Case Report

Recurrence of a cerebral arteriovenous malformation following complete surgical resection: A case report and review of the literature

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Abstract

Background: Angiography-confirmed complete resection of an arteriovenous malformation (AVM) has traditionally been considered curative. However, recurrence of AVM following angiographically proven complete resection does exist, especially in children. This rare occurrence has been reported 29 times in the English language literature. Although recurrence may be asymptomatic, many reported cases result in epilepsy or intracranial hemorrhage anywhere from 0.5 to 9 years following complete resection. We report a rare case of AVM recurrence that became symptomatic 16 years after complete resection. We review the literature and discuss the relevance of performing follow-up imaging to detect AVM recurrence.

Case Description: An 8-year-old girl presented with a right occipital hemorrhage with intraventricular extension from a ruptured AVM of the right occipital lobe. She underwent AVM resection through a right occipital craniotomy. Postoperative angiography confirmed complete resection and she made an uneventful recovery. Sixteen years later, she presented with a 2-month history of headaches, nausea and dizziness. Angiography revealed recurrence of the AVM which was completely resected, as documented on postoperative angiography.

Conclusion: In children, an AVM may recur after angiography-proven complete resection. Recurrence may be due to persistence and growth of an initially angiographically occult arteriovenous shunt left in place during surgery or the development of a new AVM. In addition to obtaining follow-up angiography 6–12 months after surgery, a late angiography 5 years after resection may be warranted in patients at risk for recurrence. Asymptomatic recurrence detection allows treatment and may prevent the morbidity associated with intracranial hemorrhage.

Key Words: Arteriovenous malformation, cerebral hemorrhage, postoperative angiography, recurrence
INTRODUCTION

Digital subtraction angiography (DSA) is the gold standard for diagnosing and confirming complete resection of arteriovenous malformations (AVMs). The absence of residual AVM following surgery has traditionally been believed to represent a cure from risk of future hemorrhage. However, recurrence of AVM following angiographically proven complete resection can rarely occur, especially in the pediatric population. Recurrence presents as hemorrhage, epilepsy, or radiological recurrence on routine follow-up imaging 0.5–9 years following resection in reported cases of the English language literature. We report a case of AVM recurrence that became symptomatic 16 years after complete resection. We review the literature, discuss the possible pathophysiological mechanisms, and relevance of recognizing this occurrence.

CASE REPORT

Initial presentation
A previously healthy, 8-year-old, right-handed girl initially presented to the emergency department of another institution with nausea and vomiting followed by a decreased level of consciousness. Upon examination, she was somnolent but arousable with intact brainstem reflexes and no motor deficit. An urgent computerized tomography (CT) scan revealed a right occipital intraparenchymal hematoma with intraventricular extension into the right lateral and fourth ventricle. There was no overt hydrocephalus. The patient received supportive therapy in this institution and she made an uneventful recovery with residual left homonymous hemianopsia. She was discharged from the hospital after 4 weeks. Three months following the hemorrhage, on November 16, 1995, she underwent a brain Magnetic Resonance Imaging (MRI) that showed an area of encephalomalacia in the right occipital lobe. A subsequent DSA was performed on December 28, 1995, which revealed a Spetzler-Martin grade III (4 × 3 × 1.5 cm) occipital AVM supplied by the posterior parietal and angular branches of the middle cerebral artery (MCA) and draining through a superficial cortical vein into the right transverse sinus. There were no feeders from the left internal carotid artery (ICA), external carotid artery (ECA) or posterior cerebral artery (PCA). The patient was then referred to our center for AVM management.

Initial treatment
On January 5, 1996, the patient underwent a right occipital craniotomy for AVM resection. Postoperative DSA performed 17 days after surgery demonstrated no residual AVM. The patient made an uneventful recovery except persistent visual field deficit. Although a Magnetic Resonance Angiography (MRA) was recommended at 8-month follow-up, the family declined this study and the patient was lost to follow-up.

