Dissecting aneurysms of the intracranial vertebral artery

AKIRA YAMAURA, M.D., YOSHIRO WATANABE, M.D., AND NAOKATSU SAeki, M.D.

Department of Neurosurgery, Chiba University School of Medicine, Chiba Emergency Medical Center, Chiba, Japan

Among 86 patients with aneurysms arising from the vertebral artery or its branches, 24 had dissecting aneurysms. The patients with dissecting aneurysms were characteristically relatively young males. Twenty-one patients presented with subarachnoid hemorrhage (SAH) and three with ischemia. Severe headache or neck pain occurred in all three patients with ischemia. Five of the 21 patients with SAH and all three patients with ischemia experienced recurrent episodes. Angiography typically showed fusiform dilatation and proximal and/or distal narrowing of the affected artery. The difficulty of diagnosing this disorder is pointed out. Surgery was performed in 19 patients, the most common technique being clip-occlusion of the proximal vertebral artery. There were no postoperative deaths or rebleeding; a lateral medullary syndrome developed in three patients. The observation at surgery of intramural clot with characteristic discoloration was limited to the cases operated on within 36 days after the ictus. After this period, the aneurysm was whitish gray in color and had become firm. Of 36 other cases of vertebral dissecting aneurysm reported in the literature, 20 were operated on. The indications for surgery are discussed.

KEY WORDS · aneurysm, dissecting · vertebral artery · posterior inferior cerebellar artery · subarachnoid hemorrhage · ischemia

Dissecting aneurysms of the intracranial vertebral artery were once considered uncommon lesions, and most of the case reports before the late 1970's were pathological studies. The first angiographically demonstrated vertebrobasilar artery dissection was the case reported by Campiche, et al., in 1969. Dissection was seen at the basilar artery and the posterior cerebral artery. In 1977, Yonas, et al.,14 reported a vertebral dissection observed by arteriography, surgery, and autopsy. Their initial diagnosis was a ruptured aneurysm of unusual shape associated with vasospasm, but the lesion was found to be a dissecting aneurysm of the vertebral artery. Several similar experiences were reported subsequently.4,10,12

Dissecting aneurysms accounted for 28% of the vertebral artery aneurysms in our recently reported series.13 In the present study, we have reviewed our own cases and those reported in the literature in order to identify the natural history of this disorder and to facilitate a correct diagnosis. The mode of treatment for dissecting aneurysms of the vertebral artery is discussed.

Summary of Cases

Patients Studied

During the period from January, 1975, until May, 1987, 230 patients with posterior circulation aneurysms were treated at Chiba University Hospital and its affiliated hospitals. These included 94 vertebral artery aneurysms found in 86 patients,13 and 26 aneurysms (28% of all vertebral aneurysms) were diagnosed as dissecting aneurysms from radiological study and/or operative observation in 24 patients.

Clinical Presentation

The 24 patients in this series were found to possess 26 dissecting aneurysms arising from the intracranial vertebral artery or its branches. Two patients had bilateral dissecting aneurysms. The 16 men and eight women in this group were aged between 37 and 69 years, with a mean age of 49.7 ± 8.6 years (Table 1); the age distribution peaked in the 40's and 50's. Twelve dissecting aneurysms were located on the right side and 14 were on the left side, including two coexisting asymptomatic dissecting aneurysms.

Seven (29%) of the 24 patients were hypertensive. Twenty-one patients presented with subarachnoid hemorrhage (SAH) and three with ischemia. It was noteworthy that all 24 patients, including those who presented with ischemia, suffered from severe occipital headache and/or neck pain. This headache or pain was severe enough to raise the suspicion of SAH, but this was ruled out in the three patients with ischemia on the
TABLE 1
Clinical summary of 24 patients with dissecting vertebral artery aneurysms

