Effect of Common Carotid Ligation on Size of Internal Carotid Aneurysms and Distal Intracarotid and Retinal Artery Pressures*

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Previous investigators have demonstrated significant changes in aneurysms of the internal carotid artery after ligation of the common carotid artery. Follow-up carotid arteriography in 26 patients treated with this method in our clinic revealed a significant decrease in aneurysm size in 14, non-visualization of the aneurysm in 9, and no change in size in 3 cases. Since these cases were reported, we have had 32 additional patients who have been treated by common carotid ligation for an aneurysm of the internal carotid artery. They have undergone follow-up studies which include repeat carotid arteriography and determination of the residual intravascular and retinal artery pressures. In this paper, we have analyzed the changes that occur in the aneurysm and in the intravascular and retinal artery pressures following carotid ligation.

Material

From November, 1957, through October, 1965, a total of 82 patients have been readmitted to the hospital in order to carry out repeat carotid arteriography and measurement of the distal intracarotid and retinal artery pressures. Each had had an aneurysm of the internal carotid artery treated by gradual ligation of the common carotid artery using a Crutchfield clamp. In 58 of the 82 patients, satisfactory follow-up carotid arteriography was accomplished. These 58 patients formed the basis for this report.†

The patients were divided into 3 groups according to the location of the aneurysm on the internal carotid artery.

Group 1. The aneurysm was situated at the site of origin of the posterior communicating artery—41 patients. Group 2. The aneurysm was located between the posterior communicating artery and cavernous sinus—12 patients. Group 3. The aneurysm was situated in the cavernous sinus or carotid canal (extradural)—5 patients.

Thirty-eight of the patients were women and 20 were men. Mean age of the women and men was 46.4 and 45.6 years, respectively. Forty-six patients had experienced one or more subarachnoid hemorrhages verified by lumbar puncture prior to surgical treatment. In 12 patients the aneurysm had not ruptured. The most common presenting clinical finding in this latter group was paralysis of the 3rd cranial nerve; 8 patients showed this sign.

Method

Bilateral carotid arteriography was performed shortly after admission to the hospital. Operation was usually carried out on the day that the arteriogram was performed. The common carotid and proximal portions of the internal and external carotid arteries were surgically exposed with the patient under local anesthesia. Intravascular pressure measurements were made through a 19-gauge needle inserted into the common carotid artery near its bifurcation. After obtaining control measurements, the common carotid was occluded proximal to the recording needle and the reduction in intravascular pressure measured.‡ A Crutchfield clamp was applied to the common carotid artery and the clamp closed to the point at which a slight reduction in the distal intracarotid pressure was effected (approximately 10% reduction). The portion of the clamp (screwdriver assembly) that remains outside the wound was brought out through a separate stab wound. The interval required for clamp closure varied from 1 day to 2

† Prior to 1960, intravascular pressures were recorded using a Sanborn electromanometer. Since this date, the measurements have been obtained with a Statham transducer, Model P23dB. The recordings were made on a Sanborn twin-viso direct writing recorder.
weeks. In each patient, the screwdriver portion of the clamp was removed 24 hours after the common carotid artery had been completely occluded.

Follow-up carotid arteriography and measurements of intravascular pressure were performed at intervals ranging from 1 day to 48 months after complete closure of the clamp. All patients were hospitalized in order to carry out these studies. Both the arteriogram and intravascular pressure measurement were accomplished by percutaneous puncture of the internal carotid artery above the site of common carotid ligation. Intravascular pressure measurements were made as described above. The per cent reduction in distal intracarotid pressure was computed by comparing it either with simultaneously measured intravascular pressure in the opposite common carotid artery or with brachial artery pressure obtained with a sphygmomanometer.

Retinal artery pressures were measured with a Baillart ophthalmodynamometer both at the time of complete clamp closure and follow-up arteriography.11 The ophthalmodynamometer is not designed to measure values in excess of 150 gm. of water. In 32 cases, the systolic pressure at one time or another was greater than 150 gm. of water. Thus, comparative studies between the two eyes both at the time of clamp closure and at the time of follow-up study could not be made in these cases.

Effect of Carotid Ligation on the Aneurysm

The data are shown in Table 1 and the changes illustrated in Figs. 1–4.

