Thrombotic Occlusion of the Middle Cerebral Artery

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Background and Purpose: Epidemiological study of middle cerebral artery occlusion is important because the indication for extracranial–intracranial arterial bypass remains in dispute. To help clarify this issue, we investigated the prognosis of thrombotic middle cerebral artery occlusion in Japanese patients.

Methods: We studied 40 patients with thrombotic middle cerebral artery occlusion who were selected on the basis of clinical features, computed tomographic findings, and angiographic findings. Patients with causes of embolism (i.e., cardiomyopathy, valvular heart disease, cardiac arrhythmia, and carotid ulceration) were excluded. The 40 patients were classified into three groups according to the site of middle cerebral artery occlusion: there were 13 patients with occlusion of the proximal portion of the M1 segment, 13 with distal M1 segment occlusion, and 14 with occlusion of the M2 segment.

Results: Good collateral circulation was associated with improved outcomes both clinically and by computed tomography in patients with occlusion of the proximal and distal portions of the M1 segment but not in those with M2 occlusion.

Conclusions: It is reasonable to assume that not only collateral circulation but also the site of occlusion plays an important role in the outcome of middle cerebral artery occlusion. Our finding that good collateral circulation improves the outcome for thrombotic occlusion of the proximal and distal M1 segments supports the possible benefits of such surgery. (Stroke 1992;23:1761-1766)

KEY WORDS arterial occlusive diseases • cerebral infarction • collateral circulation • thrombosis

Epidemiological study of middle cerebral artery (MCA) occlusion has become increasingly important because review of the literature suggests that the indication for extracranial–intracranial arterial bypass surgery remains in dispute.1-3 Strict differentiation of thrombosis from embolus is especially important because the clinical course, neuroradiological findings, treatment, and prognosis may be different.4 Thrombosis is usually thought to have a less-sudden onset, to be less severe clinically, and to have a computed tomographic (CT) image of an irregular low density area (LDA) without midline shift.5 Embolic cerebral infarction as reported by the Harvard Cooperative Stroke Registry,6 Blackwood et al,7 and Jorgensen and Torvik8 had an incidence of 37%, 48%, and 47%, respectively. Although many authors9-13 have emphasized atherosclerotic thrombosis as the most common cause of cerebral infarction, accounting for 80-95%, some14,15 have found thrombotic etiology of MCA occlusion to be less frequent. In the Japanese population, MCA occlusion is 1.8 times more common than internal carotid artery (ICA) occlusion.16 In the American Joint Study of Extracranial Arterial Occlusion,17 MCA occlusion had one fourth the incidence of ICA occlusion. The reason for the etiological dominance of embolus or thrombosis is controversial, but among the Japanese population thrombotic MCA occlusion appears to have a higher incidence.

In this study we investigated the prognosis of thrombotic MCA occlusion in Japanese patients in relation to clinical features, CT findings, and angiographic findings. To assess collateral circulation, we determined the presence or absence of retrograde filling, that is, the presence or absence of contrast media in MCA branches through leptomeningeal anastomosis on angiography (within 6 seconds after injection).

Subjects and Methods

We studied 40 patients with MCA occlusion (mean age, 66.4 years [range, 42–84 years]; 27 men, 13 women) retrospectively. With diagnosis made by CT, angiographic, and clinical findings, patients who had atrial fibrillation on electrocardiogram or angiographic findings of atherosclerotic ICA ulceration regardless of the presence of ICA stenosis were excluded from this study. All patients were admitted within 48 hours of the ictus, and the initial CT scans were undertaken within 36 hours of admission. Angiography was performed within 4 days of admission.

Angiograms were divided into the following three groups according to the site of occlusion: group A, occlusion of the proximal portion of the M1 segment; group B, occlusion of the distal portion of the M1 segment; and group C, occlusion of the M2 segment (Figure 1). We determined the presence or absence of retrograde filling, that is, the presence or absence of...
Angiographic findings of middle cerebral artery occlusion were classified into three groups. Left panel: Occlusion of the proximal portion of the M1 segment (group A). Center panel: Occlusion of the distal portion of the M1 segment (group B). Right panel: Occlusion of the M2 segment (group C).

Contrast media in MCA branches through leptomeningeal anastomoses with serial angiography. The presence or absence of angiographic retrograde filling was also analyzed.