Recurrence and re-treatment
Sixteen years after surgery, at the age of 24, the patient developed daily headaches associated with nausea and dizziness that progressed over a 2-month period. Upon consultation in another institution, neurological examination revealed left homonymous hemianopsia and mild (4+/5) motor weakness of the left lower extremity. She was otherwise neurologically intact. CT angiography revealed a recurrence of the right occipital AVM fed by MCA branches and draining into the superior sagittal sinus (SSS). The patient was referred to our center where, on August 24, 2011, a DSA confirmed the presence of the AVM.
Figure 3: Anteroposterior (AP, a) and lateral (b) right internal carotid artery angiogram, performed 4 months after hemorrhage, showing a right occipital Spetzler-Martin grade III arteriovenous malformation (4 × 3 × 1.5 cm) with feeders from the posterior parietal and angular branches of the middle cerebral artery and early superficial cortical venous drainage to the right transverse sinus. There were no feeders arising from the external carotid artery or vertebro-basilar system.

Figure 4: AP (a) and lateral (b) right common carotid artery angiogram, performed 17 days after surgery, showing no residual arteriovenous malformation.

Figure 5: CTA (a) with axial reconstruction (b), obtained 16 years after arteriovenous malformation (AVM) resection, showing recurrence of the AVM in the anterior portion of the resection cavity in the right occipital lobe.

Figure 6: AP (a) and lateral (b) right common carotid artery angiogram showing recurrence of a Spetzler-Martin grade III (3 × 3.5 × 3.5 cm) arteriovenous malformation with middle cerebral artery branch feeders and drainage through a cortical vein to the SSS. Postoperative angiography (c) shows complete resection.

DISCUSSION
Angiography is the gold standard for confirming the absence of residual cerebral AVM following resective surgery. Angiographically proven complete resection of the AVM is generally considered to represent a cure from this disease and its inherent risk.

the right occipital AVM [Figure 6a and b]. The patient underwent an uneventful second microsurgical resection of the occipital AVM recurrence through a right occipital craniotomy using ultrasonographic guidance. Postoperative DSA performed 7 days after surgery showed no evidence of residual AVM [Figure 6c]. Her preoperative symptoms resolved, but her visual deficit was mildly accentuated postoperatively. The postoperative course was otherwise uneventful and she remains stable at 5-week follow-up.
of hemorrhage.\[3,6,7,10-12,14,18,23-25,30,31\] However, recurrence of AVM following angiography-documented complete resection has been reported. This occurrence is rare, as only 29 cases have been reported in the English literature.\[2,4,5,8,9,14,16,18-20,22,26-28,32\] In surgical series of AVM treatment, recurrence of AVM and/or hemorrhage has been reported to occur in 0.6–13% of cases.\[4,19,20,22\] The actual rate of recurrence, however, is unknown. The above-mentioned incidence may be affected by a selection bias from the inclusion of re-hemorrhage cases without documented AVM recurrence or the exclusion of asymptomatic recurrences that are not detected since late follow-up DSA is not systematically performed in all institutions.

On review of the literature, it was found that AVM recurrence afflicts the pediatric population more frequently (82% of cases) [Table 1]. The average age of initial surgery is 12 years (range 1–33 years) and both sexes are equally affected (n = 14; 54% women). Five cases of recurrent AVM have been reported following AVM resection in adults.\[5,9,13,26,27\] Although some of the reported cases of AVM recurrence following complete resection have been identified as an incidental finding on routine imaging (n = 8, 31%), others have presented with seizure (n = 4, 15%) or hemorrhage (n = 12, 46%).\[2,4,5,8,9,14,16,18,20,22,26-28,32\] Reported cases in the English literature have found AVM recurrence to occur from 0.5 to 9 years after the supposed “curative” surgery.\[2,4,5,8,9,13,14,16,18,20,22,26-28\] We report a case of AVM recurrence that became symptomatic and was thus discovered 16 years following angiographically demonstrated post-surgical obliteration in an 8-year-old girl. However, the timing of radiological/asymptomatic recurrence in this patient was unknown, as no cerebrovascular imaging could be obtained in our patient after the first angiography on the 17th postoperative day. Although the exact mechanism of AVM recurrence is currently unknown, there are a number of pathophysiological theories that have been used to explain its occurrence. Recurrence may be due to the persistence and growth of an initially angiographically occult arteriovenous shunt left in place during surgery or the development of a new AVM.\[9,15,19,26\]

