Dissecting aneurysms of the vertebral artery: a management strategy

KOJI IHARA, M.D., NOBUYUKI SAKAI, M.D., KENICHI MURAO, M.D., HIDEKI SAKAI, M.D., TOSHIHI HIGASHI, M.D., SHUJI KOGURE, M.D., JUN C. TAKAHASHI, M.D., AND IZUMI NAGATA, M.D.

Department of Cerebrovascular Surgery, National Cardiovascular Center, Osaka, Japan

Object. The authors present a retrospective analysis of their experience in the treatment of vertebral artery (VA) dissecting aneurysms and propose a management strategy for such aneurysms, with special emphasis on the most formidable VA dissecting aneurysms, which involve the origin of the posterior inferior cerebellar artery (PICA).

Methods. Since 1998, 18 patients with VA dissecting aneurysms, 11 of whom presented with subarachnoid hemorrhage (SAH), have been treated by endovascular surgery at the authors’ institution. Obliteration of the entire segment of the dissected site with coils (internal trapping) was performed for aneurysms without involvement of the origin of the PICA (12 cases; among these the treatment-related morbidity rate was 16.7%). The treatment strategy applied to PICA-involved VA dissecting aneurysms presenting with SAH (three cases) included proximal occlusion of the parent artery followed by internal trapping of the aneurysm (one case), proximal occlusion of the parent artery followed by occipital artery (OA)–PICA bypass (one case), and two-staged internal trapping of the aneurysm involving double PICAs (one case). For PICA-involved VA dissecting aneurysms that were not associated with SAH at presentation (three cases), OA–PICA bypass was performed and followed by internal trapping of the aneurysm (two cases). In the remaining case in which a fetal-type posterior communicating artery was present, internal trapping was performed following successful balloon test occlusion (BTO). Overall, there was no sign of infarction in the PICA territory, despite complete occlusion of aneurysms involving the PICA. There was no recurrent bleeding or ischemic symptoms during the follow-up periods. The overall treatment-related morbidity rate for the VA dissecting aneurysms involving the PICA was 16.7%.

Conclusions. Dissecting VA aneurysms that do not involve the PICA can be safely treated by internal trapping. For those lesions that do involve the PICA, a decision-making algorithm is advocated to maximize the efficacy of the treatment as well as to minimize the risks of treatment-related morbidity based on BTO.

KEY WORDS • dissecting aneurysm • subarachnoid hemorrhage • vertebral artery • coil embolization • bypass procedure • balloon test occlusion

With increased awareness of the disease entity and its angiographic appearance, dissecting aneurysms of the VA have now come to be considered a rather common cause of SAH and brainstem ischemia. In cases presenting with SAH, previous studies have reported a high incidence of rebleeding and a high mortality rate at the time of recurrent bleeding, emphasizing the necessity of early treatment. Originally, proximal clipping of the parent artery and trapping of the aneurysms by direct surgical approach were advocated as treatments of choice. Nevertheless, relatively benign natural histories have been reported in cases presenting with ischemic symptoms, and the indications and timings for treatment of non-SAH cases remain controversial.

Recently, the advent of endovascular surgery changed treatment options for VA dissecting aneurysms, especially during the acute phase following SAH, because this technique enables not only occlusion of the parent artery but also obliteration of the entire segment of the dissected site with coils (internal trapping) more easily in a tight posterior fossa, especially with regard to securing the distal side of the parent artery. Proximal parent artery occlusion is not believed to eliminate completely the risk of rebleeding, but surgical trapping of the dissected site has been reported to be associated with a high rate of postoperative lower cranial nerve palsy. Therefore, internal trapping of the aneurysm by endovascular treatment during the acute stage post-SAH might significantly improve outcomes in patients harboring dissecting VA aneurysms, especially those presenting with SAH. Little is known about the safety and long-term efficacy of internal trapping of aneurysms by endovascular treatment in the prevention of rebleeding. In addition, if the PICA is involved in the dissecting segment (the PICA-involved type of VA dissecting lesion), internal trapping could be associated with a significant risk of morbidity if no revascularization of the PICA is achieved.
though there have been several case series of VA dissecting aneurysms of the PICA-involved type, in no previous reports have authors advocated an ideal management strategy by implementing endovascular techniques for this formidable subgroup of aneurysms. In this study we retrospectively reviewed the safety and long-term efficacy of endovascular treatment for VA dissecting aneurysms, with special emphasis on management outcomes of our novel strategy for aneurysms of the PICA-involved type, with or without revascularization of the PICA, based on the results of BTO.

