Efficacy and Safety of Endovascular Treatment in Patients with Internal Carotid Artery Occlusion and Collateral Middle Cerebral Artery Flow

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Objective: In patients with internal carotid artery (ICA) occlusion, collateral middle cerebral artery (MCA) flow has a protective role against ischemia. However, some of these patients may experience initial major neurological deficits and major worsening on following days. Thus, we investigated the safety and efficacy of endovascular treatment (EVT) for ICA occlusion with collateral MCA flow by comparing clinical outcomes of medical treatment versus EVT.

Methods: The inclusion criteria were as follows: 1) acute ischemic stroke with ICA occlusion and presence of collateral MCA flow on transfemoral cerebral angiography (TFCA) and 2) hospital arrival within 12 hours from symptom onset. The treatment strategy was made by the attending physician based on the patient's clinical status and results of TFCA.

Results: Eighty-one patients were included (30 medical treatment, 51 EVT). The EVT group revealed a high incidence of intracranial ICA occlusion, longer ipsilesional MCA contrast filling time, and a similar rate of favorable clinical outcome despite a higher mean baseline the National Institutes of Health Stroke Scale (NIHSS) score. By binary logistic regression analysis, intravenous recombinant tissue plasminogen activator and EVT were independent predictors of favorable clinical outcome. In subgroup analysis based on stroke etiology, the non-atherosclerotic group showed a higher baseline NIHSS score, higher incidence of EVT, and a higher rate of distal embolization during EVT in comparison with the atherosclerotic group.

Conclusion: In patients with ICA occlusion and collateral MCA flow, decisions regarding treatment strategy based on TFCA can help achieve favorable clinical outcomes. EVT strategy with respect to etiology of ICA occlusion might help achieve better angiographic outcomes.

Key Words: Stroke • Internal carotid artery • Collateral circulation • Thrombectomy.
shape of the occlusive ICA and the collateral strength\(^{14,18}\). Specifically, the presence of collateral middle cerebral artery (MCA) flow via the circle of Willis is associated with a protective role against cerebral ischemia; and therefore, acute stroke attributable to ICA occlusion with collateral MCA flow can generally show mild neurological deficits at onset and relatively favorable clinical outcomes\(^{4,13,14,16}\). However, in this situation, about 50% of patients with mild to moderate neurological severity at baseline experience major worsening on following days and about 25% of patients present with initial major neurological deficits\(^{13}\).

Despite recent successful clinical trials of endovascular treatment (EVT) for anterior circulation stroke\(^{3,6,7,11,21}\), the evidence regarding EVT for ICA occlusion with collateral MCA flow is still lacking. But theoretically, it can be presumed that EVT for ICA occlusion with collateral MCA flow would be difficult due to the long length of occlusion, a large clot burden, and the risk of complications, such as distal embolization\(^{2,15}\). Therefore, the clinician may hesitate to perform EVT due to the aforementioned reasons; rather, the best medical treatment for such patients may be preferred. Therefore, we investigated the safety and efficacy of EVT for ICA occlusion with collateral MCA flow by comparing clinical outcomes between a medical treatment group and an EVT group, and we tried to find good candidates who will benefit from EVT.

**MATERIALS AND METHODS**

**Patients**

This study is a retrospective review from a consecutively collected acute ischemic stroke registry at Kyungpook National University Hospital between December 2006 and May 2017. The inclusion criteria for this study were as follows: 1) acute ischemic stroke with symptomatic ICA occlusion, 2) hospital arrival within 12 hours from symptom onset, 3) presence of collateral MCA flow on transfemoral cerebral angiography (TFCA), and 4) pre-stroke modified Rankin Scale (mRS) score ≤2. Patients with other stroke etiologies, including Moyamoya disease and vasculitis, were excluded. This study was approved by the local Insitutional Review Board of Kyungpook National University Hospital (KNUH 2015-02-022).

