Management-related morbidity in unselected aneurysms of the upper basilar artery

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A series of 49 consecutively treated patients with 52 aneurysms of the upper basilar artery (BA) is presented. Thirty-nine aneurysms arose at the BA bifurcation, 11 at the origin of the superior cerebellar artery (SCA), and two from the upper BA trunk just below the SCA. The patient population consisted of 36 women and 13 men, with a mean age of 50 years (range 23–74 years). Of the 35 patients presenting with subarachnoid hemorrhage, 10 were Grade I, 10 were Grade II, 11 were Grade III, and four were Grade IV according to the Hunt and Hess scale. Treatment consisted of aneurysm neck clipping in 28, proximal occlusion of the BA in three, and endovascular therapy with coils in four patients. The remaining 14 patients with unruptured aneurysms underwent direct neck clipping. Postoperatively, 38 patients developed diplopia in at least one direction of gaze but this had resolved in 31 of them at the last follow-up evaluation. There were four deaths (8.2%): two as a result of rebleeding following coil compaction at 8 days and 9 months posttreatment, respectively; one as a result of vasospasm; and one as a result of brainstem infarction after proximal occlusion of the BA in a giant bifurcation aneurysm. Of the surviving patients, 33 (67.3%) made an excellent recovery, seven (14.3%) made a good recovery, and five (10.2%) were in poor condition at the last follow-up review. Direct microsurgical clipping of most aneurysms of the BA apex region can be performed with acceptable rates of morbidity. These data from an unselected series of patients in a general hospital provide a basis for comparison with developing alternative techniques.

KEY WORDS • subarachnoid hemorrhage • basilar artery aneurysm • surgical morbidity • management-related mortality

ANEURYSMS of the basilar artery (BA) apex are among the most difficult to manage surgically. Regardless of the approach used, exposure of the interpeduncular fossa is typically deep and confined, and the vascular anatomy is complex and variable. The intimate relation of these aneurysms to cranial nerves and perforating vessels increases the potential for surgical complications. Despite refinements in cerebrovascular imaging, neuroanesthesia, and microsurgical instrumentation, these lesions continue to pose a significant technical challenge to neurosurgeons.

Several large series of surgically treated patients harboring aneurysms of the upper BA have been reported, and, in most instances, they represent selected cases referred to centers with relatively high volumes of these otherwise uncommon lesions. Little has been published about the overall morbidity and mortality rates resulting from management of aneurysms of the BA apex. Two reports of management-related outcome for all posterior circulation aneurysms have demonstrated that poor results are generally much higher in unselected, consecutively treated series of patients than in reported surgical series and that aneurysms of the BA apex region are associated with more complications than aneurysms in other locations.

Innovation in the management of BA apex aneurysms has not been confined to microsurgery. Recent advances in endovascular techniques, particularly the availability of electrolytically detachable coils, have made it possible to treat posterior circulation aneurysms deemed unsuitable for surgery or that carry unacceptable surgical risk. Combined use of endovascular coils and surgical clipping for aneurysms that are difficult to treat has also been reported. To provide a basis for comparison with developing alternative techniques, we report our experience with an unselected, consecutively treated series of patients with aneurysms of the BA apex region. Overall management-related morbidity and mortality data specific to aneurysms in this location are presented.

Clinical Material and Methods

Patient Population

Between July 1990 and June 1996, 50 patients with angiographically confirmed aneurysms of the upper BA were admitted to the neurosurgical service at the Vancouver Hospital and Health Sciences Centre. These cases represent 13.3% of 375 patients with aneurysmal subarachnoid hemorrhage (SAH) or unruptured intracranial
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aneurysms admitted during that time period. One patient underwent treatment at another institution and therefore was not included in this analysis. The remaining 49 patients harbored 52 aneurysms of the upper BA region and form the basis for this study. There were 36 women and 13 men, with a mean age of 50 years (range 23–74 years). Information on all patients was entered prospectively into a computer database, and hospital and office charts, surgical reports, and imaging studies were also reviewed.