**Clinical Material and Methods**

Between January 1998 and May 2001, 499 aneurysms were treated at the National Cardiovascular Center. During this period, 18 cases of VA dissecting aneurysms, comprising approximately 3.6% of the total number of aneurysm cases, were treated by endovascular methods (internal trapping of the aneurysm or proximal occlusion of the parent artery) as the first line of therapy. The diagnosis was made based on characteristic features demonstrated on angiography. The location of each aneurysm was classified into one of three groups: proximal to the PICA, involving the PICA, and distal to the PICA. There were six cases of the PICA-involved type, three presenting with SAH and three not associated with hemorrhage. We retrospectively reviewed the clinical and radiological features of these aneurysms and examined the safety and management outcomes of our strategy.

**Patient Population**

The mean age of the 18 patients (14 men and four women) was 56 years (range 45–75 years). Eleven patients presented with SAH, four with ischemic symptoms, and one with headache; in the remaining two patients the aneurysm was diagnosed incidentally. Of note, in one patient who initially presented with cerebellar infarction, a minor leak later developed during the chronic phase. A previous history of hypertension was noted in six patients.

**Endovascular Procedure**

The patient was placed in a state of general anesthesia, and received systemic heparinization. A No. 6 French guide catheter or a No. 7 French balloon catheter was placed in the proximal VA. A microcatheter was delivered coaxially, with the tip placed just beyond the distal end of the dissected site, in the case of internal trapping, or just proximal to the aneurysm, in the case of proximal endovascular occlusion, with or without proximal flow control. Guglielmi detachable coils were delivered to the distal portion of the dissected site in the case of internal trapping, or just proximal to the aneurysm in the case of proximal VA occlusion. After this procedure, a pack of IDCs or fiber coils was sequentially delivered to achieve rapid permanent thrombosis.

**TABLE 1**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>WFNS Grade</th>
<th>Aneurysm Location†</th>
<th>Day Post-SAH</th>
<th>Treatment</th>
<th>Day Post-SAH</th>
<th>Morbidity</th>
<th>Treatment-Related Morbidity</th>
<th>GOS Score</th>
<th>mRS Score</th>
<th>Barthel Index (/20)</th>
<th>F/U</th>
<th>Angio</th>
<th>F/U</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52, M V prox, rt</td>
<td>2/3 3</td>
<td>ITA 3</td>
<td>lt hemiparesis, dysarthria, &amp; ataxia</td>
<td>none</td>
<td>3 (SD)</td>
<td>4 19</td>
<td>16 mos 28 mos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>60, M IV prox, lt</td>
<td>none 0</td>
<td>ITA 0</td>
<td>lt hemiparesis, hori-</td>
<td>none</td>
<td>5 (GR)</td>
<td>1 20</td>
<td>18 mos 20 mos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>58, F II prox, rt</td>
<td>none 0</td>
<td>ITA 0</td>
<td>not applicable</td>
<td>none</td>
<td>5 (GR)</td>
<td>1 20</td>
<td>12 mos 14 mos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>51, M III prox, rt</td>
<td>none 0</td>
<td>ITA 0</td>
<td>not applicable</td>
<td>none</td>
<td>5 (GR)</td>
<td>1 20</td>
<td>5 mos 13 mos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>68, M III dis, rt</td>
<td>none 0</td>
<td>ITA 0</td>
<td>brain death by pri-</td>
<td>none</td>
<td>5 (GR)</td>
<td>1 20</td>
<td>6 mos‡</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>75, M V dis, rt</td>
<td>none 0</td>
<td>ITA 0</td>
<td>primary damage</td>
<td>none</td>
<td>5 (GR)</td>
<td>1 20</td>
<td>— 6 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>57, M V dis, lt</td>
<td>none 98</td>
<td>ITA 112</td>
<td>dysphagia</td>
<td>none</td>
<td>3 (SD)</td>
<td>4 3</td>
<td>6 days 9 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>64, M IV no PICA, rt</td>
<td>2 2</td>
<td>ITA 2</td>
<td>dysarthria, dyspha-</td>
<td>none</td>
<td>3 (SD)</td>
<td>4 17</td>
<td>7 days 21 mos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>54, M III involve, rt</td>
<td>1 1</td>
<td>ITA/ITA 1/5</td>
<td>lt CN VII &amp; rt CN III deficits, dysarthria,</td>
<td>occipital infarct</td>
<td>5 (GR)</td>
<td>1 20</td>
<td>13 mos 44 mos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>60, M IV involve, rt</td>
<td>none 2</td>
<td>POPA/ITIA/ITA 2/32</td>
<td>Terson glands</td>
<td>none</td>
<td>5 (GR)</td>
<td>1 20</td>
<td>20 mos 7 mos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>51, F V involve, rt</td>
<td>0 0</td>
<td>POPA/ITIA 0/23</td>
<td>recent memory disturbance</td>
<td>none</td>
<td>5 (GR)</td>
<td>1 20</td>
<td>14 days 3 mos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Angio = angiography; bypass = OA–PICA bypass; CN = cranial nerve; D = death; dis = distal to PICA; F/U = follow up; GR = good recovery; involve = PICA location involved; ITA = internal trapping of aneurysm; mRS = modified Rankin scale; POPA = proximal occlusion of parent artery; prox = proximal to PICA; SD = severe disability; — = not applicable.
† In relation to PICA.
‡ Died of lung cancer.
Management strategy for dissecting vertebral artery aneurysms

