Regrowth of aneurysm sacs from residual neck following aneurysm clipping

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It is recognized that incomplete treatment of an aneurysm may result in recurrent hemorrhage with serious or fatal consequences. For this reason, patients treated at the authors' institution in whom a large portion of the aneurysm neck or sac remained after application of a clip or ligature have been subjected to reoperation. However, 1- to 2-mm residual necks seen in postoperative angiography have been thought to pose little risk. Some cases of aneurysms recurring from a narrow residual neck after clipping have been reported, and a few instances of recurrent aneurysm have been described after apparently complete occlusion of the neck (as observed angiographically or in the surgeon's judgment). In recent years, a surprising number of cases have been presented in which this seemingly unimportant remnant of the neck dilated over a long period to become a dangerous aneurysm. This finding stresses the importance of complete aneurysm occlusion and of postoperative angiography for the recognition of a residual aneurysm neck. This should be important not only in aneurysm clipping but also in the endovascular treatment of intracranial aneurysms with detachable balloons.

Key Words • cerebral aneurysm • subarachnoid hemorrhage • aneurysm clip • balloon embolization

For many years it has been the approach at our institution to reoperate on aneurysm cases in which a large portion of the aneurysm neck or sac remains after application of a clip or ligature. It is recognized that grossly incomplete treatment of an aneurysm may result in recurrent hemorrhage with serious or fatal consequences. However, 1- to 2-mm residual aneurysm necks have been thought to pose little risk. Several cases of aneurysms recurring from small necks left after clipping have been reported from our center, but only one other case has been found in the literature. In recent years, a surprising number of patients have presented in which this seemingly unimportant remnant of the aneurysm neck dilated over a long period to form another dangerous aneurysm. This study reviews our case material and stresses the need for complete occlusion of aneurysm necks and the importance of seeking residual aneurysm necks on postoperative angiography.

Clinical Material and Methods

Nineteen patients, 17 of whom had recurrent hemorrhage or mass effect, were referred with regrowth of aneurysms (one patient had two recurrent aneurysms). The regrowth arose proximal to the clip from a tiny portion of aneurysm neck which remained after the initial surgery. These aneurysms were originally operated on prior to 1982 and represent approximately 1% of the series treated at our institution at that time, not all of which were clipped. No patient operated on after 1981 has presented with this phenomenon. The clinical presentation and the radiological, surgical, and postmortem findings of these 19 patients were analyzed. Radiologically, a residual aneurysm neck is defined as a small segment at the base of the aneurysm proximal to a clip which still fills with contrast material on postoperative angiography. The size of the neck remnant was defined as the maximum distance between the clip and the wall of the adjacent parent vessel, measured from a film in the best projection and corrected to magnification factors. Many different clips were used (Table 1) but none of these aneurysms was reinforced, such as by gauze packing.

Results

Fourteen of the 19 patients in this series were female, one of whom had two recurrent aneurysms. The age of the patients at first surgery ranged from 18 to 66 years (mean 36.2 years), with 14 patients aged younger than 40 years. The first clinical presentation in all cases was subarachnoid hemorrhage (SAH). After successful clipping of the aneurysm, postoperative angiography was
Regrowth of cerebral aneurysms

