Headaches in patients with radiosurgically treated occipital arteriovenous malformations

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Object. The goal of this study was to determine the prevalence, characteristics, and radiosurgical outcomes of headaches associated with occipital arteriovenous malformations (AVMs).

Methods. The authors reviewed the medical records of 37 consecutive patients with occipital AVMs who had been treated by radiosurgery to identify the radiological features of the AVMs before and after treatment and the clinical features and outcomes of headaches described in accordance with the criteria of the International Headache Society (IHS).

Thirty-six patients (97.3%) were followed for a mean period of 46.6 months. The median volume of the AVMs was 1.9 cm³, to which a mean radiation dose of 21.6 Gy was delivered. In the entire study group, periodic headaches were found in 17 patients (45.9%), of whom seven (18.9%) suffered from migraines with the characteristic visual aura. Migraine was predominantly found in patients with right-sided (p = 0.038) or laterally located (p = 0.025) AVMs. Factors associated with a higher incidence of any type of headache included larger nidus volume (p = 0.02), tortuous change of feeding artery (p = 0.036), and cortical drainage with reflux in the superior sagittal sinus (p = 0.032). The actuarial rate of angiographic obliteration was 71.6% at 3 years. Headaches resolved or improved in 12 (70.6%) of 17 patients, including six (85.7%) of seven with migraine. The outcome of headache closely correlated with the obliteration results of the AVM (p = 0.002).

Conclusions. A portion of occipital AVMs do cause headaches that satisfy the current IHS criteria for migraine, and the prevalence varies by the topography of the lesion. Radiosurgery can resolve headaches in the majority of treated patients.

Key words • arteriovenous malformation • occipital lobe • headache • migraine • radiosurgery

Headaches are a common symptom of cerebral AVMs, with a reported incidence varying from 3% to 79.2%. Several authors have suggested a causal relationship between the lesions and headaches because of the much higher incidence of headaches in patients with AVMs than in the general population and the overwhelming matching rate of the side of headache pain to the side of the AVM location. There still exists, however, considerable disagreement on the frequency and outcome of headaches in patients with AVMs. Such disagreements may stem from an inappropriate diagnosis of headache and from the complexity of the clinical and radiological parameters to be assessed.

Occipital lobe AVMs are well known for their frequent manifestations of migrainelike headaches with visual symptoms. However, details of those symptoms and their treatment outcomes have not been well analyzed. In this report, we conducted a retrospective study in a relatively homogeneous series of patients with small (≤3 cm) AVMs located in the occipital lobe, who were treated by radiosurgery using a common protocol. We attempted to determine the prevalence, characteristics, and therapeutic outcomes of headaches that were clinically diagnosed following current IHS criteria for classification.

Clinical Material and Methods

Medical records for a 7-year period (June 1, 1990–August 31, 1997) were reviewed to identify patients with AVMs primarily involving the occipital lobe, who had undergone radiosurgical treatment at our institution. Thirty-seven such patients were identified. Descriptions of the clinical features of the headaches and other symptoms were obtained from notes taken during examinations before radiosurgery and at follow up, and through information from mailed questionnaires completed and returned by the patients. The headaches were characterized according to IHS criteria.

Radiosurgery was performed according to our standard protocol for AVMs by using a 201-source Co-gamma
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knife as previously described. Briefly, nidus definitions and target designations were determined using biplane stereotactic cerebral angiography, which was supplemented by thin-slice dynamic stereotactic CT scanning after April 1992. A computer system (MicroVAX; Digital Equipment Corporation, Westminster, MA) was used for complex dose planning.

Fisher’s exact test was used for statistical evaluation. A probability value below 0.05 was considered to be statistically significant.

Patient Population

There were 23 male and 14 female patients, aged 9 to 65 years (mean 28.4 ± 14.4 years, median 28 years) at the time of diagnosis. Initial manifestations included intracranial bleeding in 15 patients (40.5%), headaches in 12 (32.4%), generalized seizure in six (16.2%), and transient or permanent visual disturbances in two patients (5.4%).

The AVM was found incidentally in the remaining two patients (5.4%). During neurological examination before radiosurgery, nine patients (24.3%) exhibited persistent visual field defects: complete homonymous hemianopia in five patients and homonymous quadrantanopsia in four.

Complete hemianopsia had been caused by either intracranial hemorrhage or previous surgery, whereas none of the patients with quadrantanopsia had experienced previous apoplexy or undergone therapeutic intervention.