**Baseline assessment and endovascular procedure**

After initial neurological examination, non-enhanced brain computed tomography (CT) and CT angiography were performed. Intravenous recombinant tissue plasminogen activator (rtPA) was administered in eligible patients based on the guidelines for the early management of acute ischemic stroke\(^{10}\). In some cases, such as a late time window, brain magnetic resonance (MR) imaging and MR angiography were performed.

All included patients had TFCA and completed angiographic evaluation, including bilateral carotid and vertebral angiogram for assessment of vascular occlusion and collateral status. A 5 F guide catheter (Headhunter, Cordis, Miami, FL, USA) was used for the cerebral angiogram, and 10 mL of iodinate contrast was administered at 3 mL/sec. To evaluate the collateral circulation, we assessed the contrast filling time of the arterial phase from the ipsilesional and contralateral MCA territory. For collateral flow via the anterior communicating artery, a contralateral carotid angiogram (distal common carotid artery [CCA] or proximal ICA) was performed. In the other collateral route, two angiogram series (contralateral CCA and similar level of V2 segment of the dominant vertebral artery in collateral flow via posterior communicating artery, bilateral distal CCA in collateral flow via the ipsilesional ophthalmic artery) were used. The decision for EVT was made according to the attending physician’s discretion based on the patient’s clinical status and the results of TFCA. According to the institutional EVT protocol, contact aspiration thrombectomy was performed in most cases. If recanalization was failed after three attempts, we used a stent retriever. However, a stent retriever was used preferentially instead of an aspiration catheter in cases of difficult target access due to high vascular tortuosity or heavy calcification. Carotid balloon angioplasty or stenting was conducted in cases of extracranial ICA severe stenosis with distal flow compromise.

**Clinical and radiographic evaluation**

Data, including demographics, neurological status, and angiography findings, were collected from the patients’ record. The National Institute of Health Stroke Scale (NIHSS) score was assessed at baseline, day 1, and day 7 (or at discharge if it was before day 7). Early neurological deterioration (END) was defined as an increase in NIHSS score of 4 points or more that persists for at least 24 hours within 7 days. Early neurological...
improvement (ENI) was defined as a decrease in NIHSS score of 4 points or more 24 hours after treatment. The Alberta Stroke Program Early CT Score (ASPECTS) was calculated from the initial diffusion-weighted image (DWI). The clinical outcomes were assessed using the mRS at 3 months, and a favorable clinical outcome was defined as an mRS score of ≤2. Reperfusion status was measured using the modified Thrombolysis In Cerebral Infarction (mTICI) score 23). The mTICI score was independently evaluated by an experienced neuroradiologist and neurologist who were blinded to the clinical information. If there was a discrepancy, the final assessment was determined by consensus. Successful reperfusion was defined as an mTICI score of 2b or 3.

A follow-up brain CT scan was acquired immediately and 1 day after the EVT. The type of intracranial hemorrhage was determined according to the European Cooperative Acute Stroke Study II classification system 9). Symptomatic intracranial hemorrhage was defined as any type of hemorrhage with an increase of ≥4 in NIHSS score within 24 hours 22).

**Statistics**

Statistical analyses were performed using SPSS version 22.0 (IBM, Armonk, NY, USA). Chi-squared or Fisher’s exact tests were used for categorical data. The Student’s t or Mann-Whitney U tests were used for continuous variables. Binary logistic regression analysis was performed to identify independent predictors of favorable clinical outcome at 3 months. Independent variables with a p value less than 0.10 in univariate analysis for favorable clinical outcome were put into a binary logistic regression analysis. EVT related to the aim of this study was put into the binary logistic regression analysis, though it was not significant in the univariate analysis. A p value <0.05 was considered statistically significant.

**RESULTS**

Eighty-one patients who had an ICA occlusion with collateral MCA flow were included in this study. Thirty patients received medical treatment and 51 patients received EVT with medical treatment.

