Indications for surgical intervention in middle cerebral artery obstruction

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The clinical, angiographic, and surgical characteristics of 31 patients with high-grade middle cerebral artery (MCA) stenosis or occlusion (jointly termed “MCA obstructions”) referred for cerebral revascularization by extracranial-intracranial (EC-IC) bypass are reviewed. Overall, 12 (66%) of the 18 patients with stenosis and all 13 (100%) of those with complete occlusion experienced clinically evident infarctions. Twenty-five of these patients underwent arteriography at least twice during their clinical course. Eleven (44%) demonstrated significant improvement in flow or complete resolution of obstruction on their second study. Ten of these 11 were patients in whom the initial arteriography was done within 2 weeks of symptom onset. Five other patients with stenosis exhibited obstruction that was worse on serial arteriography without surgical intervention.

The high incidence of resolution of MCA obstructions indicates that surgery should not be contemplated in most instances until delayed arteriography has been performed, at least 6 weeks after the onset of symptoms. Proximal embolic sources, such as the cervical carotid bifurcation, should receive carotid endarterectomy and repeat arteriography in appropriate patients prior to consideration of EC-IC bypass. Persistent high-grade MCA obstructions are thereafter potential candidates for EC-IC bypass, since leptomeningeal collateral vessels are marginal in their protective ability. Overall, of 15 patients who underwent an EC-IC bypass procedure, 14 were either stable or improved postoperatively, and 13 have been free of any further ischemic events without the use of major anticoagulant agents.

Key Words • middle cerebral artery • ischemia • cerebral arteries • cerebral arteriosclerosis • revascularization • embolism • thrombosis • anastomosis

High-grade middle cerebral artery (MCA) stenosis and occlusion (jointly termed “MCA obstructions”) in this report theoretically represent the most ideal lesions to treat with an extracranial-intracranial (EC-IC) bypass procedure, because the obstruction occurs distal to the usual collateral pathways (ophthalmic, anterior communicating, or posterior communicating arteries). The increased availability of this operation, in combination with earlier and safer arteriographic investigation of the stroke-prone patient, has resulted in the identification of greater numbers of these previously surgically unapproachable intracranial vascular obstructions.

To further define the role of surgery in patients with MCA obstructions, all patients with this diagnosis seen by the neurosurgery service at the University of Florida over the past 7 years have been reviewed. The information gained from the angiographic evolution of the obstruction and from an assessment of the effectiveness of surgery in the treatment of these lesions forms the basis of this report.

Summary of Cases

Thirty-one patients were found to have appropriately symptomatic and angiographically demonstrated high-grade MCA trunk stenosis or occlusion. The MCA trunk (M1 segment) in this series includes that part of the MCA extending from the terminal internal carotid artery division to its bifurcation at the genu, as the vessel turns to enter the operculoinsular compartment of the Sylvian fissure. In distally located obstructions, the presence of an early temporal bifurcation arising from the MCA trunk did not preclude a diagnosis of MCA occlusion. Lesions were judged to be high-grade when the lumen was narrowed by at least 70% (as determined by anteroposterior angiograms), and when distal MCA run-off was slowed (relative to filling of the anterior cerebral branch).

Most of these patients were evaluated at another institution, where the initial angiographic pictures revealed the MCA lesion. They were thereafter referred to our neurosurgery service for consideration for an
Surgical indications in MCA occlusion

**TABLE 1**

*Clinical features of 31 patients with MCA obstruction*

<table>
<thead>
<tr>
<th>Clinical Features</th>
<th>MCA Stenosis</th>
<th>MCA Occlusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>no. of cases (31)</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>mean age (yrs)</td>
<td>66</td>
<td>52</td>
</tr>
<tr>
<td>male to female ratio</td>
<td>11:7</td>
<td>12:1</td>
</tr>
<tr>
<td>presenting symptoms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIA’s only</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>TIA’s + stroke</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>stroke only</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>obvious embolicsource</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>(carotid sinus)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* MCA = middle cerebral artery; TIA’s = transient ischemic attacks.

