Surgical and endovascular management of symptomatic posterior circulation fusiform aneurysms

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Object. Patients with fusiform aneurysms can present with subarachnoid hemorrhage (SAH), mass effect, ischemia, or unrelated symptoms. The absence of an aneurysm neck impedes the direct application of a clip and endovascular coil deployment. To evaluate the effects of their treatments, the authors retrospectively analyzed a consecutive series of patients with posterior circulation fusiform aneurysms treated at Stanford University Medical Center between 1991 and 2005.

Methods. Forty-nine patients (mean age 53 years, male/female ratio 1.2:1) treated at the authors’ medical center form the basis of the analysis. Twenty-nine patients presented with an SAH. The patients presenting without SAH had cranial nerve dysfunction (five patients), symptoms of mass effect (eight patients), ischemia (six patients), or unrelated symptoms (one patient). The aneurysms were located on the vertebral artery (VA) or posterior inferior cerebellar artery (PICA) (21 patients); vertebrobasilar junction (VBJ) or basilar artery (BA) (18 patients); and posterior cerebral artery (PCA) (10 patients). Pretreatment clinical grades were determined using the Hunt and Hess scale; for patients with unruptured aneurysms (Hunt and Hess Grade 0) functional subgrades were added. Outcome was evaluated using the Glasgow Outcome Scale (GOS) score during a mean follow-up period of 33 months.

Overall long-term outcome was good (GOS Score 4 or 5) in 59%, poor (GOS Score 2 or 3) in 16%, and fatal (GOS Score 1) in 24% of the patients. In a univariate analysis, poor outcome was predicted by age greater than 55 years, VBJ location, pretreatment Hunt and Hess grade in patients presenting with SAH, and incomplete aneurysm thrombosis after endovascular treatment. In a multivariate analysis, age greater than 55 years was the confounding factor predicting poor outcome. Stratification by aneurysm location removed the effect of age. Of 13 patients with residual aneurysm after treatment, five (38%) subsequently died of SAH (three patients) or progressive mass effect/brainstem ischemia (two patients).

Conclusions. Certain posterior circulation aneurysm locations (PCA, VA–PICA, and BA–VBJ) represent separate disease entities affecting patients at different ages with distinct patterns of presentation, treatment options, and outcomes. Favorable overall long-term outcome can be achieved in 90% of patients with PCA aneurysms, in 60% of those with VA–PICA aneurysms, and in 39% of those with BA–VBJ aneurysms when using endovascular and surgical techniques. The natural history of the disease was poor in patients with incomplete aneurysm thrombosis after treatment.

Key Words • fusiform aneurysm • posterior circulation aneurysm • occlusion • coil placement • outcome

DIFFERENT terms have been used to describe aneurysms that are not amenable to direct clip or coil therapy. Some of the terms, such as “dissecting aneurysm,” implicate a probable mechanism of origin, whereas others such as “dolichoectatic” and “fusiform” are morphologically descriptive. This type of aneurysm occurs less frequently than its saccular counterpart, and patient demographics, clinical presentation, and natural history are distinctly different. Data on natural history and treatment results for these aneurysms are limited, but reports of frequent early rebleedings and poor outcome have resulted in a heightened sense of urgency. Authors of a study in which nonsaccular aneurysms with angiographic features of acute dissection were excluded and in which 40% of patients were asymptomatic, demonstrated annual hemorrhage rates of approximately 1 to 2%.

Posterior circulation fusiform aneurysms present difficult treatment challenges. Proximal or parent artery occlusions (Hunterian ligation), trapping procedures, and clip reconstructions are surgical techniques used to treat aneurysms that are not amenable to direct clip application. Endovascular options include parent vessel coil occlusion, stent placement, or combinations of coil and stent therapies. The selection of the treatment modality by our neurovascular team was based on the anticipated effectiveness of

Abbreviations used in this paper: BA = basilar artery; GOS = Glasgow Outcome Scale; PCA = posterior cerebral artery; PICA = posterior inferior cerebellar artery; SAH = subarachnoid hemorrhage; TIA = transient ischemic attack; VA = vertebral artery; VBJ = vertebrobasilar junction.
the treatment, taking into consideration the characteristics of the aneurysms, including morphological features, location, and orientation. To appraise the effect of our treatments we retrospectively analyzed a consecutive series of patients with posterior circulation fusiform aneurysms treated at Stanford University Medical Center.

