Microneurosurgery for aneurysms of the basilar artery

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The authors report microsurgical treatment in 32 cases of basilar artery aneurysms, operated on with good results in 28 cases, fair results in one, and poor results in one; there were two deaths. Twenty-nine patients (91%) were able to return to social activities. Characteristics of the surgical techniques include 1) taking a transsylvian route; 2) retracting the M1 portion of the middle cerebral artery (occasionally the C1 portion of the internal carotid) medially with tapered brain retractors; and 3) approaching the aneurysm through and between perforators arising from the posterior cerebral artery in cases of high-placed basilar bifurcation. With regard to instrument improvements, tapered brain retractors, a multipurpose head frame, and bayonet clips (Sugita design) proved very helpful.

KEY WORDS • cerebral aneurysm • basilar artery • posterior communicating artery • aneurysm clip • microneurosurgery

Surgical treatment of aneurysms of the basilar artery has been one of the most difficult procedures, even in the era of the operating microscope. While many papers have reported on operative techniques and their results on aneurysms of the anterior portion of the circle of Willis, only a small number of papers have been published on aneurysms of the basilar artery. We are reporting on our surgical technique and operative results in 32 cases of basilar artery aneurysms performed under an operating microscope.

Summary of Cases

Clinical Material

From 1972 to 1978, 32 cases of basilar artery aneurysms were operated on by one of us (K.S.) at the University Hospitals of Shinshu and Nagoya and their nine affiliated hospitals. The locations of the 32 aneurysms were as follows: one at the trunk of the basilar artery, seven at the junction of the superior cerebellar artery, one in the distal superior cerebellar artery, 21 at the bifurcation of the basilar artery, and two in the P1 segment of the posterior cerebral artery (Fig. 1). The preoperative clinical state of 17 patients was classified in Botterell Grade I, that of nine in Grade II, and that of six in Grade III. Two cases were symptomatic aneurysms without history of subarachnoid hemorrhage (SAH).

FIG. 1. Schematic locations of the aneurysms of 32 basilar and 13 vertebral arteries in the present series.
Operative Procedures

All except two cases were operated on with the aid of an operating microscope under general anesthesia with normotension; in the remaining two cases hypothermia was used. Mannitol, 60 gm, was routinely used intravenously and ventricular drainage during surgery was performed in six cases. Transient hypotension as low as 65% of the preoperative systolic blood pressure was induced by trimethaphan (Arfonad) drip at the time of clipping in 22 cases. We restricted the duration of hypotension to less than 10 minutes, and if a longer period of hypotension were needed, blood pressure was elevated back to normal once and hypotension was induced again. The average time of hypotension was 6 minutes in the present series.

The head is rotated 45° to the side opposite to the approach and fixed in the Sugita skull fixation device on which a Sugita multipurpose frame is set. The side of approach to an aneurysm is determined by the position of its neck and dome in relation to the parent arteries. In the present series, 23 cases were approached from the right side and nine from the left. The skin incision is no different from our usual incision for aneurysms of the anterior circle of Willis, namely, a semi-coronal incision extending from 15 mm in front of the external ear canal and 10 mm above the upper margin of the zygomatic arch to the midline along and just behind the hairline. The bone flap is also formed in the same way as that for aneurysms of the anterior circle of Willis, that is, anteriorly along the upper margin of the orbital rim and laterally, removing a substantial portion of the sphenoidal bone.

After the dura is opened, the arachnoid over the Sylvian fissure is dissected widely enough so that the trifurcation of the middle cerebral artery can be easily exposed. The arachnoid around the optic nerve and carotid artery is removed and the oculomotor nerve is carefully dissected free from the temporal lobe. The bridging veins of the temporal lobe rarely need to be sacrificed. The temporal lobe is retracted laterally and the oculomotor nerve is followed proximally. The tapered brain retractor over the frontal lobe is then shifted down to include the M1 portion of the middle cerebral artery or occasionally the C1 portion of the carotid artery (Fig. 2 left). The M1 or C1 portion is retracted gently medially until the surgeon is able to visualize the optic tract under the M1 segment (see the left side in Fig. 2 right). The Liliequist membrane here
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Figure 3. Schematic exposition of aneurysm, arteries, and approaching routes with respect to positions of the bifurcation. Left: Aneurysm of a low-placed bifurcation. Right: Aneurysm of a high-placed bifurcation. The dotted arrow shows our routine approach. The solid arrow indicates a special route between the perforators for aneurysms of the high-placed bifurcation.

varies in thickness with different patients and, especially after massive hemorrhage, it is frequently difficult to dissect with scissors because of thickening and clots.

