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CASE SERIES

Pregnancy Risk Assessment, Management, and Delivery Plan for Pregnant Women with Moyamoya Disease Using a Multidisciplinary Collaborative Approach: A Case Series

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Purpose: This case report aimed to summarize the risk factors, clinical characteristics, imaging changes, and maternal and fetal prognosis associated with Moyamoya disease in pregnant women and to explore effective management strategies and a comprehensive delivery plan.

Case Presentation: The clinical data of four pregnant women who were diagnosed with Moyamoya disease and admitted to our hospital between January 2010 and January 2019 were retrospectively analyzed. Their diagnosis, treatment, delivery, and postpartum management during the pregnancy were analyzed. Among the four pregnant women, three were primipara and one was multipara. The age ranged from 27 to 41 years old. The gestational week of termination of pregnancy ranged between 8 and 39 weeks. During pregnancy, one case died in utero; one case was complicated with postpartum hemorrhage; one case was complicated with chronic hypertension, multiple cerebral artery stenosis and occlusion, bilateral middle cerebral artery occlusion, bilateral internal carotid artery occlusion, and Hashimoto's thyroiditis. Under epidural anesthesia, two cases underwent a lower segment cesarean section; one case underwent artificial abortion; and one case underwent induced labor during late pregnancy. Two newborns survived.

Conclusion: Moyamoya disease is a rare and serious complication of pregnancy. Pregnancy and childbirth may exacerbate the progression of this disease or induce cerebrovascular accidents, with a high mortality and disability rate, which seriously threatens the safety of mother and infant lives; however, with the close collaboration of a multidisciplinary team, it is possible to maximize a good pregnancy outcome.

Keywords: pregnancy, cerebrovascular lesions, moyamoya disease

Introduction

Moyamoya disease (MMD) is a chronic occlusive cerebrovascular disease characterized by slow thickening of the arterial intima at the end of the internal carotid artery and the starting points of the anterior and middle cerebral arteries, gradual narrowing of the arterial lumen leading to occlusion, and dilation of the skull base pia mater through the arteries to form a small and dense abnormal vascular anastomotic network.[1] The incidence of MMD exhibits distinct regional and racial characteristics, with higher rates in Asia compared to Europe, America, Africa, and Latin America. Japan is known to have the highest incidence of MMD. A nationwide epidemiological survey conducted in 2003 estimated a prevalence of 6.03 per 100,000 people and an annual incidence rate of 0.54 per 100,000 people.[2] A recent single-center epidemiological study in mainland China included 4128 Moyamoya patients and found a prevalence rate of 0.7651 per 100,000 in Beijing.[3] The incidence of cerebrovascular diseases during pregnancy ranges from 38 to 62.5 per 100,000 deliveries.[4] The incidence of cerebral hemorrhage during pregnancy is 3.5 per 100,000, with a mortality rate of about 18.4%. Among

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these cases, 10.5% involve pregnant women with MMD. Maternal mortality is closely related to conditions such as preeclampsia, HELLP syndrome, and the timing of diagnosis.[5]

The pathogenesis of MMD is not yet fully understood. It is mostly considered to be a nonspecific immunoinflammatory disease that leads to chronic intimal proliferation, smooth muscle cell migration, and stenosis of the terminal intracranial segment of the internal carotid artery, eventually resulting in occlusion.[6] This process forms collateral circulation to supply blood to the brain. The disease primarily affects children and adults. In children, it mainly manifests as insufficient blood supply to the brain, leading to reversible neurological dysfunction, sensory abnormalities, seizures, headaches, and involuntary choreiform movements, with 80.5% of Moyamoya patients experiencing motor function impairment.[7] In adults, the condition predominantly presents as cerebral hemorrhage, including intracerebral hemorrhage, intraventricular hemorrhage, and subarachnoid hemorrhage. Symptoms may include headaches, coma, hemiplegia, and sensory disturbances. At least two-thirds of adult patients present with cerebral hemorrhage as the initial symptom. After the first cerebral hemorrhage, 46% of patients have good recovery of motor function, with a mortality rate of 7%.[8]

With the improvement of people's living standards and the adjustment of fertility policies, there is an increasing trend in the reports of cases of pregnancy complicated with MMD.[9] Whether pregnancy and childbirth will exacerbate the progression of this disease or trigger cerebrovascular accidents, and how to assess the risk of pregnancy and reduce the risk of recurrent cerebrovascular diseases, is particularly important for obstetric medical personnel.[10] In this case series report, we aimed to evaluate the effectiveness of the multidisciplinary approach on the management of pregnant women with MMD. A total of four cases of pregnancy complicated by MMD who were admitted to our hospital between October 2010 and January 2019 were presented.

