ANEURYSMS OF THE ANTERIOR COMMUNICATING ARTERY

BIFRONTAL CRANIOTOMY AND ROUTINE USE OF TEMPORARY CLIPS*

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ANEURYSMS of the anterior communicating artery present a particularly difficult therapeutic challenge because of their critical location, the serious circulatory disturbances that may follow their rupture, the prevalence of associated local vascular anomalies, and their marked tendency to fatal recurrent hemorrhage unless treated properly.

Tucked between and far under the frontal lobes these single or multilobed aneurysms, which are mostly of congenital origin, arise from the anterior communicating artery that normally links the two anterior cerebral arteries.

Despite their location at such a vital crossroad of the circle of Willis such aneurysms on rupture frequently give rise to no immediate symptoms or signs other than those of acute subarachnoid hemorrhage.

Circulatory impairment, however, may develop as the result of vasospasm and lead to neurological signs, permanent brain damage or death. Critical reduction of circulation through one or both anterior cerebral arteries, for example, may initiate ischemic changes in one or both frontal lobes with consequent intellectual deficits, while involvement of perforating arteries and the recurrent artery of Huebner may initiate ischemic infarcts in the basal ganglia, internal capsule and anterior hypothalamus with resultant coma. If the circulation of the optic tracts or nerves is jeopardized or an expanding anterior communicating aneurysm seriously compresses the optic chiasm and nerves, blurred vision, visual-field defects or blindness may occur. Finally, remote widespread cerebral vasospasm or compression of blood vessels by a hematoma may result in ischemia sufficient to cause cerebral edema, infarction or remote areas of softening leading to coma or hemiplegia.

Without surgical intervention the mortality for anterior communicating aneurysms is close to 50 per cent (Table 1). Carotid ligation in the neck has often, though not always, proved equally unsatisfactory for this type of aneurysm, usually because of recurrent hemorrhage, while the morbidity from postligation hemiplegia or other disabilities can be high. It generally has been conceded therefore that intracranial surgery for this type of aneurysm is the procedure of choice, especially as it offers the best chance of eliminating the threat of a fatal recurrent hemorrhage.

While various types of intracranial operations have been practised, each of proven merit, each has in turn certain disadvantages. Proximal ligation of one anterior cerebral artery, for example, does not directly obliterate the aneurysm and may occasionally lead to serious ischemic changes in the brain. There is also the ever present possibility of a fatal recurrent hemorrhage, which may also happen after simply wrapping the aneurysm with muscle or other materials. When a unilateral craniotomy is used, even though the aneurysm is obliterated successfully, functions of the frontal...
ANEURYSMS OF ANTERIOR COMMUNICATING ARTERY

TABLE 1
Aneurysms of anterior communicating artery

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mortality*</th>
<th>Morbidity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Cases Incl. Coma</td>
<td>No Coma (Grades 1–4)</td>
</tr>
<tr>
<td>No surgery</td>
<td>50%±</td>
<td>30%±</td>
</tr>
<tr>
<td>Carotid occlusion</td>
<td>50%±</td>
<td>14%±</td>
</tr>
<tr>
<td>Intracranial surgery</td>
<td>25% (K**)</td>
<td>4.3–20%†</td>
</tr>
<tr>
<td>Bifrontal temporary clips (NINY‡)</td>
<td>17%</td>
<td>13.6%</td>
</tr>
<tr>
<td>1937–60 (23 cases)</td>
<td>—</td>
<td>7.7%</td>
</tr>
<tr>
<td>1939–60 (13 cases)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* See text.
** K = Krayenbühl.
† 4.3% Lepoiré, 9% Krayenbühl, 11% Hamilton & Falconer, 20% Botterell et al., 20% NINY‡ (techniques other than bifrontal temporary-clip method).
‡ NINY = Neurological Institute of New York.

lobe may be impaired if cerebral resection or extensive sacrifice of superior cerebral veins becomes necessary. Another problem to be considered is the important matter of planned temporary reduction of arterial supply to an aneurysm to prevent its premature rupture at operation. If this is done by precautionary occlusion of both the vertebral and carotid arteries in the neck, additional surgery is required and the circulation to the entire brain is threatened, even though hypothermia is used. Temporary bilateral routine intracranial local reduction of the circulation via a bifrontal bone flap, on the other hand, has proved to be a relatively simple and effective method of preventing premature rupture of the aneurysm and facilitating its direct exclusion from the circulation. Before describing details of this surgical approach as now used, it may be helpful to consider problems relating to the surgery of anterior communicating aneurysms.