<table>
<thead>
<tr>
<th>Factor</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>age (yrs)</td>
<td>49.7 ± 8.6</td>
</tr>
<tr>
<td>sex (M:F)</td>
<td>16:8</td>
</tr>
<tr>
<td>side (rt:lt)</td>
<td>10:14</td>
</tr>
<tr>
<td>clinical manifestation</td>
<td></td>
</tr>
<tr>
<td>ruptured</td>
<td>21</td>
</tr>
<tr>
<td>ischemia</td>
<td>3</td>
</tr>
<tr>
<td>multiple aneurysms</td>
<td>2</td>
</tr>
<tr>
<td>recurrence</td>
<td></td>
</tr>
<tr>
<td>hemorrhage</td>
<td>5</td>
</tr>
<tr>
<td>ischemia</td>
<td>3</td>
</tr>
</tbody>
</table>

VARIOUS neurological deficits were observed preoperatively (Table 2). Visual impairment due to vitreous hemorrhage (Terson’s syndrome) was observed in five patients with ruptured aneurysms. Horner’s sign was seen in two patients. The sixth cranial nerve was involved in three patients, and the ninth and 10th cranial nerves in three patients. Two patients had a lateral medullary syndrome. Heart failure and arteriovenous dissociation developed in two patients.

Sudden deterioration was very common and was recorded in seven of the 21 patients who presented with SAH. Recurrent hemorrhage was confirmed in five cases (24% of those with ruptured aneurysms), with the interval between the episodes ranging from 3 to 17 days (10.8 ± 5.6 days). Of these five patients, two died and two others showed respiratory arrest and became comatose following recurrent hemorrhage. All three of the patients presenting with ischemia experienced repeated episodes. The intervals were 4 days, 14 months, and (in a patient with three episodes) 8 years and 8 months. Two other patients suffered sudden deterioration at 4 hours and 24 hours after the initial ictus. The cause was not determined.

Radiological Study

Among 26 dissecting aneurysms, 24 dissections were located along the intracranial vertebral artery and only two were on the posterior inferior cerebellar artery (PICA). Twenty sets of angiograms were available for study of the vertebral dissecting aneurysms and two sets were obtained for the PICA dissecting aneurysms. Fusiform dilatation and proximal and/or distal narrowing were characteristically observed in all cases (Fig. 1 left). Retention of contrast medium was remarkable in 16 cases and a double lumen (a true lumen and a false lumen in dissected intramural space) was identified in six cases (Fig. 1 right).

To further define the vertebral artery dissecting aneurysms, the vertebral artery is divided into four segments. The fourth segment begins at the exit from the transverse process of the atlas and ends at the unification with the vertebral artery from the opposite side. For this study, the fourth segment of the vertebral artery was further divided into three parts: V41, between C1 and the dural penetration; V42, between the dural penetration and the origin of the PICA; and V43, between the origin of the PICA and the unification with the opposite vertebral artery.

Involvement of the vertebral artery was at V41 in eight cases and at V42,3 in 11 cases. None of the vertebral arteries showed only V41 or V42 involvement in our study. Only one patient had an extension of dissection to the basilar artery. The PICA was not visualized on the side of the involved vertebral artery in six cases. In all such cases, the dissection extended over a wide region of the intracranial vertebral artery (V42,3). In 13

A. Yamaura, Y. Watanabe, and N. Saeki

TABLE 2
Pre- and postoperative neurological deficits in 24 patients

<table>
<thead>
<tr>
<th>Deficit</th>
<th>Preop</th>
<th>Postop</th>
<th>Total†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terson’s syndrome*</td>
<td>5</td>
<td>0</td>
<td>5 (5)</td>
</tr>
<tr>
<td>Horner’s sign</td>
<td>2</td>
<td>0</td>
<td>2 (1)</td>
</tr>
<tr>
<td>cranial nerves</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>0</td>
<td>3 (1)</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>0</td>
<td>1 (1)</td>
</tr>
<tr>
<td>9, 10</td>
<td>3</td>
<td>3</td>
<td>6 (1)</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>1</td>
<td>1 (0)</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>1</td>
<td>1 (0)</td>
</tr>
<tr>
<td>long-tract signs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>motor</td>
<td>3</td>
<td>0</td>
<td>3 (1)</td>
</tr>
<tr>
<td>sensory</td>
<td>2</td>
<td>3</td>
<td>5 (3)</td>
</tr>
<tr>
<td>tremor</td>
<td>1</td>
<td>0</td>
<td>1 (0)</td>
</tr>
<tr>
<td>heart failure</td>
<td>2</td>
<td>0</td>
<td>2 (0)</td>
</tr>
</tbody>
</table>

* Terson’s syndrome: vitreous hemorrhage following subarachnoid hemorrhage.
† Numbers in parentheses indicate permanent deficits.