Patients with SAH were classified by grade according to the Hunt and Hess scale. Unruptured aneurysms included symptomatic and asymptomatic lesions, as well as those found on angiography in cases of SAH with multiple aneurysms, in which another aneurysm proved to be the source of bleeding. We included all patients with aneurysms arising at the BA bifurcation, the origin of the superior cerebellar artery (SCA), and two aneurysms of the upper BA trunk just below the SCA. Aneurysms were classified as small (< 12 mm), large (12–25 mm), or giant (>25 mm). Outcome was classified as excellent if the patient had no neurological deficit other than cranial nerve palsy (that is, ptosis or diplopia) and was able to resume all previous activities, including full-time employment, without restriction. Patients classified as having a good outcome were fully independent in all respects but had minor neurological deficits. They generally returned to work and other previous activities, but with some limitations. Those who had moderate-to-severe deficits that made them dependent on others for self-care were designated as having a poor outcome.

Treatment Methods

Subarachnoid hemorrhage was confirmed in all cases by means of computerized tomography (CT) scanning or lumbar puncture. Patients were managed in a neurosurgical intensive care unit with arterial and central venous pressure monitoring. Acute hydrocephalus was treated with external ventricular drainage as necessary. Cerebral angiograms were obtained within 24 hours of admission and surgery was performed within 72 hours of the hemorrhage except in two patients with Grade IV SAH initially who were treated 10 days and 3 weeks, respectively, posthemorrhage. All patients with SAH received nimodipine and were treated postoperatively with prophylactic volume expansion. Symptomatic vasospasm was managed aggressively with induced hypertension, hypervolemia, and balloon angioplasty as clinically indicated.

We used several surgical approaches. We chose the subtemporal approach most often, but transsylvian and transpetrosal routes were used in patients with unusually high or low bifurcations, respectively. Lumbar or ventricular drainage of cerebrospinal fluid was used in all cases. Temporary vessel occlusion and intraoperative hypotension were used to facilitate dissection according to the preference of the operating surgeon. We have generally limited temporary vessel occlusion to short periods, 3 to 5 minutes, separated by at least 5 minutes of reperfusion. We rarely induced hypotension below a mean arterial pressure of 60 mm Hg. After clipping, the aneurysms were punctured, aspirated, and collapsed.

Patients in poor medical condition or with aneurysms believed to carry unacceptably high surgical risk were treated with endovascular occlusion using pushable coils, or, more recently, electrolytically detachable coils (Guglielmi Detachable Coils [GDCs]; Target Therapeutics, Fremont, CA). Follow-up angiography was performed at 6-month intervals posttreatment, and repacking of the aneurysm sac was recommended in cases of demonstrated coil compaction.

Results

Clinical Presentation

Fourteen of 49 patients underwent surgery for unruptured aneurysms. Of the remaining 35 patients presenting with SAH, 10 were Grade I, 10 were Grade II, 11 were Grade III, and four were Grade IV. No patients with Grade V SAH underwent angiography unless their poor condition was believed to have a remediable cause such as acute hydrocephalus or temporal lobe clot. In the entire population of 375 patients with SAH or an unruptured aneurysm, 25 (6.7%) presented with Grade V SAH and died without undergoing angiography. Many of these patients exhibited a pattern of subarachnoid blood or intracerebral hematoma on CT scanning that was consistent with an anterior circulation lesion, and autopsy confirmation of the ruptured aneurysm was obtained in several of them. Extensive, diffuse subarachnoid blood was demonstrated on CT scanning in six patients. In this subgroup of 25 patients, there were none in whom an aneurysm of the posterior circulation was suspected either clinically, on the basis of CT findings, or found at autopsy. However, it is possible that the demonstrated upper BA aneurysms in 35 patients with SAH underrepresent their true incidence.

