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Case Report

Endovascular Treatment of Cerebral Artery Aneurysms during Pregnancy: Report of Three Cases

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Summary: Historically, surgical management of cerebral aneurysms during pregnancy has been controversial. Debate originally focused on early versus late intervention, before or after delivery of the fetus. More recently, treatment has centered on rapid intervention. We describe the endovascular treatment of cerebral artery aneurysms with Guglielmi detachable coils in three pregnant women.

Cerebral aneurysms diagnosed during pregnancy, after acute subarachnoid hemorrhage or acute enlargement, are a rare cause of morbidity and mortality. The prevalence of intracranial hemorrhage during pregnancy ranges from 0.01% to 0.05% (1–5), but results in high maternal mortality (40% to 83%) (3, 5–9) and accounts for 5% to 12% of all maternal deaths during pregnancy (5, 8, 10). Endovascular surgery with Guglielmi detachable coils (GDCs) is a minimally invasive method for effectively treating aneurysms in pregnant women. The use of GDCs in this high-risk population has not previously been reported.

Case Reports

Case 1

During the 11th gestational week, a 34-year-old woman developed a progressively severe headache, followed 3 days later by the worst headache of her life. A brain CT scan showed subarachnoid hemorrhage in the right prepontine cistern and an isodense right perimesencephalic mass (Fig 1A). A cerebral arteriogram revealed a fusiform aneurysm of the proximal right posterior cerebral artery (PCA), which filled during vertebral arteriography only (Fig 1B). No discernible filling via the right posterior communicating artery was seen from the right internal carotid artery injection (Fig 1C).

A right pterional craniotomy revealed a fusiform aneurysm, which could not be directly clipped. The right P1 segment was clipped to proximally occlude inflow into the aneurysm while leaving the posterior communicating artery patent to preserve the distal PCA. The aneurysm appeared to thrombose at surgery, and postoperative arteriography showed no further filling of the aneurysm. The right carotid artery angiogram showed patency of the posterior communicating artery and distal right PCA; however, there was no filling of the aneurysm at that time (Fig 1D and E).

Fourteen weeks after the clipping procedure (30th gestational week), the patient began to experience recurrent right retroorbital headaches. A CT scan revealed a 16-mm isodense mass in the right prepontine cistern (Fig 1F). Within 5 weeks of recurrent headaches (33rd gestational week), a partial right third cranial nerve palsy developed. A CT scan showed interval enlargement of the aneurysm by nearly 40%, to a diameter of 22 mm, with acute hemorrhage into the aneurysm wall (Fig 1G). Emergent cerebral arteriography showed opacification of an 18 × 15 × 20-mm fusiform aneurysm adjacent to the surgical clip. Injection of the dominant left vertebral artery showed minimal opacification of the aneurysm beyond the clip via a narrowly patent P1 segment (Fig 1H). Injection of the right internal carotid artery now showed opacification of the aneurysm via the right posterior communicating artery (Fig 1I). After consulting with the attending neurosurgeon and perinatologist, the patient elected to undergo endovascular treatment.

A Rapid Transit microcatheter (Cordis, Miami Lakes, FL) was advanced through the right posterior communicating artery into the aneurysmal sac using a digital roadmap technique. The aneurysm and distal right posterior communicating artery were occluded using 23 GDC-18 coils (Target Therapeutics, Fremont, CA), for a total coil length of 5920 mm (Fig 1J and K).

At the conclusion of the procedure, inflow to the aneurysm via the right posterior communicating artery was occluded. There was no filling of the aneurysm during the left vertebral artery injection; however, opacification of the right PCA distal to the aneurysm was better visualized. The patient was aroused from general anesthesia and was noted to have an incomplete left superior quadrantanopia. Given the patient's new visual field deficit, the decision was made to perform hypervolemic therapy and to maintain her on heparin.

