgery and

(4.76 ± 0.38), (2.87 ± 0.19) and (2.4 ± 0.19) at postoperative 3 days, 6 months and 24 months, respectively. In the Drug group, NIHSS was (4.79 ± 0.41) before treatment and (4.03 ± 0.47) and (3.97 ± 0.49) at postoperative 6 months and 24 months, respectively. In the Bypass group, MRS was (1.77 ± 0.73) before surgery and (1.63 ± 0.12), (1.13 ± 0.09) and (1.0 ± 0.07) at postoperative 3 days, 6 months and 24 months, respectively. In the Drug group, MRS was (1.79 ± 0.12) before treatment and (1.55 ± 0.14) and (1.52 ± 0.15) at postoperative 6 months and 24 months, respectively. Pre-treatment NIHSS and MRS were not significantly different between the two groups, but at post-treatment 6 and 24 months, NIHSS and MRS were significantly different between the two groups (all $P < 0.05$, Table 4).

3.3. Cerebral blood flow perfusion

Re-examination of postoperative 3 days indicated that in the 10 patients with stage-II CTP, stage-II CTP became stage-I CTP in 6 patients, CTP was unchanged in 3 patients, and stage-II CTP became stage-III CTP in one patient with an improvement rate of 60% (6/10); while in the 20 patients with stage-III CTP, stage-III CTP became stage-II CTP in 19 patients and CTP was unchanged in one patient with an improvement rate of 95% (19/20). The improvement rate of postoperative 3-day CTP was significantly higher in the patients with stage-III CTP than in the patients with stage-II CTP (95% vs 60%, $P = 0.0312$).

Re-examination of postoperative 6 months indicated that in the 10 patients with stage-II CTP, stage-II CTP became stage-I CTP in 6 patients and CTP was unchanged in 4 patients with an improvement rate of 60% (6/10); while in the 20 patients with stage-III CTP, stage-III CTP became stage-II CTP in 19 patients and CTP was unchanged in one patient with an improvement rate of 95% (19/20). The improvement rate of postoperative 6-month CTP was significantly higher in the patients with stage-III CTP than in the patients with stage-II CTP (95% vs 60%, $P = 0.0312$) (Fig. 1 and Table 5).

The improvement rates of CTP all were 92.9% (13/14) in the patients with ISICA stenosis at postoperative 3 days and 6 months; and in the patients with MCA stenosis, the improvement rates of CTP all were 75.0% (12/16) at postoperative 3 days and 6 months. There was not significantly different between the patients with ISICA stenosis and the patients with MCA stenosis in the improvement rate of CTP (92.9% vs 75.0%, $P = 0.3359$) (Table 6).

4. Discussion

IAS is the most common cause of the ischemic stroke and the atherosclerotic stroke accounts for about 45% of all ischemic strokes in China [7]. EC-IC bypass could introduce extracranial blood into ischemic brain tissue, so it was used to treat IAS for prevention of the ischemic stroke in 1967 for the first time [8]. However, there has been considerable debate on the application of EC-IC bypass in prevention of the ischemic stroke in the patients with IAS [9,10]. In 1987, a study from *New England Journal of Medicine* reported that the incidence of stroke was significantly higher in the Bypass group than in the Drug group during peroperative period (2.5% vs 0.6%), namely that EC-IC bypass could not reduce the incidence of ischemic stroke in the patients with IAS [2]. These unsatisfactory results led to a dramatic decline in the performance of EC-IC bypass, but the reliability of these results was questioned for the following reasons: ① Only half of the subjects in this study received antiplatelet therapy; ② The preoperative hemodynamic status was not assessed; ③ Many patients had a history of disabled stroke in the Bypass group; ④ The degree of vascular stenosis was not evaluated, and vertebral arteriography was not performed; ⑤ Many patients had no symptoms before surgery; ⑥ Many patients had other vascular lesions which were not suitable for EC-IC bypass; and ⑦ A lot of EC-IC bypass surgeries were performed at other institutions [8].

In view of these reasons, another RCT on EC-IC bypass for the prevention of ischemic stroke (carotid occlusion surgery study) was