### TABLE 1

**Summary of 19 cases with regrowth of aneurysm sacs***

<table>
<thead>
<tr>
<th>Case No. &amp; Year of 2nd Presentation</th>
<th>Age, Sex†</th>
<th>Aneurysm Location &amp; Size‡</th>
<th>Size of Residual Neck (mm)</th>
<th>Clip Used</th>
<th>2nd Presentation</th>
<th>Size of New Aneurysm</th>
<th>Interval (yrs)</th>
<th>Surgery</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1965</td>
<td>33, F</td>
<td>PCoA (small)</td>
<td>1-2 mm</td>
<td>McKenzie, silver</td>
<td>SAH</td>
<td>10 mm</td>
<td>4</td>
<td>yes</td>
<td>good</td>
</tr>
<tr>
<td>2, 1965</td>
<td>41, F</td>
<td>ACoA (small)</td>
<td>1-2 mm</td>
<td>Olivecrona, silver</td>
<td>SAH</td>
<td>15 mm</td>
<td>11.5</td>
<td>no</td>
<td>died</td>
</tr>
<tr>
<td>3, 1975</td>
<td>33, F</td>
<td>BB (small)</td>
<td>1-2 mm</td>
<td>Heifetz</td>
<td>SAH</td>
<td>6 mm</td>
<td>3</td>
<td>no</td>
<td>died</td>
</tr>
<tr>
<td>4, 1979</td>
<td>40, F</td>
<td>BB (small)</td>
<td>1-2 mm</td>
<td>Heifetz</td>
<td>SAH</td>
<td>large (necro)</td>
<td>5</td>
<td>no</td>
<td>died</td>
</tr>
<tr>
<td>5, 1979</td>
<td>30, F</td>
<td>BB (small)</td>
<td>1-2 mm</td>
<td>Scoville</td>
<td>SAH</td>
<td>4 mm</td>
<td>4</td>
<td>yes</td>
<td>good</td>
</tr>
<tr>
<td>6, 1980</td>
<td>22, F</td>
<td>VB junct (small)</td>
<td>1-2 mm</td>
<td>Heifetz</td>
<td>SAH</td>
<td>14 mm</td>
<td>4.5</td>
<td>yes</td>
<td>good</td>
</tr>
<tr>
<td>7, 1980</td>
<td>47, F</td>
<td>PCoA</td>
<td>1-2 mm</td>
<td>Scoville</td>
<td>SAH</td>
<td>8 mm</td>
<td>11</td>
<td>yes</td>
<td>died</td>
</tr>
<tr>
<td>8, 1980</td>
<td>34, M</td>
<td>BB (small)</td>
<td>1 mm</td>
<td>Mayfield</td>
<td>SAH</td>
<td>25 mm</td>
<td>7</td>
<td>yes</td>
<td>died</td>
</tr>
<tr>
<td>9, 1982</td>
<td>26, F</td>
<td>PCoA (small)</td>
<td>no angio</td>
<td>Weck</td>
<td>control</td>
<td>5 mm</td>
<td>5</td>
<td>yes</td>
<td>good</td>
</tr>
<tr>
<td>10, 1983</td>
<td>48, F</td>
<td>BB (small)</td>
<td>1 mm</td>
<td>Heifetz</td>
<td>mass</td>
<td>25 mm</td>
<td>13</td>
<td>yes</td>
<td>poor</td>
</tr>
<tr>
<td>11, 1984</td>
<td>36, F</td>
<td>AChA</td>
<td>NA</td>
<td>Olivecrona, silver</td>
<td>SAH</td>
<td>6 mm</td>
<td>20</td>
<td>yes</td>
<td>poor</td>
</tr>
<tr>
<td>12, 1984</td>
<td>18, M</td>
<td>VB junct</td>
<td>2 mm</td>
<td>silk ligature &amp; Heifetz</td>
<td>mass</td>
<td>25 mm</td>
<td>11</td>
<td>yes</td>
<td>good</td>
</tr>
<tr>
<td>13, 1985</td>
<td>37, F</td>
<td>PICA</td>
<td>NA</td>
<td>Heifetz</td>
<td>SAH</td>
<td>3 mm</td>
<td>7</td>
<td>yes</td>
<td>good</td>
</tr>
<tr>
<td>14, 1985</td>
<td>38, F</td>
<td>PICA (small)</td>
<td>1-2 mm</td>
<td>Heifetz</td>
<td>SAH</td>
<td>5 mm</td>
<td>10</td>
<td>yes</td>
<td>good</td>
</tr>
<tr>
<td>15, 1985</td>
<td>33, F</td>
<td>VB junct (small)</td>
<td>2 mm</td>
<td>Scoville</td>
<td>SAH</td>
<td>13 mm</td>
<td>7</td>
<td>yes</td>
<td>good</td>
</tr>
<tr>
<td>16, 1986</td>
<td>37, F</td>
<td>PCoA (small)</td>
<td>1 mm</td>
<td>Weck</td>
<td>SAH</td>
<td>17 mm</td>
<td>9</td>
<td>yes</td>
<td>good</td>
</tr>
<tr>
<td>17, 1986</td>
<td>37, M</td>
<td>BB (small)</td>
<td>1 mm</td>
<td>Drake</td>
<td>control</td>
<td>3 mm</td>
<td>6</td>
<td>yes</td>
<td>good</td>
</tr>
<tr>
<td>18, 1987</td>
<td>66, M</td>
<td>VB junct (small)</td>
<td>1 mm</td>
<td>Drake</td>
<td>SAH</td>
<td>15 mm</td>
<td>6</td>
<td>no</td>
<td>good</td>
</tr>
<tr>
<td>19, 1987</td>
<td>54, F</td>
<td>MCA (small)</td>
<td>4 mm§</td>
<td>silk ligature &amp; Heifetz</td>
<td>SAH</td>
<td>15 mm</td>
<td>24</td>
<td>yes</td>
<td>good</td>
</tr>
</tbody>
</table>