After 2 days, the heparin was discontinued and the patient was discharged home. She completed her pregnancy with weekly clinical obstetric and neurologic evaluations, and delivered a healthy infant at term by assisted vaginal technique. At 14 months' clinical follow-up, the patient was neurologically stable. The aneurysm was occluded on control arteriograms obtained 2 days and 12 months after the initial GDC procedure.

Case 2

A 36-year-old woman (gravida VII para VI) developed a severe headache during the mid-third trimester of pregnancy. A brain CT scan showed an acute subarachnoid hemorrhage in the posterior fossa, and a diagnostic cerebral arteriogram revealed a 7-mm basilar terminus aneurysm and a 1.4-mm left superior cerebellar aneurysm (Fig 2A). After consultation with the attending neurosurgeon, the decision was made to treat the aneurysm with endovascular coil embolization.

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With the patient under general anesthesia, a Tracker 10 microcatheter (Target Therapeutics) was advanced directly into the aneurysm, and four GDC-10 coils were deployed, resulting in complete occlusion of the basilar terminus aneurysm (Fig 2B). Because the superior cerebellar artery aneurysm was a less likely cause of hemorrhage, no treatment of the second aneurysm was undertaken. Instead, it was determined that the patient would undergo close surveillance for evidence of interval growth or development of irregularity in the untreated aneurysm. The patient awakened from general anesthesia without neurologic deficit. Heparinization was continued for approximately 12 hours, after which the vascular access sheath was removed. The patient made an uneventful recovery and delivered a healthy infant 37 days later. She was stable after 40 months of close follow-up.

Case 3

A 36-year-old woman (gravida V para III) developed a mild headache while in labor during the late-third trimester of pregnancy. A brain CT scan showed diffuse subarachnoid hemorrhage, and a diagnostic cerebral arteriogram revealed a 7-mm aneurysm in the right posterior communicating artery (Fig 3A). After consultation with the attending neurosurgeon and perinatologist, the decision was made to deliver the twin fetuses by cesarean section followed by immediate GDC embolization of the cerebral aneurysm.

The patient was placed under general anesthesia in the operating room, and two healthy infants were delivered by cesarean section. While still under general anesthesia, the patient was transported to the neurointerventional angiography suite, where a Tracker 18 catheter was advanced into the aneurysm, which was treated with four GDC-10 coils, producing complete occlusion (Fig 3B). The patient awakened from general anesthesia without neurologic deficit. Heparinization was continued for approximately 12 hours, after which the vascular access sheath was removed. The patient made an uneventful recovery, and she was stable after 41 months of follow-up.

Discussion

Aneurysms that occur during pregnancy arise predominantly along the circle of Willis and are multiple in up to 20% of cases, similar to that of the general population (11, 12). In a recently reported series by Witlin et al (13) of 79,301 pregnant women, only one patient had symptoms referable to a cerebral artery aneurysm during gestation. According to Barrett et al (7), however, aneurysms occur with greater frequency during pregnancy and seem to bleed more often during pregnancy and with advancing gestational age (8, 14). Whether hemodynamic stresses associated with the pregnant state contribute to the growth and development of aneurysms is unclear. Intracranial hemorrhage remains the third leading cause of maternal death from nonobstetric causes (15, 16). Rebleeding from an untreated, previously ruptured aneurysm occurs in 33% to 50% of cases (9, 17), with mortality approaching 50% to 68% (2, 3, 9, 18).

Evidence points to hemodynamic changes that are associated with pregnancy as the cause of aneurysmal instability (1, 3, 8, 14, 19). Cardiac output increases by as much as 60% by the end of the second trimester. Progressive increases in blood volume and pressure reach a maximum at term (20). Endocrine and metabolic factors during pregnancy have been implicated (21) but are, as yet, of indeterminate significance.