Sources of Supplies and Equipment

The Envoy No. 6 French guide catheter and the Commodore nondetachable silicone balloon catheter were purchased from Cordis Endovascular Systems (Miami, FL). The Patlive No. 7 French balloon catheter was obtained from Clinical Supply Inc. (Gifu, Japan). The GDCs, IDCs, and fiber coils were acquired from Target Therapeutics–Boston Scientific (Natick, MA).

Results

The management strategy was tailored to the individual case based on the presenting symptoms (SAH group/non-SAH group), angiographic features of the aneurysms (the location of the aneurysm and the dominance of the involved VA), and the neurological condition of the patient, as described later.

Patients With SAH

Among the 11 patients presenting with SAH (nine men and two women) (Table 1), the aneurysms were located proximal to the PICA in four, involved the PICA in three, and were located distal to the PICA in three patients; the PICA was absent in one patient. At admission, clinical grading based on the WFNS scale was Grade II in one patient, Grade III in three patients, Grade IV in three patients, and Grade V in four patients. Before treatment, five episodes of recurrent bleeding occurred in four patients within 3 days after the initial bleeding. In 10 patients endovascular treatment was performed on the day of admission: six patients were treated on Day 0, one on Day 1, two on Day 2, and one on Day 3 post-SAH. The remaining patient presented with a Grade V SAH and was referred to our department during the chronic stage; that patient underwent endovascular treatment 3 months after the initial hemorrhage.

If the aneurysm was located proximal or distal to the PICA without hypoplasia of the contralateral VA, the lesion was treated with the intention that the aneurysm would fill slowly in a retrograde fashion from the contralateral VA (Fig. 1b). The patient regained consciousness approximately 1 week later. Follow-up angiography was performed 3 weeks post-SAH, revealing enlargement of the aneurysmal dilation, which was filled from the left VA (Fig. 1c). Balloon test occlusion was performed to assess the feasibility of internal trapping by inflating a nondetachable silicone balloon catheter that had been transported via the contralateral VA to the distal side of the aneurysm (Fig. 1d). During balloon occlusion of the distal VA, we could observe on angiography that the AICA supplied the territory of the PICA via leptomeningeal anastomosis. After the patient tolerated a 15-minute occlusion, GDCs were deployed through the microcatheter, resulting in internal trapping of the aneurysm involving the origin of the PICA without any neurological sequelae (Fig. 1e).

