

Special Theme Topic: Stroke During Pregnancy or Delivery

Pregnancy and Delivery Management in Patients With Cerebral Arteriovenous Malformation: A Single-Center Experience

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Abstract

We described pregnancy and delivery management in 9 patients with cerebral arteriovenous malformation (AVM). Six patients presented with intracerebral hemorrhage (ICH) during pregnancy (first hemorrhagic episode); 2 patients presented with headache; and 1 patient with incidental detection of AVM. In the 3 patients with unruptured AVM, the diagnosis was made before pregnancy. In 3 of 6 patients who presented with ICH, AVM removal was performed during pregnancy. One patient required emergency surgery for the mass effect of the hematoma, and 2 patients with Spetzler-Martin grade I and II AVMs underwent elective surgery for the prevention of rebleeding. Radiosurgery for multiple AVMs was performed after delivery in one patient. Surgical resection and radiosurgery were performed after abortion in two patients. Of 3 patients with unruptured AVM, 2 patients became pregnant after radiosurgery and conservative treatment was initiated in 1 patient for Spetzler-Martin grade V AVM. Cesarean section was performed in 5 patients (one with severe uncontrollable pregnancy-induced hypertension) and vaginal delivery in 2 patients (one with grade V AVM). Delivery by obstetrical indication was possible in patients who underwent AVM resection during pregnancy. No rebleeding during pregnancy occurred. The maternal outcome was good except for the 2 patients with consequences of the initial ICH. The fetal outcome was good except for 2 cases of abortion. Pregnancy and delivery management in patients with AVM was successful in our institution. Early surgical intervention for AVM presenting as ICH during pregnancy could prevent rebleeding and improve the maternal and fetal prognosis.

Key words: arteriovenous malformation, pregnancy, delivery, surgery

Introduction

Cerebral arteriovenous malformations (AVMs) may affect the prognosis for both mother and fetus because they may result in fatal intracranial bleeding during pregnancy.^{2,4,7,15,16,18,22} The natural history of AVMs is poorly understood, and even less under-

stood in pregnant patients, because the frequency is rare and changes in the maternal body are complicated during pregnancy. No definitive guidelines for the treatment of AVMs during pregnancy exist and the management of cerebrovascular disease in pregnancy is under discussion.^{4,10,20,24} We examined the results of pregnancy and delivery management in patients with AVMs in a single institution.

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Table 1 Summary of patient characteristics

Case No.	Age (yrs)	Parity	AVM grade*	Lesion	Presentation	Gestation at time of presentation
1	27	G1P1	pial AVF	rt parietal	hemorrhage	21st week
2	34	G1P1	I	rt insula	hemorrhage	16th week
3	27	G1P1	II	lt parietal	hemorrhage	25th week
4	30	G0P0	II	multiple	hemorrhage	25th week
5	31	G2P2	II	lt occipital	hemorrhage	5th week
6	22	G0P0	III	rt midbrain	hemorrhage	15th week
7	31	G1P1	II	rt frontal	incidental	pre-pregnancy
8	30	G0P0	II	lt parietal	headache	pre-pregnancy
9	28	G1P1	V	rt parietal	headache	pre-pregnancy

* According to Spetzler-Martin grading scale. AVF: arteriovenous fistula, AVM: arteriovenous malformation, G: gravida, lt: left, P: para, rt: right.

Subjects and Methods

Nine patients with AVM in pregnancy aged 22 to 34 years (mean 28.9 ± 3.4 years) were treated in the National Cerebral and Cardiovascular Research Center between April 2005 and April 2011 (Table 1). Six patients presented with their first episode of intracerebral hemorrhage (ICH) during pregnancy, 2 with headache, and one with incidental finding of AVM. In the 3 patients with unruptured AVM, the diagnosis was made before pregnancy. The Spetzler-Martin grade was I in one patient, II in five, III in one, and V in one. One patient was diagnosed with pial arteriovenous fistula (AVF). In each of these cases, we examined the results of pregnancy and delivery management, and the maternal and fetal outcome with ruptured and unruptured AVMs.