Aneurysms located at the basilar artery trunk, the junction of the superior cerebellar artery, and some at the basilar bifurcation can be approached from the lateral route to the posterior communicating artery, as indicated by the dotted arrows in Fig. 2 right and Fig. 3. This route was taken in nine cases in this series. However, most of the aneurysms at the bifurcation of the basilar artery were difficult to approach this way, and in those cases (13 of 23 cases in this series) an easier approach was through the space between the perforating arteries of the posterior communicating artery (the solid arrows in Figs. 2 right and 3). Although in the beginning of a dissection these perforators run in complex fashion and apparently prevent access to the aneurysm, careful and meticulous dissection along the perforators gives enough space to approach the aneurysm without causing any damage to the perforators. At times, it becomes necessary to advance the tip of the tapered brain retractor further through the dissected perforators to retract some of them medially together with the M1 segment. In the case of a very high positioned bifurcation of the basilar artery, the tip of the tapered brain retractor is advanced further into the region of the mammillary bodies without difficulty, and the optic tract is also retracted dorsomedially. In approximately half of the cases, direct retraction of the aneurysmal dome and/or the parent arteries with the tip of the narrowest tapered retractor facilitated visualization of the neck of the aneurysm.

In the case of large aneurysms, transient hypotension is induced for less than 10 minutes at the time of clipping. Sugita clips are routinely applied, although Heifetz or Scoville clips were used for the initial five cases. The clip should exert strong pressure and have narrow blades. As the operating field is deep and narrow, bayonet-shaped clips or those with longer blades are preferred for clipping aneurysms in this location.

Surgical Results

All 32 patients underwent craniotomy. Clipping was performed in 30 cases, of which 28 aneurysms were completely and two were partially obliterated. The remaining two cases were treated with bipolar coagulation with Biobond coating. Twenty-eight patients (88%) returned to their preoperative occupations, one (3%) returned to society with mild
neurological deficits, most of which had existed preoperatively, one (3%) was worse than before surgery, and two (6%) died (Table 1).

The first of the three patients with unsatisfactory results sustained clouding of consciousness and hemiparesis postoperatively. In this case, clipping was difficult because the aneurysm expanded in the dorsal aspect of the distal basilar artery. First, the posterior communicating artery was sacrificed because it was so fine that we judged that this would cause no hemodynamic problems. Then the aneurysmal neck was clipped using a Sugita clip of Drake type which encircled the P1 segment with its circular portions near the fulcrum. A postoperative angiogram revealed severe vasospasm of the basilar bifurcation and the bilateral posterior cerebral arteries.

The second patient was in Botterell Grade III preoperatively, and at the time of surgery a massive clot was found in the basal cisterns. He remained in his preoperative neurological state until 3 days after operation, when he developed left hemiparesis and his level of consciousness started to deteriorate. He died on the seventh postoperative day. The cause of death was presumed to be vasospasm.

The last patient suffered from two previous attacks of SAH, and the operation was performed 4 days after the second attack. The postoperative course had been uneventful, despite the vasospasm noted on the angiogram and oculomotor paresis of the operated side, until 2 weeks after surgery, when the patient developed signs of severe intracranial infection, and died.

**TABLE 1**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Bifurcation of BA (+P1)</th>
<th>Junction of SCA</th>
<th>Trunk of BA</th>
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<tr>
<td>approach</td>
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<td></td>
<td></td>
<td></td>
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<td>1</td>
<td>19</td>
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<td>0</td>
<td>13</td>
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<td>postop complications</td>
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<td></td>
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<tr>
<td>oculomotor nerve palsy</td>
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<td>2</td>
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<td>10</td>
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<td>1</td>
</tr>
<tr>
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<td>1†</td>
<td>0</td>
<td>0</td>
<td>1†</td>
</tr>
<tr>
<td>disturbance of consciousness</td>
<td>1†</td>
<td>0</td>
<td>0</td>
<td>1†</td>
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<td>1 (3%)</td>
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<td>1</td>
<td>2 (6%)</td>
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<tr>
<td>total</td>
<td>23</td>
<td>8</td>
<td>1</td>
<td>32</td>
</tr>
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</table>

*BA = basilar artery; SCA = superior cerebellar artery, including distal area; PCoA = posterior communicating artery.
†Two patients had deficits preoperatively.
‡One patient had deficits preoperatively.

Discussion

More than 200 cases of basilar artery aneurysms reported by Drake were all approached through a subtemporal route. We employed this subtemporal approach for the initial five cases and then switched to a transsylvian route. The former approach does not allow a sufficiently large operating field, and necessitates excessive retraction of the temporal lobe, which in turn may cause transient postoperative temporal lobe edema or oculomotor paresis. Yasargil, et al., advocated a pterional approach similar to that utilized for more common aneurysms in the anterior circle of Willis. The initial part of our approach is the same as that of Yasargil, that is, to open the Sylvian fissure to a sufficient width. After that, we differ from Yasargil because we directly retract the M1 or C1 portion of the arteries with tapered retractors. Although we have performed direct retraction of parent arteries in more than 100 cases of aneurysms in the anterior circle of Willis or brain tumors, we have not experienced any postoperative complications due to direct retraction. In order to retract arteries with adequate force, it is most important to use a lightweight self-retaining retractor, because the surgeon must perceive the resistance of the vessel through the fingers holding the brain retractor while he fixes it with a self-retaining retractor on the multipurpose frame. In the same way, direct retraction of the aneurysms with or without their parent arteries was carried out in about half of the cases. The advantages of direct retraction are that the surgeon can use both hands freely and that an ample space around the aneurysm can be obtained. The multipurpose head frame has proved very useful for this purpose.