The AVM had been partially obliterated by transarterial embolization in seven patients before they underwent radiosurgery. Two patients had undergone partial resection of the nidus. One patient had required ventriculoperitoneal shunt placement for hydrocephalus that developed after ventricular hemorrhage.

Topography of the AVM

The AVM was located on the right side in 24 patients (64.9%) and on the left side in 13 (35.1%). The whole nidus was contained in the occipital lobe in 27 patients (73%), whereas it extended to the temporal lobe in five and the parietal lobe in five. The nidus involved the medial visual cortex in 27 patients (73%) and the lateral occipital cortex in 12 (32.4%).

There was a clear predominance of the localization of AVM in patients with migraine headaches. The AVMs were located in the right hemisphere in all seven patients with migraine headaches (p = 0.038) and the nidi involved cortex lateral to the visual pathways in five patients (p = 0.025). The presence of a migraine headache did not correlate with either visual cortex involvement or calcarine artery involvement. The incidence of any type of headache positively correlated with the size and specific angiographic features of an AVM. When the 37 patients were dichotomized by volume of the AVM at their median values, patients with larger AVMs (≥ 1.9 cm³) had headaches more frequently than patients with smaller AVMs (p = 0.02).

Factors Correlated With Clinical Presentation of Symptomatic Pain

There was a clear predominance of the localization of AVM in patients with migraine headaches. The AVMs were located in the right hemisphere in all seven patients with migraine headaches (p = 0.038) and the nidi involved cortex lateral to the visual pathways in five patients (p = 0.02). Likewise, existence of a dilated tortuous feeding artery (p = 0.036) or rostral reflex in the SSS (p = 0.032) was positively correlated with headaches. None of the patients with a previous intracranial hemorrhage experienced a migraine (p = 0.028) or any other type of headache (p < 0.0001; Table 1). Figure 1 shows characteristic

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### TABLE 1

Factors statistically correlated with clinical presentation of migraine and all headaches

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Incidence in All Cases</th>
<th>Migraine (7 cases) Incidence</th>
<th>p Value</th>
<th>All Headaches (17 cases) Incidence</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>history of intracranial bleeding</td>
<td>15</td>
<td>0</td>
<td>0.028</td>
<td>0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>rt-sided lesion</td>
<td>24</td>
<td>7</td>
<td>0.038</td>
<td>13</td>
<td>NS</td>
</tr>
<tr>
<td>lateral cortex involvement</td>
<td>12</td>
<td>5</td>
<td>0.025</td>
<td>8</td>
<td>NS</td>
</tr>
<tr>
<td>large nidus volume (≥1.9 cm³)</td>
<td>20</td>
<td>5</td>
<td>NS</td>
<td>13</td>
<td>0.02</td>
</tr>
<tr>
<td>dilated tortuous feeding artery</td>
<td>4</td>
<td>1</td>
<td>NS</td>
<td>4</td>
<td>0.036</td>
</tr>
<tr>
<td>cortical drainage w/ reflux in SSS</td>
<td>12</td>
<td>4</td>
<td>NS</td>
<td>9</td>
<td>0.032</td>
</tr>
</tbody>
</table>

* NS = not significant.
neuroradiological images in a patient with migraine or other headache.

**Results**

**Radiosurgical Outcome**

The mean dose of radiation delivered to the AVM margin was $21.6 \pm 2.3$ Gy (range 20–25 Gy, median 20 Gy). Of the 37 patients we studied, one patient was lost to follow-up shortly after treatment, and the remaining 36 patients (97.3%) were followed up for 12 to 103 months post-treatment (mean 46.6 ± 24.5 months, median 46 months). At the last follow-up examination, 34 patients were found to have returned to their previous activities. One suffered a cerebral infarction unrelated to the AVM and one died of hepatocellular carcinoma. On the patients’ last follow-up angiograms, complete obliteration of the AVM nidus was confirmed in 22 patients (59.5%), subtotal obliteration (no visualization of nidus with a persistent early draining vein) in two, reduction of the nidus in 10, and no change of the nidus in two patients. The actuarial complete obliteration rate, calculated using the Kaplan–Meier method, was 71.6% at 3 years posttreatment. Radiation-induced brain edema was detected in 12 (33.3%) of 36 patients, but the findings were not accompanied by symptoms, except for one patient in whom quadran-opsia developed 18 months after irradiation of the lesion. Visual field defects that existed before radiosurgery improved in two patients and were unchanged in seven. No AVM caused hemorrhage during the follow-up period.

