Intramedullary Cavernous Angiomas of the Spinal Cord: Clinical Characteristics of 13 Lesions

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Abstract
Magnetic resonance imaging has increased the incidence of the diagnosis of intramedullary cavernous angioma. Surgical therapy tends not to be recommended for asymptomatic lesions, but symptomatic lesions that bleed recurrently should be treated. The natural course of intramedullary cavernous angioma remains unknown and arguments have been raised against the surgical treatment of symptomatic lesions. We reviewed the clinical features of 13 intramedullary cavernous angiomas in 12 patients surgically treated between 1988 and 2009. The 7 men and 5 women were aged from 14 to 60 years, the preoperative interval ranged from 0 to 161 months, and the mean number of hemorrhages in the 13 lesions was 2.5. Sixteen operations were performed to treat the 13 lesions. The surgical approach depended on the lesion location. The outcome of patients with mild to moderate preoperative symptoms (McCormick grades I–III) was significantly better than that of patients with severe symptoms (McCormick grade IV) (p < 0.05). Symptomatic intramedullary cavernous angioma tends to bleed repeatedly. The lesion should be surgically removed to avoid further deterioration due to recurrent hemorrhages. The shortest path approach should be selected based on preoperative images and complete removal should be attempted. Residual lesion may be masked by surrounding gliosis, so careful postoperative follow up is necessary.

Key words: cavernoma, cavernous angioma, cavernous malformation, intramedullary spinal cord neoplasm

Introduction
Cavernous angiomas, also known as cavernous malformations, cavernous hemangiomas, or cavernomas, are considered to be congenital hamartomas in contrast to true vascular neoplasms.10) A prospective autopsy series found the incidence of central nervous system (CNS) cavernous angiomas was 0.02–0.53%.7) Intramedullary cavernous angiomas were thought to be extremely rare,1,14) but the introduction of magnetic resonance (MR) imaging has resulted in an increased incidence of intramedullary cavernous angiomas.8,9,16) Surgical therapy is considered inappropriate for asymptomatic intramedullary cavernous angiomas,8,10,16) but surgery is recommended to avoid sequelae from frequently bleeding symptomatic lesions.8,14,16) However, the surgical treatment of symptomatic intramedullary cavernous angiomas remains controversial because the natural course of the intramedullary cavernous angioma is unknown.8,10)

Here we report the clinical features of 12 patients with intramedullary cavernous angiomas and describe our surgical strategy.

Patients and Methods
We reviewed the clinical records of 12 patients with 13 intramedullary cavernous angiomas treated with 16 surgical procedures at our department or affiliated hospitals between 1988 and 2009. The patients were 7 men and 5 women aged from 14 to 60 years (mean 33.4 ± 15.5 years) at presentation. Of the 13 lesions, 5 were cervical, 7 were thoracic, and 1 was lumbar. The interval between onset and the first operation (including patients treated more than once) ranged from 0 to 161 months (mean 39.8 ± 56.5 months). The postoperative follow-up period ranged from 13 to 252 months (mean 75.9 ± 69.2 months). The clinical features of our 12 patients are summarized in Table 1.

We analyzed the clinical presentation, radiological findings, and postoperative course of the 13 lesions. Clinical presentation was determined using
Table 1 Summary of our 12 patients with 13 intramedullary spinal cavernous angiomas