Case 11. This 51-year-old woman presented with a WFNS Grade V SAH. A left VA dissecting aneurysm was discovered just proximal to the PICA and extending close to the VB junction (Fig. 2a and Table 1). On Day 0 post-SAH, proximal occlusion of the left VA was performed so that the well-developed PICA could be filled from the contralateral VA (Fig. 2b). Follow-up angiography revealed slight enlargement of the aneurysmal dilation as it filled from the contralateral VA (Fig. 2c). Because the acute angle formed by the bilateral VAs at the VB junction seemed to preclude safe and stable placement of a balloon catheter, we performed an OA–PICA bypass with clipping of the PICA, but no BTO on Day 23 (Fig. 2d). Follow-up angiography performed 14 days later revealed complete thrombosis of the remaining dissecting aneurysm distal to the PICA, without additional deficit (Fig. 2e).

Management Outcomes in the SAH Group.

Complete obliteration of the aneurysm was obtained in all cases without any treatment-related death. After our strategy for PICA-involved VA dissecting aneurysms had been applied, diffusion-weighted MR imaging demonstrated no treatment-related, ischemic lesions in the PICA territory. Among the 11 patients who presented with SAH, the final outcomes 6 months posthemorrhage were good recovery in seven patients, severe disability in three patients, and death in one patient (Table 1). The grade of each patient at presentation had a significant impact on ultimate outcome. All patients who presented with WFNS Grades I through III made good recoveries, whereas 67% with Grade IV and 25% with Grade V achieved good recoveries. No symptomatic vasospasm was noted in this series. Factors accounting for poor outcome included primary brain damage in three cases and rebleeding in one case, respectively. At the mean follow-up period of 15.8 months, there were no subsequent ruptures. Follow-up angiograms or MR angiograms were obtained after discharge in six cases at a mean interval of 14 months; no recanalization of aneurysms was observed at that time.

Patients Without SAH

The indication for treatment was limited to cases with progressive enlargement of aneurysmal dilation and recurrent ischemic symptoms. Among the non-SAH group, the aneurysms were located proximal to the PICA in one patient, involving the PICA in three patients, and distal to the PICA in three patients. The management strategy followed
for aneurysms located proximal or distal to the origin of the PICA was virtually the same as that described earlier for the SAH group. The management strategy for aneurysms involving the origin of the PICA again was tailored to the individual case, as in the SAH group.

Case 17. This 54-year-old man presented with a right AICA syndrome caused by brainstem infarction. The aneurysmal dissection was located on the PICA and involved the artery’s origin from the VA. Follow-up angiography performed 9 months later revealed enlargement of the aneurysmal dilation. To determine the feasibility of internal trapping of a dissected segment involving the origin of the PICA, BTO was performed. When the balloon was inflated, the patient complained of vertigo and tinnitus associated with documented nystagmus. Because the patient did not pass the BTO, an OA–PICA surgical anastomosis was performed on the right side. After the patient passed a second BTO, coil embolization of the site of dissection (internal trapping) was performed. Follow-up angiography revealed complete obliteration of the aneurysm. The PICA territory was supplied by leptomeningeal anastomosis from the ipsilateral AICA. Again, arrowheads indicate coils previously packed in the proximal VA.

Case 18. This 43-year-old man presented with vertigo due to cerebellar infarction. At another hospital the patient had received a diagnosis of dissections at the bilateral VAs with the pearl-and-string sign (Fig. 3 and Table 2). Sixteen days later, a spinal tap revealed xanthochromic CSF, indicating the occurrence of a previous SAH. Angiograms obtained 11 days after the spinal tap demonstrated thrombosis of the left VA and enlargement of the aneurysmal dilation on the right side (Fig. 3a). The bilateral VAs ended in the PICAs and there was retrograde filling of the basilar artery from the bilateral internal carotid arteries via fetal-type posterior communicating arteries (Fig. 3b). The patient underwent a BTO during which a silicone balloon was placed within the left VA and expanded for 20 minutes (Fig. 3c). Following the successful BTO, the aneurysm was occluded with a pack of GDCs and fiber coils (Fig. 3d). No se-
quela occurred. Bilaterally, the PICA territories were supplied from the leptomeningeal anastomosis via the bilateral AICAs.