**Clinical Material and Methods**

**Patient Population**

Between 1991 and 2005, 49 patients were treated at the authors’ institution. The mean and median ages were 53 and 55 years for men and 52 and 50 years for women, respectively (see Fig. 1 for the distribution of age in subgroups based on location). The male/female distribution was 27:22 (ratio 1.2:1). Twenty-one aneurysms (43%) were located on the VA (20 patients) or on the PICA (one patient), 10 (20%) were at the PCA, and 18 (37%) on the BA or VBJ. Based on the three locations, patient ages (p = 0.01, Kruskal–Wallis test) and pretreatment grades (p = 0.04, Kruskal–Wallis test) were different between the locations. Twenty-seven patients (55%) underwent endovascular treatment, 19 (39%) underwent surgery, and three (6%) received a combination of endovascular and surgical treatments. These three patients underwent endovascular parent vessel occlusions after undergoing an extracranial–intracranial bypass procedure. Four patients treated endovascularly underwent shunt placement for hydrocephalus (one patient 2 months before and the other three patients 1, 2.5, and 9 months after parent vessel occlusion).

**Neurological Assessment**

The Hunt and Hess scale was used for grading a patient’s neurological condition before treatment. This scale does not grade symptoms caused by mass effect or ischemia in the absence of an SAH and thus fails to account for the fact that brainstem compression and cranial nerve deficits can seriously affect quality of life. The neurological condition in patients presenting with symptoms related to mass effect or ischemia such as TIA, stroke, cranial nerve dysfunction, dysartrhia, or postural unsteadiness in addition to no SAH was graded Hunt and Hess Grade 0 with an added three-point functional subgrade (Table 1). Twenty-nine patients (59%) presented with SAH. A diagnosis of SAH varied based on aneurysm location—81% of patients in the VA–PICA group presented with SAH, whereas 60% of those in the PCA group and 33% of those in the BA–VBJ group presented with SAH (Table 2). In the other 20 patients (presenting without SAH), symptoms were attributed to brainstem compression in six (30%), cranial nerve dysfunction in four (20%), TIA or stroke in six (30%) patients, and mass effect caused by hydrocephalus in two (10%). Two patients (10%) presented with headache but no neurological deficits.

**Outcome Assessment**

Decisions about optimal treatment were made by our neurovascular team, consisting of neurosurgeons, interventional neuroradiologists, and in certain cases, stroke neurologists. The selection of treatment was based on the aneurysm location and morphological features as well as the expected results of endovascular and surgical treatment. The GOS was used to assess outcome (a GOS score of 1, dead; 2, vegetative state; 3, severely disabled; 4, moderately disabled; and 5, good outcome). The mean follow-up period was 33 months (median 12 months, range 3–142

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**TABLE 1**

<table>
<thead>
<tr>
<th>Hunt &amp; Hess Grade</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>independent &amp; able to work</td>
</tr>
<tr>
<td>1</td>
<td>independent but unable to work</td>
</tr>
<tr>
<td>2</td>
<td>dependent &amp; unable to work</td>
</tr>
</tbody>
</table>

**TABLE 2**

<table>
<thead>
<tr>
<th>No. of Patients (%)†</th>
<th>VA–PICA</th>
<th>PCA</th>
<th>BA–VBJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>no. of patients</td>
<td>21</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>median age in yrs (range)</td>
<td>52 (20–82)</td>
<td>43 (31–62)</td>
<td>60 (24–79)</td>
</tr>
<tr>
<td>median aneurysm size in mm (range)</td>
<td>12 (7–37)</td>
<td>17 (4–29)</td>
<td>22 (6–42)</td>
</tr>
<tr>
<td>pretreatment H &amp; H grade</td>
<td>0 (113)</td>
<td>4 (19)</td>
<td>4 (40)</td>
</tr>
<tr>
<td>I–II</td>
<td>8 (38)</td>
<td>4 (40)</td>
<td>1 (6)</td>
</tr>
<tr>
<td>III–IV</td>
<td>9 (43)</td>
<td>2 (20)</td>
<td>5 (28)</td>
</tr>
<tr>
<td>treatment modality</td>
<td>op</td>
<td>4 (19)</td>
<td>9 (90)</td>
</tr>
<tr>
<td>embol</td>
<td>16 (76)</td>
<td>1 (10)</td>
<td>10 (56)</td>
</tr>
<tr>
<td>embol &amp; op</td>
<td>1 (5)</td>
<td>0 (0)</td>
<td>2 (11)</td>
</tr>
<tr>
<td>GOS score</td>
<td>1</td>
<td>4 (24)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>2–3</td>
<td>4 (24)</td>
<td>1 (10)</td>
<td>3 (17)</td>
</tr>
<tr>
<td>4–5</td>
<td>13 (62)</td>
<td>9 (90)</td>
<td>7 (39)</td>
</tr>
</tbody>
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* Embol = embolization; H & H = Hunt & Hess.
† Unless otherwise specified.
months. Patients, referring physicians, and/or first-degree relatives were contacted by telephone to obtain follow-up data.

