Moyamoya-like Phenomenon in Middle and Anterior Cerebral Artery Occlusions in the Elderly

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We present here five cases of moyamoya disease-like phenomenon in the elderly patients who had moyamoya vessels in the basal ganglia as a sequela of occlusion of middle cerebral artery (MCA) and/or anterior cerebral artery (ACA). Ages ranged from 59 to 77 years (mean age: 67.6). Clinical manifestations included transient ischemic attacks (TIAs), reversible ischemic neurological deficits (RINDs) and mild hemiparesis. All the patients were living normal daily lives despite recurrent cerebral ischemic attacks. They had some risks of cerebrovascular disease, such as hypertension, and hyperlipemia. Angiography showed either MCA or ACA occlusion or both. Retrograde leptomeningeal filling of the ischemic region was maintained by the posterior cerebral artery (PCA) and ACA. Obstruction of the intracranial internal carotid artery was not visible. These neuroradiologic findings were not consistent with the criteria for moyamoya disease. The present cases may be related to congenital or acquired abnormalities in the main trunks of cerebral arteries.

Introduction

Many cases of moyamoya disease have been reported since its description in 1968, mainly by Japanese workers 1). Atypical moyamoya-like diseases also have been reported occasionally. Moyamoya vessels have been described in patients with tuberculous meningitis2), von Recklinghausen disease3), tumors4), arteriovenous malformations5), Down’s syndrome6), aortitis syndrome7), radiation arteritis (after effects of radiotherapy)8), arteriosclerosis9), and spontaneous middle cerebral artery (MCA) occlusion10-14). The blood vessels in the brain in these cases manifested the conditions that do not fulfill the criteria for moyamoya disease.

The criteria for moyamoya disease includes the following characteristic signs and symptoms on cerebral angiography: (1) The intracranial internal carotid artery is narrowed or obstructed bilaterally; (2) Moyamoya vessels are observed at the base of the brain, or the basal ganglia; and (3) The main trunks of cerebral arteries, such as the anterior, middle, and/or posterior cerebral arteries, are not, or only poorly, visualized. We present here five cases of moyamoya phenomenon in elderly Japanese patients with transient ischemic attacks (TIAs), reversible ischemic neurological deficits (RINDs), and mild hemiparesis. The patients had identifiable moyamoya vessels in the basal ganglia which probably had occurred as a sequela of MCA and/or anterior cerebral artery (ACA) occlusions.

Case Reports

Case 1

A 60-year old man (Table 1) experienced a RIND (mild left hemiparesis of 1 week’s duration)
Table 1 Clinical and Laboratory Features of Five Patients with Moyamoya Phenomenon

<table>
<thead>
<tr>
<th>Patients</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
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<tbody>
<tr>
<td>Age/Sex</td>
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<td>72/F</td>
<td>70/M</td>
<td>77/M</td>
<td>59/M</td>
</tr>
<tr>
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<td>RINDs</td>
<td>TIAs</td>
<td>mild left hemiparesis</td>
<td>TIAs</td>
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<tr>
<td></td>
<td>17 years prior</td>
<td>7 months prior</td>
<td>30 months prior</td>
<td>5 months prior</td>
<td>4 months prior</td>
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<td>Hypertension</td>
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<td>–</td>
<td>+</td>
<td>–</td>
<td>+</td>
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<tr>
<td>Diabetes mellitus</td>
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<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<td>Total cholesterol (mg/dl)</td>
<td>231</td>
<td>157</td>
<td>155</td>
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<tr>
<td>Triglyceride (mg/dl)</td>
<td>124</td>
<td>65</td>
<td>75</td>
<td>281</td>
<td>172</td>
</tr>
<tr>
<td>Fasting blood sugar (mg/dl)</td>
<td>104</td>
<td>96</td>
<td>95</td>
<td>98</td>
<td>112</td>
</tr>
</tbody>
</table>

M: male, F: female, TIAs: transient ischemic attacks, RIND: reversible ischemic neurological deficit. Fasting blood sugar (normal range): 60–110 mg/dl, Total cholesterol (normal range): 130–230 mg/dl, Triglyceride (normal range): 30–150 mg/dl

Fig. 1 (Case 1)
Towne’s view of a left carotid angiogram demonstrating middle cerebral artery (MCA) occlusion in the M1 segment, anterior cerebral artery (ACA) occlusion in the A2 segment, and moyamoya vessels in the basal ganglia (arrow heads).

