The Surgical Treatment of Aneurysms of the Basilar Artery

CHARLES G. DRAKE, M.D.

Neurosurgical Unit, Victoria Hospital, and the University of Western Ontario, London, Canada

Aneurysms arising from any portion of the basilar artery may be exposed for surgical treatment by an approach through the middle fossa under the temporal lobe. From a surgical point of view, they should be divided into two groups: those arising from the bifurcation, and those along the trunk of the artery. The latter classically occur at the origin of the basilar, superior cerebellar, and anterior inferior cerebellar arteries. While basilar superior cerebellar aneurysms may be seen clearly in this manner, exposure of aneurysms along the trunk of the artery requires division of the tentorium; the length of the tentorial split is dictated by the position of the aneurysm behind the clivus.

Division of the tentorium far laterally allows direct access to aneurysms at the origin of the basilar artery, and even to those on the distal vertebral artery; the latter type is exposed by retracting the anterior cerebellum and angling down the posterior slope of the petrous bone to the prepontine space in front of the lower aspect of the clivus.

For aneurysms at the bifurcation, the exposure is continued across the tentorial edge into the interpeduncular cistern above and behind the dorsum sellae.

We have found that two surgical adjuncts, magnification of vision and profound hypotension under normothermia, are important for safe exposure and occlusion of any aneurysms. These surgical aids seem even more indispensable for basilar aneurysms since the confining nature of the exposure makes it imperative that the investments and connections of the aneurysm be seen clearly and the clip or ligature applied accurately with minimal risk of rupture. Rupture of a basilar aneurysm before completion of this dissection is calamitous, for hurried attempts to stem bleeding may result in injury to important structures and placement of the clip in such a way as to occlude more than the aneurysm.

Once the general location of the aneurysm has been reached, the use of 2½ power Loupes will magnify the region of the aneurysm with startling clarity. The tiny tissue planes show up so that sharp dissection may be used to free attachments to arachnoid, dura, or parent vessels.

Induction of deep hypotension at the same time to 40–50 mm Hg will allow the aneurysm to be approached boldly and facilitate removing clot and dividing arachnoid adhesions. The accurate definition of the base or even the whole aneurysm is simplified when its softness and pliancy allow indentation or displacement to uncover hidden aspects. We have used profound hypotension in 70 operations on various aneurysms; however, we only use it during the period necessary to complete the occlusion of the aneurysm. In straightforward cases, the pressure need only be lowered for a few minutes, but in complicated situations, mean arterial pressures at this level have been tolerated for over an hour without known residual effect, even in older patients.

The details of the surgical technique will be described under the following headings:

1. Craniotomy and initial subtemporal exposure
2. Aneurysms at the basilar bifurcation
3. Aneurysms on the upper basilar trunk at the origin of the superior cerebellar artery
4. Aneurysms on the lower basilar trunk, including those on the terminal vertebral artery.

Craniotomy and Initial Subtemporal Exposure

The patient is positioned lying on the left side for approach under the right temporal lobe (Fig. 1); an unusual location of the aneurysm or sure knowledge of right cerebral dominance may dictate otherwise. Either the radial or femoral artery is cannulated for accurate recording of mean arterial pressure. A
FIG. 1. Positioning of patient on the left side. Location of the bone flap.
strain gauge may be used; however, a simple method may be devised by connecting an an-
aeroid blood pressure gauge by means of an
air lock to tubing containing heparinized sa-
line running in a slow drip into the arterial
cannula. This will allow a continuous and ac-
curate visual recording of the mean arterial
pressure.

The lateral position allows easy access for
lumbar puncture and drainage of all cerebro-
spinal fluid after the bone flap has been
turned down. In many instances the resulting
brain slackness will be all that is necessary
for the exposure. However, deep firm retrac-
tion of the temporal lobe may be required to
expose the basilar bifurcation; then it is best
also to use Mannitol so that the least possi-
ble retractor pressure is required and there
will be little or no bruising of the inferior
temporal cortex. In anticipation of using
Mannitol, an indwelling catheter should have
been placed in the bladder before draping
the patient.