Unruptured Aneurysms

Fifteen unruptured aneurysms were treated in 14 patients. There were nine aneurysms of the BA bifurcation and six arising at the origin of the SCA. All were small, with the exception of one large bifurcation lesion. One patient had a 5-mm SCA lesion and an 18-mm BA bifurcation aneurysm. Five patients presented with SAH caused by another lesion, four with a seizure, and four had minor neurological complaints such as headache or tinnitus. One patient presented with hemorrhage from a ruptured arteriovenous malformation (AVM). Associated developmental or acquired vascular abnormalities were common, including at least one other aneurysm in seven cases, an AVM in three cases, and moyamoya disease in one.

The subtemporal approach was used in 13 cases and the pterional/transsylvian route was used once. Direct clip obliteration of the aneurysm neck was achieved in all but one instance. A small, low-lying BA bifurcation aneurysm in a patient with SAH caused by another lesion was encaised in thick arachnoid scar tissue from the original bleed, making dissection of the perforating vessels hazardous. This aneurysm was reinforced with chopped cotton gauze to incite an inflammatory reaction. Attempted endovascular occlusion with GDCs failed because of the relatively wide neck compared with the diameter of the sac, resulting in a tendency for the coils to protrude into the BA bifurcation. Follow-up angiography 3 years later demonstrated no change in angiographic appearance.
Apart from two cases of SAH with both SCA and BA bifurcation aneurysms (see Ruptured Aneurysms), there were no instances in which an unruptured BA aneurysm was clipped at the time of initial surgery for another ruptured aneurysm. In some cases this was because the surgical exposure of the ruptured aneurysm was not compatible with exposure of the interpeduncular fossa, as with aneurysms of the posterior inferior cerebellar artery (PICA) and distal anterior cerebral artery. In two cases of ruptured aneurysms of the supracallosal carotid artery (one in the posterior communicating and one in the anterior choroidal segment), access to the interpeduncular fossa via either the opticocarotid or retrocarotid routes was prevented initially by the aneurysm sac and after clipping by the blade and/or handle of the clip itself. To avoid undue temporal lobe retraction in the swollen brain after SAH, these patients underwent clipping of their BA aneurysm via a subtemporal approach after allowing 2 to 3 months to recover from the initial hemorrhage.

Postoperatively, 12 (86%) of the 14 patients experienced diplopia in at least one direction of gaze. Complete third cranial nerve paralysis was present in seven patients and partial third nerve dysfunction in five. Two of these patients also showed evidence of fourth cranial nerve impairment. There were no instances of cerebral infarction, perforating vessel injury, or symptomatic temporal lobe swelling. All 14 patients were in excellent condition at the time of hospital discharge and remained so until the time of their last follow-up examination at a mean of 10.9 months (range 2–48 months). Resolution of diplopia with full recovery of extraocular movement was seen in 11 (91.6%) of the 12 who suffered dysconjugate gaze postoperatively. Recovery was complete at a mean of 4.1 months postsurgery (range 2–6 months). One patient who suffered an initially complete third cranial nerve paralysis improved substantially, but continues to experience an impaired upward gaze and a persistent mild ptosis that is not disabling.

### Ruptured Aneurysms

Thirty-five patients harbored 37 aneurysms of the upper BA. The distribution of these aneurysms according to location, size, and grade is presented in Table 1. One patient had ruptured BA bifurcation and incidental SCA aneurysms, and one had ruptured SCA and incidental BA bifurcation aneurysms. There were two patients with other incidental posterior circulation aneurysms (one in the PICA and one in the anterior inferior cerebellar artery) and 10 with incidental anterior circulation aneurysms. One patient had an incidental AVM.

A total of 31 patients underwent surgical treatment via a number of approaches; four underwent endovascular occlusion of their aneurysm, three with GDCs and one with pushable coils. The subtemporal approach was used preferentially, but transsylvian and transpetrosal routes were used in one patient each. Thirty aneurysms in 28 patients were treated with neck clipping. All three surgically treated patients with giant BA bifurcation aneurysms underwent proximal occlusion because direct clip ligation of the aneurysm neck was not possible.