**TABLE 2**

*Features of patients undergoing arteriography at least twice*

<table>
<thead>
<tr>
<th>Angiographic Features</th>
<th>MCA Stenosis</th>
<th>MCA Occlusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>total cases in series</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>early arteriography</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no. of cases</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>improved†</td>
<td>5 (55%)</td>
<td>5 (55%)</td>
</tr>
<tr>
<td>late arteriography</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no. of cases</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>improved†</td>
<td>0 (0%)</td>
<td>1 (50%)</td>
</tr>
<tr>
<td>total cases with repeat arteriography improved†</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>worse†</td>
<td>5 (36%)</td>
<td>6 (55%)</td>
</tr>
<tr>
<td></td>
<td>7 (50%)</td>
<td>0</td>
</tr>
</tbody>
</table>

* Early arteriography was performed within 2 weeks of symptom onset; late arteriography was carried out more than 2 weeks after symptom onset. Numbers in parentheses are percentages of the total in each category. MCA = middle cerebral artery.
† Obstruction improved or worse on second arteriographic study.

EC-IC bypass. Thus, this population does not include patients with acute lesions, and is generally biased to include either younger patients or those with a relatively good clinical status following onset of their symptoms. Furthermore, this series contains no patients with obvious cardiac embolic sources, such as atrial fibrillation or recent myocardial infarction. Most patients were also evaluated by a cardiologist and underwent echocardiography to exclude valvular disease. As referral was often delayed by several weeks, most patients had received a trial of medical therapy prior to arrival at our institution. No patient developed any new permanent deficits during this interval.

Computerized tomography (CT) scans were obtained in 30 of the 31 patients. When present, infarctions were judged to be in a lenticulostriate (usually lacunar) or cortical distribution. Before a final decision was reached whether to operate, many patients underwent repeat arteriography at least 4 to 6 weeks after the initial study, thus providing a radiographic glimpse at the effectiveness of medical therapy upon the evolution of various pathological entities. These repeat arteriograms, when correlated with CT scans and the clinical outcome following operative intervention, were then used to further define the role of surgery in the management of these lesions.

The clinical courses of all patients were then categorized as improved, stable, or worse. An improved patient was one who experienced cessation of previous transient ischemic attacks (TIA’s) without prolonged use of major anticoagulant drugs, or who exhibited objective improvement in neurological function. A stable patient was one who continued to have TIA’s (if present before treatment) or who maintained a steady neurological status without acquiring further permanent deficits from ischemic episodes. Patients were considered worse when they experienced additional ischemic deficits (transient or permanent) that were not evident at the time of the initial diagnosis of MCA obstruction.

**Results**

Obstructions were divided into two groups based on patency of the MCA at the time of original arteriography. There were 18 cases of MCA stenosis and 13 cases of total MCA occlusion. The clinical, radiographic, and surgical features of the 31 cases are shown in Tables 1 to 4.

**Clinical Features**

Table 1 summarizes the clinical features of the cases in this series.

**Stenosis Group.** The mean age at presentation (onset of symptoms) of the 18 stenosis patients was 66 years, and there was a male to female preponderance of 11:7. The presenting symptoms were generally mild (TIA’s or TIA’s plus mild stroke). None of these patients exhibited an obvious proximal source of emboli from the cervical carotid bifurcation.

**Oclusion Group.** In contrast, the mean age of the 13 patients with MCA occlusion was younger (52 years), and a more striking male to female predominance (12:1) was observed. Symptoms tended to be more severe in patients with occlusion. All patients had experienced at least a minor stroke (cerebrovascular attack). Six patients exhibited an abnormal cervical carotid bifurcation, which was thought to provide an obvious embolic source (high-grade stenosis or ulceration) in five.

**Radiographic Features**

Tables 2 and 3 present the radiographic features of the 31 patients.