**Baseline characteristics**

Baseline characteristics, including demographics and risk factors for the study group are presented in Table 1. The groups were compared using the Mann-Whitney U test for continuous variables and the chi-squared or Fisher’s exact test for categorical variables.

### Table 1. Baseline characteristics

| Variable                        | Medical treatment (n=30) | EVT (n=51) | p-value |
|---------------------------------|-------------------------|------------|---------|
| Age (years)                     | 68 (61.75–78.25)        | 73 (64–78) | 0.252*  |
| Female                          | 8 (26.7)                | 22 (43.1)  | 0.138   |
| Intravenous rtPA use            | 9 (30.0)                | 20 (39.2)  | 0.403   |
| Baseline NIHSS                  | 13 (9–17.25)            | 11 (11–20) | 0.074*  |
| Onset to door time (minutes)    | 231.5 (89–382)          | 268 (113–693.5) | 0.315* |
| ASPECTS DWI                     | 9 (8–10)                | 9 (8–10)   | 0.700*  |
| Medical history                 |                         |            |         |
| Hypertension                    | 21 (70.0)               | 33 (64.7)  | 0.625   |
| Diabetes                        | 12 (40.0)               | 18 (53.3)  | 0.672   |
| Hyperlipidemia                  | 18 (60.0)               | 18 (53.3)  | 0.031   |
| Atrial fibrillation             | 9 (30.0)                | 22 (43.1)  | 0.24    |
| Coronary disease                | 6 (20.0)                | 8 (15.7)   | 0.62    |
| Current smoking                 | 11 (36.7)               | 20 (39.2)  | 0.82    |
| Previous Stroke                 | 5 (16.7)                | 9 (17.6)   | 0.91    |
| Antiplatelet use                | 9 (30.0)                | 22 (43.1)  | 0.24    |
| Anticoagulant use               | 3 (10.0)                | 2 (3.9)    | 0.354*  |
| Occlusion location              |                         |            | 0.005   |
| Extracranial ICA                | 20 (66.7)               | 15 (29.4)  |         |
| Intracranial ICA                | 8 (26.7)                | 27 (52.9)  |         |
| ICA and tandem MCA branches     | 2 (6.7)                 | 9 (17.6)   |         |
| Route of collaterals            |                         |            | 0.676   |
| Anterior communicating artery   | 15 (50.0)               | 22 (43.1)  |         |
| Posterior communicating artery  | 8 (26.7)                | 12 (23.5)  |         |
| Anterior & posterior communicating artery | 2 (6.7) | 8 (15.7) |         |
| Ophthalmic artery               | 5 (16.7)                | 9 (17.6)   |         |
| Delay of contrast filling time  | 1.5 (1.0–2.1)           | 3.0 (2.2–4.0) | <0.001 |
| for MCA territory (seconds)     |                         |            |         |
| Stroke subtypes                 |                         |            | 0.024   |
| Large artery atherosclerosis    | 21 (70.0)               | 21 (41.2)  |         |
| Cardioembolism                  | 5 (16.7)                | 23 (45.1)  |         |
| Undetermined                    | 4 (13.3)                | 7 (13.7)   |         |

Values are presented as median (interquartile range) or number (%). *Mann whitney U test. EVT : endovascular treatment, rtPA : recombinant tissue plasminogen activator, NIHSS : National Institute of Health Stroke Scale, ASPECTS : Alberta Stroke Program Early CT Score, DWI : diffusion-weighted imaging, ICA : internal carotid artery, MCA : middle cerebral artery
factors, were summarized in Table 1. The median age was 68 (interquartile range [IQR], 61.75–78.25) years in the medical treatment group and 73 (IQR, 64–78) years in the EVT group (p=0.252). Intravenous rtPA was administered in nine patients (30%) in the medical treatment group and in 20 patients (39.2%) in the EVT group (p=0.403). The DWI ASPECTS was similar between groups (9 [IQR, 8–10] vs. 9 [IQR, 8–10], p=0.700), but the baseline NIHSS score was higher in the EVT group, though not statistically significant (13 vs. 16, p=0.074). The incidence of hyperlipidemia was higher in the medical treatment group (60.0% vs. 35.3%, p=0.031), and other risk factors for stroke were not statistically different between groups. Regarding stroke etiology, the median treatment group showed a higher proportion of large artery atherosclerosis than the EVT group. Median time (in seconds) for ipsilesional MCA contrast filling during the arterial phase was significantly longer in the EVT group (1.5 [IQR, 1.0–2.1] vs. 3.0 [IQR, 2.2–4.0], p=0.024).