Case Presentation

Case 1

Patient history and symptoms: Female, 27 years old, G1P0. The main reason for admission was 32+ weeks of amenorrhea, one-day reduction in fetal movement, and one hour absence of fetal heart rate in the abdomen. She had regular menstruation and weight gain of 10 kg during pregnancy. The patient was diagnosed with primary hypertension 14 years ago and had poor antihypertensive response to oral antihypertensive drugs. The blood pressure was around 130/90 mmHg. Two years ago, during the writing process, she suddenly experienced numbness in my right face and right hand, and her right hand was slightly clumsy in movement. It manifested as unstable holding of a pen, slow writing, no abnormal sensation or movement in my right lower limb, and no unclear speech. The symptoms persisted for about half an hour and resolved spontaneously. Carotid artery ultrasound showed uneven thickening of the right carotid artery intima-media membrane, distal lesions of both internal carotid arteries, bilateral vertebral arteries throughout the entire process (physiological), abnormal origin of the left vertebral artery with course variation, and absence of an unnamed artery.

MMD diagnosis: Transcranial color-coded duplex showed blood flow changes in both hemispheres of the brain consistent with MMD, stenosis of the right middle cerebral artery (severe), stenosis of the right end segment of the internal carotid artery (severe), and occlusive lesion of the left end segment of the internal carotid artery. The head and neck computed tomography angiography showed narrow, multiple stenosis, and occlusion of the bilateral internal carotid artery, anterior, middle, and posterior cerebral artery lumens, accompanied by intracranial capillary formation, suggesting a possibility of MMD. The left vertebral artery formed an autonomous arterial arch with vascular variation. The head magnetic resonance imaging (MRI) showed weakened or disappeared blood flow signals in the intracranial segment of the right internal carotid artery and bilateral middle cerebral arteries on T1WI, multiple tortuous blood vessels in the skull base, basal ganglia, and paraventricular regions, suggesting a possibility of smoke syndrome. Ischemic lesions in the left subcortical area of the frontal lobe and bilateral paraventricular regions and white matter degeneration were also observed. Considering cerebrovascular disease and multiple cerebral artery stenosis, the results of cerebrovascular DSA conducted by the neurology department showed the right anterior cerebral artery, main trunk, and branches of the middle cerebral artery on the right side. The posterior inferior cerebellar artery was not visualized, and the left anterior cerebral artery A1 and middle cerebral artery M1 were occluded further away. Smoke-like vessels around the

occluded vessels for compensation were observed. Ultrasound imaging of the left external carotid artery showed that the top branch of the left middle meningeal artery compensated for the blood supply area to the left middle cerebral artery. Due to thinner superficial temporal blood vessels on the same side of the bypass, there was a higher risk of postoperative occlusion. Arterial bypass surgery was not performed. Supplementary Figure 1 includes CT, MRI, and DSA images for Case 1.

After discharge from the neurology department, antiplatelet aggregation drugs, lipid-lowering and antioxidant drugs were regularly taken orally. One year ago, due to pregnancy preparation, aspirin (100 mg, q.d.) was only taken orally, and no discomfort such as dizziness, headache, or limited limb movement occurred again. Two years ago, an examination revealed a thyroid nodule with elevated thyroid-related antibodies. The levels of thyroid-stimulating hormone, free triiodothyronine, and free thyroxine were all normal. The diagnosis was Hashimoto's thyroid disease, and no special treatment was given. The results of physical examinations were as follows: temperature (T), 37 °C; heart rate (HR): 82 times/min, respiratory rate (RR): 20 times/min; blood pressure (BP): 146/90 mmHg; height (H), 174 cm; weight (W), 78 kg. The general situation was good, and there were no abnormalities in the heart and lungs. The results of the obstetric examination were as follows: The height of the uterine floor was 28 cm, and the abdominal circumference was 93 cm. The head was exposed first, without entering the pelvis or uterine contractions. The fetal heart was not heard, and the measurements outside the pelvis were normal. The results of the vaginal examination were as follows: The uterine opening was not opened, and the head was exposed first. After admission, an intra-amniotic injection of Rivanol was performed to induce labor. A dead female infant was naturally delivered 28 hours after the operation, with a length of 45 cm and a weight of 1600 g. The umbilical cord wrapped around the neck for one week was tight. The fetal skull was soft, and the skin was peeling. No obvious abnormalities were observed in the appearance. Placental adhesions were removed by hand, and postpartum curettage and perineal laceration suturing were performed. Routine postpartum infection prevention was carried out to promote uterine rejuvenation and lactation treatment. The postoperative postpartum woman was generally in good condition and was discharged on the second day. Placental pathology suggested inflammatory changes in the chorioamniotic membrane.