**Stenosis Group.** In the 18 patients with MCA stenosis, initial arteriography was performed within 2 weeks of the first symptom in 10 patients, nine of whom received a second arteriographic study. Five (55%) of these nine patients demonstrated significant improvement or resolution in the degree of stenosis, with subsequent elimination of flow impairment into the distal MCA branches (Table 2). The other eight patients with...
TABLE 3

Results of computerized tomography scanning in 31 patients*

<table>
<thead>
<tr>
<th>CT Findings</th>
<th>MCA Stenosis</th>
<th>MCA Occlusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>normal scan</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>lenticulostriate infarct</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>cortical infarct</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>lenticulostriate &amp; cortical infarcts</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>no scan</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>total cases</td>
<td>18</td>
<td>13</td>
</tr>
</tbody>
</table>

* CT = computerized tomography; MCA = middle cerebral artery.

stenosis received their initial angiography more than 2 weeks after symptom onset. Five of these eight patients underwent a second study, but none demonstrated angiographic improvement of the original obstruction. Overall, 14 patients in this group underwent arteriography at least twice, and five (36%) exhibited improvement in their stenosis on the follow-up study (Fig. 1).

Significant improvement of stenosis was not noted in patients with long-standing symptoms (longer than 2 weeks) prior to initial arteriography, or in those with definite underlying vasculitis (such as moyamoya disease); long arterial segments with multifocal areas of stenosis appeared less likely to improve between serial arteriograms. Furthermore, seven patients demonstrated worsening of stenosis during their clinical management (Table 2), and in two of these deterioration was accelerated by operative intervention.

The amount of brain destruction demonstrated by CT scanning (Table 3) tended to be quite minor in the patients with stenosis, and correlated well with the milder clinical symptoms. Eight stenotic patients had a normal CT scan, and six showed a lacunar infarct in the lenticulostriate distribution only. Cortical infarction, when present (three cases), tended to be small in size. No patient with stenosis exhibited both cortical and lenticulostriate infarcts. In one patient, no CT scan was available for review.

Oclusion Group. Among the 13 patients with MCA occlusion, 10 received their initial arteriography within 2 weeks of onset of symptoms (Table 2), nine of whom subsequently underwent a second study. Five (55%) of the nine demonstrated significant recanalization of their previous occlusion. The three other patients received their first arteriographic study more than 2 weeks after onset of symptoms. Two of these three underwent a second study, and only one demonstrated recanalization. This one patient was known to have had the occlusion for more than 8 weeks, in association with severe ipsilateral cervical carotid stenosis, and arteriography performed 6 weeks following carotid endarterectomy revealed the restoration of flow. Overall, six of the 11 patients who received at least two arteriographic studies exhibited marked resolution of obstruction on their follow-up study.

Five patients in this group demonstrated an obvious embolic source from the ipsilateral cervical carotid bifurcation. Four of these received repeat arteriography, and resolution occurred in two cases (50%).
Surgical indications in MCA obstruction

Brain destruction as recorded on CT scans was generally more severe in patients with occlusion than in those with stenosis (Table 3), and paralleled the clinical course of the patients. Overall, two of the 13 patients with occlusion demonstrated lacunar infarction in the lenticulostriate distribution only, three had cortical infarction alone, five exhibited both lenticulostriate and cortical infarcts, and three had normal scans. In the patients with occlusion, a much higher incidence and larger size of cortical infarction (eight of 13 patients) was noted, and, when present, its distribution often coincided with angiographically demonstrable persistent occlusion of the appropriate MCA branch (despite resolution of main-trunk obstruction).

Surgical Features

Table 4 details the surgical features in this series.

Stenosis Group. Nine of the 18 patients with stenosis underwent surgery, all EC-IC bypass procedures using the superficial temporal artery. Seven of these patients received postoperative arteriography, which documented graft patency in all instances and excellent flow volumes in six cases. None of these seven patients demonstrated improvement of their stenosis on postoperative arteriography, while two showed increased stenosis to total MCA occlusion.