Third cranial nerve dysfunction was present in four patients prior to surgical treatment. Two of these patients also had sixth nerve paralysis, bilateral in one case. As in the ruptured aneurysm group, postoperative diplopia was common, with new cranial nerve abnormalities noted in 25 (80.6%) of the 31 surgically treated patients. All but one of these had third cranial nerve paralysis. Three of the four patients with third nerve dysfunction at the time

### TABLE 1
Ruptured upper BA aneurysms in 35 patients: location, size, and clinical grade

<table>
<thead>
<tr>
<th>Feature</th>
<th>BA Bifurcation</th>
<th>SCA</th>
<th>Upper BA Trunk</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>aneurysm size</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>small</td>
<td>16</td>
<td>4</td>
<td>2</td>
<td>22</td>
</tr>
<tr>
<td>large</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>giant</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>totals</td>
<td>30*</td>
<td>5*</td>
<td>2</td>
<td>37</td>
</tr>
<tr>
<td>grade at presentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>9</td>
<td>1</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>II</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>III</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>IV</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>totals</td>
<td>29</td>
<td>4</td>
<td>2</td>
<td>35</td>
</tr>
</tbody>
</table>

* One small BA bifurcation and one small SCA aneurysm were clipped at the time of surgery for other ruptured upper BA aneurysms.

### TABLE 2
Complications in 31 patients undergoing craniotomy for a ruptured aneurysm

<table>
<thead>
<tr>
<th>Complication</th>
<th>No. of Patients</th>
</tr>
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<tbody>
<tr>
<td>new cranial nerve palsy</td>
<td>25</td>
</tr>
<tr>
<td>III unilt</td>
<td>16</td>
</tr>
<tr>
<td>III bilat</td>
<td>2</td>
</tr>
<tr>
<td>III &amp; IV</td>
<td>5</td>
</tr>
<tr>
<td>VI</td>
<td>1</td>
</tr>
<tr>
<td>multiple (III, IV, VI, VII)</td>
<td>1</td>
</tr>
<tr>
<td>hydrocephalus requiring shunt</td>
<td>7</td>
</tr>
<tr>
<td>symptomatic vasospasm</td>
<td>5</td>
</tr>
<tr>
<td>cerebellar hematoma/brainstem infarction</td>
<td>1</td>
</tr>
<tr>
<td>temporal contusion</td>
<td>1</td>
</tr>
<tr>
<td>perforating vessel infarction</td>
<td>6</td>
</tr>
<tr>
<td>postop seizure</td>
<td>1</td>
</tr>
</tbody>
</table>

### TABLE 3
Clinical outcome in 31 patients with ruptured aneurysms undergoing craniotomy*

<table>
<thead>
<tr>
<th>Grade at Presentation</th>
<th>Excellent</th>
<th>Good</th>
<th>Poor</th>
<th>Death</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>II</td>
<td>9</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>III</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>IV</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>total (%)</td>
<td>17 (54.8%)</td>
<td>7 (22.6)</td>
<td>5 (16.1)</td>
<td>2 (6.5)</td>
<td>31 (100)</td>
</tr>
</tbody>
</table>

* Outcome at last follow-up review (mean 10.5 months, range 1–50 months).
Twenty (80%) of the 25 patients with new diplopia postoperatively recovered fully after a mean of 6 months (range 1–10 months). Three of the five patients with residual diplopia underwent corrective extraocular muscle surgery and two died. The complications related to surgical intervention are listed in Table 2. When the SCA and BA bifurcation aneurysm groups were analyzed separately, there were no differences in the complication rates, except that all perforating vessel injuries occurred in BA bifurcation aneurysms.

Six (19.4%) of the 31 surgically treated patients suffered perforating vessel infarctions after aneurysm clipping. Infarctions were identified on postoperative CT scans as small low-density areas within the upper brainstem or thalamus, and all were associated with neurological symptoms such as hemiparesis or third cranial nerve palsy. These deficits generally improved over the course of several months and did not preclude good or excellent recovery. Four patients had diplopia in at least one direction of gaze as their only permanent deficit as a result of damage to the oculomotor nucleus, whereas two had residual hemiparesis.