Results

I. Maternal management with ruptured AVMs

Six patients presented with their first episode of ICH during pregnancy; their AVMs were previously undetected. In 3 patients (Cases 1, 2, and 3), removal of the AVM was performed prior to delivery. The ICHs occurred in the 21st week, 16th week, and 25th week of gestation, and the surgery for AVM was performed in the 21st week, 18th week, and 30th week of gestation, respectively. The interval between onset and the surgery was 0 days, 14 days, and 33 days, respectively. Emergency surgery was performed for Case 1 with severe consciousness disturbance due to the mass effect of the hematoma. In another 2 patients with Spetzler-Martin grade I and II AVM, the symptoms were mild and elective surgery for AVM was performed for the prevention of rebleeding because we expected safe resection of the AVM located in superficial lesion. The management of pregnancy after removal of the AVM was similar to

a normal pregnancy, with vaginal delivery in one case and cesarean section in two cases. In Case 4, cesarean section was carried out prior to AVM treatment in the 28th week of gestation because the mother suffered from hypoxia, hemoptysis, and transient ischemic attack due to paradoxical cerebral embolism from a pulmonary AVF. The interval from the cerebral hemorrhage onset to delivery was 24 days. In this patient, the AVM lesions were small and multiple, and gamma knife surgery was conducted 4 weeks after delivery. In Case 5, the patient presented with ICH in the fifth week of pregnancy and had a miscarriage on the 11th day after ICH. Endovascular embolization and resection for AVM were performed subsequently. In Case 6, the patient presented with ICH in the 15th week of gestation, and artificial abortion was performed 18 days after onset based on the concerns of her family. Gamma knife treatment was performed subsequently. There was no rebleeding in any patient, including the puerperal period (Table 2).

II. Maternal management with unruptured AVMs

The diagnosis in 3 patients with unruptured AVMs was made before pregnancy. In Cases 7 and 8, gamma knife surgery had been performed previously, and pregnancy occurred before confirmation of the obstruction of the AVM. In Case 9 with Spetzler-Martin grade V AVM, there was no surgical indication for AVM. The vaginal delivery had been performed previously under epidural anesthesia in this patient. Case 7 had severe pregnancy-induced hypertension, and an urgent cesarean section was performed on admission to the hospital in the 28th week of gestation because her blood pressure was difficult to control. In another two cases, blood pressure management was successfully performed during pregnancy, and the patients delivered at full

Table 2 Results of arteriovenous malformation (AVM) treatment, delivery management, and mother and infant clinical outcomes

Case No.	Timing of AVM treatment	AVM treatment	Delivery (week of pregnancy)	Reasons for CS	Outcome for the mother (mRS)	Outcome for the infant
1	21st week of pregnancy	removal (emergency)	CS (36)	hemiparesis	3	infant well
2	18th week of pregnancy	removal (elective)	CS (40)	macrosomia, previous CS	0	infant well
3	30th week of pregnancy	removal (elective)	VD (40)	—	0	infant well
4	post-delivery	RS	CS (28)	pulmonary AVF	0	infant well (temporarily intubated)
5	post-abortion	EE + removal	AB (7)	—	0	—
6	post-abortion	RS	AB (18)	—	3	—
7	pre-pregnancy	RS	CS (37)	previous CS	0	infant well
8	pre-pregnancy	RS	CS (32)	severe PIH	0	infant well (temporarily intubated)
9	pre-pregnancy	conservative	VD (39)	—	0	infant well

AB: abortion, AVF: arteriovenous fistula, CS: cesarean section, EE: endovascular embolization, mRS: modified Rankin scale, PIH: pregnancy-induced hypertension, RS: radiosurgery, VD: vaginal delivery.

term. There were no bleeding complications in any of the patients over the course of the pregnancy, including the puerperal period (Table 2).

III. Method of delivery

Vaginal delivery was performed in two cases, and cesarean section in five cases. Spontaneous vaginal delivery occurred in the 40th week of gestation after removal of the AVM in Case 3, and vaginal delivery under epidural anesthesia occurred in Case 9 with Spetzler-Martin grade V AVM in the 39th week of gestation. Among the 5 patients with cesarean section, 3 had coexistent AVM. Cesarean section was performed due to the existence of the AVM in Case 7 with severe uncontrollable pregnancy-induced hypertension, in Case 4 with pulmonary AVF, and in Case 8 who had previously undergone cesarean section. Two patients underwent cesarean section after AVM resection due to maternal factors; Case 1 with limitation of abduction of the lower limbs because of hemiplegia and twin pregnancy, and Case 3 with previous cesarean section and macrosomia. Mothers and babies suffered no complications during labor (Table 2).