years ago. One year later, he suffered a complete stroke with left hemiparesis, but he was able to continue his teaching job. Sixteen years after that, he had right hemiparesis, and was admitted to our hospital. On admission, his blood pressure was 140/80 mmHg, and his heart rate was 80/min. On neurologic examination, mild right hemiparesis was present, although aphasia or dysarthria was not observed. Laboratory examinations revealed no abnormalities (Table 1). He had no history of diabetes mellitus or hypertension, and his family
history was unremarkable. Left carotid angiograms revealed an MCA occlusion in the M₁ segment, ACA occlusion in the A₂ segment, and moyamoya vessels in the basal ganglia (Fig. 1). Right retrograde transbrachial angiography demonstrated severe stenosis of the MCA in the M₁ segment, occlusion of the ACA in the A₁ segment, and moyamoya vessels in the basal ganglia. Leptomeningeal filling from the posterior cerebral artery (PCA) area was adequate. Stenosis of the carotid siphon was not seen (Fig. 2). Magnetic resonance (MR) imaging revealed bilateral frontal atrophy and a high-intensity lesion on a T₂-weighted image adjacent to the body of the right lateral ventricle (Fig. 3 A, B). After 1 month of hospitalization the right hemiparesis resolved thanks to the administration of 200 mg of ticlopidine per day.

Case 2
A 72-year-old woman (Table 1) experienced recurrent TIAs (mild left hemiparesis of several hours duration) 7 months prior to suffering mild left hemiparesis. She had no history of diabetes mellitus or hypertension, and her family history was unremarkable. On admission, her blood pressure was 132/84 mmHg, and her heart rate was 72/min. Neurologic examination revealed mild left hemiparesis with a sensory disturbance in her left extremities. Her consciousness was clear, and neither aphasia, agnosia nor dysarthria was present. Laboratory data were unremarkable (Table 1).

Right carotid angiograms revealed MCA and ACA occlusions and growth of moyamoya vessels in the basal ganglia. Leptomeningeal filling was adequately supplied from the PCA. Stenosis of the
carotid siphon was not seen (Fig. 4). Left carotid angiogram demonstrated an ACA occlusion in the A\textsubscript{3} segment and severe MCA stenosis in the M\textsubscript{2} segment. Computed tomography (CT) revealed atrophy of the right hemisphere and a low-density area in the right parietal lobe (Fig. 5 A, B). Conservative therapy was successful, consisting of the administration of 200 mg of ticlopidine per day. The patient had residual mild hemiparesis but was able to do her daily chores after she was discharged from the hospital.

**Case 3**

A 70-year-old man (Table 1) experienced mild left hemiparesis, and 21 months later mild right hemiparesis. Further 9 months later, the onset of dysarthria, dysphagia, and a memory disturbance were noted. The patient had a history of hypertension since 60 years of age. His family history was unremarkable. On admission, his blood pressure was 150/80 mmHg, and his heart rate 72/min. Neurologic examination revealed mild left hemiparesis, dysphagia, and left hemispatial agnosia. Laboratory data were unremarkable (Table 1).

Left carotid angiograms revealed MCA and ACA occlusions and moyamoya vessels in the basal ganglia. Filling in the ischemic region was maintained through the moyamoya vessels. Right carotid angiograms demonstrated similar findings. Vertebral angiography revealed collateral pontine filling from the PCA area to the ischemic MCA and ACA areas. CT scans revealed slight atrophy of the right hemisphere and small infarcts in the right hemispheric white matter and the left centrum semiovale. His neurologic deficits resolved except for a deficit in short-term memory. The patient was discharged with the following medication regime: ticlopidine 300 mg/day, nicardipine 30 mg/day, and methyldopa 500 mg/day.

**Case 4**

A 77-year-old man (Table 1) with no history of hypertension or diabetes mellitus was admitted for TIAs. He had episodes of right hemiparesis of 5 minutes duration that occurred 3 or 4 times per week for 5 months. His family history was unremarkable. On admission, his blood pressure was 140/82 mmHg, and his heart rate was 68/min. There were
Fig. 6 A, B (Case 5)
Towne's view (A) of a right carotid angiogram revealed MCA occlusion in the M₁ segment, moyamoya vessels in the basal ganglia (arrow heads) and collateral circulations from ACA and external carotid artery. Lateral view (B) revealed stenosis of the ACA in the A₁ segment (arrow head) and stenosis of the carotid siphon was not visible.

no abnormal neurologic findings. Laboratory examinations revealed hyper-triglyceridemia (serum triglyceride concentration: 281 mg/dL; normal range: 30-150 mg/dL) (Table 1).