Nineteen (61.3%) of the 31 surgically treated patients were in good or excellent condition at the time of discharge; there were two deaths (6.5%), one as a result of severe vasospasm and one caused by brainstem infarction after proximal occlusion of the BA for treatment of a giant bifurcation aneurysm. Several patients improved after discharge, so that by the time of the last follow-up review, at a mean of 10.5 months posttreatment (range 1–50 months), there were 24 patients (77.4%) in good or excellent condition. The outcomes of patients who underwent surgical treatment are summarized in Table 3.

The four patients who were treated with endovascular occlusion were selected on the basis of anatomical or general medical factors that were believed to result in an unacceptably high risk with direct surgery. All of these aneurysms had ruptured and all were located at the BA bifurcation. A 38-year-old woman with a Grade I SAH had undergone unsuccessful surgical exploration at another institution and had sustained multiple cranial nerve palsies; she was unwilling to undergo repeated surgery. A 71-year-old woman with a Grade I SAH, who was harboring a giant posteriorly directed BA bifurcation aneurysm, and a 23-year-old woman with a Grade III SAH, who was harboring an associated complex AVM, were excluded from surgical treatment on the basis of anatomical factors alone. The fourth patient was a 64-year-old man with advanced cardiac and pulmonary disease and a large aneurysm. Pushable coils were used in one case early in the series, whereas the last three were treated with GDCs. One patient had transient diplopia after treatment and one had permanent partial third cranial nerve paralysis. Two made excellent recoveries from their SAH, whereas two had fatal recurrent hemorrhage. One patient, whose aneurysm was only partially obliterated with pushable coils, rebled 8 days posttreatment. The other fatal rebleed occurred 9 months after treatment with GDCs. Six-month follow-up angiography revealed coil compaction and migration, with partial recanalization of the aneurysm fundus. Repeated coil placement was recommended but declined.

Considering the group of 35 patients with ruptured aneurysms as a whole, regardless of treatment modality, 19 (54.3%) were in excellent and seven (20%) in good condition at the last follow-up evaluation, whereas five (14.3%) were in poor condition and four (11.4%) were dead. Outcome as a function of clinical grade at presentation for all patients is summarized in Fig. 1.

**Postoperative Angiography**

Postoperative angiography was performed routinely in cases of large or giant aneurysms and selectively in patients with small aneurysms in which the clip or anatomical structures interfered with visualization after clipping.

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**Fig. 1.** Bar graph showing summary of outcome for all patients with upper BA aneurysms.
All patients with associated AVMs underwent postoperative angiography, as did those with clinical vasospasm. Six (42.9%) of 14 patients with unruptured aneurysms and 19 (61.3%) of 31 surgically treated patients with SAH underwent postoperative angiography. Complete obliteration of the aneurysm was demonstrated on all angiograms except in the case of one aneurysm that was not clipped and in two large aneurysms with small residual neck remnants: one was left intentionally to spare a perforating vessel arising from a bulbous bifurcation and one was unexpected. Follow-up angiography was performed at intervals from 2 to 3 years postoperatively in each of these three cases, with no change in angiographic appearance.

Three (75%) of the four patients treated with endovascular occlusion of their aneurysm underwent follow-up angiography. The first patient, who was treated with partial aneurysm packing using pushable coils, suffered a fatal recurrent hemorrhage 8 days later. At least one 6-month follow-up angiogram was obtained in the three patients treated with GDCs. One angiogram showed no change, whereas two displayed some coil compaction and aneurysm refilling. In both cases repacking of the aneurysm was recommended. One patient underwent successful repacking and remains clinically well with no change seen on subsequent angiography, and one patient declined further treatment and suffered a fatal recurrent hemorrhage.