IV. Maternal outcome

The 6 patients with ruptured AVMs had modified Rankin scale (mRS) score of 0 in 4 cases and 3 in 2 cases. The latter resulted from initial cerebral hemorrhage. The 3 patients with unruptured AVMs had mRS score 0. There were no new maternal complications due to cerebral AVM, including bleeding complications, in all patients throughout the preg-

nancy, delivery, and puerperal periods after the diagnosis of AVM (Table 2).

V. Fetal outcome

One patient suffered spontaneous abortion in the 7th week of gestation (2 weeks after onset), and one patient underwent induced abortion in the 18th week of gestation (third week after onset). Two premature infants delivered by cesarean section in the 28th week and 32nd week of gestation required temporary respirator management, but their subsequent growth and development was good. In the remaining infants, the growth development was excellent (Table 2).

Discussion

I. Epidemiology of AVMs during pregnancy

The prevalence of cerebral AVMs is estimated at 0.01–0.50% of the population. AVM is generally present in patients aged between 20 and 40 years, and is more common in those over 30 years, the childbearing age for women.³⁾ A previous study reported 21 ischemic strokes and 11 hemorrhagic strokes among 58,429 deliveries, and 4 of 11 hemorrhagic cases resulted from AVM rupture.¹⁸⁾ Although the influence of pregnancy on AVM rupture is controversial among investigators,^{2,7,15)} in a recent report, the annual hemorrhage rate during pregnancy was 10.8%; the hemorrhage rate per pregnancy was 8.1%; and the hazard ratio for ICH during pregnancy was 7.91.⁴⁾ The frequency of rebleeding during the same pregnancy period could be as high as

27%, which is 4 times higher than for the natural course of a ruptured AVM in the first year.¹⁵⁾ However, conservative treatment was done in 20 of 24 cases, and surgical removal was performed during pregnancy in only 4 cases. Similarly, rebleeding of AVM occurred in one of 11 cases, and surgical treatment during pregnancy was only performed in 7 cases after delivery.¹⁶⁾ After AVM rupture during pregnancy, maternal mortality was 28% and fetal mortality was 14%.²⁾ These risks can be eliminated only by excision of the AVM. The prognosis for the mother and fetus would improve if surgical resection of the AVM is safely performed. In our ruptured cases, AVM resection was performed in 3 of 6 cases (50%) before delivery, and the rebleeding rate in the peri-pregnancy period was 0%. In view of these results, AVM in pregnant women should be treated with great care.

II. Maternal management with AVMs in pregnancy

Maternal management of patients with ruptured AVMs should be based mainly on neurosurgical indications rather than on obstetrical indications.²⁾ When neurological deterioration occurs due to AVM rupture, emergency surgery is necessary. If the fetus is sufficiently mature, simultaneous cesarean section is possible. When there is no indication for emergency surgery for AVM, blood pressure management is important.⁹⁾ However, this is not necessarily effective for the prevention of rebleeding because patients with ruptured AVM do not always have a history of hypertension. Although radical treatment tended to be performed after delivery in many case reports and case series, some authors suggested that early surgical intervention for AVM before delivery led to improved maternal and fetal prognosis.^{15,22)} We agree, and try to perform AVM resection during pregnancy with an immature fetus if the surgical risk is low after considering the high risk of rebleeding (Table 3). Indeed, we performed elective AVM resection with pregnancy continuation in 2 patients, with good postoperative maternal and fetal outcomes. The average period between onset and AVM resection was 23.5 days, and no rebleeding occurred during the waiting period. In addition to the maternal and neurosurgical treatment priorities, consideration of the fetus is also necessary and cooperation between obstetricians and anesthesiologists is essential during surgery. We routinely use intraoperative fetal heart rate monitoring. If the fetus has reached the minimum age for extra-uterine life, obstetricians prepare for emergency cesarean section in case of fetal distress.