**Statistical Analysis**

Data were analyzed using version 9.1 SAS software (SAS, Inc.). Results were considered statistically significant for two-sided data if the probability value was less than or equal to 0.05 and somewhat significant if the probability value was less than 0.10. The chi-square test for independence was used to determine the association between outcome and categorical/ordinal clinical measures. If the null hypothesis of independence was rejected, partial chi-square statistics were evaluated to determine the cells that contributed most to the overall chi-square. The Cochran–Armitage test for trend was used to determine the linearity of the binomial proportions of the dichotomous factor across the ordinal levels of outcome. The nonparametric Kruskal–Wallis test was used to determine the association between continuous clinical measures and the outcome. Generalized multinomial logistic regression analyses were conducted to evaluate the joint effect of clinical factors on outcome. In the multivariable models, outcome was recoded into three groups and covariates included those factors significantly associated with outcome in the univariate analyses. For stratified analysis based on aneurysm location, outcome was grouped into four GOS categories: 0 (0, 1, 2, and 3), 1, 2 to 3, and 4 to 5.

**Results**

Twenty-nine patients (59%) presented with SAH. In the 20 patients (41%) presenting without SAH, neurological status in five patients (25%) was Hunt and Hess Grade 0 (independent and able to work), in 11 (55%) it was Grade 1 (independent but unable to work), and in four patients (20%) it was Grade 2 (dependent and unable to work) (Table 1). In 13 (45%) of the 29 patients who presented with SAH, neurological status was Hunt and Hess Grade I or II, and in 16 (55%) it was Grade III or IV.

After a mean follow-up duration of 33 months, outcome in 29 patients (59%) was reflected by a GOS score of 4 or 5, in eight (16%) by a score of 2 or 3, and in 12 patients (24%) by a score of 1 (death) (Fig. 2). Comparing outcome at 33 months with that documented during a mean follow-up period of 13 months, we noticed an increase in mortality rate (GOS Score 1) from 10 to 25%, whereas the number of patients in the group with severe disability (GOS Score 3) decreased from 37 to 17%. The number of patients in the GOS Score 5 group (good outcome) increased from 28 to 59%.

The overall mean GOS score was 3.5. The nonparametric Kruskal–Wallis test for continuous variables revealed a significantly different outcome between the two age groups (age ≤ 55 years compared with > 55 years; p < 0.05) (Fig. 3). The mean GOS score varied from 4.3 in patients less than 45 years of age to 2.0 in those greater than 70 years of age. Of the seven patients who were over age 70 years, five died (71%), and the outcome in two (29%) was reflected by a GOS score of 4 or 5. The median age in this series was 55 years. In patients less than age 55 years the mean GOS was 4.2, the mortality rate was 7% (two of 29), and a GOS score 4 or 5 was 90%.

**Fig. 2.** Pie charts demonstrating outcomes after an average follow-up period of 33 months in patients with PICA–VA (A), BA–VBJ (B), and PCA (C) aneurysms (GOS Score 1, dead; 2, vegetative state; 3, severely disabled; 4, moderately disabled; and 5, good outcome).
of 4 or 5 was achieved in 76% (22 of 29), whereas in patients greater than 55 years of age the mean GOS score was 2.6, the mortality rate was 50% (10 of 20), and a GOS score of 4 or 5 was achieved in 35% (seven of 25) (mean GOS scores $p < 0.05$; Fig. 3). Mean age did not differ between men and women.

Age at presentation was found to vary according to aneurysm locations. In the subgroups based on location, there was no relationship between age and outcome.