Another characteristic of our approach to the bifurcation aneurysm is that neck clipping is performed through and between the perforating arteries of the posterior communicating artery in cases where the bifurcation is located high in the interpeduncular fossa, the P1 segment is very short, or the posterior communicating artery is rigid and runs markedly concave to lateral. These perforating arteries first appear course from the junction of the posterior communicating artery to the brain surface, and therefore the space between the perforators can be opened sufficiently wide to permit operative approach. It is quite different from the short length of the perforators of the anterior circle of Willis. Although as a rule any perforators should not be sacrificed, two or three perforators had to be sacrificed in our entire series. We make it a rule to avoid using bipolar coagulation after opening the Sylvian fissure to prevent heat from spreading to the adjacent crucial tissues. In fact, coagulation was not necessary at this stage in 80% of the present series.
According to Drake\textsuperscript{2} and Yaşargil, \textit{et al.},\textsuperscript{17} the \(P_1\) segment or the posterior communicating artery can be either cut or obliterated provided that there is enough collateral circulation. We think, however, that an attempt to disturb collateral circulation should always be avoided. We experienced one case where we had to cut a posterior communicating artery at the junction with the \(P_1\) segment. We had thought this very small artery would not cause any circulatory problems. Postoperatively, however, severe vasospasm ensued and the symptoms became worse. It is postulated that circulatory disturbances would have been much less if the posterior communicating artery had not been cut, even though it was an artery of small diameter.

Postoperative transient oculomotor paresis was once considered unavoidable after surgery of aneurysms located in the basilar artery.\textsuperscript{7,16,17} In our experience, however, it is possible to avoid even transient paresis of the oculomotor nerve, which may occur postoperatively in the form of slight anisocoria lasting as long as overnight. In order to avoid postoperative oculomotor paresis resulting from a transsylvian approach, it is important to carefully dissect the oculomotor nerve, which lies in close proximity under the uncus of the temporal lobe, and to exert the utmost effort not to compromise the blood supply to the nerve when trying to retract the tip of the temporal lobe posterolaterally. Furthermore, in the dissection of the interpeduncular cistern, one should be careful not to touch the nerve directly with a suction tip. It is advisable to use cotton pledgets to protect the nerve during the procedure. When approaching from the left hemisphere, a right-handed surgeon ought to be careful not to injure the third nerve with a suction tip held in his left hand, because the nerve lies on the left side of the operating field.

We used Heifetz or Scoville clips in the first five cases of this series. In two of these procedures, the Heifetz clips slipped out during surgery. Since the aneurysms in this location are exposed to a strong direct stream from the basilar artery, it is important to use clips that exert sufficiently strong pressure. Furthermore, clips with wide blades and clip holders with large heads are not applicable because of the narrow and deep operating field. For all later cases, Sugita clips were used exclusively (Fig. 4). We have not yet experienced slippage with these clips. Generally, we apply relatively longer blade clips more often in this location than in the anterior circle of Willis because, when using the longer blade clips, the head of the applicator does not interfere with the surgeon’s field of vision. For this same reason we use bayonet-shaped clips most frequently.\textsuperscript{13}

Another essential instrumental aid is a specially designed brain retractor that is tapered in width without losing its elasticity and its supporting system — a lightweight self-retaining device to hold the brain retractor and a multipurpose head frame. In a cone-shaped operating field, even the narrowest of the conventional retractors, 7 to 8 mm in width, are difficult to apply without causing any injury to the surrounding tissues. Tapered retractors of our own design, with narrow tips, 2, 4, and 6 mm in width, are essential, not only for obtaining an ample operating field but also for the direct retraction of aneurysms and their parent vessels.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{sugita_clips.png}
\caption{Representative aneurysm clips chosen from 50 differently shaped Sugita clips. Those in the bottom row are used for unusual aneurysms (modified after Drake).}
\end{figure}
The incidence of operative morbidity is lower than previously reported in the literature; additional postoperative neurological deficits were seen in only one patient (3%) in the present series. The mortality rate for surgery for vertebrobasilar artery aneurysms before the advent of the operating microscope averaged 37%, and decreased to approximately 10% in the 1970's after the introduction of magnification techniques. Results of aneurysm surgery differ among neurosurgeons depending upon their respective criteria for selecting cases for surgery and the time for surgery. Our mortality rate is 6% and this may be further improved by selective timing of surgical intervention.

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References


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