**Discussion**

Considerable improvement in the outcome for surgical treatment of posterior circulation aneurysms has been achieved in the past two decades. Recognition of the vital importance of brainstem perforating vessels, which must be preserved at all costs, enhanced diagnostic imaging techniques, and better anesthetic management, together with accumulated surgical experience, have all contributed to this progress. Several large series of surgically treated patients have been published, but these studies have dealt primarily with selected patients referred to centers with particular expertise and do not represent comprehensive management results.

Overall morbidity and mortality rates from posterior fossa SAH were investigated by Hermesniemi, et al., who reported the outcome in 93 patients with vertebrobasilar (VB) aneurysms treated over a 14-year period at one institution, a period during which surgical practice evolved substantially. Many patients underwent delayed surgery, and eight experienced fatal rebleeding. The overall mortality rate was 37%, with 86% of Grade IV patients severely disabled at follow-up review and 100% mortality in patients with Grade V. A more recent study of management results for posterior circulation aneurysms was reported by Hillman, et al. During a 1-year period, 49 cases of SAH due to ruptured VB aneurysms were treated, with a mortality rate of 27%. Poor initial grade, rebleeding, and surgical complications were the main causes of morbidity and mortality. The BA tip aneurysms were associated with higher complication rates than PICA aneurysms.

The patients in our series were consecutively treated with modern techniques at a large North American hospital. In the group with unruptured aneurysms there was no morbidity or mortality apart from postoperative diplopia, which was temporary in all but one case. Of 35 patients presenting with SAH, 20 (57%) were Grade I or II and 15 (43%) were Grade III or IV. A policy of early surgery was generally followed, with aggressive management of delayed ischemia caused by vasospasm. There were no episodes of recurrent hemorrhage prior to treatment. Four patients died (11.4%), whereas 26 (74.3%) were in good or excellent condition at last follow-up review.

In this series the majority of aneurysms were approached via the subtemporal route as described initially by Drake, et al. We prefer this route because of its simplicity and the superior view of perforating vessels obtained from the lateral aspect of the BA. With vigorous osmotic diuresis and drainage of cerebrospinal fluid, only moderate temporal lobe retraction is necessary, and this has been well tolerated, even with early surgery. Alternative approaches to the BA apex include the transylvanian, extradural temporopolar, transcavonymous, combined pterional/anterior temporal (“half and half approach”), transthiradial ventricular, and a variety of skull base techniques that require extensive bone removal to enhance exposure.

Postoperative third cranial nerve dysfunction is frequently mentioned as a complication after surgery for upper BA aneurysms, but few publications have documented the specific incidence or time to full recovery. Cruciger, et al., reported on a series of 31 patients with BA bifurcation aneurysms clipped via a standard subtemporal approach, 21 (67.7%) of whom developed an oculomotor palsy. In nine patients unilateral oculomotor dysfunction was the only complication and eight of these recovered fully. Three patients had bilateral third cranial nerve paralysis and in nine others it was associated with contralateral hemiplegia, indicating vascular injury to the midbrain. Only six of these 12 patients made a full recovery from their deficits. These authors concluded that oculomotor palsy resulting from third nerve manipulation usually resolves within 2 to 3 months, whereas recovery from paralysis caused by brainstem ischemia is often incomplete, presumably because of injury to the nucleus of the third cranial nerve or nerve fascicles within the midbrain. Solomon and Stein reported 21 postoperative third nerve palsies among 26 cranial nerve deficits in a group of 44 patients with VB aneurysms. Twenty (95%) of the patients with third nerve palsies recovered fully within 6 months.