The overall chi-square test indicated an association between outcome and aneurysm location. The mean GOS scores varied from 4.8 in the PCA group to 3.7 in the VA–PICA and 2.7 in the BA–VBJ groups. We observed that PCA aneurysms were associated with significantly better outcome ($p < 0.05$). Favorable long-term outcomes (GOS Score 4–5) were obtained in 90% of patients with PCA aneurysms, 60% of those with VA–PICA aneurysms, and 39% of those with BA–VBJ aneurysms. The association in the partial chi-square test was mostly the result of differences in the number of patients with GOS Scores 1 and 5. The mean age of patients with PCA aneurysms was 42 years, significantly younger than that in patients with aneurysms in all other locations ($p < 0.05$). Patients with BA–VBJ aneurysms presented with SAH in only nine (50%) of 18 cases, compared to 17 (81%) of 21 cases in which VA aneurysms were present. In univariate analysis, patients with PCA aneurysms fared significantly better than those with BA–VBJ aneurysms ($p < 0.05$). None of the patients with PCA aneurysms died, whereas eight (44%) of 18 patients with BA–VBJ aneurysms died.

The mean aneurysm size was 19 mm (median 17 mm, range 6–42 mm). Only a minority (14%) of the aneurysms were smaller than 10 mm. Patients with giant ($\geq 2.5$-cm) aneurysms (23%) did not fare worse than those with smaller ($< 2.5$-cm) aneurysms ($p = 0.39$). Among the three groups with different aneurysm locations, the median size varied (Table 2) and the ranges differed widely. Analysis showed that aneurysm size was not significantly different among the three groups.

Fourteen (52%) of the 27 endovascularly treated patients presented with SAH as did 13 (68%) of the 19 surgically treated patients (Table 2 demonstrates the treatment modality stratified by aneurysm location). A comparison of the surgically and endovascularly treated groups showed that patients presenting with SAH did not have significantly different pretreatment Hunt and Hess scores. The chi-square test revealed that endovascular treatment was associated with worse outcome ($p = 0.05$, two-sided probability for trend). In the stratified analysis based on aneurysm location differences in treatment modality were noted ($p = 0.09$, Kruskal–Wallis test) between the three locations. Within the three location groups treatment modality was not associated with outcome ($p = 1.0$, Wilcoxon test).

The univariate analysis showed that, overall, patients with Hunt and Hess Grade I and II neurological status did better than those with Hunt and Hess Grade III and IV status ($p < 0.05$) (Fig. 4). Of the 16 patients with pretreatment Hunt and Hess Grade III to IV status, six (38%) had a good outcome (GOS Score 4–5), whereas of the 13 patients with Hunt and Hess I to II status, 11 (85%) had a good outcome (GOS Score 4–5). Of patients in whom a Hunt and Hess Grade 0 was present, outcome was not significantly different regardless of the following added functional subscale: Hunt and Hess Grade 0, (independent and able to work), Grade 0, (independent but unable to work), and Grade 0, (dependent and unable to work). The mean GOS scores at the long-term follow-up examination were 2.5, 3.5, and 4.0, for the PCA, VA–PICA, and BA–VBJ groups, respectively. Pretreatment clinical grades varied among the three aneurysm locations ($p = 0.04$, Kruskal–Wallis test). There was no association between pretreatment clinical grade and outcome within the location groups ($p = 0.59$, Wilcoxon test).

Comparison of our outcomes obtained at a mean follow-up duration of 13 months and the current follow-up data representing a 33-month period revealed that of the 16 patients with severe disability at 13 months, two (13%) had died during the longer-term period and seven (44%) had recovered to GOS score of 4 or 5. Four of the 23 patients (17%) with GOS Score 4 or 5 outcome at a mean follow up of 13 months had died during the longer-term period; death was attributed to rehemorrhage in three patients (75%) and unknown cause in one (25%).

**Posttreatment Angiography**

Posttreatment angiograms (see examples in Figs. 5–10) were available for review in 35 (71%) of 49 patients. Five patients died before a follow-up angiogram could be obtained. In two of these patients complete thrombosis was confirmed at autopsy. Complete or virtually complete thrombosis was confirmed on early posttreatment angiography in 23 (66%) of 35 patients. A slight reduction in the size of the lesion was noted in one patient and there was a significant residual lesion in 10 patients. Of this group with residual aneurysms documented on posttreatment imaging, five (45%) of 11 patients died of SAH (three patients) or mass effect/brainstem ischemia (two patients) after treatment. None of the patients who died of posttreatment SAH had presented with SAH originally.