The scalp incision and position of the
bone flap are illustrated in Fig. 1 (lower
right). It is important to remove the squa-
mous temporal bone with rongeurs so that
the boney opening is as nearly flush with the
floor of the middle fossa as possible. This re-
moval should be carried well anterior when
exposing an aneurysm on the upper half of
the basilar artery, for the approach is angled
forward as much as 20° under the temporal
pole in order to see into the interpeduncular
cistern in front of the crus cerebri. The tem-
poral muscle may be separated from its at-
tachment to the temporal root of the zygoma
and then held back inferiorly by strong re-
traction or heavy sutures. Opening of mast-
toid or zygomatic air cells may be necessary, 
but these can be plugged with bone wax.

The dura need only be opened horizon-
tally 1 cm or so above the inferior margin of
the craniotomy and the lower leaf tied back
firmly (Fig. 2 A). The vein of Labbé should
be followed to its attachment to the lateral
sinus, often with a confluence of veins. The
integrity of this confluence must be pre-
served by protecting it with a gelfoam slab
covered by a patty and making certain that
retraction does not stretch or tear these
veins.

As the brain slackens with lumbar drain-
age of cerebrospinal fluid, the midportion of
the temporal lobe is elevated in a region
where the floor of the middle fossa is rela-
tively flat; this exposes the tentorial edge. A
few small veins and occasionally a large one
entering the dura from the inferior aspect of
the temporal lobe may have to be divided
with cautery. At this stage, magnification of
vision should be used with the 2.5 power
Loupe or the dissecting microscope. A
sheath of arachnoid covers the midbrain and
interpeduncular cistern but is so transparent
that unless the cistern is plugged with clot
the white band of the third nerve can be
seen dividing the entrance to the interpedun-
cular cistern. Often the superior cerebellar
artery is visible as it runs posteriorly on the
side of the midbrain. The arachnoid is then
torn with a sharp hook above or below the
third nerve and there opened more widely
with fine scissors. The remainder of the cere-
brosinal fluid is evacuated with suction.

As the hazardous part of the dissection is
now to be commenced, profound hypoten-
sion of 40–50 mm Hg should be instituted.
At this level of pressure, there has been no
need to use a temporary clip on the basilar

![Fig. 2 A. Exposure and tearing of the arachnoid of the interpeduncular cistern and midbrain.](image)

![Fig. 2 B. Removal of cisternal clot by suction.](image)
Aneurysms of the Basilar Artery

Fig. 3. Orientation drawings for surgical exposure of basilar aneurysms.

artery. Soft clot, if present in the cistern, can be removed with suction; one must be careful to keep the aspiration in a direction away from the known position of the aneurysm (Fig. 2 B).

Aneurysms at the Basilar Bifurcation

Figure 3 provides orientation drawings for the surgical exposure of basilar aneurysms. An appreciation of the level of the base of the bifurcation aneurysm is important, and this can be established by noting its position in relation to the posterior clinoid and lateral curve of the posterior cerebral artery in the angiogram. At operation, the dorsum sellae is seen easily, and a little extra pressure on the tip of the retractor elevating the uncus will expose the posterior cerebral artery as it curves around the crus. The carotid artery is seen anteriorly. The posterior communicating artery is usually small, but even when large has not needed to be divided. The many tiny perforating vessels that usually arise from the communicating and posterior cerebral arteries should be protected and preserved. Deep to these structures, a mamillary body may be seen (Fig. 4).

Except when dealing with the rare unusually low-placed basilar bifurcation, it is unnecessary to divide the tentorium. The approach to the bifurcation usually will be through the angle above the third nerve which passes below the posterior cerebral artery. Using CSF drainage and Mannitol, we
The posterior foramen of the cerebral nerve. Opposite to it is the lower part of the arachnoid and the peduncular pole. Gradually, the lateral aspect of the nerve is more exposed, while the sac of the aneurysm is opened. When the aneurysm is small its lower lateral aspect is exposed by following the posterior cerebral artery towards its origin.