PROBLEMS RELATED TO SURGERY OF ANEURYSMS

1. Timing of Operation. As a general principle it has seemed best to proceed with intracranial surgery for anterior communicating aneurysms (as for most other aneurysms) as promptly as possible provided the patient is in reasonably good condition. This means bilateral, and if necessary oblique and/or vertebral angiography on the day or night of admission, followed at once by surgery. Delays, especially if longer than a week, frequently result in fatal recurrent hemorrhage and occasionally in the late development of hemiplegia.

Late hemiplegia occurring on the 6th or 7th day after subarachnoid hemorrhage, as in 2 of our 22 cases, may well be caused by progressive unilateral cerebral vasospasm as demonstrated arteriographically and confirmed at operation. Our 2 patients, like those reported by others showed no clinical, lumbar-puncture or operative evidence of further bleeding or of clot formation.

Prompt surgery, however, is not advised for very ill patients who are markedly obtunded and have angiographic evidence of severe widespread vasospasm. In such cases early surgery, or even the completion of contralateral angiographic studies at one stage, has made the patient's condition worse. If their condition improves in 2 or 3 days, completion of angiographic studies and surgery is then usually tolerated.

If cerebral vasospasm is local and not yet widespread, completion of angiography at one stage and prompt surgery has generally been well tolerated even when such patients are moderately obtunded and confused (Grades 3 and 4 of Botterell et al.).

Comatose patients (Grade 5) have seldom survived surgery. However the only
100 J. LAWRENCE POOL

TABLE 2

Anterior communicating aneurysms (23 cases)

<table>
<thead>
<tr>
<th>Pre-Operative Risk</th>
<th>Grades</th>
<th>Time after Hemorrhage</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0-7 days</td>
<td>8-14 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E  G  P  D</td>
<td>E  G  P  D</td>
</tr>
<tr>
<td>Under 50 years</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(15 cases)</td>
<td>2</td>
<td>2  1  1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1  1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7  1  2  1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Over 50 year</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>(8 cases)</td>
<td>3</td>
<td>1** 1  1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3  1  1  1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(23 cases)</td>
<td>10  2  3  2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

E = excellent
G = good
P = poor
D = died (op. d. 3, late d. 1)

* Anterior cerebral clipped.
** Muscle wrap (late death).
† Myocardial disease.

chance of saving a patient with a massive fresh intracerebral hematoma is prompt "salvage" surgery.27

In a word, early surgery is recommended as soon as feasible, and preferably within the first week, as practised in 17 of our 23 cases. Eight patients were operated upon within 2-3 days after their last hemorrhage (Table 2). We feel that waiting a week or more, as suggested by some,22 is not advisable and may only court disaster.

2. Premature Rupture of Aneurysm at Operation. By premature rupture is meant bursting of the aneurysm at operation upon manipulation13,22,45 or even without direct manipulation, prior to precautionary control of its nutrient arteries. As every neurosurgeon knows, such an event can be catastrophic, particularly if the cerebral circulation is already marginal because of pre-existing arteriolar pathology,2 increased viscosity of blood because of vascular disease in older patients,57 arteriosclerosis, vasospasm,9,14,22,43 or other reasons.31,36 The circulation is then particularly vulnerable and may therefore be critically jeopardized by such added factors as:

(a) A fall in systemic blood pressure caused by sudden hemorrhage on rupture of the aneurysm, and/or

(b) a reduction of the local circulation secondary to: (1) Local loss of blood destined for the brain; (2) sudden collapse or narrowing of local arteries on rupture of the aneurysm, which I have once seen as it occurred, that may persist after hemostasis; (3) vasospasm induced either by such collapse, or by mechanical injury to arteries9,29,43 with suction tips or retractors; and/or (4) remote vascular injury caused by additional retraction of the brain.

A combination of critical local and systemic circulatory changes59 may easily lead to serious cerebral edema and/or infarction as suggested on experimental grounds36 and by clinical-pathological studies after rupture of aneurysms never operated upon.5

Rupture of an aneurysm may also result in
such widespread hemorrhage that arachnoidal reactions occur leading eventually to block of cerebrospinal fluid and hydrocephalus.1-15

PREVENTION OF COMPLICATIONS

Prevention of premature rupture of an aneurysm at operation and its serious consequences can usually be avoided by: (1) an ample operative exposure, (2) reduction of brain volume, (3) adequate access to key arteries, (4) precautionary control of local arteries by temporary clips, (5) the protection of hypothermia, (6) satisfactory exposure and permanent clipping of the aneurysm, and (7) maintenance of adequate systemic blood pressure and oxygen supply.

1) Operative Exposure. For proper access to any aneurysm "key-hole" surgery should be avoided16,27 if intracranial control of the circulation to the aneurysm is planned, and cerebral resection or excessive retraction of the brain is to be avoided. For aneurysms of the anterior communicating artery, a bifrontal craniotomy flap has therefore been used (see below), which evidently has not been a routine practice of all neurosurgeons as far as I can discover (Fig. 1).