Discharge diagnosis: as fetal death, intrauterine chorioamnionitis, pregnancy with MMD, pregnancy with chronic hypertension (existing), 32+ weeks of pregnancy, G1P1 LOA, natural delivery of newborn umbilical cord around neck for one week, delivery with multiple stenosis of perineal 1 degree laceration, occlusion of bilateral middle cerebral arteries, occlusion of bilateral internal carotid arteries (terminal segment), Hashimoto's thyroiditis, thyroid nodules.

Case 2

Patient history and symptoms: Female, 32 years old, G1P0. The main reason for admission was 38+ weeks of menstrual cessation. She had regular menstruation and weight gain of 11 kg during pregnancy. Twenty years ago, due to a headache, we sought medical attention in our hospital and underwent MRI and cerebral angiography. MMD diagnosis: The diagnosis was MMD, but no special treatment was given. After bleeding, she returned to normal without any headache or other symptoms. During pregnancy, there was no discomfort. MRI examination showed bilateral subcortical punctate ischemic lesions, right basal ganglia softening lesions, and abnormal blood flow signals from the right internal carotid artery, middle cerebral artery, and anterior cerebral artery. Supplementary Figure 2 includes MRI images for Case 1. The results of physical examinations were as follows: T, 36 °C; HR, 108 times/min, RR, 20 times/min; BP, 107/66 mmHg; H, 172 cm; W, 82 kg. The general situation was good, and there were no abnormalities in the heart and lungs. The results of the obstetric examination were as follows: The height of the uterine floor was 32cm, and the abdominal circumference was 104 cm. The head was exposed first, entering the pelvis shallowly, without uterine contractions. The measurement outside the pelvis was normal, and the vaginal was not checked. After admission, a lower segment cesarean section of the uterus was performed under epidural anesthesia. The surgical process was smooth, and a female infant weighing 2950 g was delivered alive. The newborn was in good condition, with postpartum bleeding of 500 mL. Routine postoperative prevention of infection, promotion of uterine involution, and breastfeeding of newborns were performed. The postoperative postpartum woman was generally in good condition and then discharged on the 3rd day.

Discharge diagnosis: postpartum hemorrhage pregnancy combined with MMD pregnancy 38+ weeks, G1P1 LOT cesarean section.

Case 3

Patient history and symptoms: Female, 30 years old, G1P0. The main reason for admission was 39+ weeks of amenorrhea. She had a regular menstrual cycle, with a weight gain of 15 kilograms during pregnancy.

MMD diagnosis: Six years ago, this patient presented with sudden headache and vomiting for three months and was then diagnosed with MMD and cerebral hemorrhage at an external hospital. Supplementary Figure 3 includes non-invasive cerebral vascular ultrasound images for Case 1. She underwent left superficial temporal artery patch surgery and took sodium valproate orally for one month after the surgery. The results of physical examinations were as follows: T, 36.5 °C; HR, 80 times/min; RR, 20 times/min; BP, 123/85 mmHg; H, 172 cm; W, 70 Kg. The general situation of this patient was good, and there were no abnormalities in the heart and lung. The results of the obstetric examination were as follows: uterine floor height, 32 cm; abdominal circumference, 100 cm; head exposed; shallow into the pelvis; no uterine contractions; normal measurements outside the pelvis. The vaginal examination was not performed. After admission, the lower segment cesarean section of the uterus was performed under epidural anesthesia. The surgical process was smooth, and a female infant weighing 3300 g was delivered alive. The newborn was in good condition, with postpartum hemorrhage of 300 mL. Routine postoperative prevention of infection, promotion of uterine involution, and breastfeeding of the newborn were performed. The postoperative mother was generally in good condition and discharged on the 3rd day.

Discharge diagnosis: postoperative Moyamoya disease (left superficial temporal artery application), history of cerebral hemorrhage, placental adhesion, pregnancy 39+ weeks, G1P1LOT cesarean section.