**Summary of Deficits**

Neurological status worsened within 30 days of treatment in 14 (29%) of 49 cases, in seven of which (50%) it resulted in death. Neurological complications were more prevalent in the BA–VBJ group (44%) than either the VA–
patients who experienced a neurological decline after treatment fared significantly worse during the long-term follow-up period (p = 0.02). In five patients this manifested as new or worsening of unilateral hemiparesis, in six as worsening of dysarthria and/or dysphagia, and in two as mild tetraparesis, and in one patient as transient aphasia. Neurological deficits were attributed to ischemia in seven patients and progression of brainstem compression in four. Severe vasospasm required prolonged intensive care unit stays for five (17%) of the 29 patients presenting with SAH. Medical complications included aspiration pneumonia in two patients and myocardial infarction in one. In four cases hydrocephalus required placement of a ventriculoperitoneal shunt. Surgical mortality was 13% (four of 29 patients). A Summary of Deaths Recurrent SAH was confirmed to be the cause of death in three patients (occurring 1, 3, and 13 months after treatment), whereas increasing mass effect or brainstem ischemia was the cause of death in three patients (at 1, 2, and 8 months after treatment). In all of these patients there was residual aneurysm filling (partial thrombosis) after treatment. One patient died as a result of an unrelated cardiac event 7 months after treatment, and in four patients the exact cause of death at 2, 3, 4, and 9 months could not be determined. In eight patients the BA or VBJ was the location of the aneurysm, and in three patients the VA was involved. Most deaths (eight of 11) occurred early, within the first 6 months after treatment.

Discussion

Natural History

In the evaluation of the efficacy and safety of therapies, it is important to compare treatment outcome with the expected natural history without treatment. Data on the natural history of untreated posterior circulation fusiform aneurysms are limited. In general, the natural history is thought to be unfavorable, although more benign courses have been described. In the series described by Mizutani et al. early aneurysm rupture occurred before treatment in 30 (71%) of the 42 patients mostly with VA dissecting aneurysms and presenting with SAH. Eventually 29 (69%) of the 42 patients underwent treatment. Most of the remaining 13 patients (11 [85%] of 13), who received conservative treatment due to poor clinical condition or anatomical constraints, died.

Attempts to identify higher- and lower-risk groups have resulted in a number of classifications. A classification proposed by Mizutani et al. was based on correlating imaging findings, clinical features, and intraoperative appearance.
ance to pathological findings, although pathology reports were only available in a portion of the 85 patients. Four types were distinguished. Type I was the classic dissecting aneurysm that most frequently presented with an SAH, had a so-called pearl-and-string appearance on angiography, and exhibited a high rebleeding rate. In Type II, or segmental ectasia, the aneurysm was mostly asymptomatic and had smooth contours on angiography with no thrombus. None of the patients in this group exhibited signs of clinical deterioration. Type III was the dolichoectatic dissecting aneurysm, which presented with cranial nerve deficits, hydrocephalus, or brainstem dysfunction. Angiography generally revealed luminal thrombus and aneurysm growth. Hemorrhage was seen frequently during follow up, accounting for the observed 50% mortality rate. Finally, the Type IV, or saccular aneurysm arising from the arterial trunk, presented with SAH and had a high mortality rate due to rebleeding (three of four patients). Although no pathology data were available for most of our 49 patients, these were mostly Mizutani Types I and III lesions, which have high rehemorrhage rates with associated morbidity and death.

In the study published by Flemming et al., only five (3%) of 159 patients presented with SAH. Dissecting aneurysms were excluded from their study and 40% of patients had symptoms unrelated to the aneurysm. Differentiation between dissecting and nondissecting nonsaccular intracranial aneurysms is not always possible based on imaging. In ultrasonography studies specific abnormalities that are diagnostic for dissection aneurysms such as intramural hematomas or intimal flaps have been reported to present in less than one third of cases.

In a series of patients with unruptured fusiform aneurysm, aneurysm size (diameter ≥ 10 mm) was found to be a risk factor for future growth, as measured on computed tomography angiography. The authors of a study of patients with mostly unruptured nonsaccular VB aneurysms demonstrated that aneurysms of 10 mm in diameter or greater enlarged over time and that this feature was predictive of future rupture. In 86% of the patients in our study the diameter of the aneurysm was 10 mm or larger (mean 19 mm, median 17 mm), which suggests greater risk of future rupture.