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Sex</th>
<th>Location</th>
<th>Age at initial symptoms (yrs)</th>
<th>McCormick grade*</th>
<th>Duration of symptoms at surgery (mos)</th>
<th>No. of surgeries</th>
<th>Surgical approach (1st/2nd surgeries)</th>
<th>Duration of follow up (mos)</th>
<th>No. of bleedings</th>
<th>Ogilvy score of presentation and progression**</th>
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<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>T7-8</td>
<td>60</td>
<td>II</td>
<td>15</td>
<td>2</td>
<td>NA/NA</td>
<td>10</td>
<td>1</td>
<td>1</td>
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<tr>
<td>2</td>
<td>M</td>
<td>C2-3</td>
<td>18</td>
<td>I</td>
<td>15</td>
<td>1</td>
<td>posterior subpial</td>
<td>24</td>
<td>1</td>
<td>1</td>
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<tr>
<td>3</td>
<td>M</td>
<td>T4-5</td>
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<td>1</td>
<td>2</td>
<td>1</td>
<td>MM/anterior</td>
<td>4</td>
<td>2</td>
<td>2</td>
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<tr>
<td>4</td>
<td>F</td>
<td>C4</td>
<td>41</td>
<td>II</td>
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<td>1</td>
<td>DREZtomy</td>
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<td>2</td>
<td>13</td>
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<td>5</td>
<td>F</td>
<td>T10-11</td>
<td>21</td>
<td>II</td>
<td>1</td>
<td>1</td>
<td>DREZtomy</td>
<td>25</td>
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<td>1</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>C4-5</td>
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<td>II</td>
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<td>1</td>
<td>MM</td>
<td>25</td>
<td>2</td>
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<tr>
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<td>M</td>
<td>T7-8</td>
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<td>MM</td>
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<td>2</td>
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<td>C8</td>
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<td>MM</td>
<td>66</td>
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<tr>
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<td>II</td>
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<td>MM</td>
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<tr>
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<td>C5-6</td>
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<td>1</td>
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<td>IV</td>
<td>3</td>
<td>1</td>
<td>MM</td>
<td>13</td>
<td>2</td>
<td>13</td>
</tr>
</tbody>
</table>

*According to McCormick et al.11) **According to Ogilvy et al.14) See Table 2. F: female, M: male, MM: midline myelotomy, NA: not available.

Table 2 Clinical presentation according to Ogilvy classification14)

1. Acute episode of stepwise neurological deterioration
2. Slow progression of neurological deterioration
3. Acute onset of neurological deterioration with rapid decline
4. Acute onset of mild symptoms of neurological deterioration with gradual decline over weeks to months

the Ogilvy classification (Table 2), and symptoms were evaluated on the McCormick scale.11)

Results

Of the 13 lesions, 6 manifested as acute episodes of stepwise neurological deterioration, 2 as slowly progressing neurological deterioration, 1 as acute onset neurological deterioration and rapid decline, and 4 as acute onset of mild symptoms of neurological deterioration with gradual decline over weeks or months. The mean number of bleeds in the 13 lesions was 2.5.

The mean McCormick grade was 2.3 at onset, 2.9 shortly before surgery or before the last operation in patients receiving more than one surgical treatment, and 1.8 at the last follow-up visit. Comparison of the McCormick grade shortly before the operation (7 lesions graded as I–III, and 6 as IV) and the grade obtained at the last follow up showed that one lesion was grade II at both time points and the other 6 lesions with grades I–III were grade I. On the other hand, 4 lesions with preoperative grade IV had postoperative grade III, indicating that the treatment outcome in these patients was poor (p < 0.05, Mann-Whitney U test) (Fig. 1).

The 13 lesions were surgically treated 16 times, as re-operations were performed for 3 lesions due to recurrence of hemorrhage from residual intramedullary cavernous angiomas. In Case 1, MR imaging detected residual intramedullary cavernous angioma after the first surgery and was observed. However, in Cases 4 and 6, postoperative MR imaging did not reveal the residual intramedullary cavernous angiomas, which were found at recurrence of hemorrhage. In Cases 1 and 6, re-bleeding occurred at 4 years and 1 year after 1st operation, respectively, when 2nd surgery was performed. In Case 4, re-bleeding occurred 1.5 years after 1st surgery, but the patient was willing to be observed, so 2nd surgery was performed 5 years after 1st surgery.

The intervals between the initial symptoms and the 1st operation varied considerably (0–161 months). Long intervals were due to delayed diagnosis, after conservative treatment under diagnoses of myelitis or intramedullary hemorrhage in other
Fig. 1 Preoperative and long-term follow-up McCormick grades. Of 7 lesions with preoperative grades I–III, six achieved grade I at long-term follow up, and one patient (Case 3 in Table 1) remained grade II. Of 6 lesions with preoperative grade IV, four lesions improved only to grade III. The surgical treatment outcomes were significantly worse in patients with preoperative McCormick grade IV (*p < 0.05, Mann-Whitney U test). Follow-up period ranged from 13 to 252 months (mean 75.9 ± 69.2 months).

hospitals. After deterioration occurred and intramedullary cavernous angioma was suspected, the patients were transferred to our institution for surgical treatment. In contrast, patients with short intervals were transferred to our institution at first onset, and rapidly deteriorated. These patients underwent emergent surgery, resulting in the short interval.