The persistence of an arteriovenous shunt has been suggested by some authors.\[4,5,9,20\] One possible explanation for AVM recurrence is the hidden compartment theory proposed by Pellettiere et al.\[26\] The AVM may harbor unfilled mature vessels within, adjacent, or remote from the angiographically visible nidus resected during surgery.\[26\] These vessels, which are initially poorly solicited due to an internal steal phenomenon that favors flow through the visible nidus, may become recruited following resection of the AVM nidus.\[26\] Recently reported cases where a different compartment of arterial feeders has been recruited to supply a recurrent AVM lends further support to this theory.\[8,19\] Instead, in the early postoperative period, a persistent shunt may be masked by cerebral edema, vasospasm, and/or transient thrombosis.\[4,5,9,20\] The resolution of these mechanisms in the early postoperative period could allow the eventual re-opacification and growth of the persistent AVM. However, this theory cannot explain all cases of AVM recurrence, as AVM recurrence has been reported to occur despite no residual AVM on postoperative angiography performed several months after the operation.\[8,20,22\] Furthermore, recurrence is more exceptional in adults than in children, suggesting that immature cerebrovascular factors play an important role in recurrence.\[19\] Also, the recruitment of new arterial feeders in some recurrent cases cannot be explained solely by the theory of vessel compression, spasm or thrombosis.\[6,20,22\]

Alternatively, recurrence may be the result of de novo AVM formation. Small angiographically occult immature vessels may persist following AVM resection in pediatric patients.\[9,13,19\] These vessels, although initially small and invisible, may actively grow under the influence of pro-angiogenic factors throughout childhood and adolescence.\[19,26\] This hypothesis may explain the propensity of AVM recurrence in the pediatric population, where AVMs are believed to grow before reaching maturity in the adult brain.\[15,20\] On the other hand, AVM recurrence may be a marker of a state of a heightened pro-angiogenic tonus in the AVM and/or its surrounding tissue.\[12,21\] Angiogenesis may play a role in the formation of all AVMs, as the endothelium of resected AVMs has been shown to harbor vascular endothelial growth factor (VEGF) and its receptor.\[1,21\] However, the rarity of AVM recurrence following angiographic “cure” suggests that only certain patients harbor this state of inappropriate pro-angiogenic hypersecretion. This hypersecretion of pro-angiogenic factors may result from inherent or acquired factors.\[2\] Sonstein et al. found that astrocytic VEGF expression was higher in pediatric cases of post-resection AVM recurrence as compared to non-recurrent pediatric and adult controls.\[28\] This suggests that there may be a subgroup of AVMs with inherent relative hypersecretion of pro-angiogenic factors compared to other groups.\[2\] Factors following the AVM resection may also play a role, as subsequent loco-regional ischemia and inflammation may stimulate hypersecretion of pro-angiogenic factors.\[2\]