**Morphology Features**

In a study on vertebrobasilar dissecting aneurysms published by Pozatti and colleagues, patients were included with angiographic evidence of the pearl-and-string sign in six (38%) of 16 cases, a double lumen in one (0.6%) of 16 cases, and fusiform dilation in four (25%) of 16 patients. Two (50%) of the four patients with fusiform dilations presented with SAH, and without treatment they all fared well. Data reported by other authors, however, especially on patients presenting with SAH, strongly contradict this benign
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Patients originally presented with SAH. Likewise, in Fleming and associates’ study none of the nine patients in whom rebleeding occurred during the follow-up period had originally presented with SAH.

The risk of hemorrhage has been related to aneurysm morphological features. Transitional and fusiform aneurysms have been found to be associated with increased hemorrhage rates. “Transitional” has been defined as a uniform aneurysmal dilatation of an entire arterial segment greater than 1.5-fold its normal size with superimposed dilatation of a portion of the involved arterial segment. The risk of (recurrent) posterior circulation ischemia was found to exceed the risk of rehemorrhage in this series of mostly asymptomatic unruptured aneurysms, and cerebral ischemia and BA thrombosis were found to be the most common causes of death. The different anatomical locations in the present study were associated with differences in presentation (hemorrhage compared with mass effect) and age at presentation. Two thirds of the patients with BA–VBJ aneurysms presented with symptoms of mass effect, whereas most patients with PCA and VA aneurysms presented with an SAH (Table 2).

The effects of local vessel curvature and aneurysm size on aneurysm hemodynamics was studied in a computational fluid dynamic analysis performed by Hoi et al. They found that a high degree of parent vessel curvature and wide-necked aneurysm were associated with increased pressure, wall shear stress, and aneurysm growth. Although the authors of in vitro studies have suggested that partial coil therapy and stent placement dramatically decreased the slipstream, reducing the risk of future rupture, partial thrombosis failed to protect against late-onset neurological complication in our present series and previous endovascular and surgical series.

Clinical Outcome After Treatment

Given the generally poor natural history of untreated symptomatic posterior circulation fusiform aneurysms larger than 10 mm, we consider our overall long-term good outcome (GOS Score 4 to 5) of 90% for PCA and 62% for VA to reflect favorable clinical results. As expected the results for BA and VBJ aneurysms were less favorable: good outcome (GOS 4–5) in 39% and death in 44%. Twenty-seven percent (three of 11) of deaths in our series at long-term follow up were caused by SAH and were confirmed on imaging and/or at autopsy. Of the 16 patients who underwent treatment in Flemming and colleagues’ series, three (19%) suffered rebleeding after treatment compared with six (4%) of 143 untreated patients. Data on the clinical outcome after SAH in these nine patients was not provided. In the study by Mizutani et al. of 42 patients with dissecting aneurysms presenting with SAH, 29 patients (69%) underwent treatment. Outcome was good in 14 patients (52%) and poor in 11 (38%); four died (14%). Leibowitz and colleagues divided a series of consecutive fusiform aneurysms in patients undergoing endovascular parent vessel occlusion into two groups based on clinical presentation, suspected neuropathological findings, and clinical course. One group was composed of patients with acutely dissecting aneurysms that typically presented with SAH; the other group contained patients with chronic fusiform aneurysms, which gradually enlarged and presented with mass effect or
Infarction. Parent vessel occlusion in the acutely dissecting aneurysm group resulted in angiographically confirmed complete thrombosis whereas in the second group complete thrombosis was neither attempted nor obtained. The outcomes were significantly worse in patients with gradually enlarging aneurysms presenting with mass effect and with incomplete thrombosis after treatment (p < 0.02), with four (57%) of seven patients dying compared with no deaths in the six patients in the acute dissecting aneurysm group with complete thrombosis after treatment. Death was attributed to continued mass effect on the brainstem in two patients and unrelated cardiac causes in the other two patients.

In the long-term outcome series of 201 vertebrobasilar aneurysms reported by Steinberg et al., patients were treated with Hunterian ligation, and outcome was good to excellent in 73%, poor in 3%, and 24% of patients died. A comparison of the present data and that of the aforementioned series published in 1993 reveals an important difference in aneurysm size. In the 1993 series the majority (174 [87%] of 201) of aneurysms were giant (> 2.5 cm) in size whereas in the present series a minority (11 [22%] of 49) were giant in size. In the Steinberg et al. population all arterial ligations were performed surgically using clips or tour-
basilar aneurysms, Sasaki et al. noted two groups distinct in age at presentation, clinical course, and aneurysm location. One group (mean age at presentation 38 years) had brainstem infarctions resulting from subintimal dissections at the VBJ. In the other group (mean age at presentation 50 years) SAH due to a subadventitial VA dissection was the cause of death.