Five patients with MCA stenosis were judged improved after the procedure, while three were stable and one was mildly worse. All five improved patients had cessation of TIA's following surgery, with two also exhibiting substantial neurological improvement. Four of these five patients received postoperative arteriography, and excellent flow was present in each case. Of the three patients judged to be stable, two had experienced preoperative infarction without TIA's, while the other had continued to experience TIA's after her infarction (secondary to moyamoya disease). The two patients with infarction only have experienced no postoperative ischemic episodes, and bypass patency was excellent in the one case receiving a postoperative study. The one patient with persistent postoperative TIA's from moyamoya disease exhibited very poor flow through the arterial bypass, and ultimately received another arterial and saphenous vein bypass without relief of symptoms.

The only permanent deficit following surgery was very mild, and occurred in a young woman whose stenotic MCA thrombosed after an EC-IC bypass procedure with clipping of a giant MCA aneurysm. Two other patients experienced transiently increased deficits that were probably related to thrombosis of the stenotic segment (one case was not documented angiographically). In these two patients, the new deficits resolved quickly; one was ultimately classified as improved and the other as stable following surgery (Fig. 2).

The average postoperative follow-up period for this group was 2½ years, and is still continuing in all patients. Postoperative antiplatelet drugs are routinely maintained for the duration of the patient's life in cases of stenosis.

Occlusion Group. Ten of the 13 patients with total MCA occlusion underwent a surgical procedure, including five carotid endarterectomies and six EC-IC bypasses (Table 4). One patient received two procedures, one of each type. Of the five carotid endarterectomy patients, one patient with a long-standing occlusion demonstrated main-trunk recanalization following the procedure, while another demonstrated recanalization prior to endarterectomy. No EC-IC bypass was contemplated thereafter in these two patients. Two other endarterectomy patients did not receive a bypass procedure. One of these patients developed an intracerebral hemorrhage into an area of MCA infarction while on heparin therapy, and his poor clinical standing precluded further consideration for EC-IC bypass; the other one did not wish to undergo another procedure. In the fifth endarterectomy patient, the MCA occlusion did not resolve following the initial procedure, and he subsequently received an EC-IC bypass. No clinical improvement that could be related to carotid endarterectomy was noted in any of these five patients.

Six patients with MCA occlusion underwent an EC-IC bypass (Table 4); five of these had postoperative arteriography. In two patients, recanalization was seen on the postoperative study. The graft was patent in both instances but filled only the distal segment of the MCA branch to which it was anastomosed; the remainder of the viable MCA territory filled via the main trunk in a natural (orthograde) fashion (Fig. 3). These patients with recanalized obstructions received no obvious benefit from the EC-IC bypass, and have exhibited a stable neurological course without any new deficits during the follow-up period. Both of these patients had received only one preoperative study early after the onset of symptoms.

The remaining four patients with occlusion who underwent EC-IC bypass reported improvement in neurological status after bypass surgery. Three of these received postoperative arteriography, which showed excellent patency in all. Each of these three patients exhibited preoperative clinical cortical deficits (two of

<table>
<thead>
<tr>
<th>Surgical Features</th>
<th>MCA Stenosis</th>
<th>MCA Occlusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC-IC bypass</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>angiographic results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no. with postop angiography</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>no. patent</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>no. with excellent patency</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>clinical status improved</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>stable</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>worse</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>carotid endarterectomy</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>EC-IC bypass &amp; carotid endarterectomy</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

* EC-IC = extracranial-intracranial; MCA = middle cerebral artery.
which were major) but no brain destruction of the appropriate cortex was shown on CT scanning. Each experienced significant and often dramatic postoperative improvement (including the two patients with major deficits), which could be clearly related temporally to their procedure. One of these improved patients developed a recurrent deficit in the originally affected MCA territory 1 year postoperatively. This ischemic event was associated with cortical infarction and thrombosis of a documented successful superficial temporal artery bypass graft, thus causing the patient to revert to his initial preoperative state. Although substantial postoperative improvement had occurred in this patient for 1 year, he has been classified as stable following his second ischemic episode.