**Angiographic and clinical outcomes between medical treatment and EVT groups**

Clinical outcomes of both groups are summarized in Table 2. The median NIHSS score measured 1 day after stroke onset was 10 (IQR, 5.75–14) in the medical treatment group and 12 (IQR, 6–18) in the EVT group (p=0.172), and the median score measured 7 days after stroke onset was 8.5 (IQR, 3.75–14) in the medical treatment group and 8 (IQR, 2–15) in the EVT group (p=0.941). The EVT group revealed a lower incidence of END and a higher incidence of ENI, but the differences were not statistically significant. The rates of favorable clinical outcome at 3 months were 43.3% of patients in the medical treatment group and 52.9% of patients in the EVT group (p=0.040), and the mortality rate was not statistically different between groups (13.3% vs. 7.8%, p=0.460). By binary logistic regression analysis, intravenous rtPA (p=0.006) and EVT (p=0.041) were independent predictors of a favorable clinical outcome. And atherosclerotic ICA occlusion (p=0.084) showed a tendency for a favorable clinical outcome (Table 3).

Subgroup analysis of angiographic and clinical outcomes according to treatment strategy and etiology of ICA occlusion

Baseline characteristics and clinical outcomes according to treatment strategy for each ICA occlusion etiology are summarized in Table 4. The overall non-atherosclerotic ICA occlusion group showed a higher baseline NIHSS score (13 vs. 16.5, p=0.011) and EVT was more commonly applied (51.2% vs. 76.3%, p=0.019). The median NIHSS score at the baseline and day 1 was significantly higher in the non-atherosclerotic ICA occlusion group, but became similar between groups at day 7. The favorable clinical outcome at 3 months was not statistically different between groups (58.1% vs. 39.5%, p=0.094). In comparison between treatment strategies within each etiology, the EVT group revealed a higher baseline NIHSS score (11 vs. 16.5, p=0.027) and similar clinical outcomes in the atherosclerotic ICA occlusion group. In the non-atherosclerotic ICA occlusion group, the EVT group achieved a higher rate of favorable clinical outcome, but the result was not statistically significant (22.2% vs. 44.8%, p=0.273).

Angiographic outcomes of the patients who received EVT were summarized in Table 5. The atherosclerotic ICA occlusion group revealed a higher rate of mTICI 2b or 3 of reperfusion, but the result was not statistically significant (90.9% vs. 86.6%)

| Variable | Medical treatment (n=30) | EVT (n=51) | p-value |
|----------|-------------------------|------------|---------|
| NIHSS 1 day | 10 (5.75–14) | 12 (6–18) | 0.172* |
| NIHSS 7 day | 8.5 (3.75–14) | 8 (2–15) | 0.941* |
| Early neurological deterioration | 7 (23.3) | 6 (11.8) | 0.215† |
| Early neurological improvement | 15 (50.0) | 32 (62.7) | 0.262 |
| mRS 0–2 at 3 months | 13 (43.3) | 27 (52.9) | 0.404 |
| Mortality | 4 (13.3) | 4 (7.8) | 0.460† |

