The use of intraarterial papaverine in the management of vasospasm complicating arteriovenous malformation resection

Report of two cases


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The authors report two cases of treatment by intraarterial papaverine of cerebral vasospasm complicating the resection of an arteriovenous malformation (AVM). Both cases had successful reversal of vasospasm documented on angiography. In the first case sustained neurological improvement occurred, resulting in a normal outcome by the time of discharge. In the second case, neurological deterioration occurred with the development of cerebral edema. This complication was thought to be due to normal perfusion pressure breakthrough, on the basis of angiographic arterial vasodilation and increased cerebral blood flow.

These two cases illustrate an unusual complication of surgery for AVMs and demonstrate that vasospasm (along with intracranial hemorrhage, venous occlusion, and normal perfusion pressure breakthrough) should be considered in the differential diagnosis of delayed neurological deterioration following resection of these lesions. Although intraarterial papaverine may be successful in dilating spastic arteries, it may also result in pathologically high flows following AVM resection. However, this complication has not been seen in our experience of treating aneurysmal subarachnoid hemorrhage by this technique.

KEY WORDS • arteriovenous malformation • vasospasm • papaverine • normal perfusion pressure breakthrough

The most commonly recognized causes for delayed neurological deficit following resection of an arteriovenous malformation (AVM) of the brain are intracranial hematoma, propagated venous occlusion, and the normal perfusion pressure breakthrough syndrome. Intracranial hemorrhage has been reported as a complication of AVM resection but is uncommon, as attested to by the absence of discussion of this condition in large series in which complications are reported. However, the true incidence of cerebral vasospasm arising as a consequence of AVM resection is unknown because of the difficulty in determining the cause of arterial narrowing following extirpation of these lesions. This difficulty arises because vasospasm must be differentiated from the expected reduction in the size of feeding arteries due to reflex narrowing that occurs because of an increase in the transmural pressure of these vessels with the ablation of the arteriovenous shunt. Angiographically, these two conditions may prove difficult to differentiate.

The use of intraarterial papaverine in the management of cerebral vasospasm arising as a consequence of aneurysmal subarachnoid hemorrhage (SAH) appears to hold promise. However, in the event of vasospasm following AVM resection the result of papaverine infusion is unknown because of the lack of reported cases and the variability in the responsiveness of AVM feeding vessels.

As part of the management of cerebral vasospasm at Royal North Shore Hospital, angiography is routinely performed in the event of neurological deterioration following aneurysm or AVM surgery. The two cases of vasospasm reported here occurred during the first 12-month period (August, 1992 to July, 1993) of this protocol. During this period 80 cerebral aneurysms were repaired in 70 patients, 21 of whom subsequently underwent infusion of intraarterial papaverine. Also during this period 25 AVMs of the brain were resected; the two patients reported here were the only cases of AVM treated with papaverine.

Case Report

Case 1

This 36-year-old man presented following a single seizure. On admission he was neurologically intact.

Examination. Computerized tomography (CT), magnetic resonance (MR) imaging, and angiography revealed a 2.5-cm AVM (Fig. 1) involving the right gyrus rectus and
the rostrum of the corpus callosum. Feeding vessels were identified arising bilaterally from the anterior cerebral artery immediately distal to the anterior communicating artery. There were no aneurysms seen, and venous drainage was largely superficial through a large cortical vein into the sagittal sinus.

Operation. Surgical resection was performed through a low bifrontal craniotomy, dividing the falx anterior to the major draining vein, providing an interhemispheric approach. Resection was completed with preservation of both A2 segments and the right frontopolar artery. No untoward bleeding occurred during surgery and a postoperative CT scan on the following day confirmed minimal hemorrhage in the resection bed. Included in postoperative management were strict systolic blood pressure control (between 90 and 120 mm Hg), low-molecular-weight heparin (2500 U twice daily), and aspirin (150 mg daily).

Postoperative Course. On the first postoperative day the patient was alert and well oriented with no focal neurological deficits. He remained well until Day 3, when he became difficult to rouse, was confused, and could obey only simple commands.