**Management Outcomes in the Non-SAH Group.** Complete obliteration of the aneurysm was obtained in all cases without any treatment-related death. There was a 0% permanent treatment-related morbidity rate at 6 months postoperatively and there was only one case of transient amnesia (Case 12 [Table 2]) in the non-SAH group. Follow-up angiography was performed after discharge in four cases, and no recanalization was revealed at the mean follow-up period of 9.3 months. No recurrent ischemic symptoms or conversions to hemorrhage were seen following treatment.

**Safety of the Endovascular Procedure**

No major bleeding complications occurred during placement of coils in the affected VAs. Minor extravasation during coil placement and rebleeding during placement of the guide catheter were seen in one case each and were controlled by delivery of coils to the dissected site.

With our management strategy for the PICA-involved type (six cases), there was one case (16.7%) of treatment-related morbidity (occipital infarction due to embolism in Case 9 [Table 1]). There was no new lesion in the PICA territory on diffusion-weighted MR imaging posttreatment. The morbidity rate for PICA-involved VA dissecting aneurysms was the same as that for VA dissecting aneurysms without any PICA involvement.

**Discussion**

In this article we reported on the safety of endovascular treatment for VA dissecting aneurysms and the long-term efficacy of prevention of recurrent bleeding after SAH. In line with previous reports, our results of endovascular treatment for VA dissecting aneurysms located proximal or distal to the PICA were satisfactory, with an acceptable,
treatment-related rate of morbidity and no treatment-related death. Unfortunately, there is no established protocol for the management of VA dissecting aneurysms of the PICA-involved type. We assessed the feasibility of sacrifice of the PICA by applying a BTO when possible in such cases during the chronic stage after SAH, and sacrificed the PICA with or without revascularization, depending on the result of this test, without any neurological sequela.

**Indications and Optimal Timing of the Treatment**

It is known that VA dissecting aneurysms that present with SAH are associated with a high risk of rebleeding, especially within the first 24 hours posthemorrhage and within the 1st week if left untreated. Therapeutic intervention should thus be performed as soon as possible to prevent subsequent bleeding. In addition, because a VA dissecting aneurysm has been reported to rebleed more than 1 month after the initial episode during the chronic stage following SAH, and sacrificed the PICA with or without revascularization, depending on the result of this test, without any neurological sequela.

**Mode of Treatment: Endovascular or Surgical Treatment**

Originally, proximal clip occlusion or trapping was advocated as the treatment of choice for VA dissecting aneurysms if the contralateral VA is equal or greater in caliber, and wrapping of the dissection if the affected artery is dominant. Using BTO, Halbach, et al., have shown that patients can tolerate permanent occlusion of the dominant VA and, even, bilateral VA occlusion without deficits. Because the dissecting aneurysms are extremely fragile and easily ruptured during surgery, endovascular proximal occlusion of the parent vessel seems to be the safest method, especially during the acute stage following SAH. In recent papers, however, authors have shown that proximal occlusion achieved by endovascular means as well as by clipping

---

**Fig. 3. Case 18.** Angiograms obtained in a patient with a VA dissecting aneurysm involving the PICA who presented with a cerebellar infarction. The angiograms demonstrate bilateral dissecting aneurysms with the pearl-and-string sign.

a: Follow-up angiogram showed thrombosis of the left VA and an aneurysmal dilation on the right VA involving the PICA (arrows). b: Carotid angiogram demonstrating retrograde filling of the basilar artery and bilateral PICA territories supplied via fetal-type posterior communicating arteries. c: The patient tolerated a 20-minute BTO of the right VA. Arrowheads indicate nondetachable balloon placed in proximal VA. d: Angiogram confirming that the aneurysm is occluded with GDCs and fiber coils (arrowheads) packed in the VA.
Management strategy for dissecting vertebral artery aneurysms