2) Reduction of Brain Volume. While hypothermia tends to reduce the volume of the brain by reduction of cerebral blood flow,16,28 exposure of the site of the aneurysm is even more satisfactorily achieved by the addition of intravenous urea. Spinal drainage16 is often unsatisfactory because the needle or tubing sometimes fails to work when most needed. Intravenous urea, on the other hand, has proved both reliable and highly effective25 but should not be used if there is pre-operative evidence of cardiac, renal or hepatic insufficiency. Improper dilution of the urea can lead to hemolysis and of course the use of a single dose of urea will not permanently correct existing or induced cerebral edema. Its proper use at operation, however, helps provide an excellent exposure usually without the need of cerebral resection or appreciable retraction of the brain.

Whenever postoperative cerebral edema seems likely because of excessive retraction or manipulation occasioned by premature rupture of an aneurysm, or because a major artery has had to be permanently ligated, prophylactic resection of cerebral tissue should then be done.9,22,27 Personal experience with 2 cases of this series strongly suggests that this can be a lifesaving measure. Maintenance of hypothermia in the postoperative period may also be of aid in these patients.

For patients who do not regain consciousness promptly after operation and have any respiratory difficulty, immediate tracheostomy has proved beneficial.

Some patients, moreover, intact and alert the first day after operation who then become rapidly lethargic, can be saved by prompt re-operation for partial resection of edematous frontal lobe (2 cases).

3) Access to Nutrient Arteries. This is
facilitated by adequate exposure aided by reduction of brain volume as discussed above.

4) Local Control of Circulation by Temporary Clips. The key to prevention of rupture of an aneurysm, as is well known, is adequate precautionary hemostasis. There are several ways of accomplishing this. One of the first appears to have been passage of a loose ligature around the carotid artery intracranially in an operation at the Cushing clinic in 1926. However, there is no indication in the original operative report that the ligature was used to shut off the circulation temporarily. Apparently the first resort to precautionary reduction of circulation for this type of surgery was the use of temporary clips intracranially by Jefferson in 1928. These were modified Michel clips which, he added, tended to slip off at inopportune moments. Cairns was apparently next to develop a temporary clip for this purpose; then Olivecrona, Black and German, Schwartz, Mayfield, and others. Hamby and others perfected various techniques of temporarily shutting off the carotid arteries in the neck while Botterell et al., using hypothermia, occluded both vertebral and both carotid arteries in the neck. Perusal of the literature indicates however that the use of temporary precautionary intracranial clips or ligatures has not been a routine practice, as most writers who mention the subject have indicated that they use this technique either occasionally or after an aneurysm has burst.

Temporary clips, strategically placed on segments of the circle of Willis can be used routinely with safety, I believe, as tested personally in 40 consecutive cases of intracranial aneurysm. First of all they do not completely shut off all arterial flow to the cerebral tissue ordinarily supplied by the clipped arteries as indicated by the "back bleeding" that occurs should the aneurysm then rupture. Such "back bleeding," easily controlled with one suction tip, clearly represents retrograde circulation from collateral channels. The fact that temporary clips do not shut off all circulation, together with the protective effects of hypothermia,

undoubtedly explains why they can be used safely for as long as 20 minutes on both anterior cerebral arteries simultaneously. Their continuous application for longer than 20 minutes, however, has led to difficulties such as postoperative edema and a prolonged or unsatisfactory recovery.

The main objection to their routine use has been the reasonable fear that they may injure an artery and thus lead to its thrombosis. As far as I can tell, however, they do not result in any significant vascular injury, thrombosis or other ill effects, as others have also found, unless there are extenuating circumstances such as: (a) excessively low blood pressure while applied (2 cases), and (b) prolonged period of application: over 20 minutes (2 cases) or reapplication (2 cases).

(a) Inadequate Blood Pressure. A 58-year-old patient with known myocardial disease before operation died shortly after surgery. This was the only case in this series in which there was development of auricular fibrillation and unobtainable blood pressure. He had suffered repeated episodes of subarachnoid hemorrhage making surgery a "salvage" procedure. At autopsy the neck of the anterior communicating aneurysm was clipped successfully but there was thrombosis of each anterior cerebral artery.

Adequate Blood Pressure. In the 3 other patients that came to autopsy after temporary clips had been applied to each anterior cerebral artery for 20 minutes, there was no evidence of arterial thrombosis in any of the vessels so clipped.