Aneurysm Location

Patients with PCA aneurysms in the present study were younger, more often underwent surgery, and had better outcomes, whereas patients with BA–VBJ aneurysms were older and had poorer outcomes. Favorable long-term outcome was achieved in 90% of patients with PCA aneurysms, 60% of those with VA–PICA aneurysms, and in only 39% of those with BA–VBJ aneurysms. The BA location was also found to be predictive of a worse outcome in a study published by Seifert et al. In 24 BA and VBJ aneurysms, they found that patients with aneurysms smaller than 10 mm fared better. Brainstem perforating vessels incorporated into the aneurysm sac can complicate treatment of fusiform BA aneurysms. Perforating artery occlusion due to thrombus may already have occurred at the time of diagnosis with collateral supply to the perforating artery territory. Three cases of basilar trunk endovascular occlusion have been reported in cases of giant and fusiform aneurysms of the BA with good outcome. Good results were reported in 72% of the 46 BA cases managed surgically in Steinberg and associates’ study (24% mortality rate), whereas only 26% of the patients were reported to make a good recovery (mortality rate 53%) in a report by Amin-Hanjani and colleagues. Yoshimoto et al. reported favorable outcomes in four (40%) of 10 patients with BA dissection aneurysms, of whom four presented with SAH. Two of the four patients who presented with SAH underwent endovascular treatment. One of the two patients died and the other had a good recovery. In our present series 10 (56%) of the 18 patients with BA–VBJ aneurysms were treated endovascularly; seven (39%) fared well at long-term follow up, and eight died (44%). The complexity of treatment of this particular type of aneurysm has been illustrated by the report of a staged bilateral VA occlusion with extracranial–intracranial bypass for large fusiform proximal basilar trunk aneurysm. In this case treatment failed to prevent further expansion of the aneurysm, necessitating surgical decompression and a trapping procedure. The patient eventually died of BA thrombosis.

Andoh and coworkers’ reported on a series of 10 patients with fusiform VA aneurysms who presented with SAH;
outcome was graded as good in eight (80%) of 10 patients and two (20%) died. These rates compare with those in the present series of patients with VA aneurysm; there were nine (60%) of 15 patients with GOS scores of 4 to 5 and a 21% mortality rate (12 [80%] of 15 of whom presented with SAH).

In one patient (2%) in the present study the aneurysm involved the PICA. This patient presented with SAH, had a pretreatment Hunt and Hess Grade IV SAH because of a rehemorrhage, underwent aneurysm trapping, and recovered completely (GOS score of 5). Nussbaum et al. reported on seven surgically treated patients with fusiform PICA aneurysms who had all presented with SAH. Six aneurysms were trapped with distal revascularization of the occipital artery, and one patient underwent excision of the aneurysm and end-to-end anastomosis. Outcome was good in six (86%) of these patients and poor in one.

Hunterian proximal ligation or endovascular parent vessel occlusion of VBJ aneurysms has resulted in virtually complete thrombosis in 46 to 84% of patients in previous studies and 60% in the present series. Incomplete thrombosis was associated with a poor subsequent natural history due to rebleeding and increased mass effect or brainstem ischemia in our study and prior reports.

Conclusions

We present a series of patients treated for symptomatic posterior circulation fusiform aneurysms. Technical advancements and growing surgical experience with endovascular techniques have resulted in an increased percentage of patients undergoing endovascular therapies. Potentially important differences in inclusion criteria, patient and aneurysm characteristics, and treatment paradigms complicate direct comparisons among series. The low prevalence and variable clinical course of these aneurysms may explain contradictory observations of natural history and recommendations for therapy that appear in the literature. In our series of 49 patients, three different location groups (VA–PICA, PCA, and BA–VBJ) were distinguished. Age less than or equal to 55 years was strongly associated with more favorable outcome. Once the strong effect of age was taken into account in multinomial models, the effect of other factors such as pretreatment clinical grade, treatment modality, and residual aneurysm on outcome did not remain statistically significant. However, stratification by aneurysm location removed the effect of age on outcome.

Fig. 11. Bar graph demonstrating mean GOS scores (+ SEM) obtained in patients presenting with (+) and without (−) SAH.
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