Surgery for AVM is determined primarily by the

Table 3 Management decision chart for patients with intracerebral hemorrhage from arteriovenous malformation (AVM) during pregnancy

	Operative risk	
	Low	High
Fetus immature/ Early pregnancy	removal of AVM →delivery based on obstetrical indications	conservative maternal management →modified vaginal delivery/ cesarean section once fetus was mature →AVM treatment based on neurosurgical indications
Fetus mature/ Advanced pregnancy	modified vaginal delivery/ cesarean section →removal of AVM	modified vaginal delivery/ cesarean section →AVM treatment based on neurosurgical indications

Spetzler-Martin grading scale.¹⁹⁾ A potential complication of surgery for AVM during pregnancy is the risk of intraoperative bleeding leading to deterioration of the uterine and placental circulation. Although preoperative embolization is possible for cases with a high risk of intraoperative bleeding, such as deep-seated AVMs, the endovascular treatment itself carries the risk of ischemic and hemorrhagic complications.^{5,12,21)} In addition, there is not enough evidence to presume the safety of iodinated contrast agents which cross the human placenta and enter the fetus. The potential radiation risk and the potential added risks of contrast medium should be considered in the preoperative study.²³⁾ Previous reports of endovascular treatment for AVM during pregnancy are limited.¹⁷⁾ There would be wider surgical indications by discussing the efficacy and risk more about endovascular treatment for AVMs during pregnancy.

Radical treatment for ruptured AVMs in patients with a mature fetus tends to be performed in the early postpartum period.²²⁾ It is desirable for patients with unruptured AVMs to undergo radical treatment before pregnancy due to the increasing risk of AVM rupture during pregnancy. Prior to pregnancy, multimodal therapies such as direct surgery, endovascular embolization, and radiosurgery can be performed. In patients with unruptured AVMs diagnosed during pregnancy, conservative treatment is performed based on the risk of surgical treatment.

III. Delivery management

If the AVM is completely resected during pregnancy, the method of delivery can be determined based on the obstetrical indications. Our three patients who underwent AVM surgery during pregnancy could deliver at a mature gestational age. In

patients with AVM during pregnancy, problems during labor are related to the excessive cerebral hemodynamic changes, and cesarean section tends to be performed in these circumstances.⁸⁾ Cesarean section can be provided relatively safely, and is becoming more common. Recently, the rate of cesarean section has increased with the increase in high-risk pregnancies, such as with older maternal delivery age, and complicated pregnancies, which have increased up to 15% in a recent report from the Japanese Ministry of Health, Labour and Welfare. On the other hand, the maternal risks of cesarean section were reported to be 7 times higher than those of vaginal delivery and included maternal death, massive bleeding, infection, thrombosis, and injury to organs such as the bladder, although the frequency was very low.^{1,11,14)} If a patient's previous delivery was performed by cesarean section, repeated cesarean section tends to be performed to prevent uterine rupture. There is no definitive evidence that cesarean section prevents the hemorrhagic complications of AVM.^{2,7,13)} However, it is desirable to use epidural anesthesia or to shorten the second stage of labor with forceps/vacuum delivery techniques during labor.⁶⁾ When determining the parturient method, we should understand these points and inform the patient and her family to obtain consent.

We conducted painless vaginal delivery with epidural anesthesia combination in patients with AVM. In one patient with inoperative high-grade AVM, it was possible to perform vaginal delivery safely with this method. However, cesarean section allows easy control of blood pressure during labor, and is more desirable for patients with severe pregnancy-induced hypertension syndrome, as in our Case 7. Cesarean section is also indicated in patients with consciousness disturbance or hemiplegia preventing a dorsosacral position due to the consequences of ICH.

IV. Conclusion

We achieved good maternal and fetal outcomes in our cases, excluding 2 patients with mRS 3 due to the initial ICH. Surgical intervention for ruptured AVM during pregnancy could prevent rebleeding, and allow for determination of the delivery method based on the obstetrical indications. Cooperation between neurosurgeons, obstetricians, and anesthesiologists, and sufficient information about the treatment strategy given to the patients are essential. Finally, for better maternal and fetal prognosis, guidelines for female patients with cerebral AVMs should be established.

Conflicts of Interest Disclosure

The authors declare that they have no conflicts of interest. All authors who are members of The Japan Neurosurgical Society (JNS) have registered online Self-reported COI Disclosure Statement Forms through the website for JNS members.

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