Fig. 1. Left: Vertebral arteriogram (arterial phase) in a 42-year-old man presenting with ischemia showing fusiform or tubular enlargement of the right vertebral artery. Right: Vertebral arteriogram (venous phase) showing contrast medium remaining in the intramural false lumen.
Vertebral artery dissecting aneurysms

cases of vertebral dissecting aneurysm, the PICA was visualized. It is interesting that in six of these patients the PICA was patent in spite of dissection proximal to and distal to the origin of the PICA.

Angiography showed a fusiform dilatation in both cases of PICA dissecting aneurysms, retention of contrast medium in one case, and the only poorly visualized distal PICA in the other case. The vertebral artery was normal. Both PICA dissections were confirmed at surgery.

The contralateral vertebral artery was abnormal in five cases. Fusiform dilatation associated with adjacent narrowing was observed on the contralateral vertebral artery in one case and on the contralateral PICA in one case. Segmental narrowing distal to the PICA was seen in one case. The opposite vertebral artery was occluded at the C1 level in one case and at the origin of the subclavian artery in one case.

Operative Procedure

When the size of the opposite vertebral artery was equal to or larger than the affected artery, a proximal clip-occlusion of the affected artery was carried out and vital signs were observed closely for 20 minutes. When the affected vertebral artery was dominant, wrapping of the lesion was the method of choice. Surgery was considered even for the cases with ischemia to prevent further extension of the dissection.

Nineteen patients underwent surgery (Table 3). Two others died before surgery and three were alive and followed without surgery. One of these three, a 42-year-old man who had a dissection on the dominant vertebral artery, could not tolerate the test balloon-occlusion of the affected vertebral artery and no further procedure was proposed. In a 69-year-old man with SAH, the vertebral dissection was overlooked at angiography; however, the diagnosis was made subsequently during follow-up review. The third, a 55-year-old woman who had been comatose following SAH, required ventricular drainage and ventriculoperitoneal (VP) shunt placement. She eventually regained consciousness and returned to normal life without surgery.

Of the 19 patients undergoing surgery, 17 had ruptured and two had unruptured aneurysms. The timing for operation was very late in our series. Only six patients underwent surgery within 1 month after the ictus. Nine patients were operated between 1 and 3 months and the other four were treated between 4 and 8 months after presentation (Table 3).

Among the 17 dissecting aneurysms arising from the vertebral artery, 10 were treated by proximal clip-occlusion of the vertebral artery, two by entrapment of the involved segment, and five by wrapping or coating (Table 3). The material used for wrapping was Biobond and muscle. Two lesions arising from the PICA were treated by clip-occlusion of the proximal PICA and entrapment. A VP shunt was required in seven cases. The contralateral dissection in two cases was not operated on and these patients have been asymptomatic for 5 years 8 months and 2 years 4 months.

At surgery, all of the aneurysms were symmetrically or asymmetrically fusiform in shape. Characteristic intramural hematoma was observed in four cases at 7, 17, 28, and 36 days following SAH. The most extensive intramural hematoma was observed 7 days after ictus and the hematoma was soft. In another case, observed 36 days following ictus, only a small portion of the hematoma was soft. In a case of PICA dissection, intramural hematoma extended into a distal portion of the PICA. The other dissecting aneurysms were whitish gray in color with shiny, smooth surfaces; these were firm and not compressible. Vascularization of the outer wall was prominent in three cases at 48, 62, and 241 days after ictus. Atheroma was not seen on aneurysmal dilatation and was minimal, if present, on the parent artery.

Postoperative Course

There were no postoperative deaths. Postoperative neurological deficits appeared in some cases (Table 2), including hoarseness of voice and dysphagia (three cases), 11th nerve paresis (one case), and 12th nerve paresis (one case). These deficits eventually cleared. Lateral medullary syndrome appeared in three patients with ruptured dissecting aneurysms treated by clip-occlusion of the vertebral artery distal to the PICA. They represented 25% of the cases undergoing proximal clip-occlusion (10 cases) or entrapment (two cases). Postoperative angiography revealed a patent PICA in all three, but one of them developed a lateral medullary
syndrome as late as 45 days following surgery. None of these patients was incapacitated.