The bulge of the aneurysm should be followed across the anterior aspect, opening the arachnoid further if necessary as well as cutting any light adhesions. Depression of the anterior wall may provide a glimpse of the opposite posterior cerebral artery and third nerve.

The next stage is to see and separate the vital perforating vessels from the base of the aneurysm hidden in the depths of the interpeduncular space (Fig. 4). With a small curved spatula the crus is retracted posteriorly to expose the posterior aspect of the posterior cerebral artery, the basilar artery, and the neck and waist of the aneurysm. As the crus is displaced posteriorly, the tiny vessels arising from the top end of the basilar artery and adjacent portions of the posterior cerebral artery are seen straightening out and usually separating themselves from the aneurysmal bulge. With this knowledge of their position, it is now possible to discontinue retraction of the crus.

The spatula or blunt hook is then used to displace the base of the soft aneurysm forward, working the instrument behind the sac in front of these vessels so that it is even possible to see the opposite posterior cerebral artery (Fig. 5a). The blunt hook should be used to separate and define the far lateral aspect of the neck from the opposite posterior cerebral artery both in front and behind. Gentle pressure with the tip of the instrument usually suffices to free this hidden portion of the neck so that the hook can be used to feel the angle made by the slope of the neck and the posterior cerebral artery.

Any displacement of the third nerve during these maneuvers should be as gentle as possible. Frequent irrigation with saline will prevent "drying out" of these structures or "sticking" of an instrument to the nerve, vessels, or even to the aneurysm, with disastrous consequences.

With the neck of the aneurysm defined, a decision must be made as to whether it can be occluded and, if so, how this is to be done. A small-necked aneurysm, sitting erect at the bifurcation with large angles of separation from the posterior cerebral artery, is usually ideal for application of a clip since in spite of the confinement there is enough room for manipulation of the clip-applying forceps. Preliminary isolation of the neck of the sac from the perforating vessels is carried out in the same fashion as has been described for larger sacs although much more simply. Ligatures may be used on small aneurysms but take more care and time and require more manipulation of nearby structures.

The problem is not with the small-necked sac but with either a broad-necked one that is really an extension of a fusiform dilatation of the top of the basilar artery, or an aneurysm that is yellow with atheroma. To chance the rupture of a fragile atheromatous neck with a clip or ligature is unwise in any situation, and particularly so at the bifurcation. When faced with this problem, it is better to abandon any attempt at ideal treatment and try to dissect free the whole of the aneurysm for encasement with muslin gauze or plastic. Under magnification and deep hypotension this is quite possible with smaller
sacs and larger sacs that are low-placed.

Figure 5 illustrates the application of a ligature or Mayfield clip to the neck of the more usual larger bifurcation aneurysm. Often it is not possible to work the ligature carrier behind the base of the aneurysm in one stage either because of the size of the sac or because of the tethering effect produced by the posterior communicating artery on the posterior cerebral artery. Even so, the ligature carrier can be passed behind the neck of the aneurysm in front of the perforators and the far end of the ligature grasped and pulled through to a convenient length (Fig. 5 b). Then, as the carrier is withdrawn from behind the aneurysm, it can be directed along the lateral aspect of the neck above the origin of the posterior cerebral artery and medial to any perforating branches of this vessel. The proximal end of the ligature is then drawn through the carrier so that the entire neck of the aneurysm is encircled and the perforating vessels not in jeopardy (Fig. 5 c). We have not found it necessary to divide the posterior communicating artery in order to mobilize the posterior cerebral artery.