Radiosurgery provided good outcomes in headaches. At the last follow-up examinations in the 17 patients who had had headaches before radiosurgery, pain was resolved completely for more than 1 year in seven patients (41.2%) and was decreased more than 50% in frequency in five patients (29.4%). There were three patients whose headaches transiently increased in frequency for several months after irradiation, but the headache subsequently ceased within a year in all cases. In particular, migraine headaches resolved or improved in all patients, except one who died of hepatocellular carcinoma before any follow-up information could be obtained. Headache outcomes closely correlated with the obliteration results of AVMs. Headache disappeared in seven (87.5%) of eight patients with totally or subtotally obliterated AVMs, whereas none of seven patients with partially or nonobliterated AVMs had complete resolution of the syndrome (Table 2). This difference is statistically significant ($p = 0.002$).

**Discussion**

The prevalence of migrainelike headaches in the present study (seven [18.9%] of 37) was much higher than the
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reported incidence in a nationwide survey of migraine in Japan (2.6% of 4029 patients, p < 0.0001) and was comparable to previous observations in patients with an AVM in the occipital lobe (19.2–21.4%). Our findings also support the reported characteristic features of migraine-like symptoms associated with AVMs, which include: 1) absent family history of migraines; 2) lack of predominance in female patients; 3) onset at older ages; and 4) strict occurrence of pain on the side ipsilateral to the lesion. Several authors have argued that headaches in patients with occipital AVMs are distinguishable from genuine migraine, whereas others have reported that complete symptomatical migraine with visual symptoms could be seen in some patients. Our study supported the latter, showing that the symptoms do satisfy the current IHS criteria in a portion of patients with AVMs.

We found some interesting relationships between AVM topography and headaches. First, migraine headaches were significantly more common in patients with a lesion in the lateral cortical region, the area where electrophysiological abnormality is known to start in patients with genuine migraines. Second, migraine headaches were far more commonly caused by lesions on the right side. The reason remains unknown, although the right hemisphere has been suggested to have an advantage in pain processing, and that may be related to our findings. Third, radiological evidence of larger volume of the nidus, existence of a tortuous feeding artery, and cortical drainage with retrograde fl ow in the SSS, all of which suggest a high blood flow through the malformation, were each a significant risk factor for headaches. The predominant location of an AVM in patients with migraine headaches may contribute to understanding the mechanism of migraines or other types of headaches, which are currently under vigorous investigations using state-of-the-art techniques including functional MR imaging or perfusion-weighted MR imaging.

Therapeutic outcomes of headaches in patients with AVMs have been controversial. Several authors have documented the resolution of symptoms immediately after surgical excision of an AVM, whereas some have reported no benefit from surgery. As for radiosurgery, the results have been also equivocal. Although several publications have suggested favorable outcomes in most studies the headaches were not well defined according to the current IHS classification criteria and, therefore, treatment outcomes were not evaluated appropriately. In this study, we showed that radiosurgery improved headaches in a signifi cant portion of patients with occipital lobe AVMs. Outcome closely correlated with the obliteration results of the AVM, strongly indicating that AVMs indeed caused the symptoms. Furthermore, the specific topography of AVMs commonly observed in patients with migraine argues against the notion that the abnormal blood vessels themselves produce the pain. Instead, our data indicate that the effect of the AVM on the surrounding brain is more likely to be the cause of the headaches. Reduction of mass eff ect or improvement of ischemia and congestion following treatment might have been the reason for the improvement in headaches, or it may have been the direct eff ect of a single burst of high-dose radiation to surrounding neural parenchyma. A similar therapeutic eff ect of radiosurgery on symptoms of abnormal brain function caused by an AVM, such as epilepsy and extrapyramidal dysfunction, has been reported.

Conclusions

Our results showed that migraine, as well as other types of headaches, could be manifestations of small occipital AVMs. Radiosurgery was effective in improving symptoms of headache in patients with AVMs while preserving visual function. Radiosurgery seems to be a good treatment option for such AVMs, although further studies of larger series of patients and longer follow-up periods may still be needed.

References


Manuscript received December 30, 1999.
This work was supported in part by grants-in-aid for scientific research awarded to Dr. Kurita from the Ministry of Education, Science, and Culture of Japan (Grant Nos. 08771056 and 09771031).
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