In the first of these 3 cases the thin neck of an anterior communicating aneurysm tore into the wall of one anterior cerebral artery so that the latter had to be clipped permanently distal to the aneurysm. Each anterior cerebral artery had meanwhile been clipped temporarily for 20 minutes. For over 24 hours this 42-year-old patient was bright, alert and neurologically intact. Soon thereafter she became progressively lethargic and died. Autopsy showed massive cerebral edema on the side of permanent occlusion of the anterior cerebral artery, thrombosis dis-
tal to the permanent clip on the anterior cerebral artery, but no thrombosis at the sites of 20-minute temporary clipping.

In the second patient, a man aged 58 years, the aneurysm, which formed part of the junction of the anterior cerebral-anterior communicating arteries, was so brittle from arteriosclerotic plaques that it could not be clipped or ligated. It was therefore wrapped with muscle. Both anterior cerebral arteries were occluded with temporary clips for 20 minutes each. The patient made a prompt and perfect recovery and was discharged in 3 weeks. A month after discharge he was re-admitted in coma and died, because of recurrent hemorrhage. This case is therefore listed as a late rather than a purely operative death and was the only case in which I have wrapped an anterior communicating aneurysm with muscle (Hamilton and Falconer reported a similar incident). Autopsy showed hemorrhage from the aneurysm but no trace of injury or thrombosis at the site of the temporary clips.

The third patient, a man aged 42, was restless, incoherent and at times lethargic before operation. At autopsy there was no evidence of thrombosis of either anterior cerebral artery at the sites of temporary-clip application, first for 30 minutes followed by reaplication later for 5 minutes each. There was, however, extensive infarction of the basal ganglia, perhaps pre-operative in onset, similar to that described in patients who died of ruptured aneurysm without surgery.

The blood pressure was adequate throughout all of these 3 operations.

(b) Prolonged Temporary Clipping. In 2 cases of this series both anterior cerebral arteries were clipped continuously for over 20 minutes (23 minutes in 1 and 27 in the other). Recovery was unusually slow in both and 1 patient still suffers impairment of memory, while the other has recovered fully. Reapplication of clips (2 cases) may also contribute to a slow or poor postoperative course.

Postoperative angiography (4 cases) after similar 20-minute use of temporary clips for each anterior cerebral artery has shown no evidence of thrombosis (Fig. 2). Two of these patients are active and mentally intact although the others, very ill prior to surgery, remain mentally retarded.

Since clinical experience (Table 2) also points to the safety and effectiveness of routine temporary-clip applications in the hypothermic patient, it is concluded that temporary clips can be used safely and routinely, even for patients with cerebral arteriosclerosis, for as long as 20 minutes on each anterior cerebral artery if the body temperature is close to 28°C, and there has been no critical or prolonged fall of the systemic blood pressure. Experience with the use of temporary clips for the surgery of other intracranial aneurysms is wholly similar.

5) Hypothermia. Hypothermia is used mainly to protect the brain from the effects of existing or induced circulatory impairment particularly if temporary clips are to be used for periods of 10 to 20 minutes. Hypothermia may also facilitate the surgical exposure by reducing cerebral blood flow and hence volume of the brain. In using hypothermia we have sought as low a body temperature as possible within the range of safety as to cardiac action. We have found that temperatures close to 28°C seem effective as to protection of the brain against temporary circulatory insufficiency, safe as to cardiac action, and easy to attain without delaying the operative procedure. The greatest risk of hypothermia is the susceptibility of the heart to cardiac arrhythmias that may terminate in fatal auricular fibrillation. There have been no recent instances of such a catastrophe in close to 200 patients in whom hypothermia has been used excepting 2 elderly patients, 1 with an anterior communicating aneurysm (mentioned above), and each with known myocardial disease.

Serious cardiac arrhythmias have been prevented or, on rare occasions when they occurred, have been promptly corrected by appropriate blocking agents such as additional Pentothal Sodium, chlorpromazine or atropine.

6) Exposure and Clipping the Aneurysm. Exposure of the aneurysm, I now feel, should not be attempted until satisfactory tempo-
Aneurysm of anterior communicating artery.

Upper photographs: Pre-operative left and right anteroposterior angiograms showing aneurysm.

Lower photographs: Postoperative angiograms showing good filling of both anterior cerebral arteries after bifrontal temporary-clip procedure for clipping aneurysm. (Courtesy of Dr. John E. Scarff)

Primary control of nutrient arteries to the aneurysm has been accomplished first. Otherwise these aneurysms may rupture prematurely, sometimes with dire consequences. While the routine use of temporary clips has always prevented premature rupture of the aneurysm, it has not always prevented subsequent rupture, usually from the fundus or dome. After local circulatory control has been accomplished, however, rupture has then usually proved a help rather than a hindrance, for the aneurysmal sac and its neck can then be dissected more easily, clipped permanently and tested for any residual blood supply through feeding arteries that may not have been seen. The reduction of local arterial flow by temporary clips also facilitates occlusion of the aneurysm because the tension or tautness of its sac is thus reduced, thus lessening appreci-
ably the possibility of its being torn as it is being clipped permanently.