Bilateral carotid angiograms revealed bilateral ACA occlusions, a left MCA occlusion, and moyamoya vessels in the left basal ganglia. Findings on CT scanning were normal. The TIAs disappeared following the administration of 200 mg of ticlopidine per day.

Case 5
A 59-year-old man with hypertension (Table 1) had experienced TIAs (mild left hemiparesis of
several hours' duration) since September 27, 1995. On September 30, he suffered a complete minor stroke with left hemiparesis, and was admitted to our hospital. On admission, his blood pressure was 154/90 mmHg, and his heart rate was 66/min. On neurologic examination, mild left hemiparesis involving the face was present, but he could walk and was doing his daily work by himself. His family history was unremarkable. Laboratory examination revealed hyperlipemia (serum total cholesterol concentration: 269 mg/dL; normal range: 130-230 mg/dL, serum triglyceride concentration: 172 mg/dL; normal range: 30-150 mg/dL).

Four months later, bilateral carotid angiography revealed bilateral MCA occlusions in the M₁ segment with bilateral ACA stenosis in the A₁ segment and moyamoya vessels in the basal ganglia (Fig. 6 A, B) (Fig. 7 A, B). Leptomeningeal filling from the PCA area was adequate (Fig. 8). MR imaging revealed small infarcts in the bilateral white matters and basal ganglia, and adjacent to the bodies of the bilateral lateral ventricles (Fig. 9 A, B). The patient was discharged with the following medication regime (ticlopidine 200 mg/day, nifedipine 40 mg/day), and was able to continue his job.

Fig. 8 (Case 5)
Vertebral angiography revealed an adequate leptomeningeal filling from the PCA area.

Fig. 9 A, B (Case 5)
MR on a T₂-weighted image (TR 5000/TE 88) demonstrated small infarcts in the bilateral white matters and basal ganglia, and adjacent to the bodies of the bilateral lateral ventricles.
Discussion

Clinical imaging and laboratory findings of either of the present five cases did not fulfill the criteria for moyamoya disease. Angiography did not show narrowing or obstruction of the intracranial internal carotid arteries. In moyamoya disease, the most important manifestation is bilateral basal arterial occlusive changes of unknown etiology. The moyamoya vessels of our patients showed non-specific neuroradiologic changes, such as the extraordinarily dilated collaterals of the striate arteries. Narrowing or occlusion of the carotid siphon must be present to warrant diagnosis of moyamoya disease. Therefore, our cases could not be identified with moyamoya disease. Our patients did not exhibit these symptoms.

Our patients shared some common risk factors for developing cerebrovascular disease and arteriosclerosis, such as hypertension, and hyperlipemia. Clinical manifestations in the patients included TIAs, RINDs, and mild hemiparesis, without suffering major inconveniences in daily life. They had few sequelae despite recurrent ischemic attacks. The neurologic deficits were minimal because there was enough collateral filling of the ischemic region from the PCA (and ACA), as revealed by angiography. Computed tomography and magnetic resonance imaging showed no massive lesions, but small multiple infarctions and cortical atrophy were visible.

These clinical manifestations suggest that obstruction of the MCA and ACA developed extremely slowly, and there was enough time for a collateral retrograde circulation to develop. Occlusions in our patients' arteries must have progressed more slowly than those in moyamoya disease. That's why they could survive. In contrast, patients with moyamoya disease usually suffer major ischemic strokes during childhood and experience fatal hemorrhagic strokes by 30-40 years of age.

The chronic ischemia due to MCA and ACA occlusions provokes the development of lenticulostriate arteries and abnormal networks in the basal ganglia, resulting in the growth of the moyamoya vessels. A long duration of ischemia seems to be necessary for the growth of the moyamoya vessels. It is not clear when the cerebral ischemia started and the moyamoya vessels appeared in our patients are unknown. The time gap between the initial symptoms and angiographic studies ranged from 4 months to 17 years (mean: 50.0 months) (Table 1).