**TABLE 2**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>Presentation</th>
<th>Aneurysm Location†</th>
<th>Procedure</th>
<th>Timing After Symptom Onset</th>
<th>Morbidity</th>
<th>Treatment-Related Morbidity</th>
<th>Treatment F/U</th>
<th>Barthel mRS Score</th>
<th>Angio (mos)</th>
<th>F/U (mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>49, M</td>
<td>incidental</td>
<td>prox, rt</td>
<td>ITA</td>
<td>—</td>
<td>none</td>
<td>transient amnesia</td>
<td>none</td>
<td>5 (GR)</td>
<td>0</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>13</td>
<td>55, F</td>
<td>ischemia</td>
<td>dis, rt</td>
<td>ITA</td>
<td>11 mos (re cannalization)</td>
<td>none</td>
<td>none</td>
<td>5 (GR)</td>
<td>1</td>
<td>20</td>
<td>8</td>
<td>28</td>
</tr>
<tr>
<td>14</td>
<td>50, M</td>
<td>ischemia</td>
<td>dis, rt</td>
<td>ITA</td>
<td>8 mos</td>
<td>none</td>
<td>none</td>
<td>5 (GR)</td>
<td>0</td>
<td>20</td>
<td>—</td>
<td>27</td>
</tr>
<tr>
<td>15</td>
<td>47, F</td>
<td>HA</td>
<td>dis, lt</td>
<td>ITA</td>
<td>2 mos</td>
<td>none</td>
<td>none</td>
<td>5 (GR)</td>
<td>1</td>
<td>20</td>
<td>—</td>
<td>6</td>
</tr>
<tr>
<td>16</td>
<td>45, M</td>
<td>ischemia (rt CN VII &amp; CN VIII deficits)</td>
<td>involve, rt</td>
<td>bypass/ITA</td>
<td>10 mos</td>
<td>rt CN VII &amp; CN VIII deficits</td>
<td>none</td>
<td>5 (GR)</td>
<td>1</td>
<td>20</td>
<td>7</td>
<td>24</td>
</tr>
<tr>
<td>17</td>
<td>54, M</td>
<td>ischemia (rt cerebellum)</td>
<td>involve, rt</td>
<td>BTO/bypass/ITA</td>
<td>1 mo</td>
<td>none</td>
<td>none</td>
<td>5 (GR)</td>
<td>1</td>
<td>20</td>
<td>—</td>
<td>9</td>
</tr>
</tbody>
</table>

* HA = headache.
† In relation to PICA.

Summary of patients with VA dissecting aneurysms presenting with non-SAH symptoms

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>Presentation</th>
<th>Aneurysm Location†</th>
<th>Procedure</th>
<th>Timing After Symptom Onset</th>
<th>Morbidity</th>
<th>Treatment-Related Morbidity</th>
<th>Treatment F/U</th>
<th>Barthel mRS Score</th>
<th>Angio (mos)</th>
<th>F/U (mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>49, M</td>
<td>incidental</td>
<td>prox, rt</td>
<td>ITA</td>
<td>—</td>
<td>none</td>
<td>transient amnesia</td>
<td>none</td>
<td>5 (GR)</td>
<td>0</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>13</td>
<td>55, F</td>
<td>ischemia</td>
<td>dis, rt</td>
<td>ITA</td>
<td>11 mos (re cannalization)</td>
<td>none</td>
<td>none</td>
<td>5 (GR)</td>
<td>1</td>
<td>20</td>
<td>8</td>
<td>28</td>
</tr>
<tr>
<td>14</td>
<td>50, M</td>
<td>ischemia</td>
<td>dis, rt</td>
<td>ITA</td>
<td>8 mos</td>
<td>none</td>
<td>none</td>
<td>5 (GR)</td>
<td>0</td>
<td>20</td>
<td>—</td>
<td>27</td>
</tr>
<tr>
<td>15</td>
<td>47, F</td>
<td>HA</td>
<td>dis, lt</td>
<td>ITA</td>
<td>2 mos</td>
<td>none</td>
<td>none</td>
<td>5 (GR)</td>
<td>1</td>
<td>20</td>
<td>—</td>
<td>6</td>
</tr>
<tr>
<td>16</td>
<td>45, M</td>
<td>ischemia (rt CN VII &amp; CN VIII deficits)</td>
<td>involve, rt</td>
<td>bypass/ITA</td>
<td>10 mos</td>
<td>rt CN VII &amp; CN VIII deficits</td>
<td>none</td>
<td>5 (GR)</td>
<td>1</td>
<td>20</td>
<td>7</td>
<td>24</td>
</tr>
<tr>
<td>17</td>
<td>54, M</td>
<td>ischemia (rt cerebellum)</td>
<td>involve, rt</td>
<td>BTO/bypass/ITA</td>
<td>1 mo</td>
<td>none</td>
<td>none</td>
<td>5 (GR)</td>
<td>1</td>
<td>20</td>
<td>—</td>
<td>9</td>
</tr>
</tbody>
</table>