Only a simple knot is used on a wet 000 black silk suture. Ordinarily, when tightened, this simple knot will hold while the second half of the square knot is placed, although the neck of the aneurysm must be occluded or nearly so to prevent its slipping. Knot-tying forceps with the grooves running longitudinally should be used to tighten the first knot gradually (Fig. 5 d) while the surgeon watches the effect of the narrowing of the neck on the posterior cerebral arteries. If
these appear kinked, a single simple knot can be loosened whereas the complete knot cannot be released without more difficulty and hazard.

The difficulty with the broad neck is that the posterior cerebral arteries arise from the lower portion and are applied to its mid lateral aspect where they are also tethered by the posterior communicating artery. Usually it is possible to pass a ligature around the base, but as the knot is tightened the posterior cerebral arteries may be kinked, stenosed, or even occluded. Tying the knot short of this point may narrow the neck enough so that a clip may be applied or another ligature may be tied down more firmly just beyond. Another difficulty with the broad neck is that a ligature tends to "saw" on the tiny perforators as it is drawn underneath them, perhaps promoting spasm.

Due to the narrow angle of the exposure, application of the clip may be difficult unless the waist of the sac can be tilted forward so that the posterior blade of the clip can be slipped in behind the neck in front of the posterior cerebral and perforating vessels (Fig. 5 e). A trial closure with the tips of bayonet forceps will often set the stage for application of the clip. After closure, it should be quickly determined that the jaws cross the neck completely but do not involve the opposite posterior cerebral artery; this complication requires reapplication. The development of a clip with a circular opening at the base of the jaws to contain the posterior cerebral artery would allow a direct lateral application across the neck and simplify the procedure greatly.

**Low Basilar Bifurcation Aneurysms.** In a few cases, the bifurcation of the basilar artery giving origin to an aneurysm is unusually low and behind the dorsum sellae. This position provides some advantage to the surgeon in that less temporal lobe retraction is required and the danger of injury to the hypothalamus is reduced when the dome of the aneurysm must be exposed for investment with gauze or plastic. However, the tentorium must be divided to expose the neck, and the room for dissection of the lower aspect of the aneurysm and maneuver with the clip-applying forceps or ligature carrier is substantially reduced by the dorsum and clivus.

Heretofore, aneurysms that projected posteriorly from the bifurcation were considered extremely hazardous (Fig. 6 A). Recently, however, it was possible to clip such an an-

---

**Fig. 6 A.** Aneurysm projecting posteriorly from the basilar bifurcation. B. Neck of aneurysm exposed by traction on the posterior cerebral artery and retraction of the peduncle.
Aneurysms of the Basilar Artery

Fig. 7. Division of the tentorium, protecting the fourth nerve.

Aneurysm by using traction on the posterior cerebral artery in order to withdraw the aneurysm slightly from the interpeduncular space. At the same time retraction of the crus allowed enough exposure of the neck that the perforators could be separated from it. Then the blades of the clip could be worked across behind the posterior cerebral artery and above the perforating vessels (Fig. 6 B).

Division of the tentorium requires definite care to avoid injury to the trochlear nerve and to preserve the integrity of this thin strand during prolonged surgical dissection either above or below. This tiny nerve winds around closely applied to the side of the midbrain just under the tentorial edge to its exit into the cavernous sinus in the petroclinoid ligament. Before the tentorium is cut, its edge should be elevated with a sharp hook to visualize the attachment of the fourth nerve so that the line of division of the edge is well behind this point (Fig. 7). Subsequently, great care must be taken to avoid injury or tearing of this tiny filament; even with the utmost care we have inadvertently damaged it on three occasions.

Figure 8 demonstrates the exposure of a low-placed but large and globular aneurysm. The neck was broad, a continuation of a fusiform dilatation of the termination of the basilar artery, and the posterior cerebral arteries arose from its side. Large yellow patches of atheroma could be seen in the neck and basilar artery, precluding the application of the clip or ligature. Its low position however made it possible to dissect free the whole of the aneurysm so that it could be wrapped in muslin gauze strips.