A CT scan demonstrated early infarction of the caudate nucleus on the right side, with no evidence of hemorrhage. Immediate angiography confirmed surgical excision of the AVM, but there was severe vasospasm of the anterior cerebral artery bilaterally (Fig. 2A and B). After progressive infusion of papaverine (250 mg into the right internal carotid artery (ICA) and 150 mg into the left ICA) there was a significant increase in the caliber of the arteries on either side (Fig. 2C and D).

Following the angiogram, on return to the intensive care unit, an induced hypertensive regimen (between 150 and 180 mm Hg systolic) was established and continued for 10 days. Four hours postangiography there was mild improvement in the patient’s clinical condition; he became somewhat less drowsy and more comprehensible. Twenty-four hours postangiography there was a marked and sustained improvement. On Day 20 following surgery he was well and was discharged home.

Case 2

This 65-year-old hypertensive man presented with a 2-day history of headache and a progressive speech deficit.

Examination. Neurological examination elicited a mild expressive dysphasia and no long tract signs. He underwent CT, MR imaging, and cerebral angiography, which revealed a 3-cm AVM in the left posterior temporal lobe associated with a 3-cm intracerebral hemorrhage (Fig. 3 left). The AVM was fed mainly by two large middle cerebral artery (MCA) branches, and venous drainage was via the superior sagittal sinus and a large varix in the vein of Labbé. There was an irregular bilobed aneurysm of the left intracavernous ICA and another aneurysm at the distal bifurcation of the MCA.

Operation. Prior to operative resection (1 month following the hemorrhage), one of the major MCA feeding vessels was embolized with avitene and alcohol. Surgery was conducted via a large left-sided craniotomy. The sylvian fissure was widely split and the remaining large MCA feeding vessel followed back to the AVM. Prior to excision of the AVM, the 1-cm distal bifurcation aneurysm was clipped. The AVM was excised from the posterosuperior temporal gyrus and the operculum of the parietal lobe. The associated hematoma was evacuated.

Postoperative Course. Immediately following surgery the patient had a severe expressive and moderate receptive dysphasias along with mild right-sided weakness. Included in postoperative management were strict systolic blood pressure control (between 90 and 120 mm Hg) and low-molecular-weight heparin (2500 U twice daily) in combi-
result was dramatic in that the left A1 segment disappeared. Papaverine was slowly infused into the left ICA. The vessel narrowing might be due to vasospasm. The course of the patient’s neurological deterioration suggested that the vessel narrowing of the distal middle cerebral artery branches in the vicinity of the resection bed. Note the antegrade flow in the left A1 segment.

nation with aspirin (150 mg daily). The deficits improved progressively for 7 days, to the point of equal strength on both sides and markedly improved language function.

On the 9th postoperative day the patient’s ability to follow two-step commands and to perform simple calculations deteriorated. He had undergone an extensive sylvian fissure split along the length of the large MCA feeding vessel (in the presence of intracerebral and subarachnoid clots), it was thought that the deterioration might be due to vasospasm.

An angiogram showed no residual AVM (Fig. 3 right). The flow in the left A1 segment was antegrade, and there was evidence of narrowing of this vessel, representing a reversal of flow compared with the preoperative angiogram. The distal MCA branches appeared mildly narrowed, consistent with either vasospasm or reflex narrowing with an increase in the transmural pressure of these vessels as a consequence of arteriovenous shunt ablation. The major draining veins were patent. Although the narrowing of vessels may have been the result of removal of the arteriovenous shunt, with an improvement in the perfusion pressure to these distal arteries, the time course of the patient’s neurological deterioration suggested that the vessel narrowing might be due to vasospasm.

Because of the presumed vasospasm, 240 mg of papaverine was slowly infused into the left ICA. The result was dramatic in that the left A1 segment disappeared on the left carotid angiogram, while the arteries surrounding the AVM bed near the left MCA increased significantly in size. With injection of the right carotid artery reversal of flow back to the preoperative state (right to left) was demonstrated in the left A1 segment (Fig. 4), with an increase in the vessel caliber.

However, immediately following the papaverine administration and angiography the patient showed a marked deterioration in language function, with “word-salad” speech, inability to follow one-step commands, and anomia. He remained alert with no hemiparesis. A CT scan revealed marked hemispheric edema with a significant left-to-right shift. There was no acute hemorrhage.