Values are presented as median (interquartile range) or number (%). *Mann whitney U test. †Fisher’s exact T test. EVT : endovascular treatment, NIHSS : National Institute of Health Stroke Scale, mRS : modified Rankin Scale

| Variable | Odds ratio (95% CI) | p-value |
|----------|---------------------|---------|
| Age (/1 year) | 0.956 (0.901–1.013) | 0.128 |
| Sex (female) | 0.502 (0.154–1.641) | 0.254 |
| Intravenous rtPA | 5.367 (1.609–17.907) | 0.006 |
| Baseline NIHSS | 0.909 (0.816–1.012) | 0.081 |
| Endovascular treatment | 3.452 (1.054–11.304) | 0.041 |
| Atherosclerotic occlusion | 2.837 (0.868–9.268) | 0.084 |

CI : confidence interval, rtPA : recombinant tissue plasminogen activator, NIHSS : National Institute of Health Stroke Scale.
75.9%, $p=0.268$). The time from groin puncture to achieving final reperfusion was 64.5 minutes (IQR, 46.5–79.25) minutes in the atherosclerotic occlusion group and 69 minutes (IQR, 44–141) minutes in the non-atherosclerotic occlusion group ($p=0.430$). But, the distal embolization rate into the downstream of the occluded ICA during the EVT procedure was significantly higher in the non-atherosclerotic occlusion group (0 vs. 58.6%, $p<0.001$). Symptomatic intracerebral hemorrhage did not occur in either group.

### Table 4. Baseline characteristic and clinical outcomes according to treatment strategy of each etiology of ICA occlusion

| Variable                  | Atherosclerotic ICA occlusion group (n=43) | Non-atherosclerotic ICA occlusion group (n=38) | p-value | p-value |
|---------------------------|-------------------------------------------|-----------------------------------------------|---------|---------|
| Overall                   | Overall                                   | Medical Treatment (n=21)                        | EVT (n=22) | p-value |
| Baseline NIHSS            | 13 (9–19)                                 | 11 (7.5–14.5)                                 | 16.5 (10–20) | 0.276*  | 0.011* |
| ASPECTS DWI               | 9 (7–10)                                  | 9 (8–10)                                      | 8 (7–10) | 0.148*  |         |
| NIHSS 1 day               | 9 (5–13)                                  | 7 (3–12)                                      | 11 (6.75–15.5) | 0.051*  |         |
| NIHSS 7 day               | 7 (3–13)                                  | 8 (3–12.5)                                    | 7 (2.75–15.25) | 0.922*  |         |
| END                       | 7 (16.3)                                  | 5 (23.8)                                      | 2 (9.1) | 0.240†  |         |
| ENI                       | 24 (55.8)                                 | 10 (47.6)                                     | 14 (63.6) | 0.364†  |         |
| mRS 0–2 at 3 months       | 25 (58.1)                                 | 11 (52.4)                                     | 14 (63.6) | 0.455  |         |
| Mortality                 | 4 (9.3)                                   | 3 (14.3)                                      | 1 (4.5) | 0.345†  |         |
| Mortality                 | 4 (9.3)                                   | 3 (14.3)                                      | 1 (4.5) | 0.345†  |         |

Values are presented as median (interquartile range) or number (%). *Mann whitney U test. †Fischer’s exact T test. ICA : internal carotid artery, EVT : endovascular treatment, NIHSS : National Institute of Health Stroke Scale, ASPECTS : Alberta Stroke Program Early CT score, DWI : diffusion-weighted imaging, END : early neurological deterioration, ENI : early neurological improvement, mRS : modified Rankin Scale