**Outcome**

Two of our 24 patients died before surgery and diagnosis was made by angiography. Of the 19 patients undergoing surgery, the outcome was favorable (good recovery or moderately disabled) in 15 patients and poor (severely disabled or vegetative state) in four patients (Table 4). Of the patients with a poor outcome, two had respiratory arrest and required ventilator support following hemorrhage, and all four required shunt operations for hydrocephalus. These patients were in poor condition preoperatively and remained so after surgery. There were no postoperative deaths. In patients with late surgery, the preoperative grading (using the classification of Hunt and Hess) was Grade III in four patients and Grade IV in two patients.

Follow-up periods ranged from 2 years 10 months to 9 years 11 months (mean 7 years) for patients undergoing wrapping and from 2 years to 7 years 8 months (mean 4 years) for those treated with proximal clipping or occlusion. There were no instances of recurrent hemorrhage or ischemia after surgery.

Two patients were not operated on in spite of SAH. Their follow-up periods were 2 years 7 months and 4 years 3 months; there was no recurrent hemorrhage in either patient. There was only one untreated case of ischemic onset, a 42-year-old man who had two episodes of ischemia. He had a third ischemic attack during the follow-up period, but has returned to his previous lifestyle with moderate deficits. The intervals between ischemic attacks were 8 years then 8 months. His aneurysmal dissection was extensive, involving the left vertebral artery and the basilar artery.

**Discussion**

Intracranial dissecting aneurysms have been considered rather rare. Berger and Wilson found only 36 vertebral and/or basilar artery dissecting aneurysms reported in the literature, 15 of which involved the vertebral artery or its branches. The first vertebral angiographic and direct surgical observation of such an aneurysm was made by Yonas, et al., in 1977; earlier case reports were all pathological studies. In 1984, Friedman and Drake reported 14 ruptured dissecting aneurysms in the vertebrobasilar system, 12 of which were located on the vertebral artery or PICA. Shimoji, et al., reported seven ruptured dissecting aneurysms of the vertebral artery. In addition to the above-mentioned cases we found 14 more previously reported dissecting aneurysms of the vertebral artery or its branches. We have analyzed a total of 36 vertebral artery dissecting aneurysms reported since 1970 and 24 cases in our series.

The true frequency of dissecting aneurysms is not known. The difficulty of diagnosing these lesions may have obscured the true incidence. In our series of 94 dissecting aneurysms, 28% were found in the vertebral system, including the PICA.

**Clinical Features**

The clinical features of dissecting aneurysm of the vertebral system are unique.

*Patients' Age and Sex.* Manz and Luessenhop and Berger and Wilson pointed out that dissecting aneurysms occur in a relatively young age group. In the 36 reported vertebral dissecting aneurysms, the mean age was 45.6 ± 8.7 years. This was similar to the mean age in our series. The peak age of onset was in the 40's, both in the 36 previously reported cases and in our series. Manz and Luessenhop analyzed 14 cases of basilar artery dissection and found that these lesions tended to affect an even younger age group, ranging from 15 to 69 years (mean 31.7 years).

In contrast to the female dominance in vertebral saccular aneurysms (70% incidence in females), dissecting aneurysms showed a male dominance (67% in males) in our series. The reported cases of vertebral artery dissecting aneurysm showed a male:female ratio of 27:9 (75% in males). The analysis by Manz and Luessenhop also showed a preferential affliction of males, with a 78% prevalence among those with basilar artery dissection, 60% in those with dissecting aneurysms of the vertebral artery, and 58% in the carotid arterial system.

*Side of Aneurysm.* The right:left ratio was 12:14 in the present series of dissecting aneurysms. Among the 36 reported cases with 40 lesions, this ratio was 26:14. A right-sided dominance was also reported by Manz and Luessenhop.