A rare but distressing complication, also mentioned by others,\textsuperscript{9,37} has been the occasional postoperative slipping off of a well placed clip from the neck of an aneurysm. This happened with a fatal result in 1 hypertensive patient with an aneurysm of the middle cerebral artery, and without ill effects thus far in another (with an aneurysm of the internal carotid artery) who refuses re-operation. Both aneurysms had unusually broad necks and both patients were hypertensive. A special locking clip was therefore designed, somewhat similar to that described by Wise and Green\textsuperscript{64} but accompanied by an applicator.\textsuperscript{44} This has now been used on 6 intracranial aneurysms with large necks, including 2 anterior communicating aneurysms, with no fatalities. Because of its rounded edges\textsuperscript{57} this clip does not cut.

7) \textit{Adequate systemic blood pressure and oxygen supply} are essential, as already indicated, to avoid compounding any existing or induced insufficiencies of the cerebral circulation. For this reason monitoring of the electrocardiogram\textsuperscript{42} and carbon-dioxide tension of the blood is used throughout each operation, while induced hypotension\textsuperscript{4~} is not used.

\textbf{CASE MATERIAL}

This series of aneurysms of the anterior communicating artery operated upon by the bifrontal approach includes 13 patients treated by the author and 10 by fellow members of the Staff.* The ages of these 23 patients ranged from 34 to 60 years. In 17 despite their mental confusion, bilateral carotid angiography and surgery were carried out promptly after admission. In only 2 patients were angiography and surgery delayed for 3 or more days because of their poor initial condition.

Seventeen patients were operated upon within the first 7 days and 8 of these within 3 days after their last subarachnoid hemorrhage. Only 6 were operated upon after a 2-week interval.

Long-documented vascular hypertension was present in over a third of the group and myocardial disease in 2 patients. One of the latter died postoperatively and the other still suffers impairment of memory, as mentioned above.

Anomalies of the anterior cerebral circulation were noted on angiography and/or at operation in close to three-fourths of these cases, such as a small anterior cerebral artery on one side and/or accessory branches of one or both anterior cerebral arteries. More than half of these aneurysms were multilobed and some were so adherent to the optic nerves and chiasm as to require sharp dissection.

Multiple aneurysms\textsuperscript{24,47} were noted and treated in 3 of these cases, the additional (unruptured) aneurysm having been treated in 1 by carotid ligation in the neck prior to admission and in the other 2 cases at the same operation.

\textbf{TECHNIQUE}

\textit{Preparation}.\textsuperscript{44,45} If urea is to be used, an indwelling catheter is inserted prior to the induction of anesthesia. After induction with intravenous Pentothal Sodium and intratracheal intubation for nitrous-oxide-oxygen or Fluothane anesthesia in the usual manner, the patient is placed on a Thermorite\textsuperscript{†} mattress; ice bags are put in each axilla and groin and the operation is started at once. By the time the aneurysm is exposed the temperature is usually close to 28° C. Electrocardiographic recordings are obtained throughout the procedure and the carbon-dioxide content of the blood is also monitored.

\textit{Operation}. (a) \textit{Exposure}. Through a transcoronal incision of the scalp a bifrontal craniotomy flap is turned, usually hinged on the right temporal muscle. Only four burr openings are necessary, two anterolaterally, one in the midline anteriorly, and one in the midline posteriorly just forward of the coronal suture. The dura mater on each side is opened at its anterior aspect only and the superior longitudinal sinus, small at this point, is ligated doubly and divided. After cutting the underlying falx the head is lowered, allowing the frontal lobes to fall away from the floor of the

* With thanks to Drs. John E. Scarff, Lester A. Mount, Thomas J. Bridges, and Joseph Ransohoff.