### Table 5. Angiographic outcomes according to the etiology of ICA occlusion

| Variable                        | Atherosclerotic occlusion (n=22) | Non-atherosclerotic occlusion (n=29) | p-value |
|---------------------------------|---------------------------------|-------------------------------------|---------|
| Door to puncture time (minutes) | 94 (87.25–116.25)               | 82 (69–103)                         | 0.058   |
| Groin puncture to final reperfusion time (minutes) | 64.5 (46.5–79.25)               | 69 (44–141)                         | 0.430   |
| EVT procedure time (minutes)    | 44.5 (19.75–56.25)              | 47 (21–116)                         | 0.274   |
| Onset to final reperfusion time (minutes) | 459 (263.75–1008.25)          | 444.5 (306–702.25)                  | 0.755   |
| EVT strategy                    | MT only                        | MT & carotid stenting | MT & balloon angioplasty | mTICI 2b–3 of reperfusion | Distal embolization | Hemorrhagic complications | Intraparenchymal hemorrhage | Parenchymal hematomat | Subarachnoid hemorrhage | Symptomatic ICH | mRS 0–2 at 3 months |
| MT only                         | 11 (50.0)                      | 9 (40.9)                            | 2 (9.1) | 20 (90.9) | 0 | 0 | 0 | 0 | 14 (63.6) |
| MT & carotid stenting           |                                | 0                                   | 0       | 22 (75.9) | 17 (58.6) | 4 | 0 |
| MT & balloon angioplasty        |                                |                                     |         |          |           |   |   |
| mTICI 2b–3 of reperfusion       | 20 (90.9)                      |                                     |         |          |           |   |   |
| Distal embolization             | 0                              |                                     |         |          |           |   |   |
| Hemorrhagic complications       |                                |                                     |         |          |           |   |   |
| Intraparenchymal hemorrhage     | 0                              |                                     |         |          |           |   |   |
| Parenchymal hematomat           | 0                              |                                     |         |          |           |   |   |
| Subarachnoid hemorrhage         | 0                              |                                     |         |          |           |   |   |
| Symptomatic ICH                 | 0                              |                                     |         |          |           |   |   |
| mRS 0–2 at 3 months             | 14 (63.6)                      |                                     |         |          |           |   |   |

Values are presented as median (interquartile range) or number (%). *Fischer’s exact T test. ICA : internal carotid artery, EVT : endovascular treatment, MT : mechanical thrombectomy, mTICI : modified Treatment in Cerebral Infarction, ICH : intracerebral hemorrhage, mRS : modified Rankin Scale
DISCUSSION

The exact mechanism of a developing ICA occlusion with collateral MCA flow is still unknown. We suppose two possible mechanisms. First, when antegrade ICA flow diminishes due to carotid stenosis or a thrombus, collateral channels via the Willisian route are opened. If the collateral flow is sufficient, retrograde ICA flow from collateral flow could prevent further distal migration of the blood clot and promote coagulation within the ICA by stasis of arterial flow. Second, complete arrest of ICA flow caused by a large burden of clotted blood or underlying atherosclerosis can also make an ICA occlusion with collateral MCA flow. Either way, a large amount of blood clot within the occluded ICA can be expected.

When considering EVT, it is definitely a difficult procedure due to large clot burden or underlying stenosis, and the possibility of distal embolization during EVT is also high.\textsuperscript{2,5} Also, considering medical therapy, clinical deterioration is possible due to diminished collateral flow and/or distal embolization due to clot fragmentation/migration. Therefore, the clinician cannot help but wonder whether EVT or medical treatment is better for patients with an ICA occlusion with collateral MCA flow.

The main finding of this study was that EVT demonstrated reasonable clinical outcomes in patients with an ICA occlusion with collateral MCA flow. Moreover, favorable clinical outcome was affected by administration of intravenous rtPA and EVT. Further analysis regarding etiology of the ICA occlusion was as follows: 1) In the atherosclerotic ICA occlusion group, both medical treatment and EVT groups showed a high rate of favorable clinical outcome, and EVT seemed to be safe and 2) In the non-atherosclerotic occlusion group, the clinical outcome for the medical treatment group was dismal, and the EVT group revealed a high rate of distal embolization during the procedure despite a relatively higher favorable clinical outcome (22.2% vs. 44.8%, p=0.273).

