Moyamoya Disease in Pregnancy: A Single Institute Experience

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Abstract

Moyamoya disease is a rare chronic, occlusive cerebrovascular disease characterized by bilateral steno-occlusive changes at the terminal portion of the internal carotid artery and an abnormal vascular network at the base of the brain. Moyamoya disease particularly affects children and young adults with female predominance, thus pregnant patients with moyamoya disease are not uncommon. Among 4,400 patients with consecutive deliveries in our hospital, 6 patients (0.14%) aged from 24 to 40 years (mean 32.7 years) were found to have moyamoya disease, all of whom underwent cesarean section. Four patients who had been diagnosed with moyamoya disease before pregnancy did not show neurological events in pregnancy and puerperium, but two patients who were newly diagnosed or progressed during the perinatal period suffered neurological deterioration due to ischemic stroke. Surgical revascularization at the subacute stage relieved their symptoms and they did not suffer permanent neurological deficit. We recommend that pregnant patients with moyamoya disease should be carefully managed under the collaboration of obstetricians and neurosurgeons, and that the procedure of the delivery should be selected by the obstetricians to avoid unfavorable sequelae caused by hyperventilation and/or blood pressure elevation.

Key words: moyamoya disease, pregnancy, delivery, single institute

Introduction

Moyamoya disease is a chronic, occlusive cerebrovascular disease with an unknown etiology characterized by bilateral steno-occlusive changes at the terminal portion of the internal carotid artery and an abnormal vascular network at the base of the brain. Moyamoya disease is a rare entity, but particularly affects children and young adults with female predominance, so it is not uncommon in the clinical setting to encounter patients with moyamoya disease at pregnancy and/or delivery. In fact, pregnant patients with moyamoya disease are often referred to the neurological service, but there are no established management guidelines for moyamoya disease in pregnancy and puerperium. The present retrospective analysis of 4,400 consecutive deliveries in our hospital investigated the incidence and clinical picture of pregnant patients with moyamoya disease. We further discuss the pathology and how to manage patients with moyamoya disease in pregnancy and puerperium.

Patients and Methods

The present study included 4,400 deliveries in the Department of Obstetrics in the National Hospital Organization, Sendai Medical Center from January
2008 to December 2012. The diagnosis of moyamoya disease was based on the criteria of the Research Committee on Spontaneous Occlusion of the Circle of Willis, of the Ministry of Health, Labour and Welfare, Japan. Our surgical indications for superficial temporal artery (STA)-middle cerebral artery (MCA) anastomosis with indirect pial synangiosis included all of the following items: presence of ischemic symptoms, apparent hemodynamic compromise on N-isopropyl-p-\([^{123}\text{I}]\) iodoamphetamine single-photon emission computed tomography, independent activity of daily living (modified Rankin scale scores 0–2), and absence of major cerebral infarction.\(^{1,2}\)

### Results

Among 4,400 patients with consecutive deliveries, six patients (0.14%) were found to have moyamoya disease, including one patient with unilateral involvement (Table 1). These 6 patients were aged from 24 to 40 years (mean 32.7 years). Four patients had been diagnosed with moyamoya disease before pregnancy, whereas two were newly diagnosed with moyamoya disease in pregnancy and puerperium. The gestational age at delivery was 37 weeks in the 5 patients who underwent scheduled cesarean sections. One patient who presented with progressive stroke underwent emergency cesarean section at the gestational age of 34 weeks. Four patients who had been diagnosed with moyamoya disease before pregnancy did not suffer neurological events during pregnancy and puerperium. Among the two patients with newly diagnosed or progressive moyamoya disease in pregnancy and puerperium, one patient suffered progressive stroke at the gestational age of 33 weeks and was successfully managed by emergency cesarean section and bilateral revascularization surgery. The other patient was known to have right MCA (M\(_1\)) stenosis before pregnancy and underwent scheduled cesarean section, but she suffered minor completed stroke on postpartum day 3. Magnetic resonance (MR) angiography after stroke showed apparent progression of the steno-occlusive change and catheter angiography demonstrated moyamoya disease with unilateral involvement. Early surgical revascularization at subacute stage relieved her symptom. The final activities of daily living were good with modified Rankin scale of 0 in all six patients.

**Representative case:** A 27-year-old woman at 33 weeks of pregnancy suffered progressive monoparesis of the left hand. MR imaging and MR angiography demonstrated definitive moyamoya disease appearing as acute spotty cerebral infarctions in the right cerebral hemisphere. She was transferred to our hospital at 34 weeks of pregnancy, where both neurosurgeons and obstetricians were involved in her management. She underwent emergency cesarean section on the day of admission without deterioration of her neurological status, but MR imaging demonstrated a newly-formed spotty infarction on the left hemisphere (Fig. 1A). Catheter angiography showed steno-occlusive changes at the terminal internal carotid artery with abnormal vascular network at the base of the brain, leading to the definitive diagnosis of moyamoya disease (Fig. 1B, C). She was managed by antithrombotic therapy for 4 weeks, and then underwent right STA-MCA anastomosis (Fig. 2A), followed by left STA-MCA anastomosis one month later without complication. Postoperative course was uneventful, and MR imaging after these surgeries showed no expansion of ischemic lesion. MR angiography demonstrated apparently patent bilateral STA-MCA bypasses (Fig. 2B). She was discharged without complication, and her symptom was significantly improved 2 weeks.