In the early experience of Drake, et al., the third cranial nerve was usually dissected circumferentially from its surrounding arachnoid sheath, but later it was realized that the nerve could be elevated out of the field as the aneurysm was raised with the tip of a retractor, minimizing trauma and resulting in fewer (67%) third nerve palsies with a better tendency for recovery (92%). We did not observe any difference in the rate of third nerve dysfunction between SCA and BA bifurcation aneurysms. In our entire population of 49 patients there were 37 (75.5%) cases of postoperative third nerve palsy, with full recovery seen in 31 (83.8%). None of the third cranial nerve palsies in the 12 patients with unruptured aneurysms was associated with brainstem injury, and these palsies were assumed to be caused by manipulation alone. Eleven (91.7%) of these patients recovered fully and one partially. In the surgical-
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ly treated patients with ruptured aneurysms, 20 (83.3%) of 24 with postoperative third nerve paralysis recovered fully. The four who did not recover fully had evidence of associated brainstem injury caused by perforating vessel occlusion, indicating ischemic damage to the oculomotor nucleus or nerve fascicles. In one patient an isolated sixth cranial nerve injury occurred at the time of surgery, and the nerve did not recover. After endovascular therapy with GDCs, one patient with a large BA bifurcation aneurysm developed bilateral third nerve paresis caused by a dorsal midbrain infarction. Recovery was incomplete, and death due to recurrent hemorrhage occurred 9 months later.

None of the four giant aneurysms in our series could be treated with direct neck clipping. Three patients underwent proximal occlusion of the BA,3,19 and one was treated with GDCs. Intraoperative temporary balloon occlusion of the BA2,22 and deep hypothermia with circulatory arrest27 have been described as methods to facilitate clipping of giant aneurysms, but these techniques are also associated with considerable potential for morbidity and were not used during our study.

Endovascular therapy for posterior circulation aneurysms has become a valuable alternative to surgical clipping in cases in which anatomical factors or the medical condition of the patient significantly increase the operative risks and has also been used in combination with surgery for complex or incompletely clipped aneurysms.5,20 Treatment with electrolytically detachable coils to occlude the aneurysm and preserve the parent artery has been reported, with promising early results,9,13,21 but additional angiographic and clinical follow up are required to validate the long-term efficacy of this technique. Analysis of the completeness of occlusion in aneurysms treated with coils has shown that the degree of occlusion is highly dependent on the width of the aneurysm neck. Zubillaga, et al.,31 were able to achieve complete aneurysm thrombosis in 85% of aneurysms with necks measuring 4 mm or less but in only 15% of aneurysms with necks larger than 4 mm. The value of “clinical cure” (subtotal aneurysm thrombosis, prevention of early rebleeding) as opposed to anatomical cure (complete aneurysm obliteration) with respect to long-term prevention of recurrent hemorrhage has yet to be conclusively demonstrated. For incompletely treated BA bifurcation aneurysms, the “water-hammer effect”18 of pulsatile blood flow within the BA with pulsation transmitted into the coil–thrombus complex may result in eventual coil compaction or aneurysm regrowth with potential for late rebleeding.

In our series of 49 patients, 41 (83.6%) underwent surgical clipping of the aneurysm neck. One aneurysm was explored but could not be clipped. Unfortunately, the neck was relatively wide compared with the aneurysm dome and treatment with GDCs was unsuccessful. There were four giant aneurysms, none of which was amenable to neck clipping. Three were treated with proximal occlusion of the BA, with one death resulting from brainstem infarction. The other was treated with GDCs with a good result. Overall, 45 (91.8%) of the patients in this series were treated surgically whereas four (8.2%) were deemed unsuitable for operation because of the aneurysm configuration or complicating medical factors. In the entire patient population, 33 (67.3%) made an excellent recovery, seven (14.3%) were in good and five (10.2%) in poor condition at the last follow-up evaluation. Outcome was highly dependent on clinical grade at the time of admission.

Conclusions

Because the patients treated with endovascular therapy in this series were a small group selected on the basis of complex aneurysm anatomy or serious complicating medical factors, a comparison of the surgical and endovascular results significantly underestimates the potential value of endovascular treatment if more generally used. However, direct microsurgical clipping of most nongiant aneurysms of the BA apex region can be performed with low procedure-related morbidity and mortality rates, and the giant sacs that are most difficult to manage surgically are generally those least suitable for endovascular coil obliteration. A shift in management strategy away from surgical clipping as the primary method of aneurysm obliteration should be considered only if early and late overall management results are shown to be superior with alternative techniques.

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