The clinical course of patients with ICA occlusion with collateral MCA flow is still unknown due to a lack of large clinical trials. However, Kim et al.\textsuperscript{13} reported the clinical outcome of 24 medically treated patients with ICA occlusion and collateral MCA flow. The patients in that report had mild neurological deficits (median baseline NIHSS score of 6); 33.3% of those patients had END, and 41.7% had an mRS 0–2 at 3 months\textsuperscript{13}. However, this study demonstrated a lower incidence of END and a higher incidence of favorable clinical outcomes regardless of treatment strategy. The authors speculated that the better outcome in this study was associated with the decision of treatment strategy based on the assessment of collateral status by the TFCA.

The collateral circulation has a protective role for ischemic brain injury and would be recruited to preserve cerebral perfusion to compensate for the effects of ischemia after arterial occlusion.\textsuperscript{4,16} Collateral flow via the circle of Willis maintains cerebral perfusion through a rapid change of blood flow direction, and this phenomenon can be seen with a balloon test occlusion of the ICA and carotid clamping during carotid endarterectomy.\textsuperscript{1,12,20} Whereas, secondary collateral flow, such as from the leptomeningeal collaterals, needs more time for formation. Although all enrolled patients in this study had collateral MCA flow via the circle of Willis or an ophthalmic artery, there were discrepancies in baseline neurological deficits relative to ICA occlusion etiology. Atherosclerotic ICA occlusions were related to preceding intra/extracranial carotid stenosis, which could promote collateral flow.\textsuperscript{17} Therefore, the atherosclerotic ICA occlusion group might be associated with a lower baseline NIHSS score.

Regarding the ICA occlusion etiology, 51.2% of atherosclerotic ICA occlusions and 76.3% of non-atherosclerotic ICA occlusions received EVT. For this aspect of EVT, the EVT strategy was significantly different between the groups (Table 5). Additional procedures, such as balloon angioplasty and/or carotid stenting, were applied more frequently in the atherosclerotic occlusion group. Considering EVT strategy relative to the etiology of the ICA occlusion could be helpful toward achieving a better EVT outcome. Another concern is downstream distal embolization, which can cause I type ICA occlusions, T type ICA occlusions, or MCA occlusions. Therefore, a balloon guide catheter was applied during EVT for the prevention of distal embolization, except in four cases. Distal embolization occurred in 17 patients (33.3%) during EVT, which occurred only in the non-atherosclerotic occlusion group. Although the distal embolization rate was high, mTICI 2b or 3 of reperfusion was achieved in 75.9% of patients in the non-atherosclerotic occlusion group. This reperfusion rate is comparable to the result of meta-analysis, which showed an mTICI 2b or 3 reperfusion rate of 71%.\textsuperscript{8} Furthermore, downstream distal embolization can occur regardless of EVT. Major neurological deterioration with an 8-point increase in NI-
HSS score occurred for two patients (6.7%) in the medical treatment group, which resulted in a carotid terminus and an MCA occlusion through spontaneous distal embolization. The mechanism might be similar with spontaneous recanalization in cardioembolic stroke. In the early period from index stroke, patients should be closely monitored for their neurological status.

However, this study has several limitations. First, this study excluded patients who did not receive TFCA due to minor neurological deficits and a low NIHSS score. Therefore, our results did not represent all patients with symptomatic ICA occlusion and collateral MCA flow. Second, it was retrospective study at a single center over a long period of data gathering. However, there were only two cases in the EVT group where modern thrombectomy devices, such as the Penumbra reperfusion catheter and the stent-retriever, were not available. So, even though the study inclusion period was long, the authors thought that the technical impact on EVT related to advances in devices would be minor.

CONCLUSION

In patients with symptomatic ICA occlusion and collateral MCA flow, decisions regarding treatment strategy based on the TFCA and stroke etiology can be helpful for achieving favorable clinical outcomes. EVT might be feasible for patients with atherosclerotic ICA occlusion and collateral MCA flow. For patients with a non-atherosclerotic ICA occlusion, EVT should be performed cautiously to prevent distal embolization for a better clinical outcome. Further prospective trials are needed to confirm the results of this study.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

INFORMED CONSENT

This type of study does not require informed consent.

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