Case 4

Patient history and symptoms: Female, 41 years old, G3P1. The main reason for hospitalization was cessation of pregnancy after 8+ weeks of amenorrhea. Twelve years ago, due to amniotic fluid contamination, a lower segment cesarean section was performed in an external hospital. Four years ago, due to vomiting and coma, she sought medical attention from a neurology department in another city and underwent MRI and cerebral angiography examinations.

MMD diagnosis: The diagnosis was MMD and cerebral hemorrhage. Due to a small amount of bleeding, she underwent conservative treatment and recovered. The results of physical examinations were as follows: T, 36.5 °C; HH, 80 times/min; RR: 20 times/min; BP: 110/70 mmHg; H, 148 cm; W 46 kg. Double diagnosis was made: anterior position of the uterus, enlarged as at 8+ weeks of pregnancy, with no abnormalities in both appendages. The ultrasound showed an intrauterine fetal sac of 4.2 × 1.5 cm, a gestational bud length of 1.2cm, and reachable to the original cardiac tube for pulsation. After admission, painless negative pressure suction surgery was performed under general anesthesia, and postoperative routine prevention of infection promoted uterine involution. The postoperative patient was generally in good condition and discharged on the first day.

Discharge diagnosis: early pregnancy with moyamoya scar uterus.

A summary of the main outcomes of these cases is presented in Table 1. A summary of MMD diagnosis and management of these cases is shown in Table 2.

Discussion

Diagnostic Criteria for MMD

The diagnostic criteria for MMD include (1) DSA findings: This imaging technique reveals the following: stenosis or occlusion at the terminal portion of the internal carotid artery and/or the initial segments of the anterior cerebral artery and/or middle cerebral artery. Additionally, an abnormal vascular network at the base of the brain appears in the arterial phase. These findings may be bilateral or unilateral, with possible different stages of disease on each side. (2) MRI and MRA findings: MRI and MRA scans show stenosis or occlusion at the terminal portion of the internal carotid artery and/or the initial segments of the anterior cerebral artery and/or middle cerebral artery. An abnormal vascular network in the basal ganglia region is indicated by more than two clear flow voids in the basal ganglia area on a single scan layer. These findings are typically bilateral, though the stages of disease may differ on each side. (3) Exclusion of associated diseases: To confirm a diagnosis of MMD, the following conditions must be excluded: cerebral atherosclerosis, autoimmune

Table 1 A Summary of Main Outcomes of These Cases

Case	Age	Gravida	Para	Gestational Week at First Prenatal Check	Gestational Week at Termination	Delivery Method	Anesthesia Method	Neonatal Outcome	Obstetric Complications/Comorbidities
1	27	1	0	6	32+	Amniotic sac injection with rivanol, vaginal delivery	None	Stillborn female, 1600g	Chorioamnionitis, chronic hypertension during pregnancy, Hashimoto's thyroiditis
2	32	1	0	5	38+	Lower segment cesarean section	Epidural anesthesia	Live female, 2950g	Postpartum hemorrhage (500mL)
3	30	1	0	5	39+	Lower segment cesarean section	General intravenous anesthesia	Live female, 3300g	History of cerebral hemorrhage, placental adhesion
4	40	3	1	5	8+	Vacuum aspiration		–	History of cesarean section

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Table 2 A Summary of MMD Diagnosis,Managementof These Cases

Case	Age at Diagnosis	Clinical Symptoms	Diagnostic Examination	Treatment for MMD	Clinical Monitoring During Pregnancy	MMD Status During Pregnancy	Management of MMS During Pregnancy	Pregnancy Outcome
1	25	Numbness in right face and right hand	Cerebral angiography	Aspirin 100mg qd, Atorvastatin 20mg qn, Probeco 0.5g bid	Regular prenatal check-ups; Labetalol 0.1g q8h for hypertension control	Stable condition	Regular neurology and neurosurgery monitoring; interdisciplinary consultations at hospital level	Discharged 2 days postpartum, follow-up at 42 days without discomfort
2	12	Headache	Observation	Observation	Regular prenatal check-ups; Uncomplicated pregnancy	Stable condition; MRI shows bilateral cortical infarcts, right basal ganglia lacunes, abnormal blood flow signals in right internal carotid artery, middle cerebral artery, and anterior cerebral artery	Regular neurology and neurosurgery monitoring; interdisciplinary consultations at hospital level	Discharged 3 days postpartum, follow-up at 42 days without discomfort
3	25	Headache, vomiting	CT + Cerebral angiography	Left superficial temporal artery branch patching	Regular prenatal check-ups; Uncomplicated pregnancy	Stable condition	Regular neurology and neurosurgery monitoring; interdisciplinary consultations at hospital level	Discharged 3 days postpartum, follow-up at 42 days without discomfort
4	37	Vomiting, coma	MRI	Conservative treatment	Preoperative evaluation	Stable condition	Neurosurgery, neurology, and anesthesia assessments preoperatively	Discharged 1 day post-surgery, follow-up at 30 days without discomfort