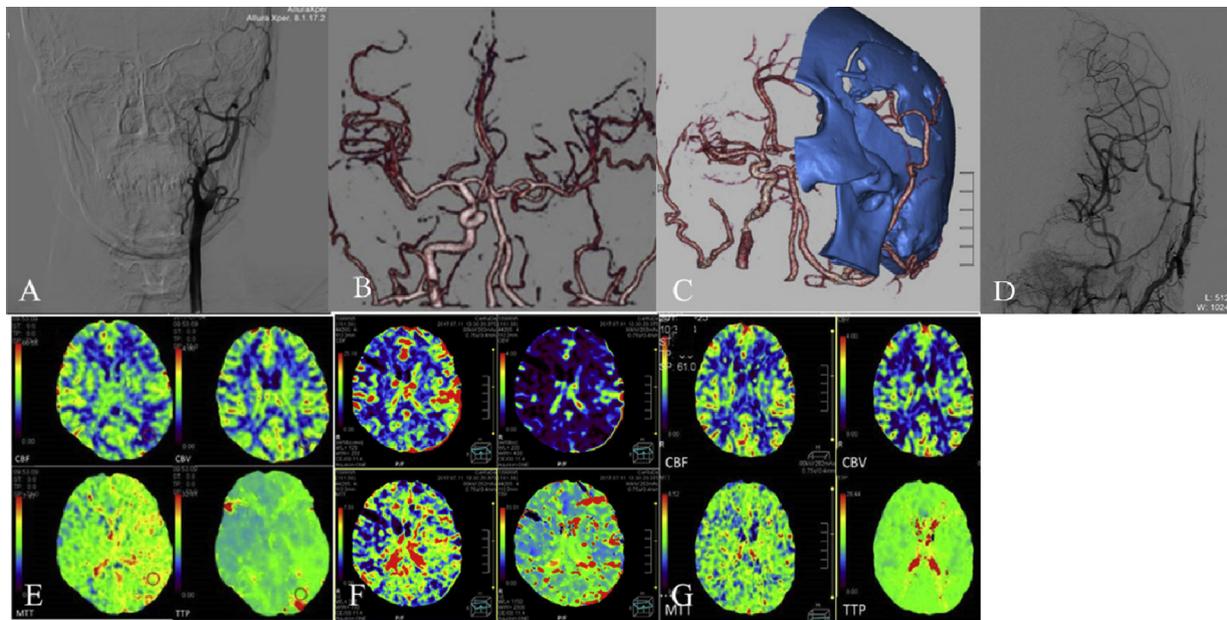


Fig. 1. The Changes in DSA and CTP before and after STA-MCA bypass in a 59-year male patient.
 Notes: A and B: Preoperative DSA and CTA all show that the intracranial segment of left internal carotid artery is occlusion. C: Postoperative 6-month CTA shows anastomotic patency. D: Postoperative 6-month DSA shows anastomotic patency. E: Preoperative CTP shows a stage II cerebral perfusion with decreased CBF, and increased MTT and TTP. F: Postoperative 3-day CTP shows a stage I cerebral perfusion with normal CBF and CBV, mildly high MTT and normal TTP. G: Postoperative 6-month CTP shows a stage I cerebral perfusion with normal CBF and CBV, mildly high MTT and normal TTP.
 DSA: digital subtraction angiography; CTP: computer tomography perfusion; STA-MCA: superficial temporal artery-middle cerebral artery; CTA: computer tomography angiography; CBF: cerebral blood flow; CBV: cerebral blood volume; MTT: mean transit time; TTP: time to peak.

Table 3
 Comparison of ischemic events between the two groups.

Groups	Case (n)	Ischemic events [n (%)]	Annual stroke rate (%)
Bypass	30	4(13.3 %)	6.7 %
Drug	33	16(48.5 %)	25.6 %
χ^2		8.961	9.96
P		0.0028	0.0016

carried out. This study included 97 patients in the Bypass group and 98 patients in the Drug group. All EC-IC bypass surgeries were completed at the same institution. The anastomotic patency rate reached 96%. The perioperative stroke rate was 14.4% in the Bypass group and 2% in the Drug group. The 2-year stroke rate was 22.7% in the Bypass group and 21% in the Drug group. This study also suggests that EC-IC bypass can not decrease the risk of ischemic stroke [3]. However, this study displayed that EC-IC bypass improved the oxygen extraction fraction and blood flow perfusion of brain tissue.

Neither of the 2 RCT studies mentioned above support EC-IC bypass as a preventive measure for ischemic stroke. Inexplicably, however, why can not a successful EC-IC bypass which introduces fresh blood into the ischemic brain tissue prevent ischemic stroke? This may be that

Table 4
 Comparison of NIHSS and MRS between the two groups.

Groups	Cases (n)	NIHSS				MRS			
		At admission	Postoperative 3 days	Postoperative 6 months	Postoperative 24 months	At admission	Postoperative 3 days	Postoperative 6 months	Postoperative 24 months
Bypass	30	4.83 ± 0.38	4.76 ± 0.38	2.87 ± 0.19	2.4 ± 0.19	1.77 ± 0.13	1.63 ± 0.12	1.13 ± 0.09	1.0 ± 0.07
Drug	33	4.79 ± 0.41	/	4.03 ± 0.47	3.97 ± 0.49	1.79 ± 0.12	/	1.55 ± 0.14	1.52 ± 0.15
t		0.124		2.22	2.84	0.115		2.34	3.11
P		0.902		0.029	0.006	0.91		0.022	0.003

Notes: NIHSS : National Institute of Health Stroke Scale; MRS : Modified Rankin Scale.

there are some problems in the selection of cases due to the inadequacy of understanding of cerebral hemodynamics.

The understanding of cerebral blood flow perfusion has been gradually established with the progress of detection means for cerebral hemodynamics in recent years. At present, the main methods for the assessment of cerebral hemodynamics include positron emission tomography, single photon emission CT, xe-CT, magnetic resonance perfusion imaging and CTP imaging. In China, CTP imaging is commonly used to evaluate the status of preoperative cerebral blood flow perfusion and the therapeutic effects of EC-IC bypass.