All surgical procedures were performed under the operating microscope. Motor evoked potential (MEP) monitoring performed by a professional clinical technician has been used since 2007. However, intraoperative MEP is not available in emergent surgery. Cases 1–8 were treated before 2006, and Cases 10 and 12 were treated emergently. Only Cases 9 and 11 were treated with intraoperative MEP.

The surgical approaches were via midline myelotomy of the posterior median fissure (n = 9), DREZtomy (n = 2), and transpial (n = 2, anterior and posterior in one each). The remaining 3 surgical approaches could not be determined from the records.

**Representative Cases**

**Case 4:** A 41-year-old woman experienced left arm weakness one week after sudden onset of pain. At her first consultation, 2 weeks after onset, the pain had lessened. An intramedullary lesion on the cervical cord (Fig. 2A, B) was surgically removed by midline myelotomy via the posterior median fissure 5 weeks after onset and her arm weakness improved postoperatively. However, the weakness recurred due to re-bleeding from the residual intramedullary cavernous angioma 22 months after onset. She refused re-operation because her symptoms had improved significantly, so she received conservative therapy. Third hemorrhage occurred 3 years 10 months after the first bleeding episode, and she underwent re-operation 2.5 months later. Residual intramedullary cavernous angioma was found at the ventral portion of the spinal cord (Fig. 2C, D), so the anterior approach with C4 corpectomy was selected. Opening of the dura mater and subarachnoid membrane revealed a mass protruding through the pia mater adjacent to the C4 rootlet. Therefore, a pial rostral-to-caudal incision was made and the intramedullary cavernous angioma was removed. Her McCormick grade II immediately after surgery was the same as her preoperative grade, but had improved to grade I at her last follow-up visit.
Case 9: A 36-year-old man experienced sudden pain in the right shoulder when he carried baggage with his right arm. Urinary retention began on the 5th day and gradually progressed. Weakness of both legs emerged on the 20th day. He consulted another neurosurgical hospital, where an abnormal lesion of the thoracic cord was found. Biopsy was discussed, but avoided due to surgical risk. Then he came to our department.

Mild paraparesis, hypalgesia below the T2 level, gait disturbance, and neurogenic bladder were found at the first visit to our department, 40 days after the first onset. MR imaging showed intramedullary hematoma at the T1 level, hemosiderin at the T1-T2 levels, and broad cord swelling (Fig. 3A–C).

The lesion location was left ventral to the thoracic cord, so the surgical risk was estimated as high. Discrimination of neoplasm or arteriovenous malformation was difficult based on the MR images taken at this time. Re-evaluation with MR imaging was planned after the hematoma was expected to be absorbed. However, 2 months after the first visit to our department, his symptom deteriorated to McCormick grade IV. Re-bleeding and progression of spinal cord edema were recognized on MR imaging (Fig. 3D). Therefore, surgical removal was performed 4 months after the first onset. The cavernoma was removed by the posterior midline approach, with incision of the posterior median sulcus. His symptoms improved since removal, but remained at McCormick grade III.

Discussion

Intramedullary spinal cord cavernous angiomas represent only 3–5% of all identified CNS lesions. Diagnosis is difficult because, unlike their extradural counterparts, intradural cavernous angiomas are avascular and angiographically negative. MR imaging has increased the detection of intramedullary cavernous angiomas to 5–12% of all spinal vascular abnormalities. The prevalent age at the manifestation of initial symptoms is the 3rd to 4th decades of life and the female:male ratio is 2:1. On the other hand, a male preponderance was observed among pediatric patients. In our series, there was no female preponderance, as 7 of our 9 patients were male. The thoracic spinal cord is the site most often affected. In our series, 5 lesions were cervical and 7 were thoracic cord lesions. However, as the cervical spine is comprised of 7 vertebrae and the thoracic spine of 12 vertebrae, and the spinal cord terminates at the L1 level in many individuals, the apparent thoracic cord preponderance may be attributable to the length ratio of the spinal cord.

Clinical presentation based on Ogilvy’s classification showed 6 of the 13 lesions manifested as acute episodes of stepwise neurological deterioration, and 2 lesions as slow progression of neurological deterioration. Our findings coincide with those of others. Lesions resulting in rapid deterioration are not common. The mechanism(s) underlying cell growth without mitosis is unclear and differs from neoplastic lesions. Hyalinization of the wall secondary to hemorrhage or compensation for dilation of vascular channels, and hemorrhage and thrombosis with organization and recanalization have been suggested. In patients younger than 18 years, a...
rapid decline due to bleeding is common.\textsuperscript{13} In our series, only one patient, a 14-year-old boy, presented with an Ogilvy score of 3, and acute onset neurological deterioration and rapid decline.