* PCoA = posterior communicating artery; ACoA = anterior communicating artery; BB = basilar bifurcation; VB junct = vertebrobasilar junction; AChA = anterior choroidal artery; PICA = posterior inferior cerebellar artery; MCA = middle cerebral artery; SAH = subarachnoid hemorrhage; NA = films not available but reported as tiny or small residual neck; angio = angiography; necro = necropsy.

† Age (years) at first surgery.
‡ Small = < 12 mm; large = 12 to 25 mm; giant = > 25 mm.
§ Ligature used instead of clip to protect adherent branch.

performed on all patients except one (a young pregnant woman, Case 9). In that case, the aneurysm neck was coagulated prior to clipping and the sac was opened and evacuated prior to its occlusion; however, a small "dog ear" can be seen in the operative photograph just inside the clip (Fig. 1). This was the only recurrent aneurysm in which the original neck was coagulated.

Angiograms after the first operation showed that the residual neck was not more than 1 mm wide in six aneurysms, 1 to 2 mm wide in 10, and 4 mm wide in one. In two other cases, the films were not available and only the report indicating "small" or "tiny" residual neck was given (Table 1). Necks measuring 1 mm or less were reported postoperatively as "complete obliteration of the aneurysm." This is similar to the two cases reported by Ebina, et al., in which a small residual neck of the aneurysm may be suspected from the postoperative angiograms published in the article. Three of our earlier recurrences were also initially misinterpreted as due to a "slipped clip." The locations of the aneurysms in this series were: six at the basilar bifurcation and four at the vertebrobasilar junction, two arising from the posterior inferior cerebellar artery, four from the posterior communicating artery, one from the anterior choroidal artery, one from the anterior communicating artery, and two from the middle cerebral artery (Table 2). Most original aneurysms were small (< 12 mm in maximum diameter) as shown in Table 1. There was no correlation between regrowth and the type of clip used.

These 19 patients presented again at intervals ranging from 3 to 24 years (average almost 9 years). Fourteen patients rebled at the site of the surgically treated aneurysm and one (Case 1) bled from another aneurysm. Two other patients had symptoms of mass effect caused by the new sac that grew to giant size (Fig. 2), and in the two remaining cases the recurrent aneurysm was

### TABLE 2

**Location of 20 recurrent aneurysms in 19 patients**

<table>
<thead>
<tr>
<th>Artery of Origin</th>
<th>No. of Aneurysms</th>
</tr>
</thead>
<tbody>
<tr>
<td>basilar bifurcation</td>
<td>6</td>
</tr>
<tr>
<td>vertebrobasilar junction</td>
<td>4</td>
</tr>
<tr>
<td>posterior inferior cerebellar</td>
<td>2</td>
</tr>
<tr>
<td>posterior communicating</td>
<td>4</td>
</tr>
<tr>
<td>anterior choroidal</td>
<td>1</td>
</tr>
<tr>
<td>anterior communicating</td>
<td>1</td>
</tr>
<tr>
<td>middle cerebral</td>
<td>2</td>
</tr>
<tr>
<td>total</td>
<td>20</td>
</tr>
</tbody>
</table>
found in a delayed follow-up angiogram. In one patient who rebled (Case 14), two recurrent aneurysms were found (Fig. 3). The tiny remaining neck grew to a large (12 to 25 mm) or giant (> 25 mm) size in 50% of the patients in this group.

Three patients in the present study (Cases 2, 3, and 4) died from massive SAH before treatment could be given. Postmortem examination demonstrated rupture of a recurrent aneurysm located proximal to the surgical clip as well as an old fibrotic sac distal to it.