Group 1. 41 cases. The aneurysm was not visualized in 12 patients (Fig. 1), was significantly smaller in 19 (Fig. 2), was unchanged in 9, and was larger in 1 case.

Group 2. 12 cases. The aneurysm was not visualized in 4 (Fig. 3), was significantly smaller in 4, and was unchanged in 4 cases.

Group 3. 5 cases. Of this group, 1 was not visualized, 3 were significantly smaller (Fig. 4), and 1 showed no change.

Thus, in 58 patients with aneurysms on the internal carotid artery, the aneurysm was not visualized in 17 patients (29.3%), was significantly smaller in 26 (44.8%), was unchanged in size in 14 (24.1%), and was larger in 1 case (1.7%). The mean time interval between complete closure of the clamp and follow-up arteriography was 14.6 months in the group in whom the aneurysm was not visualized, 9.4 months in those patients in whom the aneurysm was significantly smaller, and 10.6 months in those patients in whom the aneurysm was unchanged.

Pressure Measurements

A. Intravascular pressure. The terms “immediate” and “late” intravascular pressures refer to measurements made at the time of application of the Crutchfield clamp and at the time of follow-up carotid arteriography, respectively. Immediate intravascular pressure recordings were made in all 58 cases and late intravascular pressure measurements in

<table>
<thead>
<tr>
<th>Location of Aneurysm</th>
<th>No. of Cases</th>
<th>Interval* (mean) mos.</th>
<th>Status of Aneurysm (No. of Cases)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not Visualized</td>
</tr>
<tr>
<td>Group 1. Bifurcation, post-comm.</td>
<td>41</td>
<td>11.74</td>
<td>12</td>
</tr>
<tr>
<td>Group 2. Between post-comm. and cavernous sinus</td>
<td>12</td>
<td>11.88</td>
<td>4</td>
</tr>
<tr>
<td>Group 3. Cavernous sinus, carotid canal</td>
<td>5</td>
<td>16.67</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>58</td>
<td></td>
<td>17 (29.3%)</td>
</tr>
</tbody>
</table>

* Interval between complete closure of clamp and follow-up arteriography.
Effects of Common Carotid Ligation

42 patients. Mean values for immediate and late intravascular pressure reductions for the 42 cases that had both sets of measurements are shown in Table 2. In 10 patients in whom the immediate pressure reduction was less than 40%, the average immediate and late pressure reductions were 31.1 and 30.8%, respectively; in 28 patients in whom there was an immediate reduction from 40 to 60%, the average immediate and late reductions, respectively, were 50.0 and 28.1%; for those with immediate reductions greater than 60%, average immediate and late reductions were 66.0 and 25.5%. These data show that although the initial, or immediate, reduction in intravascular pressure was not maintained, a significant decrease persisted. It is noteworthy that there is less difference in the late than in the immediate intravascular pressure reduction; the average late pressure reduction ranged from 25.5 to 30.8%, whereas, the average immediate pressure reduction ranged

**Fig. 1.** Case 53. Right lateral carotid arteriogram (a) before and (b) 8 months after carotid ligation for internal carotid aneurysm at site of origin of posterior communicating artery. The aneurysm is not visualized and the internal carotid artery is decreased in size on follow-up arteriography.

**Fig. 2.** Case 49. Right lateral carotid arteriogram (a) before and (b) 16 months after carotid ligation. Aneurysm in same location as Case 53 (Fig. 1). There is significant decrease in size of the aneurysm on follow-up arteriography.
from 31.1 to 66.0% (Table 2).

B. Retinal artery pressures. "Immediate" and "late" retinal artery pressures refer to measurements made at the time of complete clamp closure and at the time of follow-up carotid arteriography, respectively. In 26 patients, immediate and late systolic and diastolic pressures were obtained. These data are shown in Table 3. The average difference between the two eyes in immediate and late systolic retinal artery pressure was 40 and 30% respectively. Immediate and late diastolic pressure differences were 33 and 23% respectively.

