Artery-to-Artery Embolism From a Thrombus Formed in Stenotic Middle Cerebral Artery
Report of an Autopsy Case

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The authors report an autopsy case with repeated transient ischemic attacks and subsequent strokes demonstrating evidence of artery-to-artery embolism from thrombi generated in the stenotic middle cerebral artery to the distal cortical branches. This case substantiates the existence of intracranial artery-to-artery embolism as a cause of transient ischemic attacks and subsequent strokes, and has potential relevance for therapy. (Stroke 1987;18:680-684)

Stenosis of the middle cerebral artery (MCA) associated with atherosclerosis is a much less common cause of symptomatic ischemia than is embolism of the MCA. Stenosis is, however, important in that it often presents as transient ischemic attacks (TIAs) and subsequent cerebral infarction through the possible mechanisms of hemodynamic changes or artery-to-artery embolism from thrombi formed on such lesions. In addition, stenosis has recently received much attention because it provides an opportunity for extracranial-intracranial (EC-IC) arterial anastomosis. We report an autopsied case with TIAs and subsequent completed strokes demonstrating a definite evidence of artery-to-artery embolism from thrombi generated on the intimal surface of the stenotic lesion in the MCA.

Report of a Case
The patient was a 67-year-old, right-handed woman who had been suffering from hypertension for 3 years. Forty-five days before her death, she had a sudden attack of numbness in the right half of the lips and difficulty pronouncing words, lasting for 5 minutes. On the next day, a similar episode of numbness of the lips and speech difficulty occurred again, associated with right lower extremity weakness. The symptoms disappeared within 5 minutes. Eleven days after the initial episode, she developed speech difficulty, numbness of the right fingers and toes, and weakness of the right hand on awakening. The symptoms gradually improved thereafter. Seventeen days after the initial episode, she was transferred to the Stroke Care Unit of the National Cardiovascular Center.

The neurologic examination on admission revealed nonfluent aphasia, dysarthria, right hemiparesis including the face, and hypesthesia of the distal portions of the right extremities. Hyperreflexia and pathologic reflexes were evident on the right. Her blood pressure was 150/70 mm Hg. The remainder of her physical examination was normal. Complete blood count, serum cholesterol, total protein, fibrinogen, prothrombin time, partial thromboplastin time, chest x-ray, and ECG were normal.

Left carotid arteriography demonstrated severe stenosis of the horizontal portion of the left MCA and occlusion of the cortical branches other than the posterior temporal and orbitofrontal arteries (Figure 1). The left MCA area was largely supplied by retrograde leptomeningeal collaterals, mostly from the left anterior cerebral artery.

Her symptoms had been improving gradually, but 12 days after the onset of the last ischemic event of the brain, she suddenly exhibited a shock state and died within 8 hours. Neither anticoagulation nor antiplatelet therapy had been prescribed for the ischemic events of the brain.

Results
Autopsy examination revealed thromboemboli to the trunks of the pulmonary arteries of both lungs, which were responsible for the sudden onset of shock and were the cause of death. There was hypertrophy of the left ventricle of the heart. There were no specific pathologic changes in the left atrium, ventricle, and valves, and both carotid arteries showed only mild stenosis at their bifurcations.

The brain demonstrated a fresh infarct in the left MCA territory, involving the posterior half of the insular cortex, the putamen, and the internal capsule (Figure 2). The infarct consisted of ischemic necrosis of the neurons, vacuolization of neuropils, macrophages, and punctate hemorrhage mostly around small blood vessels.

The atherosclerosis of the circle of Willis was slight to moderate, but the left MCA showed severe stenosis
due to atheromatous plaque proximally where fresh fibrin-platelet thrombi were generated on its intimal surface (Figure 3). One of the cortical branches shortly after branching from the MCA was occluded by mixed thromboemboli containing a large amount of fibrin and platelets (Figure 4 top). Some of the other cortical branches of the MCA were partially occluded with fibrin-platelet thromboemboli (Figure 4 bottom). There was no atherosclerotic change in these cortical branches containing emboli. The diameter of the lumen of the stenotic MCA shown in Figure 3 was 180 × 400 μm, while that of the embolus occluding the cortical branch shown in Figure 4 top was 600 × 950 μm. Complete serial sections between the stenotic site of the MCA and the occluded cortical branches were made to confirm the discontinuity of the thrombi. This study showed the patency of the artery in areas between thrombi, undoubted evidence of artery-to-artery embolism from thrombi generated on the surface of the stenotic lesion of the proximal MCA to the distal cortical branches.

Discussion
The clinical importance of arterial stenosis in the cerebrovascular system lies in its relation to the occurrence of cerebral ischemic events, such as TIAs and strokes. Its pathophysiologic mechanisms have been considered to be either hemodynamic changes or artery-to-artery embolism. It is, however, difficult to tell which mechanism is responsible for an individual patient’s condition and to determine the relative importance of such mechanisms.

Anticoagulation⁴ and antiplatelet therapy⁵ have been shown to have a prophylactic effect for subsequent cerebral ischemic events in patients with TIAs. These results suggest that artery-to-artery embolism from thrombi formed on ulcerated atherosclerotic lesions in stenotic cerebral arterial trees is responsible for the occurrence of the cerebral ischemic events at least in a significant proportion of such patients.

The prognosis for patients with MCA stenosis was described in two reports.⁴,⁵ Hinton et al reported success of anticoagulation therapy in their follow-up study of patients with MCA stenosis, suggesting microembolism distal to a stenotic lesion of the MCA as a possible cause of TIAs in some patients.⁴ Adams and Gross were the first to histologically confirm a microembolus from the stenotic lesion of the MCA in a patient with TIA.⁶ In this patient, a 3-mm long white embolus emerged in the cortical arteries at the site of a
craniotomy for superficial temporal artery-to-MCA anastomosis. Microscopic examination of the removed embolus demonstrated an unorganized fibrin-platelet clot. In our patient, both the emboli in the cortical branches of the MCA and the origin of the emboli at the stenotic site of the MCA stem were confirmed histologically at autopsy. The possibility that the thromboemboli originated from other lesions proximal to the MCA stenosis is excluded because the lumen at the site of stenosis in the MCA was too small to permit passage of the embolus lodging in the cortical branch. This case thus undoubtedly demonstrates clear evidence of artery-to-artery embolism from the thrombi generated on the intimal surface of the stenotic lesion of the MCA. Antithrombotic therapy is essential for the prevention of subsequent ischemic events in such a patient.

The EC/IC Bypass Study Group recently published results of its study and demonstrated a failure of EC–IC bypass to reduce the risk of developing ische-
Figure 4. Photomicrographs of the cortical branches of the left middle cerebral artery. Top: The lumen is distended and occluded with a thromboembolus (E) (bar = 200 μm). Bottom: A thromboembolus (E) partially occludes the lumen (bar = 200 μm). Hematoxylin and eosin stain.

...mic stroke. It is reasonable that cerebral ischemic events caused by artery-to-artery embolism cannot be prevented by EC-IC bypass. However, it is also clear that regional cerebral blood flow is improved by EC-IC bypass; thus patients with hemodynamically induced TIAs are ideal candidates for EC-IC bypass. It is necessary to establish a methodology that permits distinguishing which mechanism, hemodynamic or...
microembolism, is responsible and allows deciding on the appropriate therapeutic approaches, antithrombotic therapy, EC–IC bypass, or both.

References

Key Words • artery-to-artery embolism • MCA stenosis • transient ischemic attacks • thromboembolism
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