Discussion

The main trunk of the MCA is a common location of intracranial obstructive lesions, and is the site of involvement in 12% to 20% of patients subjected to EC-IC bypass procedures.5,13,24 This vessel has been appropriately termed “the artery of embolism,” as it offers a frequent lodging site for migrating thrombi from the heart or cervical carotid bifurcation.7 This segment, however, may also be affected by other pathological entities, including: 1) focal atheroma with or without associated thrombus, intramural hemorrhage, or embolization; 2) reactive spasm; 3) vasculitis; and 4) subintimal hemorrhage and dissection.2,6,7,17,18,22 In the absence of obvious embolic sources (heart or carotid bifurcation), differentiation of the underlying etiology (and its natural history) may be extremely difficult on a single early arteriographic study.

Such confusion surrounding the underlying pathology and its natural history assumes greater importance in the present era of EC-IC bypass surgery.4 As reflected by our data, many of these patients had embolic occlusions or secondary events within atheromas which resolved within several weeks. The unwary microvascular surgeon who operates on such patients without the benefit of delayed repeat arteriography may find the surgery unnecessary and less than ideally successful. Careful study of other bypass series may disclose similar instances when the procedure was done on the basis of a single early arteriographic study made shortly after symptom onset.20

Resolution of these obstructions can occur regardless of location, supposed underlying pathology (such as emboli or atheromas), or degree of severity (stenosis or occlusion).2,4,6,15,18 Overall, 25 patients in this series underwent arteriography at least twice during their clinical course (Table 2) and 11 (44%) demonstrated

Fig. 2. Angiograms of the left common carotid artery, anteroposterior view, showing progressive middle cerebral artery (MCA) stenosis in a 74-year-old man with multiple transient ischemic attacks (Group 4). For a description of groups see text. Left: Angiogram after 6 months of anticoagulant therapy. There is persistent MCA stenosis with poorer MCA filling, compared to an earlier study. Right: Study 9 days after extracranial-intracranial bypass. There is excellent MCA filling via the bypass, and no further orthograde filling of the MCA beyond the lenticulostrate origins. Three days after surgery, the patient experienced expressive dysphasia which cleared rapidly.
Surgical indications in MCA obstruction

significant improvement in flow via the normal MCA pathway or complete resolution of obstruction on the second study. The initial arteriography was done within 2 weeks of symptom onset in 10 of 11 cases in which obstruction resolved. Thus, the ability to identify such lesions and determine their evolution appears directly related to the timing of arteriography. If a patient with long-standing symptoms undergoes arteriography that demonstrates a high-grade MCA obstruction, such a lesion would be very unlikely to resolve on a later study. In addition, arteriography performed more than 2 weeks after onset of symptoms may completely miss the interval during which the artery was obstructed, allowing the diagnosis to remain obscure.

Although resolution of obstruction is generally believed to be unimportant in most instances in the patient’s recovery from neurological deficits sustained following the initial ischemic event, four patients in this series exhibited a clinical course that might suggest otherwise.4,10 Each of these four patients demonstrated persistent MCA obstruction (after serial arteriography) and cortical deficits out of proportion to the CT evidence of brain destruction. Each substantially improved shortly after EC-IC bypass, suggesting a causal relationship to the procedure. Furthermore, such resolution of obstruction is very important in the selection of potential surgical candidates; improved flow eliminates a basic requirement for maximal efficacy of the EC-IC bypass: reduced MCA perfusion pressure with delayed branch filling.