The occurrence of AVM recurrence following complete removal raises the issue of timing for follow-up angiography. There is a general agreement that DSA should be performed in the immediate postoperative period to rule out residual AVM, as this is known to have an increased risk of immediate hemorrhage from surgically altered hemodynamic factors, warranting early re-operation.\[3,6,25,29\] Recurrence of AVM following complete resection has been hypothesized to harbor an increased risk of hemorrhage,\[2\] which may have
| Author, year          | Case | Age, sex | Initial presentation | AVM characteristics | Timing postop angiography | Delay to recurrence | Recurrence presentation | AVM characteristics | Tx | Obliteration |
|----------------------|------|----------|----------------------|--------------------|--------------------------|---------------------|----------------------|--------------------|----|-------------|
| Yasargil et al., 1988 | 1    | 17, F    | ICH                  | Rt frontal / moderate size | 2 days | 7 years | ICH | Lt frontal / 3 × 2 cm |
| Hladky et al., 1994  | 2    | NS       | NS                  | NS                 | Early Late | Routine angiography | Routine angiography | Same / NS | NS | NS | SRS | Complete |
|                      | 3    | NS       | NS                  | NS                 | Early Late | Routine angiography | Routine angiography | Same / NS | NS | NS | SRS | Complete |
| Kondziolka et al., 1992 | 4   | Ped      | ICH                  | Temporal / NS       | NS         | 3 months | 3 years ICH | NS / small | NS | NS | NS | NS |
|                      | 5    | Ped      | ICH                  | Temporal / NS       | NS         | 3 years | ICH | NS / small | NS | NS | NS | NS |
| Kader et al., 1996  | 6    | 8, F     | ICH                  | Diffuse Rt orbito-frONTAL-sylvian / 4 × 3 cm | SSS | Immediate | 6 years ICH | 2 AVM: 1. Orbito-frONTAL / 1.5 × 2 cm, 2. Anterior sylvian region / 3 × 2 cm | NS | Resection | Complete |
|                     | 7    | 6, F     | Headache, hemiplegia | Rt sylvian / <1 cm  | Rt MCA | Superficial sylvian v. | 6 days | 9 years ICH | Posterior to original / larger | Lateral lenticulostraite a., MCA | SSS | Embolization | Awaiting surgery |
|                     | 8    | 11, M    | IVH                  | Lt parietal / NS    | RT and Lt ACA, MChA, Lt PCA | Ventricular v., superficial sinus | 7 days | 3 years ICH and IVH | Not done due to death | NA | NA | None | NA |
|                     | 9    | 5, F     | ICH                  | Posterior sylvian fissure / small | MCA | SSS, transverse sinus | 7 years | Seizure | Parietal, more medial with intraventricular extension / larger (3 cm) | AChA, MCA | Superficial cortical v. | Resection | Complete |
|                     | 10   | 13, F    | ICH                  | Lt parieto-occipital / NS | PCA | V. of Galen | 7 days | 1 year | Routine angiography | PCA | V. of Galen | SRS | NA |
| Gabriel et al., 1996 | 11   | 19, M    | ICH                  | Lt fronto-temporal / NS | LT ACA, MCA, ICA | 2 draining v. | 7 days | 9 years Seizure | Lt fronto-temporal / 3 × 2 × 2.5 cm (larger) | Lt ACA, MCA, ICA | NS | Resection | Complete |
| Author, year | Case | Age, sex | Initial presentation | AVM characteristics | Timing postop angiography | Delay to recurrence | Recurrence presentation | AVM characteristics | Tx | Obliteration |
|--------------|------|----------|---------------------|-------------------|------------------------|-------------------|-------------------------|-------------------|----|-------------|
| Sonstein et al., 1996 | 12 | 8, F | SAH and ICH | Rt sylvian | NS | NS | 6 years | NS | NS | NS | NS |
| | 13 | 11, M | IVH | Lt medial parietal | NS | NS | 3 years | NS | NS | NS | NS |
| | 14 | 6, F | ICH | Lt sylvian | NS | NS | 9 years | NS | NS | NS | NS |
| | 15 | 11, F | ICH and IVH | Lt occipital | NS | NS | 1 year | NS | NS | NS | NS |
| Pelletieri et al., 1997 | 16 | 29, F | ICH | Rt frontal | NS | NS | 7 days | Routine angiography | Rt frontal | ACA, MCA, ECA | NS | None |
| | 17 | 28, M | Seizure | Rt frontal | MCA | SSS | 15 days | 3 years | SAH | Rt lateral lenticulostraite | Cortical v. | SRS | NA |
| | 18 | 11, M | ICH / IVH then ICH / SAH 6 years later | Lt occipital | PChA | V. of Galen | 3 months | 5 years | ICH | Lt PCA, Lt callosomarginal a. | NS | Resection | Complete |
| Santoro et al., 2000 | 19 | 24, M | Seizure | Rt posterior temporal | Rt PCA, MCA | NS | 10 days | 6 years | Seizure | Same location | Rt ICA | NS | Resection | Complete |
| Ali et al., 2003 | 20 | 7, M | ICH | Lt frontal | NS | NS | 2 days | 8 years | ICH | Lt frontal / 3 × 2 cm | ACA | Cortical draining v. | Resection | Complete |
| | 21 | 7, M | ICH | Rt parietal | NS | NS | 1 day | 8 years | ICH and IVH | Lt parietal / 2 cm | Rt MCA, choroidal a. | NS | Resection | Complete |
| Andaluz et al., 2003 | 22 | 4, M | ICH | Lt temporal / 2 × 3 cm | Lt MCA, Lt PCA | Basal v. Rosenthal and 10 days | 5 years | Headaches | Lt temporal / 1.5 × 1.5 cm | Same / NS | NS | Resection | Complete |
| | 23 | 6, F | IVH | Corpus callosum | Pericallosal arteries | NS | 3 years | Routine MRI | Same / NS | NS | No | Re-hemorrhage |
| Klimo et al., 2007 | 24 | 11, M | ICH | Diffuse Rt parietal | Rt MCA | NS | 7 months | Routine angiography | Same / same | Rt MCA | SRS | NA |
| | 25 | 12, M | ICH | Diffuse Lt parietal | NS | NS | Immediate | 7 years | Seizure | Lt parietal | Lt MCA | Transverse sinus | Resection | Complete |
| | 26 | 7, F | ICH | NS | Pericallosal arteries | NS | 7 months | Routine angiography | Same / NS | NS | Resection | Complete |
| | 27 | 1, F | Nystagmus | Lt temporal lobe | PCA, PLChA | NS | 2 years | IVH | Involved midbrain | NS | Resection, SRS | Increase AVM and repeat IVH |
In children, an AVM may recur and become symptomatic many years after angiography-proven complete resection. Recurrence may be due to the persistence and growth of an initially angiographically occult arteriovenous shunt left in place during surgery or the development of a new AVM. In addition to obtaining a second follow-up angiography 6-12 months after surgery, a third late follow-up angiography 5 years or more after surgery may be warranted in high-risk cases. Although some pediatric patients at risk for recurrence may allow for the detection of asymptomatic late recurrence, the natural history of these lesions is incompletely understood.