Independent of pregnancy, but applicable to the treatment procedure in our first case, Artmann et al (22) reviewed a series of growing intracranial aneurysms and found that partially thrombosed aneurysms on admission arteriography were more likely to increase in size to giant proportions than were aneurysms without intraaneurysmal thrombosis. Whether the enlargement process involved actual ''growth'' of the aneurysm wall, to use those authors' terminology, or merely expansion of the aneurysm wall is uncertain.

Most authors now favor immediate treatment with or without delivery of the infant (1–4, 8, 9, 12, 14, 17, 19, 21, 23–28). Multivariate analysis indicates that mother and fetus benefit from surgical treatment after aneurysmal subarachnoid hemorrhage, with a maternal mortality of 11% in the operative group and 63% in the untreated group. The fetal mortality rate of 5% in the operative group is also significantly decreased as compared with the untreated group, which has a 27% mortality rate (8, 18). Although open surgical management of aneurysms during pregnancy has been described, the role of endovascular embolization using GDC coils has not previously been reported.

One of the most commonly expressed concerns about angiography during pregnancy is the potential risk of fetal abnormalities resulting from radiation exposure. Radiation effects are, however, highly dependent on the stage of fetal development at the time of radiation exposure (29–33). During embryogenesis (first two weeks of pregnancy), radiation damage may result in the death of the embryo. During organogenesis (weeks 2 through 7 of gestation), radiation damage may result in congenital abnormalities in the surviving fetus. The probability of radiation damage increases with increasing absorbed dose. The fetal period (week 8 until birth) is characterized by growth and development of the fetus. Radiation risk during the fetal period includes growth retardation with microcephaly, retardation due to neuron depletion, and development of childhood cancer. The risk of neuron depletion is greatest during weeks 8 to 15 of gestation. It is during this period that neuroblast proliferation and migration to the cerebral cortex occurs (32).

Possible hazards of X-ray exposure during pregnancy have been evaluated by the International Commission on Radiation Protection and the National Council on Radiation Protection (NCRP). Although no specific dosimetric evaluations of the gravid uterus have been performed during cerebral arteriography, calculated doses to the fetus during skull radiography have been obtained (34). Estimates performed by Feygelman et al (35) of absorbed dose to the patient for both cut-film and digital subtraction arteriography produced an estimated average effective dose equivalent in the range of 10 millisieverts (msV), similar to that ob-