These findings combined with the intravascular pressure measurements show that

![Fig. 3 Case 40. Left lateral carotid arteriogram (a) before and (b) 8 months after carotid ligation for internal carotid aneurysm (Group 2). The aneurysm is not visualized and the internal carotid is smaller on follow-up arteriography.](image)

![Fig. 4. Case 8. Right lateral carotid arteriogram (a) before and (b) 13 months after carotid ligation for internal carotid aneurysm in cavernous sinus. There is significant decrease in size of the aneurysm.](image)
although the initial pressure reduction is not maintained, a significant reduction in pressure persists on the side of carotid ligation.

Correlation of Immediate and Late Pressure Reductions with Changes in Size of the Aneurysm

A. Intravascular pressure.

1. Immediate pressure reductions. The data are shown in rows 1 and 2 of Table 4. The reduction in intravascular pressure was 50% or less in 37 patients. In this group, the aneurysm was significantly smaller in 17, and in 9 cases showed no change in size on follow-up arteriography. In 21 cases, the intravascular pressure reduction was greater than 50%. In 6 cases the aneurysm was not visualized, in 9 it was significantly smaller, in 5 it showed no change, and in 1 case it was larger.

2. Late intravascular pressure reductions. The data are shown in rows 3 and 4 of Table 4. The reduction in intravascular pressure above the site of ligation was less than 25% in 20 cases. There was no visualization of the aneurysm in 7. It was significantly smaller in 9, and in 4 cases there was no change. In the remaining 22 cases, the intravascular pressure reduction was greater than 25%. The aneurysm was not visualized in 7 cases, was significantly smaller in 10, and in 6 cases showed no change. These data indicate that the changes which occur in the aneurysm are not related to either the "immediate" or "late" reduction in intravascular pressure. The changes in the aneurysms in those patients showing a small reduction in intravascular pressure were comparable to those with a greater pressure reduction.

B. Retinal artery pressures. There was no correlation between the per cent difference between the two eyes, either "immediate" or "late," and the changes which occurred in the aneurysm shown on follow-up carotid arteriography.

| TABLE 2 |

Average “immediate” and “late” intravascular pressure reductions

<table>
<thead>
<tr>
<th>&quot;Immediate&quot; Reduction</th>
<th>No. of Patients</th>
<th>Average Interval (mos.)</th>
<th>Average Pressure Reductions</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;60%</td>
<td>10</td>
<td>11.8</td>
<td>81.1%</td>
</tr>
<tr>
<td>60-60%</td>
<td>28</td>
<td>13.9</td>
<td>50.0%</td>
</tr>
<tr>
<td>&gt;60%</td>
<td>4</td>
<td>9.5</td>
<td>60.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25.5%</td>
</tr>
</tbody>
</table>

| TABLE 3 |

"Immediate" and “late” systolic and diastolic retinal artery pressures (26 patients)

<table>
<thead>
<tr>
<th></th>
<th>Avg. % Difference Between the Two Eyes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;Immediate&quot;</td>
</tr>
<tr>
<td>Systolic</td>
<td>40</td>
</tr>
<tr>
<td>Diastolic</td>
<td>33</td>
</tr>
</tbody>
</table>

| TABLE 4 |

Relation of “immediate” and “late” intravascular pressure reductions to changes in the aneurysm

<table>
<thead>
<tr>
<th></th>
<th>% Reduction</th>
<th>No. of Patients</th>
<th>Status of Aneurysm (No. of Cases)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not Visualized</td>
</tr>
<tr>
<td>“Immediate” intravascular pressure reductions (38 cases)</td>
<td>50% or less</td>
<td>37</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>&gt;50%</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td>“Late” intravascular pressure reductions (42 cases)</td>
<td>25% or less</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>&gt;25%</td>
<td>22</td>
<td>7</td>
</tr>
</tbody>
</table>
TABLE 5
Relation of interval elapsing between ligation and follow-up carotid arteriography to changes in aneurysms (58 patients)

<table>
<thead>
<tr>
<th>Interval Between Ligation and Follow-up Arteriography</th>
<th>No. of Patients</th>
<th>Interval* (mean) mos.</th>
<th>Status of Aneurysm (No. of Cases)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not Visualized</td>
</tr>
<tr>
<td>&lt;6 mos.</td>
<td>18</td>
<td>1.9</td>
<td>1</td>
</tr>
<tr>
<td>6 mos. to 1 year</td>
<td>15</td>
<td>8.4</td>
<td>5</td>
</tr>
<tr>
<td>&gt;1 year</td>
<td>25</td>
<td>18.6</td>
<td>11</td>
</tr>
</tbody>
</table>

* Mean in months elapsing between carotid ligation and follow-up arteriography.