diseases (such as systemic lupus erythematosus, antiphospholipid antibody syndrome, polyarteritis nodosa, and Sjögren's syndrome), meningitis, neurofibromatosis, intracranial tumors, Down syndrome, head trauma, radiation injury, Turner syndrome, Alagille syndrome, Williams syndrome, Noonan syndrome, Marfan syndrome, tuberous sclerosis, congenital megacolon, type I glycogen storage disease, Prader-Willi syndrome, Wilms' tumor, oxalate deposition disease, sickle cell anemia, Fanconi anemia, spherocytosis, eosinophilic granuloma, type II fibrinogen deficiency, leptospirosis, pyruvate kinase deficiency, protein deficiency, myofibromatosis, osteogenesis imperfecta, polycystic kidney disease, oral contraceptive use, and drug intoxication (such as cocaine).

Pregnancy Risk Assessment of MMD Patients of Childbearing Age

MMD is a chronic and progressive cerebrovascular disease, characterized by gradually worsening stenosis and occlusion of the main arteries in the anterior circulation, abnormal compensatory vascular network hyperplasia in the skull base, continuous enhancement of posterior circulation compensation, and compensatory phenomena in the external carotid artery.[11] MMD can be divided into two types: ischemic type and hemorrhagic type.[12] Hemorrhagic type is an important type of MMD, mainly occurring in adults, while ischemic type MMD is more common in children.[13] The severity of these diseases cannot be underestimated and requires our high attention and timely treatment.

MMD during pregnancy can be divided into three types: those discovered before pregnancy, those that occur during pregnancy, and those that occur after childbirth.[14] According to the 2017 MMD diagnosis and treatment consensus, digital subtraction angiography (DSA) and MRI/MRA examination are the main diagnostic methods for MMD.[15] Through these examinations, it can be found that I. the end of the internal carotid artery and/or the anterior cerebral artery and/or the starting segment of the middle cerebral artery are narrow or occluded; II. abnormal vascular network at the skull base appears in DSA arteries or abnormal vascular network appears in the basal ganglia area in MRA; III. the above manifestations are bilateral, but the staging of the lesion may vary. If all the above manifestations are met, and other secondary factors (atherosclerosis, autoimmune diseases, meningitis, brain tumors, Down's syndrome, neurofibromatosis, cranial trauma, radiation head irradiation, etc.) are excluded, the disease can be diagnosed. In this case report, MMD was diagnosed through pre-pregnancy, previous MRI, and/or head and neck computed tomography angiography.

Whether pregnancy increases the risk of cerebrovascular disease in patients with MMD is not yet determined.[14] Pregnant age MMD patients should undergo a pregnancy risk assessment by a joint obstetrician and neurologist before pregnancy. The medical history should be inquired in detail, such as whether there are risk factors for cerebrovascular disease (eg, family history, smoking history, drinking history, labor intensity, sleep disorder, hypertension, diabetes, hyperlipidemia, hyperhomocysteinemia, hyperuricemia, and hypohemoglobin). The clinical symptoms (eg, asymptomatic, dizziness, headache and vomiting, muscle weakness, sensory disorders, visual disorders, language disorders, and consciousness disorders) and signs of having a history of bleeding and performing auxiliary examinations to determine the cerebral vascular dynamics should also be considered. All four patients in this report were diagnosed with MMD before pregnancy, with obstetrics as the leading factor. Under the collaborative model of multiple disciplines such as neurology, neurosurgery, and imaging, combined with clinical symptoms, cerebral perfusion, and metabolic data, the condition was comprehensively judged, and pregnancy risks were fully communicated with patients and their families.