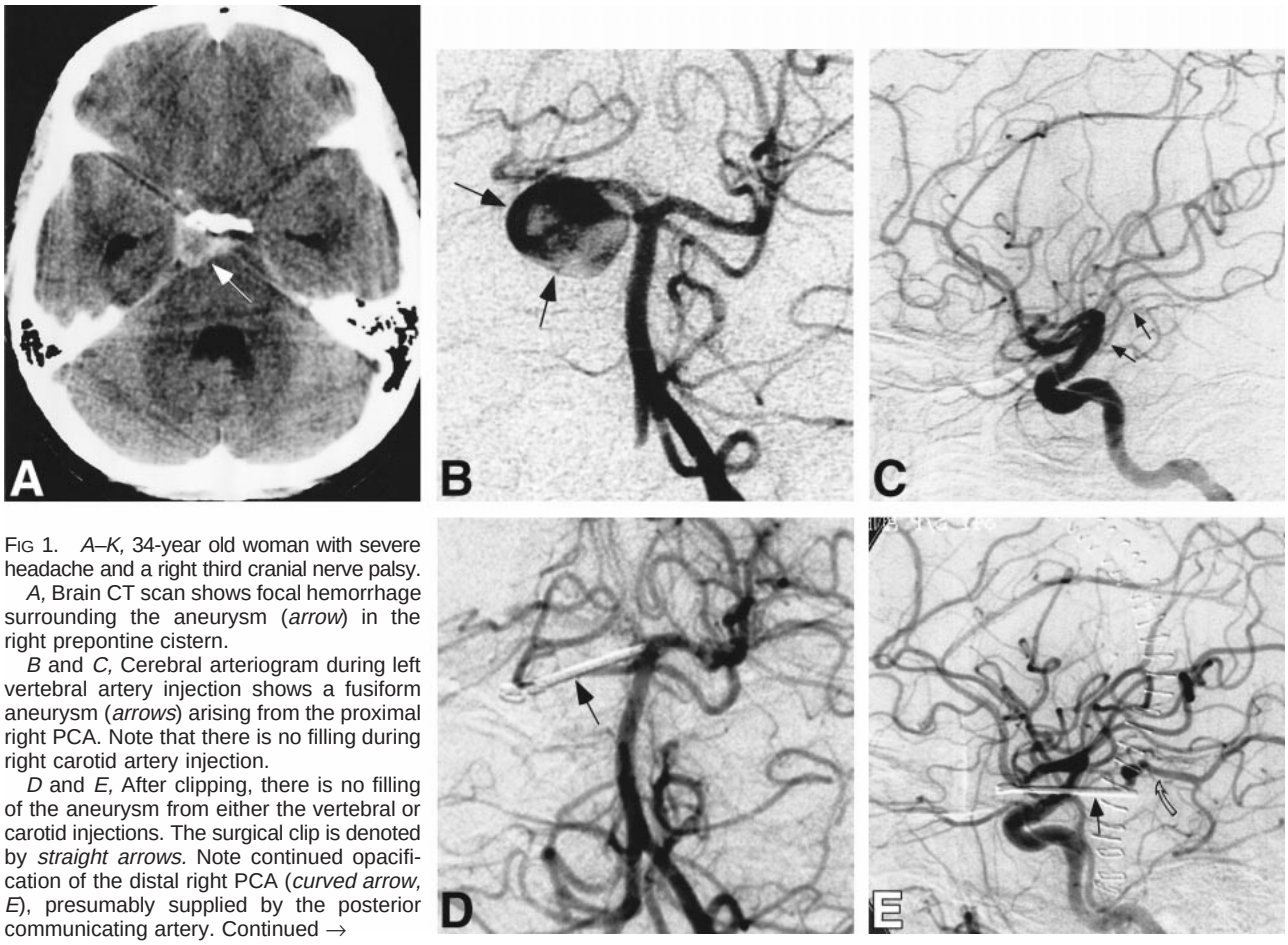

FIG 1. *A–K,* 34-year old woman with severe headache and a right third cranial nerve palsy.

A, Brain CT scan shows focal hemorrhage surrounding the aneurysm (*arrow*) in the right prepontine cistern.

B and *C,* Cerebral arteriogram during left vertebral artery injection shows a fusiform aneurysm (*arrows*) arising from the proximal right PCA. Note that there is no filling during right carotid artery injection.

D and *E,* After clipping, there is no filling of the aneurysm from either the vertebral or carotid injections. The surgical clip is denoted by *straight arrows.* Note continued opacification of the distal right PCA (*curved arrow, E*), presumably supplied by the posterior communicating artery. Continued →

tained from five to eight CT scans of the head. (Note: The sievert is a measure of the biological impact of radiation. The conventional unit is the rem, which is equivalent to the rad for X-ray fluoroscopy; the SI unit is the sievert: 1 Sv = 100 rem.) Marshall et al (36) reported an average effective dose equivalent to the patient of approximately 3.6 mSv, less than half the dose reported by Feygelman et al. Extrapolation from absorbed patient dose to absorbed fetal dose is difficult. However, scatter radiation to the abdomen and pelvis from direct exposure of the cranium is minimal. Based on a four-image radiographic series of the skull, the measurable dose to the uterus and embryo using the standard reference phantom was less than 0.1 mrad (34). According to the NCRP, at exposure levels below 1 rad, the statistical probability of a detectable radiation effect is so small that it is outweighed by the medical benefits of the procedure to the mother and, therefore, indirectly to the fetus (37, 38).