The natural history of intramedullary cavernous angiomas is not well understood. The reported bleeding rate of asymptomatic lesions is low at 1.4–1.6\% per year.\textsuperscript{5,10} Although surgical therapy is not generally recommended to treat asymptomatic intramedullary cavernous angiomas,\textsuperscript{6,10,13,16,19} surgical removal may be indicated in children because the potential for devastating hemorrhage is particularly significant.\textsuperscript{12} The bleeding rate of symptomatic lesions is high at 17.6\%,\textsuperscript{18} 66\%,\textsuperscript{10} and prospective and retrospective rates of 66\% and 4.5\%, respectively.\textsuperscript{15} Ten of our 12 patients with intramedullary cavernous angiomas suffered multiple hemorrhages, and 6 of these 10 were treated conservatively and suffered re-bleeding.

Surgical removal of the symptomatic intramedullary cavernous angioma has been recommended because recurrent episodes of bleeding raise the risk for neurological deterioration and surgery yields satisfactory long-term results.\textsuperscript{6,14,16} On the other hand, surgery has been contra-indicated in patients with symptomatic intramedullary cavernous angioma because full recovery can be achieved without surgery, and postoperative outcomes may not be superior to the results of conservative therapy.\textsuperscript{9,10} A retrospective analysis reported that none of 10 symptomatic patients treated conservatively suffered re-bleeding.\textsuperscript{9} However, no prospective studies have identified predictive factors in subgroups at low risk for re-bleeding. In our series, some patients had long intervals between first onset and deterioration, and had good outcome. Possibly some patients can be treated conservatively, but prediction is difficult. Symptomatic patients should be treated surgically unless predictive factors are established. We obtained long-term postoperative improvements in our patients with preoperative McCormick grades I–III. However, the prognosis of surgically treated patients with high preoperative grades was significantly worse. Based on our findings, we recommend the surgical removal of symptomatic lesions as recurrent bleeding raises the risk for neurological deterioration.

Most of our patients were treated via the posterior approach with incision of the posterior median fissure, but DREZtomy or the anterior approach were also used. The size and location of the cavernous angioma and hematoma on preoperative images determined the appropriate approach route. The timing of surgical intervention is one problem. Treatment in the subacute stage 4–6 weeks after a bleeding episode has been suggested because the hematoma is resolving and glial scar is developing at that point.\textsuperscript{10} Gliosis surrounding the lesion protects the normal spinal cord and the border between the intramedullary cavernous angioma and normal tissue is obvious, which facilitates complete removal.\textsuperscript{13,14} Therefore, we recommend that removal of intramedullary cavernous angioma should be performed in the subacute stage unless the symptoms show rapid decline, although not possible if referral is delayed.

Three of the 13 lesions required re-operation due to residual intramedullary cavernous angioma. The reported risk for re-bleeding of residual cavernous angiomas is 9\%\textsuperscript{10} or 17.6\%,\textsuperscript{10} or an even higher rate,\textsuperscript{6,13,14} so complete removal is desirable. Surrounding gliosis sometimes conceals hidden intramedullary cavernous angioma, resulting in residual lesion. Residual cerebral cavernous angioma can be detected by intraoperative ultrasonography,\textsuperscript{2} which we adapted for intramedullary lesions. Further investigation is needed whether ultrasonography is useful for the detection of residual intramedullary cavernous angioma. Postoperative MR imaging did not detect 2 of 3 residual intramedullary cavernous angioma, indicating the importance of postoperative observation. If re-bleeding occurs and residual intramedullary cavernous angioma is suspected, removal should be considered again.

The present analysis of the clinical features of 12 patients with 13 intramedullary cavernous angiomas suggests that symptomatic lesions tend to bleed repeatedly, and surgery does not leave these patients in a condition worse than their preoperative status except for patients with severe preoperative neurological disorders. Surgical removal should be attempted before the clinical condition deteriorates further due to recurrent hemorrhage. Based on preoperative imaging studies, the shortest path approach should be selected and complete removal should be attempted. Residual cavernous angiomas may be masked by surrounding gliosis, so careful intraoperative inspection and postoperative follow up is necessary.

\textbf{References}


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