*Hypertension.* Hypertension was recorded in 29% of our cases. This information was available in only 21 of the 36 collected cases and 15 were hypertensive. Berger and Wilson stated that hypertension and ath-

---

**TABLE 4**

*Outcome in the present series and cases from the literature*

<table>
<thead>
<tr>
<th>Patient Group of Aneurysm Cases</th>
<th>Location of Aneurysm</th>
<th>Total Cases</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>surgical cases</td>
<td>VA</td>
<td>17</td>
<td>GR 10 MD 3 SD 1 V 0</td>
</tr>
<tr>
<td></td>
<td>PICA</td>
<td>2</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>total</td>
<td>VA</td>
<td>19</td>
<td>15 3 0 0 0</td>
</tr>
<tr>
<td></td>
<td>PICA</td>
<td>1</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>total</td>
<td>VA</td>
<td>20</td>
<td>16 3 0 0 1</td>
</tr>
<tr>
<td>nonsurgical cases</td>
<td>VA</td>
<td>16</td>
<td>3 2 0 0 11</td>
</tr>
</tbody>
</table>

*VA = vertebral artery; PICA = posterior inferior cerebellar artery; GR = good recovery; MD = moderate disability; SD = severe disability; V = vegetative state; D = dead.
Vertebral artery dissecting aneurysms were rare in dissecting aneurysms of the vertebral artery.

Symptomatology. Subarachnoid hemorrhage was confirmed in 27 cases in the literature, and was not present in eight cases; in one the data were not recorded. Thus, the incidence of hemorrhage was 77% (27 of 35 cases) in the literature and 86% (21 of 24 cases) in our series. It is noteworthy that all of our patients, including three who presented with ischemia, complained of sudden and severe headache. Among the 36 previously reported cases, headache and/or coma were observed in all except one for whom the information was not available.

Friedman and Drake stated that headache, which heralds dissection, may precede neurological deficits by days or weeks, and that occasionally the stroke is not complete at its onset but proceeds in a stepwise fashion. In our observation, the pain waxed and waned in some cases and in others appeared repeatedly at intervals of several hours to weeks. The occipital headache or the neck pain intensified immediately before clinical deterioration. Such a clinical picture seems to be quite unique. However, none of the above findings could be considered pathognomonic, as stated by Berger and Wilson. Lateral medullary syndrome was observed preoperatively in two of our 24 cases, in three of seven cases reported by Shimoji, et al., and in one case of Senter and Sarwar. In those six patients, the dissection was located at the vertebral artery distal to the PICA (V42) in three, at the intracranial vertebral artery proximal to the PICA (V42) in one, and at the PICA in two. In the literature, there were also two cases with a persistent pain syndrome, in which the dissections were extensive and involved not only the vertebral artery but also the basilar artery and the posterior cerebral artery.

Radiological Findings

The diagnosis of dissecting aneurysms of the vertebral artery is not easy, even with angiography. The most common erroneous diagnosis was a ruptured saccular aneurysm of unusual shape (with intraluminal thrombus), associated with vasospasm of its parent artery. This is probably one reason why so few reports have been published. Many authors have reported the angiographic findings of intracranial dissecting aneurysms, such as the string sign, occlusion, rosette, intimal flap, proximal and/or distal dilatation, double lumen, retention of contrast medium, and intramural pooling. The sole pathognomonic sign of a dissecting aneurysm is a double lumen (true lumen and intramural dissection), but this has been confirmed radiologically in only a few cases.

Dissecting aneurysms of the PICA were seen in only two of our 24 cases and in only one of the 36 collected cases (Case 13 of Friedman and Drake). Bilateral involvement of the vertebral artery is not rare. There were five instances in the 36 collected cases.

Operative Procedure

The first surgical procedure for dissecting aneurysm was performed by Yonas, et al., in 1977. Operations were carried out in 19 (79%) of our 24 patients (including two patients with ischemic onset and 17 with SAH) and in 20 (56%) of the 36 collected cases (including two patients with ischemia and 18 with SAH). The surgical technique was similar in both groups. In the collected series, proximal clip-occlusion of the parent artery was carried out in 14 cases and entrapment in five cases.