The interventional neuroradiologist can take certain actions to limit radiation exposure to the mother and fetus. Abdominal shielding, limited fluoroscopy in proximity to the uterus, and use of modern imaging equipment are highly recommended. Precautions to limit radiation exposure to the patient are of paramount importance. The abdomen should be shielded both anteriorly and posteriorly. Fluoroscopy should only be performed cephalad to the aortic arch using low X-ray photon flux and low pulse frequency settings available on modern equipment. Catheter position must be achieved rapidly but safely. Proper positioning of the fluoroscopic equipment to maximize diagnostic information from each angiographic series is imperative if dosage is to be curtailed as much as possible. Modern digital imaging systems require lower rates of photon production than do older equipment, owing to improvements in X-ray tube and image intensifier design.

Anesthetic considerations during pregnancy are governed primarily by maternal-fetal physiology and arterial pressure control to reduce the risk of aneurysmal hemorrhage. Participation of perinatal anesthesiologists experienced in obstetric anesthesia is desirable. Physiological maternal hyperventilation with compensated respiratory alkalosis reduces the required dosage and concentration of anesthetic agents. Anesthetic agents must be selected to limit deleterious effects to the fetus. While certain studies have shown teratogenicity of some anesthetics in animals and humans, a recent review of 14 studies from 1967 to 1982 determined that