CT scans were classified into the following five categories: basal ganglia–centrum semiovale type, in which an LDA was localized in the basal ganglia and/or centrum semiovale; localized cortex–subcortical type, in which an LDA was localized in a small area of the cortex and subcortex of the frontal, temporal, or parietal lobe; lobular cortex–subcortical type, in which an LDA involved the cortex and subcortex of the frontal, temporal, and parietal lobes; hemispheric type, in which an LDA extended to one hemisphere including the basal ganglia; and normal type, in which an LDA was not found on CT (Figure 2). For the CT classification described above, CT scans that showed the maximum extent of LDA during repeated studies were selected.

Degree of hemiparesis on admission was graded as mild, moderate, or severe using DeJong's definition, in which mild was defined as normal or movement against gravity and resistance, moderate was movement against gravity with resistance eliminated, and severe was partial movement with gravity eliminated, with a trace of muscle contraction. Outcomes were also graded: good outcome, full work and minimal disability; fair outcome, partial disability; and poor outcome, bed rest, vegetative state, or death. The follow-up period was from 43 days to 4 months (with the exception of four patients who died of complications). Correlations were made between the angiographic site of occlusion, retrograde filling, CT findings, degree of hemiparesis on admission, and outcome.

Results

Occlusion of the MCA occurred on the left side in 24 patients and on the right in 16. Eleven of the 40 patients had hypertension and had been treated by antihypertensive medications. The prevalence of diabetes mellitus was 8% in this study. Mortality was 10%.

At the onset of stroke, 22 patients (55%) had a mild disturbance of consciousness, but no patients were comatose. Mild hemiparesis was found in 14 patients, moderate hemiparesis in nine, and severe hemiparesis in 17. Two patients (5%) had a transient ischemic attack (TIA), and the remaining 38 patients had a complete stroke. Four patients (10%) had had previous ischemic events in the symptomatic side. Two of these four patients had TIA, and the remaining two had complete stroke.

In 13 patients the MCA was occluded at the proximal portion of the M1 segment. Another 13 patients showed the MCA occluded at the distal portion of the M1 segment, and the remaining 14 had occlusion of the M2 segment. Two patients had mild ipsilateral ICA stenosis of less than 50%.

The degree of hemiparesis of each patient on admission is indicated in Figure 3, in relation to the site of occlusion, retrograde filling, and CT findings. Figure 4 shows outcomes of the patients in relation to the site of occlusion, retrograde filling, and CT findings. All 13 patients with occlusion of the proximal M1 (group A) showed basal ganglia–centrum semiovale or hemispheric type findings on CT. Of seven patients with basal ganglia–centrum semiovale type findings on CT, six patients (86%) showed retrograde filling from the anterior cerebral artery (ACA), whereas of six patients...
FIGURE 2. Computed tomographic findings were classified into five categories (see text): basal ganglia–centrum semiovale type; localized cortex–subcortical type; lobular cortex–subcortical type; hemispheric type; and normal type (not shown).

with hemispheric type findings on CT only two (33%) showed retrograde filling. In the patients with occlusion of the distal M1 (group B), findings on CT were basal ganglia–centrum semiovale in four, localized cortex–subcortical in four, lobular cortex–subcortical in three, hemispheric in one, and normal in one patient. The group B patients with basal ganglia–centrum semiovale type findings on CT showed an LDA in the centrum semiovale but not in the basal ganglia. In the patients with occlusion of the M2 (group C), findings on CT

<table>
<thead>
<tr>
<th>Site of occlusion</th>
<th>Proximal M1 (Group A)</th>
<th>Distal M1 (Group B)</th>
<th>M2 (Group C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal ganglia –</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>centrum semiovale</td>
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<td>type</td>
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<tr>
<td>Localized cortex</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
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<tr>
<td>– subcortical</td>
<td>O</td>
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<td>type</td>
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<tr>
<td>Lobular cortex</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>– subcortical</td>
<td>O</td>
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<td>type</td>
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<td>Hemispheric</td>
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<tr>
<td>Normal type</td>
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FIGURE 3. Chart showing degree of hemiparesis on admission in relation to site of occlusion, computed tomographic (CT) findings, and retrograde filling. O, Mild hemiparesis; Δ, moderate hemiparesis; x, severe hemiparesis.
were localized cortex–subcortical type in 10 and normal type in four patients (Figures 3 and 4).

Most patients with severe hemiparesis showed lobular cortex–subcortical and hemispheric type findings on CT. All patients with normal type findings on CT showed mild hemiparesis, and most patients with basal ganglia–centrum semiovale or localized cortex–subcortical type findings on CT had moderate hemiparesis (Figure 3). The degree of hemiparesis on admission was well correlated to the CT findings.