Aneurysms of the Upper Basilar Trunk (Basilar-Superior Cerebellar)

This group is perhaps the most satisfactory for surgical treatment, principally because the neck is usually easily definable and the central perforating branches of the basilar artery are not intimately related to the aneurysm; in none of our four cases of this sort has the sac projected posteriorly.

In two, the aneurysm projected forward free in the subarachnoid space of the interpeduncular cistern with the fundus adherent to the clivus. In neither was it necessary to divide the tentorium. The neck comes into full view after the clot has been removed and a few arachnoid adhesions divided. In spite of limited space, after the limits of the base to the sac have been defined with a blunt hook, the accurate application of a clip (Fig. 9) is facilitated because the clip-applying
forceps are directed straight in along the line of vision, since the neck is at right angles to the surgeon. However, the third nerve is more likely to be injured because its course to the cavernous sinus tends to cross the line of approach to the neck of these aneurysms. The nerve must therefore be retracted superiorly or inferiorly to allow dissection of the aneurysm and application of the clip.

In two of our cases, the aneurysm projected laterally, lying in a shallow bed in the peduncle (Fig. 10 a); only in one was it necessary to divide the tentorium. The neck is defined by using a blunt hook to separate it from the superior cerebellar artery, its bed, and any adherence to the basilar artery (Fig. 10 b). The fundus may obscure the anterior aspect of the neck and require the retractor to be angled forward, as with the basilar bifurcation aneurysms. A clip must be applied nearly vertically to the surgeon’s view, and in this narrow space the clivus may interfere with its application. A ligature may be more satisfactory for encirclement of the neck, using a carrier shaped like a small aneurysm needle to obviate the need for more space. Figure 10 c illustrates the projected use of this ligature carrier where a left laterally projecting aneurysm is approached from the right side. This carrier was developed because in such a case none of the standard clip applying forces or ligature carriers could be manipulated satisfactorily in the narrow space behind the clivus, and thus, al-
though the neck was in full view, its obliteration had to be abandoned.

**Aneurysms on the Lower Basilar Trunk, Including Those on the Terminal Vertebral Artery**

Exposure of the lower two-thirds of the basilar artery as well as the terminal portion of the vertebral artery is accomplished by the subtemporal approach through a lateral cut in the tentorium long enough to expose the basilar artery adequately (Fig. 11 a).

The same care of the fourth nerve must be observed in the initial division of the tentorium but ordinarily the line of dissection will be low enough that its integrity will not be a problem. However, as the tentorial cut is extended laterally 1 cm or so behind the petrous ridge, the petrosal vein will be seen bridging the space midway between the fifth nerve medially and the combined bundle of the seventh and eighth nerves laterally. Usually it will be necessary to coagulate and divide this vein. The narrow flap of tentorium attached to the petrous ridge is then folded back on itself and tied down with sutures to the dura of the middle fossa.

The retractor can then be used to elevate the temporal lobe and displace the anterior cerebellum away from the posterior slope of the petrous bone (Fig. 11 b). Gradually the retractor can be extended down the anterior cerebellum to the cerebellar peduncle so that it finally lies with its tip on the pons between the fifth nerve medially and the bundle of the seventh and eighth nerves laterally. Gentle pressure is enough to open up the postcerebellar space and allow removal of clot and exposure of the aneurysm. The terminal portion of the vertebral artery is little more than halfway down the clivus, and it has not proved unduly difficult to visualize aneurysms here or at the origin of the basilar artery. The fundus has often been adherent to the dura of the clivus and may have to be separated to facilitate exposure of the neck. The sixth nerve usually has an intimate relation to these aneurysms and must be dis-
sected free and then displaced to one side or the other so that the instruments can be manipulated beyond it.

In Fig. 11 c, the lower loculus of the aneurysm is being separated from its adherence to the anterior inferior cerebellar artery with a small curved dissector. This vessel must be seen clearly and separated before the application of a clip (Fig. 11 d). It may be necessary to retract lightly the bundle of the seventh and eighth nerves, but it can be expected that any seventh nerve palsy following gentle manipulation may be expected to be transient.