Reynolds et al [4] evaluated the cerebral hemodynamics using 3 stages including stages I, II and III (Table 1). From the Table 1, we can see that the stage I is normal, and stages II and III are in low blood flow perfusion. It was reported that the annual stroke rate was 10% in the patients with stages II and 31% in the patients with stages III [4]. A Japanese study indicated that the annual stroke rate was 17%-24% in the patients with decreased cerebral blood flow reserve [11,12]. Facing high incidence of stroke, surgeons have to reconsider EC-IC bypass and try to select the subgroup that can benefit from the EC-IC bypass.

Low et al [5] reported that the incidence of ischemic events was significantly lower in the STA-MCA bypass group (13%, 6/46) than in the Drug group (45%, 14/31) (P = 0.008), suggesting that STA-MCA

Table 5
Improvement of cerebral blood perfusion in the patients with different CTP.

Preoperative CTP	Postoperative 3 days		Postoperative 6 months	
	Improved (n)	Not improved (n)	Improved (n)	Not improved (n)
Stage II (10 cases)	6 with Stage I (60 %, 6/10)	3 with Stage II and 1 with Stage III	6 with Stage I (60 %, 6/10)	4 with Stage II
Stage III (20 cases)	19 with Stage II (95 %, 19/20) *	1 with Stage III	19 with Stage II (95 %, 19/20) *	1 with Stage III
Total	25	5	25	5

Notes: * indicates Fisher's exact test which shows that there are significant differences in the improvement rates of CTP between the patients with stage II and the patients with stage III at postoperative 3 days and 6 months ($P = 0.0312$). CTP: computer tomography perfusion.

Table 6
Changes in CTP for different responsible vessels at postoperative 3 days and 6 months.

Responsible vessels	Postoperative 3 days		Postoperative 6 months	
	Improved (n)	No changes/progression (n)	Improved (n)	No changes/progression (n)
ISICA	13 (93.9%, 13/14)	1	13 (93.9%, 13/14)	1
MCA *	12 (75.0%, 12/16)	4	12 (75.0%, 12/16)	4
Total	25	5	25	5

Notes: * indicates Fisher's exact test which shows that there are no significant differences in the improvement rates of CTP between the patients with ISICA occlusion/stenosis and the patients with MCA occlusion/stenosis at postoperative 3 days and 6 months ($P = 0.3359$). CTP: computer tomography perfusion; ISICA: intracranial segment of internal carotid artery; MCA: middle cerebral artery.

bypass can significantly decrease the incidence of stroke. Garrett et al [13] reviewed all the available related literatures published since 1985, and found that the patients with severe cerebral hemodynamic disorder secondary to intracranial atherosclerosis would benefit from EC-IC bypass. This conclusion is not consistent with that of the study performed in 1987 [2], so Garrett recommended that RCT study about EC-IC bypass should be carried out once again. In this study, the annual stroke rate (6.7% vs 25.6%) was significantly lower, and NIHSS and MRS were significantly better in the Bypass group than in the Drug group, suggesting that Bypass is effective on the prevention of ischemic stroke in the strictly selected patients.

In this study, cerebral hemodynamics was markedly improved in 25 patients (83.3%), was unchanged in 4 patients (13.3%) and was aggravated in one patient (3.3%). In the 5 patients with unimproved hemodynamics, anastomotic patency was observed in 3 patients. In other words, although the 3 patients had anastomotic patency, the cerebral hemodynamics failed to show improvement probably due to lower blood-supply. One important finding of this study is that the more severe the reduction of cerebral hemodynamics before STA-MCA bypass, the more marked the improvement of cerebral hemodynamics after STA-MCA bypass. This finding has not been reported in other studies. In this study, in the 20 patients with stage III CTP, 19 had stage II CTP after STA-MCA bypass; while in the 10 patients with stage II CTP, 6 had stage I CTP after STA-MCA bypass, with a significant difference in the improvement rate of CTP between the patients with stage III CTP and the patients with stage II CTP. We speculated that a more severe reduction of blood perfusion can cause a higher requirement of the brain tissue for blood, so once the brain tissue obtains extracranial fresh blood, the hemodynamics will be markedly improved. This further confirms that the reduction of preoperative cerebral perfusion is an essential and necessary for the patients receiving EC-IC bypass to prevent ischemic stroke.

In addition, the results of this study suggest that postoperative improvement of CTP is not associated with different responsible vessels (ISICA and MCA). This is not consistent with the conclusion reported by Yonekawa [14], which may be that the sample-size is small in this study. Our results also showed that there was no marked change in CTP between postoperative 3 days and 6 months, but whether the changes in CTP occurs during longer follow-up period remains to be further investigated.

In this study, there were some limitations such as being not a

prospective study and small sample-size.

In summary, although there are currently no RCTs supporting bypass surgery as a preventive measure for ischemic stroke; based on our results, we still believe that STA-MCA bypass is effective to prevent ischemic stroke. The key is to select the patients with appropriate indications including ISICA and (or) MCA-related symptoms, 70% -100% of stenosis, and more than stage-ICTP.

Acknowledgments

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