The outcome was rated good in 12 (30%), fair in eight (20%), and poor, including death, in 20 (50%) patients. Four patients (10%) died of complications at the acute stage of the disease. Outcomes of patients in group A and group B were poor. However, the outcome was better in patients in group A and group B with retrograde filling than in those without retrograde filling. Outcomes of patients in group C were generally good irrespective of the presence or absence of retrograde filling (Figure 4). Patients with occlusion of the distal MCA branches to the motor cortex, however, showed poor outcome.

Discussion

Most of the published studies on MCA occlusion have not excluded embolic occlusion. The differential diagnosis between thrombotic and embolic MCA occlusion may be difficult. To improve the reliability of the selection of thrombotic MCA occlusion, patients who had atrial fibrillation or carotid artery ulceration were excluded based on clinical features, CT findings, and angiographic findings. It has been reported frequently that embolic MCA occlusion is more common than thrombotic MCA occlusion; Lhermitte et al. found that only 12.5% of 40 MCA occlusions were due to local thrombosis. However, in the Japanese population thrombotic MCA occlusion is reported to be more common.

In this study, the mean age of 66.4 was higher than that in other reports. The mortality rate of this series was essentially the same as that in the study of Bogousslavsky et al. Therefore, age did not have a significant influence on death. Male predominance was noted in this series, as in other reports. Allcock reported no laterality of the side of the lesion, although others have reported left side predominance.

In this series we reported no laterality of the lesion. In our patients, 18 of 40 (45%) had hypertension, and three (8%) had diabetes mellitus resulting in hypertension. Hypertension is an important risk factor in thrombotic MCA occlusion. This finding agrees with other reports.

TIA has been defined as a temporary, focal neurological deficit presumably related to ischemia, lasting less than 24 hours. Only two patients presented with TIA; the remaining 38 patients presented with complete stroke. Caplan et al. and Sindermann et al. reported that TIA, as an initial symptom, was more frequently observed in ICA occlusion than in MCA occlusion. Thrombotic MCA occlusion has a more benign effect than embolic MCA occlusion, perhaps because the development of collateral circulation is better in gradual thrombotic occlusion than in sudden embolic occlusion. Therefore, although disturbance of consciousness was found in 21 patients (53%), severe disturbance of consciousness as occurs in the case of embolic occlusion was not observed.

In group A, most patients with good retrograde filling showed basal ganglia–centrum semiovale type findings on CT, whereas four of five patients without retrograde filling showed hemispheric type findings on CT (Figures 3 and 4). We offer two possible explanations for the fact that basal ganglia–centrum semiovale type findings oc-
perforators of M1 segment are most distal to collateral circulation. Center panel: Atherosclerotic changes may involve origin of perforators. Right panel: Paraventricular zone may be supplied by medullary branches (arrows) rising from distal middle cerebral artery (MCA). See text for further discussion.

Outcomes were worse in patients with hemispheric type findings than in patients with basal ganglia—centrum semiovale type findings. In addition to CT findings, presence or absence of retrograde filling appears to affect the outcome and degree of hemiparesis in group A patients. Krayenbuhl and Yasargil, Fisher et al., and Saito et al. found that the amount of collateral circulation was intimately related to final outcome. In contrast, Sindermann et al. noted no correlation between collateral circulation and outcome. In our series, collateral circulation was found to affect outcome in group A and group B patients but not in group C patients. It is reasonable to assume that not only collateral circulation but also the site of occlusion plays an important role in the outcome of MCA occlusion.

Taking MCA distribution into consideration, it is understandable that most of the patients in group B showed localized cortex—subcortical or lobular cortex—subcortical type findings on CT. However, basal ganglia—centrum semiovale type findings on CT were also shown in four patients in group B. LDAs in these four patients were found in the centrum semiovale but not in the basal ganglia. These findings suggest that the centrum semiovale in these patients was supplied by the medullary branches rising from the distal MCA (Figure 5, right panel). Patients in group C showed either localized cortex—subcortical or normal type findings on CT.

No ischemic events occurred in this series, probably because of the short duration of the follow-up period (from 43 days to 4 months). According to Bogousslavsky et al., ischemic events during the follow-up period (35–72 months) occurred in only 10% of the patients with isolated MCA occlusion. Therefore, surgical indication for revascularization after thrombotic MCA occlusion should be determined carefully in the chronic stage. If surgical revascularization is regarded as the construction of an artificial collateral circulation, our finding that good collateral circulation improves the outcome for thrombotic occlusion of the proximal and distal M1 segments supports the possible benefits of such surgery.

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