Relation of Time Interval Between Carotid Ligation and Follow-up Arteriography to Status of Aneurysm

These data are shown in Table 5. In 18 patients in whom follow-up arteriography was performed within 6 months of clamp closure, the aneurysm was not visualized in 1 patient, was significantly smaller in 11, and was unchanged in 6 patients. In 15 patients in whom follow-up arteriography was performed between 6 months and 1 year of clamp closure, the aneurysm was not visualized in 5 patients, was significantly smaller in 7, and was unchanged in 3 patients. The interval between clamp closure and repeat arteriography was greater than 1 year in 25 patients, ranging from 13 months to 4 years (mean—18.6 mos.). In 11 patients (44%), the aneurysm was not visualized, in 8 it was significantly smaller, in 5 patients there was no change, and in 1 patient, the aneurysm was larger.

Thus, the changes which occurred in the aneurysms correlated with the time interval elapsing between carotid ligation and follow-up study in that there was a significantly higher incidence of aneurysms not visualized when the interval of follow-up was 1 year or longer. In 18 patients in whom follow-up arteriography was performed in less than 6 months, the aneurysm was not visualized in only 1 case (5.6%), whereas in 25 cases in whom follow-up studies were carried out 1 year or more from the time of carotid ligation, the aneurysm was not visualized in 11 patients (44%).

Other findings noted on follow-up arteriography included a decrease in caliber of the ipsilateral internal carotid artery. There was a significant decrease in the size of the internal carotid artery above the site of carotid ligation in 30 of 58 patients (52%).

Relation of Presence of Posterior Communicating Artery to Change in Aneurysm

These data are shown in Table 6. In 16 patients, the ipsilateral posterior communicating artery was visualized on the preoperative carotid arteriogram. Follow-up arteriography in this group showed that the aneurysm was not visualized in 5, was significantly smaller in 8, and was unchanged in size in 3 patients. The results were similar in those patients in whom the ipsilateral posterior communicating artery was not visualized on the preoperative carotid arteriogram. In this group of 41 cases, the aneurysm was not visualized in 11, was significantly smaller in 23, was unchanged in 6, and was larger in 1 case.

Clinical Features

Forty-six of 58 patients had experienced at least one subarachnoid hemorrhage prior to surgical treatment. Follow-up arteriography

TABLE 6
Relation of presence of posterior communicating artery to status of aneurysm

<table>
<thead>
<tr>
<th>Preoperative Ipsilateral Visualization of Posterior Communicating Artery</th>
<th>No. of Cases</th>
<th>Status of Aneurysm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Not Visualized</td>
</tr>
<tr>
<td>Present</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>Absent</td>
<td>41</td>
<td>11</td>
</tr>
</tbody>
</table>
in these patients showed that the aneurysm was not visualized in 14 patients, was significantly smaller in 20, was unchanged in size in 11, and was larger in 1 patient. Twelve patients had not experienced a subarachnoid hemorrhage prior to carotid ligation. In these 12 cases, follow-up arteriography revealed that the aneurysm was not visualized in 3, was significantly smaller in 6, and showed no change in 3 cases.

Paralysis of the oculomotor nerve on the side of the aneurysm was present in 19 of the 58 patients. Following carotid ligation there was functional return in this nerve in 8 and no improvement in 11 patients. The mean interval from carotid ligation to follow-up study in the 8 cases showing functional return was 10.3 months, and in the 11 patients with no improvement, 12.2 months. In 4 of this latter group, the interval was less than 4 weeks.

Recurrent subarachnoid hemorrhage following carotid ligation has occurred in 2 cases in the present series and was fatal in both instances.