### Table 1 Summary of 6 cases of moyamoya disease (MMD) and pregnancy among 4,400 consecutive deliveries

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Diagnosis of MMD before pregnancy</th>
<th>Gestational age at delivery (weeks)</th>
<th>Procedure of delivery</th>
<th>Cerebrovascular event during perinatal period</th>
<th>Neurosurgical management</th>
<th>Outcome (mRS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>34</td>
<td>yes</td>
<td>37</td>
<td>cesarean section</td>
<td>none</td>
<td>none</td>
<td>0</td>
</tr>
<tr>
<td>24</td>
<td>yes</td>
<td>37</td>
<td>cesarean section</td>
<td>none</td>
<td>none</td>
<td>0</td>
</tr>
<tr>
<td>40</td>
<td>yes</td>
<td>37</td>
<td>cesarean section</td>
<td>none</td>
<td>none</td>
<td>0</td>
</tr>
<tr>
<td>32</td>
<td>yes</td>
<td>37</td>
<td>cesarean section</td>
<td>progressive stroke (33–34 weeks)</td>
<td>STA-MCA bypass (bilateral)</td>
<td>0</td>
</tr>
<tr>
<td>27</td>
<td>no (M(_1) stenosis)</td>
<td>34</td>
<td>cesarean section</td>
<td>minor stroke (postpartum day 3), stage progression</td>
<td>STA-MCA bypass (unilateral)</td>
<td>0</td>
</tr>
</tbody>
</table>

mRS: modified Rankin scale, STA-MCA: superficial temporal artery-middle cerebral artery.
Fig. 1  A: Diffusion-weighted magnetic resonance images after cesarean section demonstrating spotty infarction in the bilateral hemispheres predominantly on the right (arrows).  B, C: Preoperative right internal carotid (B) and left internal carotid (C) angiograms demonstrating steno-occlusive changes at the terminal portion of bilateral internal carotid arteries and abnormal vascular network at the base of the brain, leading to the definitive diagnosis of moyamoya disease.

Fig. 2  A: Intraoperative view of right superficial temporal artery (STA)-middle cerebral artery (MCA) anastomosis. The M4 segment of the right MCA was explored, and anastomosis between the STA stump and MCA was performed (arrow at the anastomosis site).  B: Magnetic resonance angiogram after bilateral STA-MCA anastomosis demonstrating bilateral STA-MCA bypasses as thick hyperintense areas (arrows).

Discussion

Moyamoya disease is one of the most important pathologies which should be considered as a cause of stroke in children and young adults.\(^5\) Most patients with moyamoya disease present with ischemic stroke or intracranial hemorrhage, but recent advances in non-invasive diagnostic modalities such as MR imaging and MR angiography have increased the diagnosis of asymptomatic cases of moyamoya disease.\(^5\) Therefore, neurosurgeons are more frequently encountering pregnant patients with moyamoya disease than before. Although reports about moyamoya disease and pregnancy are limited,\(^4,8\) pregnant patients diagnosed with moyamoya disease before pregnancy are known to have relatively lower potential risk for cerebrovascular events.\(^3,8\) Strict blood pressure control, in particular precautions against pregnancy-induced hypertension, might lead to better prognosis for the patients.\(^8\) This recommendation is based on the observations that, in addition to the increase in circulating plasma volume and enhanced blood coagulation during pregnancy, pregnancy-induced hypertension may result in blood-brain barrier disruption and vasospasm, and subsequently cause neurological deterioration of patients with moyamoya disease.\(^3\) In our present series, all four patients who had been diagnosed with moyamoya disease before pregnancy underwent scheduled cesarean section, and none of them suffered neurological events in pregnancy and puerperium.

On the other hand, patients suffering cerebrovascular events during late pregnancy, who were newly diagnosed with moyamoya disease, are known to have poorer prognosis.\(^4,8\) Among such patients, hemorrhagic-onset moyamoya disease during pregnancy is reported to carry the poorest prognosis.\(^4,8,9\) Moyamoya disease is reported to account for 25% of cases of perinatal intracranial hemorrhage,\(^9\) which is one of the major causes of perinatal death. In our series, we experienced two patients with newly diagnosed or progressive moyamoya disease during the perinatal period who presented with neurological deterioration caused by ischemic stroke. Our representative case was considered to be rare since the patient had progressive stroke which deteriorated during late pregnancy,\(^6\) but emergency cesarean section and subsequent bilateral revascularization surgeries led to the favorable outcome. Our other patient was considered to be even more unusual because she demonstrated the disease progression from MCA stenosis to moyamoya disease with unilateral involvement, which ultimately manifested as minor completed stroke. Although revascularization surgery during the subacute stage relieved her symptom, it should be noted that patients with moyamoya disease have a potential risk for stage progression during pregnancy.

Scheduled cesarean section is commonly employed in Japan, based on the observation that vaginal delivery may facilitate hyperventilation and elevation of blood pressure during natural labor and thus result in cerebral ischemia.\(^5,7\) In contrast to this observation, adequate control of blood pressure,
respiration, and body temperature at delivery are the most important factors for better prognosis regardless of the procedures of delivery.\(^3\)\(^,\)\(^9\) In our present series, we exclusively employed cesarean section for pregnant patients with moyamoya disease, and the final outcomes were favorable in all 6 cases. Taken together, we believe that pregnant patients with moyamoya disease should be carefully managed under the collaboration of obstetricians and neurosurgeons, and that the delivery procedure should be selected by the obstetricians to avoid unfavorable sequelae caused by hyperventilation and/or blood pressure elevation.

**Conflicts of Interest Disclosure**

We have no conflicts of interest to declare. Further, all authors have registered online Self-reported COI Disclosure Statement Forms through the website for JNS members.

**References**


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