† Therm-O-Rite Products Corporation, Buffalo, New York.
anterior fossa (Fig. 1). It is seldom necessary to sacrifice more than one or two of the smaller most anterior superior cerebral veins on each side. Intravenous urea (used during the past year) greatly facilitates the exposure, \(^{29}\) while hypothermia (average 28°C.) is always used.\(^{5,37,68}\)

(b) Stepwise Application of Temporary Clips. On approaching the base of the brain no attempt is made to save the olfactory tracts or to visualize the aneurysm at once, lest it rupture prematurely. The first step at this point is release of cerebrospinal fluid laterally by opening the arachnoid surrounding one and then the other optic nerve and internal carotid artery. This is always done first on the side from which the aneurysm derives its major blood supply. When each internal carotid artery has been exposed, a temporary clip of the Mayfield-Kees variety\(^{*}\) is placed on the carotid artery first exposed. If the aneurysm fills equally from both sides both carotid arteries are clipped temporarily. With the major blood supply thus reduced the carotid artery on the first side is now exposed further by peeling away arachnoid until the origin of the anterior cerebral artery comes into view. This usually takes 2-3 minutes. A small temporary clip is then placed gently across the anterior cerebral artery close to its origin and the temporary clip on the carotid artery is removed. The same process is repeated on the opposite side unless the opposite anterior cerebral artery is known to be small because of angiographic evidence of hypoplasia or spasm. If the anterior cerebral artery is small, clipping of the carotid artery on that side is not necessary and the anterior cerebral artery is therefore exposed directly and clipped temporarily close to its origin.

At this stage both anterior cerebral arteries (Figs. 1 and 3) are thus shut off close to their points of origin, usually for 3-6 minutes. Experience has indicated that both anterior cerebral arteries should be occluded temporarily even if one is small, as a small anomalous thread-like anterior cerebral artery can provide an uncomfortably vigorous arterial flow if the aneurysm ruptures after the larger anterior cerebral artery is clipped temporarily. Further dissection of each anterior cerebral artery towards the aneurysm is now pursued until overlying blood clot and adherent brain are freed so that another small temporary clip can be placed on first one (Fig. 3) and then the other anterior cerebral artery close to the anterior communicating artery. The original laterally placed clips on the proximal part of each anterior cerebral artery are then removed.

(c) Attack on Aneurysm. The aneurysm itself is now attacked boldly without fear of consequences should it rupture since its chief blood supply is shut off temporarily. Usually 10 to 20 minutes are required for exposing and clipping the aneurysm, whereupon each temporary clip is removed. The permanent clip or clips are of course placed so as to occlude the neck or crimp the waist and body of the aneurysm and yet preserve circulation through each anterior cerebral artery.

(d) Closure. Wounds are closed in the usual manner after watertight closure of the dura mater. If the frontal sinuses have been opened, as usually proves necessary, the openings are sealed tightly by reflecting a flap of the periosteum or galea over them and stitching it to the dura mater followed by local extradural irrigation with Neobacin. (There have been no complications from opening the frontal sinuses.) Drains are removed in 24 hours.

RESULTS

In considering these 23 cases of anterior communicating aneurysms it may be pointed out that the technique as now practised was not always carried out exactly as described. For this reason several poor results occurred as the method was being evolved. In 2 cases, for example, although both internal carotid arteries and the lateral portions of both anterior cerebral arteries were exposed, no temporary clip was applied because the aneurysms had looked so easy to clip on angiography, and because it was thought advisable to avoid occlusion by temporary clipping as much as possible. It was planned to pursue dissection of the anterior cerebral artery medially for application of the temporary clip closer to the anterior communicating artery. At this point, however, the aneurysms ruptured prematurely making application of the temporary clip difficult and excessively prolonged. In 2 other cases the anterior cerebral artery on one side looked so small and almost thread-like on angiography and at operation (from hypoplasia), that no temporary clip was applied, although the opposite larger anterior cerebral artery had been occluded temporarily. However, the aneurysm in each case ruptured with such a surprisingly vigorous flow from the small anterior cerebral artery that considerable difficulty was experienced. When these technical errors were corrected in subsequent cases by routine stepwise application of temporary clips to both carotid arteries and then

* Kees Surgical Specialty Co., Alexandria, Kentucky.
Fig. 3. (a) Bifrontal craniotomy bone flap showing 3 anterior and 1 midline posterior burr holes. Temporal muscle stripped off for photograph.

(b) After occlusion of anterior communicating aneurysm with 2 metal clips. Note good condition of both carotid and both anterior cerebral arteries after application of temporary clips. Intravenous urea was used to reduce volume of brain.

(c) Exposure without use of intravenous urea showing 2 temporary clips on double right anterior cerebral artery. Anomalous left anterior cerebral artery was also shut off for 20 minutes, and multilobed aneurysm was successfully occluded.

(d) Shows good condition of brain after occluding aneurysm with 1 spring clip and 1 Olivcrona clip (same case as in Fig. 4).

Please substitute this color plate for page 107 in the January 1961 number of the Journal of Neurosurgery.
both anterior cerebral arteries regardless of size, everything went smoothly. No aneurysm burst in any case during exposure and control of the carotid arteries and adjacent, lateral portions of the anterior cerebral arteries, but only as dissection was being carried closer to the aneurysm without the precautionary use of temporary clips. For these reasons it is concluded that routine application of temporary clips should always be bilateral and stepwise as described, if this technique is used.