Discussion

Numerous clinical observations support the conclusion that carotid ligation is an effective method for treatment of aneurysm on the internal carotid artery. These observations include: (1) a significant reduction in the incidence of recurrent subarachnoid hemorrhage; (2) significant decrease in the size of the aneurysm on follow-up carotid arteriography which in some cases amounts to apparent disappearance; (3) functional recovery of oculomotor paralysis; (4) persistent reduction in both intravascular and retinal artery pressures on the side of carotid ligation.

Several investigators have evaluated the frequency of recurrent subarachnoid hemorrhage from an aneurysm following carotid ligation. McKissock and Walsh reported 53 patients with aneurysms of the internal carotid artery treated by carotid ligation. They concluded that common carotid ligation affords a high degree of protection against further hemorrhage from aneurysms on the intracranial carotid artery at the site of origin of the posterior communicating artery. In a more recent study, McKissock et al. reported that 45 (17%) of 266 patients had a recurrent hemorrhage following carotid ligation. However, this group was composed of patients with aneurysms at sites other than the internal carotid artery. German and Black surmised that proximal arterial ligation is a reasonably benign and effective procedure for the treatment of aneurysms of the internal carotid artery. Pool and Potts stated...
"immediate" reduction in the intravascular pressure, the "late" pressure reductions recorded in the internal carotid artery above the site of ligation were similar. For example, in those patients whose "immediate" pressure reduction was less than 30%, the mean "late" pressure reduction was 30.8%, while in the group showing more than 60% "immediate" reduction, the mean "late" pressure reduction was 25.5% (Table 2). There was no correlation between the intravascular pressure reduction and the changes which occurred in the aneurysm following carotid ligation.

One possible mechanism for apparent disappearance or decrease in the size of an aneurysm might conceivably be thrombosis, a process facilitated by the stasis of blood in an aneurysm brought about by the ipsilateral reduction in intravascular pressure accompanying carotid ligation.6 Stasis of blood in an aneurysm after occlusion of the ipsilateral carotid artery has been demonstrated arteriographically by Ecker and Riemenschneider.5

The results of our study indicate that a correlation exists between the duration of follow-up and the changes that occur in the aneurysm. The longer the interval between carotid ligation and follow-up arteriography, the more likely it is that the aneurysm will disappear. In 18 patients in whom the interval was less than 6 months, only 1 case (5.6%), was not visualized; whereas, in 25 cases in whom the interval was 1 year or greater, there were 11 cases (44.0%) in which the aneurysm was not visualized. Also, in those cases in which the aneurysm was not visualized (Table 1) the mean interval between carotid ligation and follow-up arteriography was 14.6 months, and in those in which the aneurysm was unchanged, the interval was 10.6 months.

Gibbs6 thought that the presence of a posterior communicating artery visualized on the preoperative carotid arteriogram may have some influence on the response of the aneurysm to carotid ligation. His findings in a small number of cases suggested that when the ipsilateral posterior communicating was not visualized on the preoperative arteriogram, there was a greater chance for the aneurysm to show a significant reduction in size or to undergo thrombosis. However, the results of our study are not compatible with this viewpoint since the changes in the aneurysm following carotid ligation bore no relationship to the presence of the ipsilateral posterior communicating artery on the preoperative carotid arteriogram (Table 6).

Summary

Follow-up carotid arteriography was performed in 58 patients with a diagnosis of internal carotid aneurysm treated by gradual ligation of the common carotid artery with a Crutchfield clamp. These studies, which included measurement of the intracarotid and retinal artery pressures, were performed from 1 day to 48 months after carotid ligation. There was good visualization of the parent vessel of the aneurysm in each case. The aneurysm could no longer be visualized in 17 patients, was significantly reduced in size in 26, was unchanged in 14, and was larger in 1 patient. Recurrent subarachnoid hemorrhage occurred in 2 cases.

Intravascular pressure in the common carotid artery above the clamp remained significantly lower than systemic arterial pressure and showed a good correlation with retinal artery pressure. The changes in the aneurysm did not correlate with the degree of intravascular pressure reduction measured at the time of application of the Crutchfield clamp, but did correlate with the time interval elapsing between carotid ligation and follow-up study. There was a higher incidence of cases showing non-visualization of the aneurysm when arteriography was performed 1 year or more from the time of carotid ligation.

References


17. **Murphy, F.** Discussion, Luessenhop et al., 13 pp. 554–556.