It is this author’s opinion, therefore, that most patients with an angiographic diagnosis of high-grade MCA obstruction (stenosis or occlusion) should not receive an EC-IC bypass until a sufficient interval has elapsed to exclude the chance of recanalization. The possibility of a proximal embolic source should be carefully investigated during the initial evaluation, with particular emphasis on the heart and ipsilateral cervical carotid bifurcation. Thereafter, angiography should be repeated approximately 6 weeks after the initial ischemic symptom, a period chosen arbitrarily from our data and from various other reports in the literature.2,9,15

FIG. 3. Angiograms in a 40-year-old man with acute hemiparesis and no repeat arteriography prior to extracranial-intracranial (EC-IC) bypass (Group 3). For a description of groups see text. Left: Lateral view of the right common carotid artery 1 week after onset of the deficit showing the proximal middle cerebral artery (MCA) occlusion. The patient later received EC-IC bypass without clinical improvement. Right: Lateral view of the right internal carotid artery 9 months after the EC-IC bypass procedure. The MCA trunk occlusion has recanalized. Lower: Lateral view of the right external carotid artery, also at 9 months after bypass. “Successful” EC-IC bypass filling is seen in only one distal cortical branch.
Short-term medical management appears safe and should be maintained in the interval between studies.\(^{14}\)

Selection for surgery is facilitated by segregation of patients into several groups based on clinical, CT, and serial angiographic information (Fig. 4). Group 1 includes patients with cervical carotid bifurcation disease ipsilateral to the MCA obstruction. These patients should be considered strong candidates for endarterectomy, assuming a reasonable neurological status. Even if the obstruction does not resolve, the potential continued risks of embolization places other intracerebral vessels in jeopardy. Furthermore, one of our patients in this group demonstrated late resolution of his occlusion after endarterectomy, possibly related to the increased proximal intravascular pressure afforded by the procedure. Assuming successful completion of endarterectomy, persistent MCA obstruction may then receive consideration for an EC-IC bypass, as indicated below.

Group 2 includes patients with major cortical and subcortical brain destruction (as determined by CT scanning) and major neurological dysfunction. This group contains most patients with major embolic MCA obstructions, and many will have experienced major cerebral infarctions. Patients with active arterial inflammatory diseases, such as herpes zoster, were also included in this group. The number of Group 2 patients in our series is small because, as previously mentioned, obvious cardiac embolic sources, severe deficits, or other severe medical illnesses generally precluded referral. In such patients with excellent correlation between major clinical and CT findings, the limitations of cerebral revascularization are obvious, even if the MCA obstruction has not resolved. Unless such patients improve clinically, this group should not receive repeat arteriography.

Group 3 includes patients with resolved stenosis or occlusion who are left with good neurological function. After satisfactory treatment of proximal embolic sources, medical management in this group is advised. A restricted trial of anticoagulant drugs, followed by conversion to antiplatelet drugs, may be most ideal, but a clear advantage to the initial use of major anticoagulant agents cannot be derived from our experience. If new symptoms develop in spite of medical management, a repeat study and EC-IC bypass may be indicated.

Group 4 includes those patients with unresolved MCA obstructions (occlusion or stenosis) and acceptable CT and neurological deficits. This was the largest clinical category in this series. Hinton, \textit{et al.} \(^{14}\) have suggested that, at least for stenotic lesions, the clinical course of many of these high-grade obstructions is quite benign when managed medically. No new permanent deficits were noted in our patients with stenosis during a brief trial of medical treatment (at least 6 weeks), thus providing some support for the views of these authors. However, while our data suggest that the natural history of MCA stenosis is less severe than that of occlusion, the benign nature of stenosis at this site cannot be confirmed. Twelve of the 18 stenosis patients in this study experienced a clinical infarction (Table 1). Many of these patients had been receiving minor anticoagulation therapy (aspirin and dipyridamole).