Another technical error leading to a poor result in 1 case and death in another was failure to resect frontal-lobe tissue at the initial operation when indicated. Premature rupture in 1 case made hasty and excessive retraction of the right frontal lobe necessary. This led to postoperative edema that was corrected by re-operation 2 days later. While life was saved, this patient’s recovery has been marred by hemiparesis and impairment. In another early case the right anterior cerebral artery had to be clipped permanently distal to the anterior communicating aneurysm (cf. p. 102). Prompt resection of the right frontal lobe might well have saved her life.

Prolonged application of temporary clips, especially in older arteriosclerotic patients, apparently contributed to a poor postoperative course. Such a prolonged time of temporary clipping (over 20 minutes) occurred in most instances when this technique was first being used. It was then not fully appreciated that once temporary clips are placed properly on both anterior cerebral arteries, one must boldly and swiftly expose the aneurysm and not be concerned if it should now rupture. Rupture after control of its major arterial supply by temporary clips has of itself seldom led to poor results.

The relative success of this technique is illustrated by the results in Table 1 which show that the last 13 patients so treated (1959–60) have fared remarkably well (Fig. 4) as a result of familiarity with the procedure and its possible pitfalls and recognition of the need for strict adherence to every step.

Of the 13 successive cases of patients operated upon personally in evolving this technique, postoperative results have been excellent in 9 and poor in 2. There was 1 operative death caused by massive cerebral edema that followed permanent occlusion of one anterior cerebral artery (see p. 102) and 1 late death that occurred in the only case in which the aneurysm was treated by wrapping with muscle instead of occlusion by clips. After a perfect recovery and discharge in 2 weeks, death a month thereafter was caused by sudden recurrent hemorrhage (cf. above).

In the remaining 10 cases my colleagues have likewise attained excellent results provided there have been no deviations from the procedure as outlined (Tables 1 and 2). Their 2 deaths occurred in the patients who were very ill (Grade 4) prior to surgery.

Even though most patients were confused (Grade 3 or 4) and operated upon during the first 3 to 7 days after subarachnoid bleeding, there were no operative deaths and only 2 poor results in 14 cases in which the aneurysm was clipped without premature rupture. Trouble ensued when an anterior cerebral artery was clipped permanently (1 case), when a serious fall of systemic blood pressure

*Excellent means that the patient is as intact mentally, emotionally and physically (with the exception of anosmia) as he or she was prior to rupture of the aneurysm, as illustrated in Fig. 4.

Good means resumption of usual work with approximately 5–10 per cent impairment as to memory or emotional control.

Poor means inability to work because of appreciable intellectual impairment, difficulties of memory or hemiparesis.
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occurred (1 case), or when temporary clips were used for longer than 20 minutes on each anterior cerebral artery (in some cases).

Altogether it would appear that this technique can be a useful one for the treatment of these difficult aneurysms. Its relative simplicity and effectiveness may contribute to further progress in this type of aneurysmal surgery which has improved so much over the past 10 years. It is of interest in this regard that in 1950 Elvidge and Feindel wrote “Relatively few instances of successful surgical treatment of aneurysms located on the . . . anterior communicating arteries have appeared in the literature,” while in 1953 Steelman et al. said “The surgeon is well-advised to leave these alone.”

DISCUSSION

Advantages of this approach are:
(1) Prevention of premature rupture of the aneurysm which may lead to immediate technical difficulties and serious complications as mentioned above.
(2) Sufficient exposure so that the surgeon can visualize and study the aneurysm and any associated vascular anomalies with considerable confidence after bilateral control of the local circulation.
(3) Avoidance as a rule of resection of the frontal lobe.
(4) Minimal retraction of the brain, especially if urea is used, so that manual retraction can be replaced largely by bent retractors simply left in place over each frontal lobe.

Disadvantages are:
(1) Anosmia.
(2) Risk of arterial thrombosis because of the use of temporary clips.

Anosmia, in the opinion of patients with whom I have discussed the matter, is of comparatively little importance in such major lifesaving surgery. As someone said: “It is better to be alive and smell bad than to be dead and smell good.” Furthermore, in dealing with large difficult aneurysms in this location, particularly those that have to be cut away by sharp dissection from the optic chiasm, even a unilateral approach and resection of the frontal lobe may demand sacrifice of both olfactory tracts.

The greatest hazard in this technique is of course the danger of thrombosis at the site of application of temporary clips. When, however, the technique has been followed strictly step by step as now practised and described above (Figs. 1 and 3), there has been no clinical, arteriographic or postmortem evidence of arterial injury or thrombosis.