Over the subsequent 2 weeks, with rigorous blood pressure control (maintaining a systolic blood pressure under 120 mm Hg), there was slow resolution of symptoms with eventual return to the preangiography state.

Discussion

Vasospasm Following AVM Resection

Cerebral vasospasm as a complication of AVM resection has been previously reported. However, it is sufficiently uncommon to be excluded from discussion of this topic in the review of results of most large series. It has been recently reported in a list of causes of surgical morbidity by Korosue and Heros, but they cited Yaşargil’s evidence for this complication rather than evidence from personal experience. The cases presented in the current report are the first two cases in the authors’ experience, and the vasospasm occurring in these cases is presumably on the basis of SAH in the resection bed.

Case 1 appears to clearly represent a case of vasospasm (as distinct from the expected reduction in the size of feeding arteries as a consequence of the altered physiological determinants of vessel size following shunt ablation), and although Case 2 is less convincing from an angiographic point of view, the mild vascular narrowing along with the time course for neurological deterioration suggest vasospasm. However, neither case was associated with undue hemorrhage at surgery and the postoperative CT scans were unremarkable with regard to hematomas.

Concern must be raised that the protocol of aspirin with low-dose heparin (a regimen employed to reduce the likelihood of venous occlusive complications) in combination with mild hypotension (used to reduce the likelihood of hyperemic complications) may increase the risk of vasospasm by allowing postoperative oozing of blood around the vessels in the resection bed as well as a reduction in tension in the involved vessels. This protocol has been used only since July, 1992 in the authors’ unit and may explain the lack of previous experience with this complication of AVM resection.

Papaverine Infusion

Intraarterial infusion of papaverine is useful in the reversal of angiographically documented vasospasm.
Papaverine in the management of AVMs and vasospasm

resulting from aneurysmal SAH.\textsuperscript{6,7,9} As demonstrated by these two cases, vasospasm can be angiographically reversed by papaverine despite the apparent lack of vasocostriction seen at other times following AVM resection.\textsuperscript{11–13}

The response in the second case resulted in pathological hyperemia. This complication has not been previously identified following papaverine administration for vasospasm due to aneurysmal SAH. That the flow in this case was hyperemic can be deduced from the observation that, in conjunction with the development of arterial vasodilation, flow in the ipsilateral anterior cerebral artery was rendered retrograde following intraarterial papaverine administration. In the absence of stenosis in the carotid circulation or proximal ipsilateral A\textsubscript{1}, retrograde flow in the ipsilateral A\textsubscript{1} must indicate that resistance is lower within the ipsilateral MCA territory than within the contralateral MCA territory.

Although occlusion of normal venous outflow is increasingly recognized as a cause of neurological deterioration following AVM resection,\textsuperscript{17} it is not likely to be the explanation for the neurological deterioration seen in Case 2. Venous occlusion would result in an increase in resistance and were this to be the case reversal of flow within the left A\textsubscript{1} segment must not have occurred. Normal perfusion pressure breakthrough would appear to be the more likely explanation for the sequence of events resulting from the time of papaverine administration. This exaggerated response to papaverine may well be consistent with the suggestion by Batjer and Devous\textsuperscript{1} that in some cases of AVM the surrounding arterial vascular bed is more responsive than the normal vascular bed. It also cautions against the use of intraarterial papaverine to the point of maximum angiographic reversal of vasospasm, in which vasospasm arises as a consequence of AVM resection.

Conclusions

Resection of AVMs may be complicated by the development of cerebral vasospasm and this should be considered (along with intracranial hemorrhage, venous occlusion, and normal perfusion pressure breakthrough) in the differential diagnosis of delayed neurological deterioration following surgery, even in the absence of significant hemorrhage at the time of surgery. This complication may be more likely to occur with the use of aspirin and low-dose heparin (prescribed to reduce the risks of venous occlusive complications) in combination with hypotension (prescribed to reduce the risk of normal perfusion pressure breakthrough). The vessels in spasm may be responsive to intraarterial papaverine infusion, but caution must be exercised in its use as normal perfusion pressure breakthrough may ensue.

References


Manuscript received December 13, 1993.
Accepted in final form June 9, 1994.
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