**CONCLUSION**

In children, an AVM may recur and become symptomatic many years after angiography-proven complete resection. Recurrence may be due to the persistence and growth of an initially angiographically occult arteriovenous shunt left in place during surgery or the development of a new AVM. In addition to obtaining a second follow-up angiography 6-12 months after surgery, a third late follow-up angiography 5 years or more after surgery may be warranted in high-risk cases. Although some pediatric patients at risk for recurrence may allow for the detection of asymptomatic late recurrence, the natural history of these lesions is incompletely understood.

**Table 1: Contd....**

| Author, year | Case | Age, sex | Initial presentation | AVM characteristics | Timing postop angiography | Delay to recurrence | Recurrence presentation | AVM characteristics | Tx | Obliteration |
|--------------|------|----------|---------------------|---------------------|---------------------------|---------------------|------------------------|---------------------|----|-------------|
| Codd et al., 2008 | 29  | 33, F | ICH | Lt occipital / <3 cm | Lt PCA calcarine branch | Deep vein | Early | 7 years | ICH | Lt PCA calcarine branch | SSS | Resection | 2nd recurrence at 1 year |
| Present case | 30  | 8, F | ICH and IVH | Rt occipital / 4 × 3 × 1.5 cm | Rt MCA Transverse sinus | | 17 days | 16 years | ICH | Rt occipital / 3 × 3.5 × 3.5 cm | SSS | Resection | Complete |

M: Male, F: Female, Ped: Pediatric, ICH: Intracerebral hemorrhage, IVH: Intraventricular hemorrhage, AVM: Arteriovenous malformation, Rt: Right, Lt: Left, postop: postoperative, NS: Not specified, SAH: Subarachnoid hemorrhage, Tx: Treatment, SRS: Stereotactic radiosurgery, NA: Not available, MCA: Middle cerebral artery, PCA: Posterior cerebral artery, PLChA, PChA: Posterior choroidal artery, ACA: Anterior cerebral artery, ECA: External carotid artery

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