SUMMARY

1. The treatment of aneurysms of the anterior communicating artery by various therapeutic approaches is discussed.
2. Complications from premature rupture of an aneurysm of the anterior communicating artery at operation, such as cerebral edema, vasospasm and infarction, are considered.
3. Means of avoiding such complications are outlined, with special attention to maintenance of an adequate systemic as well as local circulation.
4. A bifrontal craniotomy approach is described (based on 23 cases) for routine stepwise application of temporary clips to both anterior cerebral arteries prior to exposure and occlusion of an aneurysm of the anterior communicating artery. Advantages and disadvantages of this approach are discussed.
5. Postoperative results compare favorably with other techniques. As now evolved (last 13 of 23 cases) this bifrontal procedure of temporary clipping carries a mortality rate of only 7.7 per cent although most operations were done within 7 days after the last subarachnoid hemorrhage.

REFERENCES

4. Baumann, C. H. H., and Bucy, P. C. Aneurysms


28. LAZORTHES, G. Étude anatomotopographique de l’artère cérébrale antérieure et de l’artère communicante antérieure. In: Krayenbühl. 27


30. LEPPOHÉ, J. Cited by Krayenbühl. 27


35. MAYFIELD, F. M. Personal communication.


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52. Schwartz, H. G. Personal communication.

DISCUSSION

Dr. Edwin B. Boldrey: It has been a real pleasure to review this work, to hear the paper itself presented by Dr. Pool here today, and to have the opportunity to discuss his observations.

Most of us, I am sure, do not regard with great pleasure the appearance in our wards of patients with aneurysms of the anterior communicating artery because of the morbidity and mortality experienced in handling them. At the University of California, starting with Dr. Dunbar several years ago and, more recently, Dr. Adams, Dr. Wia and Dr. Witt, this approach has been used with some variations. In general, I have gathered that they like it. My own approach has still been via one side alone, since I felt there was less disturbance of the brain when only one hemisphere received major surgical disturbance.

The mortality of 7 per cent mentioned by Dr. Pool and the impressively reduced morbidity by the method he has described demand that we give critical consideration to turning to it when we have patients faced with this problem. One cannot argue with success. There are a couple of points to which I would give special consideration.

The transection of the frontal sinus, even in this time of antibiotics, still gives me great concern. I have seldom been satisfied that I have achieved a watertight closure of the dura mater, and I am certain I have seen meningitis and abscess in patients who have had the sinus entered deliberately during surgery for similar though not identical reasons.

We have not felt that general hypotension with hypothermia is as undesirable as I gathered is the case in other centers. When properly controlled, taking the added pitfalls from hypothermia into consideration, it has been of major help at times and should not, I believe, be discarded summarily from our available resources in the handling of hemorrhagic problems under hypothermia.

Another problem is the compression of arteries by hematoma. I have not yet seen convincing evidence that this occurs, though it is commonly mentioned. I hope Dr. Pool can give us his reasons, now or later, for feeling the hematoma per se produces ischemia by direct mechanical compression of major arteries.

The work on the renal effects presented yesterday would seem to fit into the problem of delayed manifestation of cerebral dysfunction postoperatively.
During this meeting there has been proper and repeated emphasis on the development of workable techniques and their perfection; and the admonition in this paper concerning the value of familiarity with the procedure and its possible pitfalls is to be strongly supported. However, to this must be added the comment that all means of handling a problem may have their occasional place. We need to have several avenues of approach and acquaintance with all courses of approach is, of course, but common sense.

In airplane circles there is a saying known as Murphy's law, which states, "If something can go wrong, it will." No more applicable words could be said about the handling of anterior communicating aneurysms.

DR. J. LAWRENCE POOL: I would like to thank Dr. Boldrey very much. I certainly agree something can and often will go wrong during aneurysmal surgery! The 7 per cent mortality figure is for our last 13 cases as stated, and the morbidity was about the same. In reckoning these results, as Dr. Boldrey and his group have pointed out, one must cite morbidity as well as mortality, because the two go together.

As to the compression of arteries by a hematoma, Dr. Boldrey, that was a quotation from an article by someone else, which I mentioned as a possibility. I am not personally convinced this happens at all.

The problem of sealing the opened frontal sinus is a very important point. While these sinuses have been boldly opened in practically all these cases of necessity, as we do for large subfrontal meningiomas, we have had no postoperative trouble on this count whatsoever. We make a point of making a little flap of periosteum, or of galea on the under surface of the reflected scalp flap, and folding that down over the sinus openings to form a tight protective sheath which is stitched to the dura mater after it has been closed in water-tight fashion. Neobacin irrigation is then used locally as an antibiotic. We have had no trouble from this part of the procedure.