Management Strategy for VA Dissecting Aneurysms Involving the PICA

Dissecting aneurysms of the VA that involve the PICA represent the most formidable subgroup. The therapeutic goal for a VA dissecting aneurysm must be complete exclusion of the lesion from the circulation. As long as even the slightest filling is present, the patient remains at risk for hemorrhage. According to a recent case report,32 therefore, internal trapping of the dissected site is now deemed as the best treatment of choice, if feasible, for VA dissecting aneurysms.32 There are several important technical aspects of internal trapping of the dissecting aneurysms. The GDC system allows controlled placement and detachment of soft platinum coils within the true lumen of the dissected segment to collapse the false lumen.32 Appropriate selection of the GDCs that are first used, and the subsequent use of fiber coils and IDCs enables safe and rapid occlusion of the affected segment. In addition, temporary proximal flow arrest, achieved using a nondetachable balloon, may reduce the risk of distal emboli and preclude difficulties in the dispersal of coils into the arterial flow stream.6 Also, it is important to prevent the coils from becoming inadvertently packed into the pseudolumen, which would make it not only dangerous but also difficult to pack the aneurysm tightly.

Proximal PICA combined with trapping of the aneurysm resulted in cerebellar and brainstem infarction.2 Because the portion of the PICA proximal to the choroidal point (the site at which the PICA produces small rami to the anterior aspect of the tonsil and the choroid plexus of the fourth ventricle) may produce critical perforating arteries to the brainstem and deep cerebellar nuclei,15 it is hard to predict whether it is safe to trap an aneurysm involving the origin of the PICA without revascularization. On the other hand, in previous cases proximal clip placement or endovascular proximal occlusion of the VA led to later reoperation for trapping of the dissected segment in two (40%) of the five cases, either because a repeated rupture occurred (one case)11 or because enlargement of the aneurysms was detected at serial angiograms (one case).33 Although it is possible to perform revascularization of the PICA and trapping of the aneurysm during a single operation to eliminate the risk of rebleeding, this is technically much more demanding, especially during the acute stage post-SAH. To overcome the dilemma this raises, we advocate use of a decision-making algorithm for the treatment for the VA dissecting aneurysms of the PICA-involved type (Fig. 4).

As soon as the diagnosis of dissecting aneurysm involving the PICA is established, endovascular proximal occlusion of the VA should be performed using a pack of GDCs and fiber coils, as described earlier. If the other intact VA is hypoplastic or absent, BTO of the affected parent VA should be performed under neurophysiological monitoring to determine whether it has been safely performed, as described previously.25 After the patient has survived the acute stage of SAH with improvement in consciousness, follow-up angiography is performed to examine whether the aneurysm continues to be filled from the contralateral VA. Progressive thrombosis may occur in the segment distal to the PICA because the small perforating vessels or a very small PICA provides an inadequate supply to keep this segment patent from retrograde flow from the basilar artery. If the aneurysm continues to fill from the contralateral VA, a nondetachable silicone balloon catheter is delivered via the contralateral VA, placed just distal to the dissected site, and inflated for 20 minutes to determine whether the dissect-
ed site can be safely trapped with coils (internal trapping). During BTO, contralateral VA and ipsilateral external carotid arteriography are performed to examine whether the PICA territory is supplied from collateral routes such as leptomeningeal anastomoses from the AICA and superior cerebellar artery or anastomoses from the posterior meningeal artery. If the patient tolerates a 20-minute occlusion with angiographic demonstration of filling of the PICA territory from collateral routes, and if no neurological manifestation of ischemia in the PICA territory (such as vertigo, tinnitus, and nystagmus [see Case 17]) is present, internal trapping of the dissected site can be performed. In the case of an unsuccessful test occlusion of the distal end of the dissected site, the PICA should be revascularized by means of an OA–PICA or a PICA–PICA bypass and the origin of the PICA should be clipped. At this stage, the dissected site will likely become thrombosed because this segment between the PICA and the VB junction becomes a blind sac, with no sufficient demand to keep the segment open. Of note, in our series, there was no treatment-related infarction in the PICA territory associated with our strategy for treating the PICA-involved type of lesion, and the overall treatment-related morbidity rate was the same as that for other VA dissecting aneurysms.