In 1981, Fukawa et al. reported 10 cases of spontaneous MCA occlusion with moyamoya phenomenon and described their clinical and angiographic characteristics. These patients consisted of three men and seven women ranging in age from 16 to 62 years (mean age: 45.0). Seven of these patients were 40-50 years of age. Six suffered ischemic strokes and the others suffered intracranial hemorrhages. Clinical manifestations included headaches, TIAs, mild hemiparesis, and motor aphasia with the exception of one case. Conservative therapies were successful in nine patients, and they were discharged without any neurologic sequelae and returned to normal life. They had no history of diabetes mellitus or hypertension, and their family histories were unremarkable. Angiograms showed unilateral involvement in six cases and bilateral involvement in four. Obstruction or stenosis of the intracranial internal carotid artery was not visible. Moyamoya vessels in these cases were surrounded the basal ganglia, in contrast to those of moyamoya disease appearing as widespread fan-shaped vessels on lateral-view angiograms. Clinical and neurologic features of these patients described by Fukawa et al. resembled those of our patients (light neurologic deficits, few neurologic sequelae, and successful conservative therapies). Likewise, the neuroradiologic findings (no obstruction or stenosis of the intracranial internal carotid arteries, circumscribed-shaped moyamoya vessels in the basal ganglias, and small lesions on CT scans and MR imaging) were similar.

In 1982, Fukawa et al. presented the pathologic autopsy findings of one of these patients. The patient was a 53-year-old Japanese woman, who had experienced her initial episode of right hemiparesis (6 months duration) at 7 years of age. Forty six years later, she suffered a recurrence of the right hemiparesis and a motor aphasia, and was hospitalized. Laboratory findings were unremarkable. She had no history of diabetes mellitus or hypertension,
and her family history was unremarkable. Left carotid angiograms revealed an occlusion of the left MCA at its origin with surrounding moyamoya vessels, but did not demonstrate occlusion or stenosis of the intracranial internal carotid artery. Right carotid and bilateral vertebral angiograms showed nothing abnormal. CT scanning revealed a small low-density lesion in the left putamen. Conservative therapy was successful, and she was discharged without any neurologic sequelae. However, she committed suicide by ingesting a poison 1 month later. Pathologic examination of her left MCA revealed severe stenosis with a minimum diameter of 900 microns. The diameters of right and left intracranial carotid arteries were 2,600 and 2,500 microns in the C2 segment, respectively. Atherosclerotic or inflammatory changes were not visible. The tunica media was very thin or nonexistent. The elastica interna was reduplicated, frayed, and at times, discontinuous. Fukawa et al. suggested she had congenital hypoplasia of the MCA.

Becker et al. reported 8 symptomatic patients aged 32–56 years with isolated stenosis of MCA who had TIAs or minor strokes. Angiography showed MCA stenosis in the M1 segment in 7 patients, and proximal M1 occlusion that later recanalized with persistent stenosis in one patient, without evidence of more widespread atherosclerotic disease. During the follow-up observation for 39–82 months, no further ischemic events occurred. They concluded that isolated MCA stenosis in younger adults may be a unique pathologic entity with a benign long-term course, and speculated that nonatherosclerotic progressive thrombosis with partial recanalization seems possible in some of these younger patients.

The clinical and neuroradiologic characteristics of our patients were similar to those of the above Fukawa’s and Becker’s patients; they do not fulfill the criteria for moyamoya disease. Narrowing or occlusion of the carotid siphon was not visible, and CT scanning and MR exams revealed small infarcts without massive lesions. They survived the cerebrovascular abnormalities without suffering major inconveniences in performing daily activities or significant neurologic sequelae. The etiology of MCA (and ACA) occlusions is unknown. The present cases may be related to congenital or acquired abnormalities in the main trunks of cerebral arteries.

References
高齢者における中大脳動脈・前大脳動脈
閉塞に伴なうモヤモヤ現象

新谷周三*, 三浦義治**, 椎貝達夫**, 小寺 実**

中大脳動脈（MCA）・前大脳動脈（ACA）閉塞に伴ない、大脳基底核部にモヤモヤ現象を認めた
高齢者5例について報告した。5例の年齢は、50歳より77歳までで、平均年齢67.6歳である。臨床
症状は、いわゆる一過性脳虚血発作（TIAs）、再発した虚血性神経障害（RINDs）、軽い片麻痺であ
る。5例とも、何回ものTIAs・RINDsなどの発作にもかかわらず、日常生活活動の上で自立して
いることが特徴である。脳血管写では、MCA・ACAの閉塞と後大脳動脈（PCA）から虚血部位へ
向けたretrograde leptomeningeal fillingが明らかであった。通常のモヤモヤ病に認められる内頸
動脈の狭窄・閉塞は認められず、神経放射線学的にはモヤモヤ病ではない。十分なretrograde leptom-
eningeal fillingが成長するに要する長い時間をかけてMCA・ACAの閉塞は徐々に形成されたと
考えられるが、そのetiology（congenital or acquired）は不明である。

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