Furthermore, in five of the patients with stenosis who had no surgical intervention, the lesions appeared worse on serial arteriography, indicating that in many cases the stenosis may progress toward occlusion. In addition, the exact cause of the persistent occlusion in some cases was frequently unclear in the absence of a proximal embolic source, and some of these unresolved cases may have represented arteriosclerotic stenoses that progressed to occlusion. Since total occlusion is typically

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**Fig. 4.** Suggested management schema in cases of middle cerebral artery (MCA) obstruction. CT = computerized tomography; TIA's = transient ischemic attacks; EC-IC = extracranial-intracranial.
Surgical indications in MCA obstruction

associated with a higher incidence and severity of infarction (Tables 1 and 3), aggressive surgical treatment appears reasonable, especially if the lesion is persistently high-grade and/or threatens to progress to occlusion.

The overall safety and efficacy of the bypass procedure are listed in Table 4. Fourteen of 15 patients who received an EC-IC bypass procedure were either stable or improved postoperatively. Two patients exhibited transient neurological worsening following the procedure, probably due to postoperative progression of stenosis to total occlusion.\(^\text{8,12}\) The only permanent operative deficit was mild, and occurred in a woman in whom the conversion from stenosis to occlusion was greatly influenced by the clipping and removal of her giant MCA aneurysm. Excluding two patients who need not have had the procedure (Fig. 3), and three others who did not receive postoperative arteriography, nine of 10 patients (90%) in this series exhibited excellent angiographically proven bypass patency.

Unlike the situation with the more common obstructions at the bifurcation or intracavernous carotid sites, the area distal to the MCA trunk has greater limitations in collateral circulation capabilities. The anterior communicating (from the opposite carotid artery), posterior communicating (vertebrobasilar arteries), and ophthalmic (external carotid sources) vessels cannot contribute flow, as the obstructive lesion is located at the final common pathway beyond the insertion of these communications. Thus, the entire MCA territory is dependent on leptomeningeal collateral vessels only, and these channels, connecting the anterior and posterior cerebral vessels with the MCA, are marginal in their protective capabilities.\(^\text{4,19,23}\)

Although major anticoagulation drugs (heparin or sodium warfarin) appeared greatly effective in the experience of Hinton, et al.,\(^\text{16}\) the long-term use of such medicines carries substantial risks\(^\text{14,21}\) and accounted for a disastrous complication in one of our patients with MCA occlusion. Furthermore, such medicines would not be expected to increase blood flow into an ischemic area. An EC-IC bypass, however, does achieve this theoretical aim, and within the group of 15 such procedures, 13 patients have been free of any further ischemic events without the postoperative use of major anticoagulant drugs.

The exact mechanisms (emboli versus reduced blood flow)\(^\text{4}\) responsible for the symptoms associated with persistent MCA obstructions are not always apparent, but the delay of blood flow distal to the obstruction is strikingly clear angiographically in many instances. Certainly, lesser degrees of stenosis, which produce no flow delay, should be initially managed medically for presumed embolic causes. Surgery may thereafter be indicated for persistent high-grade obstructions, especially if breakthrough symptoms occur on medical treatment and the age and general medical health of the patient are optimal. Following a successful bypass procedure, the incidence of postoperative MCA thrombosis is significant. However, thrombosis was not associated with any major permanent neurological sequelae in our series.

A subcategory of Group 4 in this series included four patients with unresolved MCA obstruction in whom the cortical neurological deficit appeared out of proportion to the amount of brain destruction visualized on CT scanning. These patients, while suffering from an admittedly uncommon condition, might be ideal candidates for preoperative positron emission tomography scanning to determine oxygen extraction ratios in the clinically affected areas. A bypass operation appears quite reasonable within this subgroup, as it may restore metabolic substrates to potentially viable cortex, thereby promoting recovery.\(^\text{3,11}\)

Summary

Symptomatic MCA obstruction has many causes, and its angiographic demonstration should not be considered an automatic indication for EC-IC bypass, especially if the study is done early after the onset of symptoms. A brief trial of medical management, followed by a second arteriographic study approximately 6 weeks later, will minimize the number of hemodynamically unnecessary operative interventions. Thereafter, EC-IC bypass is highly effective in relieving TIA's, and may promote major clinical improvement in some patients with cortical neurological deficits but without radiographic evidence of cortical infarction.

References


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