Pregnancy Management and Treatment of Pregnant Women with MMD

The French MMD clinical practice guidelines indicate that the risk of complications in pregnancy and perinatal MMD is currently unclear, and it seems that cerebrovascular complications have not significantly increased until delivery.[16] During the perinatal period, the reported complications (cerebral hemorrhage and TIA) are mainly related to patients who have not yet been diagnosed with MMD. Pregnant women with MMD during pregnancy are clearly diagnosed before pregnancy, and regular prenatal examinations are conducted during pregnancy while closely observing the function of cerebral blood vessels. The most common complication during pregnancy is cerebral hemorrhage, especially when the gestational age is greater than 24 weeks, postpartum cerebral infarction is the most common.[9] Pregnancy treatment is challenging and requires multidisciplinary collaboration, considering the probability of bleeding and rebleeding, as well as the complexity and risk assessment of cerebral blood vessels.[17] During pregnancy, blood pressure should be regularly monitored, especially for pregnant women who undergo strict and regular self-monitoring to maintain stable blood

pressure. If necessary, antihypertensive and spasmodic treatment should be carried out. Actively controlling hypertension in pregnant women has become an important measure for preventing stroke.

Different Methods of Termination of Pregnancy and Anesthesia Management

The multidisciplinary collaborative model is a new diagnostic and treatment model that emphasizes patient-centered approach, with team members working closely together to develop targeted intervention plans tailored to the needs of patients and improve the treatment effectiveness of patients during the perioperative period.[18] There is currently no consensus on the optimal delivery method for pregnant women with MMD. The timing and method of delivery should be comprehensively considered based on the location, severity, and gestational age of cerebral vascular lesions in MMD patients. Negative pressure suction surgery should be used in early pregnancy.[19] Unless the cause of cerebral hemorrhage is relieved, drug-induced labor should not be used in mid pregnancy.[20] For example, mifepristone plus Misoprostol should not be used for induced labor in patients with thrombosis or hypertension. Intraamniotic injection of Rivanol can be used for induced labor, which has a high success rate and is relatively safe.[21] When deciding on the way to terminate pregnancy in late pregnancy, patients, neurologists, obstetricians, and anesthesiologists need to make a joint decision. Cesarean section has a short time and high controllability, which can effectively control blood circulation stability, maintain normal levels of carbon dioxide in the blood, and maintain appropriate fluid balance.[22] There are also studies suggesting that vaginal delivery is not associated with excessive occurrence of cerebrovascular complications.[23] Takahashi et al[24] also found that the safe delivery rate for pregnant women, with MMD undergoing vaginal natural delivery after epidural anesthesia is 74.1%. If the labor process progresses smoothly and the mother's condition is stable, the vaginal trial can be strictly monitored.

Our hospital has an incidence rate of 98.1 per 100,000 deliveries for pregnancy-related stroke, with extensive experience in treatment. When patients present symptoms such as headaches, vomiting, or limb numbness, the possibility of concomitant neurological disorders should be considered. Therefore, for pregnant women with a history of moyamoya disease, in addition to monitoring the risk of recurrent cerebrovascular accidents during pregnancy, attention should also be given to the occurrence and progression of late obstetric complications. Proactive prevention and management are crucial, necessitating enhanced prenatal care with increased frequency of antenatal visits to improve maternal and neonatal outcomes.

Conclusions

In conclusion, patients with MMD have impaired cerebral hemodynamics, decreased cerebrovascular reactivity, and impaired cerebral blood flow self-regulation ability, which can exacerbate ischemic cerebral perfusion insufficiency. Pregnancy complicated by cerebrovascular diseases has high mortality and disability rates, posing a serious threat to the safety of both mother and baby. It requires joint attention from obstetricians and neurologists to ensure early diagnosis and proper treatment. When a patient exhibits symptoms such as headache, vomiting, or limb numbness, the possibility of concurrent neurological disorders should be considered. If there is suspicion of cerebral hemorrhage or cerebral infarction, a CT scan should be the first choice. For patients with MMD, DSA remains the most accurate method for diagnosing cerebrovascular diseases. However, due to its invasive nature and high technical demands, it is not the preferred initial method. For patients with coexisting cerebrovascular malformations, hematological, and cardiovascular diseases, focused monitoring and management through multidisciplinary collaboration are essential. Any neurological symptoms should prompt immediate attention from doctors, with early diagnosis and appropriate treatment based on imaging studies. Selecting the appropriate method and timing for terminating the pregnancy is crucial to improving maternal outcomes and enhancing the quality of life for patients. Further prospective investigations are needed to validate the findings observed in these cases.

Data Sharing Statement

The original contributions presented in the study are included in the article. Further inquiries can be directed to the corresponding author.

Ethics Approval and Informed Consent

Written informed consent was obtained from the patients. We have received Xuanwu Hospital Capital Medical University's ([2017]021) approval to publish the case details.

Consent for Publication

Consent to publish was obtained from the patients.

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Disclosure

The authors declare that they have no competing interest in this work.

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