### Unsolved Problems

The safety of internal trapping of the dissected site remains unestablished. At surgery, large perforating arteries are often observed to arise from dissecting aneurysms. Nevertheless, patients tolerate complete thrombosis of the aneurysm by the adjacent segment of the VA without the development of brainstem ischemia because the perforating vessels arising from the dissected segment are more likely to be occluded already. As in our Case 7, however, in which the dissection was located distal to the PICA, internal trapping of the dissected site can be associated with the development of a brainstem infarction. In Case 7, we did not perform a BTO because the dissection was located distal to the PICA. Anatomical studies have shown critical perforating vessels arising from the distal VAs, especially the nondominant, usually right-sided VA, and also arising from VB arteries between approximately 14 mm proximal and 16 mm distal to the VB junction. In line with these findings, complications in the series conducted by Yamaura occurred in all three patients who underwent clip occlusion of a dissecting aneurysm arising from the vertebral segment above the origin of the PICA. Therefore, it seems more critical to determine when the distal side of the dissection should be occluded and at what particular site. So far, there has been no reliable way to predict the safety of trapping of the dissected site involving the origin of the PICA, although some angiographic criteria have been proposed. We consider the best and most realistic method for this purpose to be BTO in which the nondetachable balloon is placed at the distal side of the dissection at the earliest opportunity after the patient regains consciousness.

We must admit that there remain unsolved problems in our strategy. First, the patient continues to be subject to the risk of rebleeding until internal trapping is performed. In this context, it is important to note that VA occlusion proximal to the PICA carries a greater risk than occlusion distal to the PICA in the treatment of unclippable VA aneurysms, although this is inconsistent with findings of other series. Second, the patient has to have recovered consciousness to determine the safety of the test occlusion, although a possible alternative is to use neurophysiological monitoring. Because the reliability of neurophysiological monitoring during the BTO of the PICA remains unknown, we waited until the patient regained consciousness after SAH in this series. It is apparent that more clinical experience is necessary to answer all these questions. Our

---

**Fig. 4. Proposed management strategy for VA dissecting aneurysms. An = aneurysm.**
Management strategy for dissecting vertebral artery aneurysms

preliminary experience, however, has indicated that our management strategy for VA dissecting aneurysms that involve the PICA is close to optimal in safety as well as in intermediate-term efficacy of prevention of bleeding after devastating SAH.

Conclusions

The present case series provided us with a unique opportunity to consider the optimal management strategy for VA dissecting aneurysms, especially the most formidable lesions involving the PICA. We have described our successful treatment of this type of aneurysm, with an acceptable rate of morbidity, by proximal endovascular occlusion performed during the acute stage followed by internal trapping of the dissected site, if possible, based on the results of a BTO of the distal VA segment of the dissected site. Based on our preliminary experience, we advocate a decision-making algorithm for this subgroup of VA dissecting aneurysms.

References


Manuscript received November 8, 2001. Accepted in final form April 29, 2002.
Address reprint requests to: Koji Ihara, M.D., Department of Cerebrovascular Surgery, National Cardiovascular Center, 5-7-1, Fujishiro-dai, Suita, Osaka, 565-8565, Japan. email: kihara@hsp.ncc.go.jp.

J. Neurosurg. / Volume 97 / August, 2002 267