The most characteristic operative findings were a fusiform or tubular enlargement of the affected artery and discoloration due to intramural hematoma. The latter has been described as "black," "bluish," "bluish black," "purple," "purple red," or "brown." Such discoloration might depend upon the time elapsed since the ictus, but the interval was not described in most of the reported cases. In our series, intramural hematoma was recognized in the cases operated on before 36 days following hemorrhage. After a certain period, the wall of the dissecting aneurysm becomes whitish gray and firm, probably due to organized intramural clot. Other interesting observations include a neovascular pattern in the aneurysm's outer wall (Case 2 of Berger and Wilson), and serous fluid beneath the adventitia (resolution of intramural hematoma) (Case 3 of Berger and Wilson).

Postoperatively, a lateral medullary syndrome developed in Case 1 of Friedman and Drake treated by entrapment of V42 and application of a Sundt encircling clip at V42. Pontomedullary infarction with cerebellar involvement was seen following entrapment of the vertebral artery in Case 1 of Berger and Wilson.

Outcome

Among the 20 operatively treated cases reported in the 1970's and 1980's and the 19 surgical cases in our series, there was only one death, reported by Yonas, et al. (Table 4); however this death was not related to surgery. Rebleeding after surgery was reported in only one patient (Case 1 of Friedman and Drake). In that patient, proximal clipping was carried out distal to the PICA, the site of dissection. The rebleeding was due to extended dissection below the PICA, which was then entrapped. In the collected series, 16 patients achieved good recovery and three were moderately disabled.

The clinical course of the unoperated cases is very important. In 16 unoperated cases reported in the literature, three achieved good recovery after SAH, with a follow-up period of 4 years, 2 years, and 2 years; two others were moderately disabled for 4 years after ischemia and for more than 12 months after SAH. The remaining 11 patients died without operation: two of rebleeding at 5 days and 15 days after the initial hemorrhage and the other nine of the initial ictus. Clinical manifestation was SAH in eight cases and other symptoms in seven cases; in one case the presentation was
not described. Of the eight patients with hemorrhagic manifestation, four achieved good recovery or were moderately disabled and the other four died. Of those with other presenting symptoms, only one achieved a moderately disabled status and six died.

Friedman and Drake performed repeat angiography in their unoperated patients. One patient (Case 5) showed resolution of the dissecting aneurysm and a return to normal of the arterial caliber after 4 years. In another (Case 9), the proximal half of the dissecting aneurysm resolved after 6 months.

Surgical Indications

Recurrent hemorrhage occurred in five patients (24%) of our series within 17 days of the initial ictus, and the outcome of these patients was extremely poor. Review of the literature revealed two instances of fatal rebleeding at 5 and 15 days. Surgery is required to prevent such early rebleeding; however, dissecting aneurysms are naturally unclippable and the occlusion of the affected vertebral artery would pose considerable risks in the acute stage. There were no instances of rebleeding after surgery in our series.

All of the three patients who presented with ischemia suffered postoperative recurrence of their symptoms but at much longer intervals. Two surgically treated patients had no recurrence during follow-up periods of 4 years and 9 years. One untreated patient suffered a third attack after 8 months.

Some arguments against surgical treatment should be presented. Among six untreated patients (four in the collected group and two in our series) who survived the first 2 weeks after their initial hemorrhage, there have been no recurrent episodes during a follow-up period of 1 to 4 years. Contralateral vertebral artery dissections were asymptomatic. Our intraoperative observations suggest that a ruptured dissecting aneurysm becomes a firm whitish gray mass probably due to organized intramural clot, approximately 1 month after ictus, and rebleeding is less likely to occur at that stage. Resolution of dissection has been also reported.

Very few untreated patients have been reported in the literature and also in our series; thus, the natural history of this lesion cannot be fully defined. The indications for surgical treatment of the vertebral dissecting aneurysms remain controversial. A longer follow-up study and an analysis of a larger number of untreated cases are required to identify when surgical treatment is indicated.

Acknowledgments

We are grateful to our colleagues at our affiliated hospitals who referred patients to us. We also thank Ms. H. Sato and Y. Fujimoto for their secretarial help.

References


Manuscript received June 6, 1988. Accepted in final form July 24, 1989.

Address reprint requests to: Akira Yamaura, M.D., Department of Neurosurgery, Chiba University School of Medicine, Inohana 1-8-1 Chiba-ken 280, Japan.