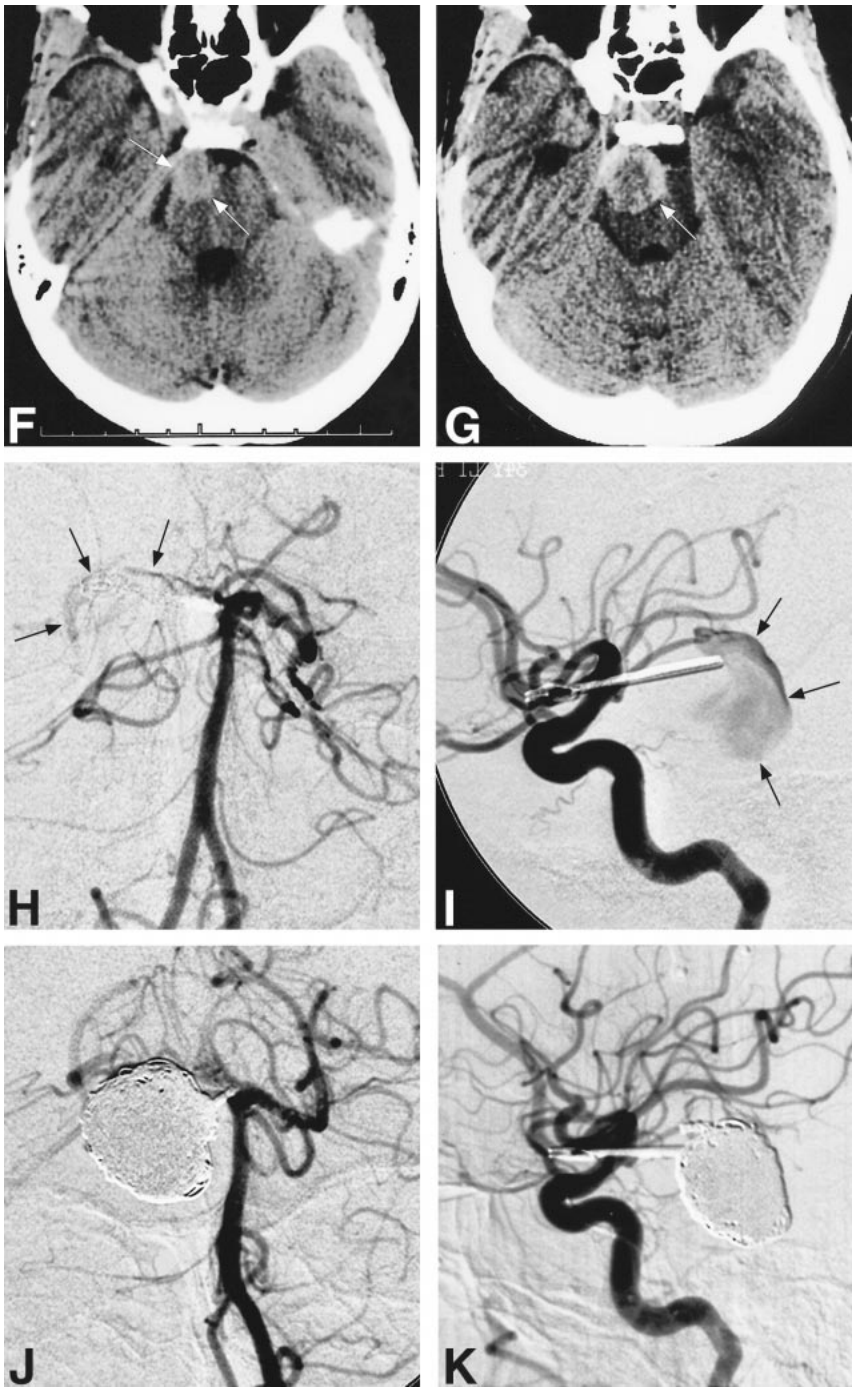

FIG 1 (continued). *F–K,* 17 weeks after surgical clipping, the patient presented with recurrent headaches and a right third nerve palsy. Brain CT scans (*F* and *G*) show interval aneurysm growth from 16 mm to 21 mm (*arrows*) despite prior surgical clipping of the proximal right P1 PCA segment. Cerebral arteriograms (*H* and *I*) show renewed opacification of the aneurysm (*arrows*) via posterior communicating artery to a greater degree than the PCA. Cerebral arteriograms after GDC coiling procedure (*J* and *K*) now show complete occlusion of the aneurysm and improved visualization of the distal right PCA.

no adverse effect of anesthetic gases could be inferred (39). On the basis of a survey reported in the literature, no teratogenicity of anesthetics was found (39). The largest survey, which included 5405 pregnant women who underwent a variety of surgical procedures under anesthesia, found no significant difference in the rate of congenital malformations or stillbirths as compared with the control population (40). Blood pressure control without hypotension and maintenance of euvolia are important to maintain uterine blood flow and transplacental oxygenation of the fetus at all times (39). Factors limiting ventricular filling pressure, such as inferior vena cava impingement by the gravid uterus, excessive mechanical ventilator pressures (41, 42), and excessive intraoperative blood loss, must be carefully monitored. The torso should be rotated to the left after placement of an arterial access catheter in the right common femoral artery to displace the gravid uterus from the inferior vena cava. Continuous fetal monitoring is important to detect early evidence of fetal distress and is critical for good fetal outcome. Fetal distress despite optimization of maternal physiology may require emergent cesar-