Fifteen patients underwent surgery again and in all cases a new sac was found ballooning out beneath an intact clip (14 cases) or ligature (one case). In many instances the old wrinkled sac could be identified beyond the clip blades. In some cases the old clip was...
Regrowth of cerebral aneurysms

removed but in others this maneuver was considered too dangerous. The recurrent aneurysm was occluded by clip in 12 patients, and in three cases of giant aneurysm of the posterior circulation, occlusion of the parent vessel (two with a Drake tourniquet) was considered the only feasible method of treatment. One patient in this study (Case 18) did not undergo reoperation after the diagnosis of recurrent aneurysm because of his age and severe atherosclerotic involvement of the intracranial vessels noted at the time of his first surgery. The outcome of the 15 patients treated by surgery was good in 11 and poor in two. Two patients died (Cases 7 and 8): one from an inexplicable contralateral carotid thrombosis after successful surgery and the other from rupture of the new giant aneurysm in spite of basilar artery occlusion.

Discussion

In 1965, McKissock reported an extraordinary case of recurrence of a middle cerebral artery aneurysm 11 years after it had been double-clipped and excised. The first such case at our center appeared in the same year, and the preoperative radiological diagnosis was a “slipped clip.” In the following year three cases were diagnosed at autopsy examination and two subsequent cases were misdiagnosed as being caused by a slipped clip. Our present experience in these 19 patients suggests that the incidence of an aneurysm regrowing after incomplete clipping, although infrequent, has been underestimated. One of the reasons may be the lack of recognition of this phenomenon, not only by neuroradiologists but also by neurosurgeons: diagnosis may be of a new aneurysm rather than regrowth from a remnant of the neck. We believe that the two cases published by Ebina et al. fall into that category, although no mention is made of a tiny residual neck.

The mean age of our group of patients at the first aneurysm rupture was significantly younger than that reported by the Cooperative Study and McCormick and Acosta-Rua. Alcock and Canham, in an angiographic study of the growth of intracranial aneurysms, found a significant negative correlation of growth with the age of the patient, concluding that aneurysms in young people grow more rapidly than in older individuals. Our experience in aneurysm regrowth agrees with their findings, suggesting that young patients have a higher risk of developing larger aneurysms from the tiny remnant at the incompletely clipped neck. The marked female predominance in our study is in accordance with the fact that females are generally more susceptible to aneurysm formation. No other risk factors were identified in this group of patients.

No consistent rate of regrowth of aneurysmal sacs was noted. The size of the new sac was not related...
either to the size of the original aneurysm or to the
time interval between the first and second presentations
(Table 1).

Aneurysm regrowth from a residual neck is signifi-
cant in that a potentially fatal SAH may subsequently
occur. Two-thirds of our patients presented with recur-
rent hemorrhage, three of which were fatal. The single
case in the series of Feuerberg, et al.,11 which demon-
strated regrowth also rebled. Most of the patients in our
group had recurrent aneurysms of the posterior cir-
(20 cases of the series), whereas only one of 27
patients in the Feuerberg study had aneurysms of the
vertebrobasilar circulation. This difference must be re-
lated to the larger percentage (nearly 50%) of poste-
terior aneurysms operated on at our unit and also to the
fact that these aneurysms are less easily or less widely
exposed for clipping and proportionately more neck
remnants may be left. Basilar bifurcation aneurysms,5,18
which comprised one-third of this series, are notorious
for having broad and bulbous bases which are difficult
to clip completely. Presumably, the mechanism of re-
growth reflects the existence of the same biophysical
forces described for the growth of the original aneu-
rysm.4,10,20

This study shows that opening the aneurysm after
clipping, a standard procedure at our institution, does
not preclude the existence of a residual neck proximal
to the clip. The value of coagulating the neck at surgery
is controversial since the heat may weaken the artery
wall. The only way to be completely sure that no
aneurysm remnant exists is to confirm that fact on postoperative angiograms. The conclusion that postop-
erative angiography is required for full evaluation of
the results of clipping was also drawn by Suzuki, et al.19
They proposed that patients with residual aneurysm
neck be followed either by reoperation or by careful
monitoring; however, the extent of incompleteness of
clipping was not documented.

In conclusion, our experience stresses the importance
of placing an aneurysm clip flush with the origin of the
neck of the aneurysm and in the long axis of the
bifurcation, if possible, to avoid “dog ears.” Even a
small portion of the remaining neck has the potential
to enlarge and form another dangerous aneurysm. Al-
though a small residual neck measuring from 1 to 2
mm may not justify immediate reoperation, the risk of
aneurysm recurrence over a long period of time should
be considered. Thus, when a residual neck remains, a
long-delayed postoperative reassessment by angiog-
raphy or magnetic resonance imaging (3 to 5 years after
clipping) may be of value, especially in young patients.

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