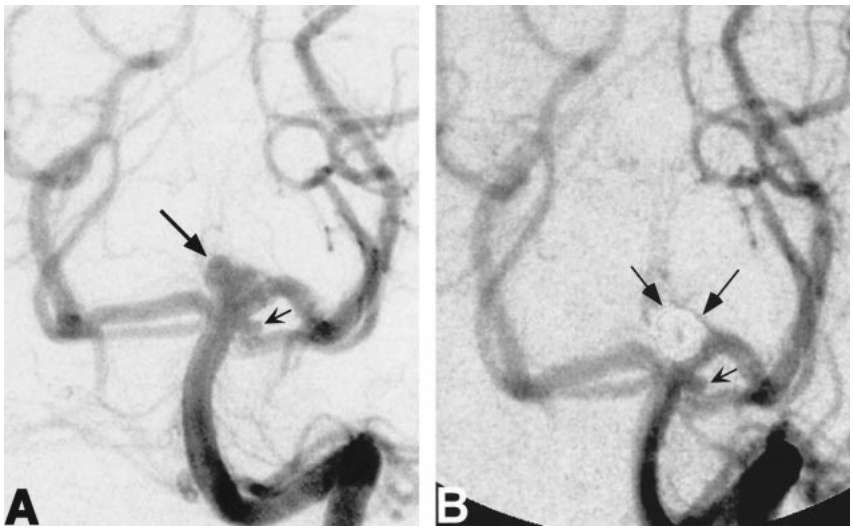

FIG 2. *A,* 36-year-old woman with severe headache and grade II subarachnoid hemorrhage from a ruptured 7-mm basilar terminus aneurysm (*long arrow*). Note the presence also of a 1.4-mm left superior cerebellar artery aneurysm (*short arrow*).

B, Complete obliteration is achieved after GDC occlusion of the basilar terminus aneurysm (*arrows*). The patient was followed up closely for the small, unruptured superior cerebellar artery aneurysm.

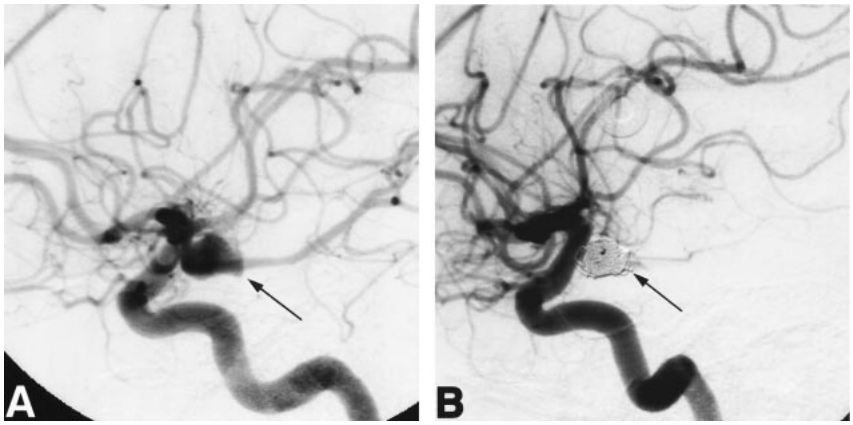

FIG 3. *A,* 36-year-old woman with severe headache and a grade I subarachnoid hemorrhage from a ruptured posterior communicating artery aneurysm (*arrow*).

B, Postembolization angiogram after GDC occlusion shows complete obliteration of the aneurysm (*arrow*).

ean section with interval suspension of aneurysm treatment (14).

Obstetric management had been guided by the concept that increased intravascular pressure during labor and delivery for patients with intracranial vascular lesions is deleterious (43). In the past, elevated intravascular pressure resulting from straining (Valsalva) during active labor was thought to increase the risk of intracranial hemorrhage; however, recent studies suggest that the risk of intracranial hemorrhage in the presence of an untreated cerebrovascular lesion is not significantly different between vaginal delivery and cesarean section (4, 8, 14, 18, 23, 44). In our series, two patients underwent uncomplicated vaginal delivery after endovascular embolization with GDC occlusion of their aneurysms and the third patient had a cesarean section immediately before endovascular treatment for a ruptured posterior communicating artery aneurysm. In both types of delivery, mothers and infants did well. Adjunctive measures, such as epidural or caudal anesthesia with low forceps-assisted vaginal delivery, may be used at the obstetrician's discretion (14, 18, 42).

Conclusion

Our early experience indicates that endovascular techniques may play an important role in the management of symptomatic cerebral artery aneurysms during pregnancy. Limited alterations in maternal-fetal physiology, low relative risk of significant radiation exposure to the fetus when appropriate techniques are observed, and successful outcomes suggest that the endovascular approach to aneurysms during pregnancy is warranted and may be less invasive to both the mother and fetus than conventional neurosurgery.

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