SIDE-TO-SIDE ANASTOMOSIS BETWEEN THE EXTERNAL AND INTERNAL CAROTID ARTERIES
IN THE TREATMENT OF CAROTID INSUFFICIENCY*

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With the increased use of arteriography there has been opened to the neurosurgeon an expanding potential field of usefulness in the treatment of cerebrovascular diseases. A better understanding of the pathology of cerebrovascular diseases and of the mechanisms by which symptoms arise, plus the development of better techniques for vascular surgery have now equipped the neurosurgeon to investigate the possibilities for the surgical treatment of thrombotic and embolic disease of the major vessels supplying the brain. That this investigation is already well under way can be seen by some of the papers appearing during the last few years.1,2,6,9-11,13 The present paper is an attempt to illuminate one small facet of the problem.

The most common type of arteriosclerosis to attack the carotid vessels is atherosclerosis, which does not produce a generalized involvement of the vessel wall but a segmental one. The limited area of involvement presents an atherosclerotic plaque in the intima consisting of connective-tissue proliferation and a deposit of lipids. Not only does the plaque grow by the addition of more lipid material and connective tissue but there is formed on its intimal surface a thin layer of blood clot which helps occlude the vessel. Once the vessel is completely occluded, secondary thrombi form distally and proximally,5 and may occlude the whole linear extent of the common and internal carotid arteries. The length of time necessary for such clots to form and to become organized seems to vary from one case to another in our experience.

COMPLETE OCCLUSION

Four persons were operated upon by us for complete occlusion of the common or internal carotid artery. Some of the details of these 4 cases are shown in Table 1. The first thing that strikes one about these patients is that they are relatively young, and this needs emphasis so that one will be looking for the disease in an age group not usually associated with arteriosclerosis. Another thing to note is that there is poor correlation between the duration of symptoms and the apparent age of the clot exposed at operation. But the clot exposed at operation is not the only one to be considered, for

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beyond the limits of exposure there may be other clot of a different age. In each of the 4 patients reported here we were able to remove the clot and atheroma exposed at operation and to restore the lumen of the exposed part of the vessel, yet in each instance there was an obstruction of the vessel at some point beyond our reach. Thus in no instance in which the internal carotid artery was completely obstructed could we establish a return flow of blood through the vessel from its intracranial end, nor could we secure a

### TABLE 1

Four cases of complete carotid occlusion treated by thrombectomy

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Type of Onset</th>
<th>Time from Onset to Operation</th>
<th>Type of Clot Found</th>
<th>Site of Occlusion</th>
<th>Result of Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. E.H.</td>
<td>50</td>
<td>Sudden</td>
<td>9 days</td>
<td>Black, semioorganized clot</td>
<td>Entire internal carotid artery</td>
<td>No improvement</td>
</tr>
<tr>
<td>2. J.S.</td>
<td>58</td>
<td>Sudden</td>
<td>44 days</td>
<td>Soft, black, partly organized clot</td>
<td>Entire internal and common carotid artery</td>
<td>No improvement</td>
</tr>
<tr>
<td>3. B.R.</td>
<td>45</td>
<td>Stuttering</td>
<td>14 days</td>
<td>Atheroma and soft organized clot</td>
<td>Distal part of common and entire internal carotid artery</td>
<td>No improvement</td>
</tr>
<tr>
<td>4. J.C.</td>
<td>52</td>
<td>Slowly progressive</td>
<td>1 year</td>
<td>Atheroma and organized clot</td>
<td>Internal carotid and part of distal common carotid artery</td>
<td>No improvement</td>
</tr>
</tbody>
</table>

flow from the aorta or innominate artery when the lower part of the common carotid was completely obstructed.

These 4 operations must therefore be counted as failures. It is hoped, however, that they will not serve to prevent further attempts at thrombectomy in this type of obstruction because such a small number of cases is too few from which to draw broad generalizations and they should rather be regarded as preliminary attempts at surgical treatment, recognizing that the field of vascular surgery is rather new to neurosurgeons. The thought arises that if one could operate upon atherothrombotic disease of the carotid vessels before the obstruction is complete one might be more successful, and that leads to the presentation of 2 more cases and the main theme of this paper.

### PARTIAL OCCLUSION

In 1951 Miller Fisher suggested that if the carotid occlusion were confined to the region of the carotid bulb it should be possible to relieve it by anastomosing the external carotid artery or one of its branches to the internal carotid beyond the site of obstruction. Strully and his co-workers in 1953 made the same suggestion, but were unable to carry it out in their case because the obstruction was too high. In the past year we have had 2 patients who seemed to lend themselves to this procedure. Table 2 gives a brief summary of the data in these 2 cases. Figs. 1 and 2 show the findings on arteriography which demonstrated the narrowed lumen just above the bifurcation of the common carotid.

The surgical procedure consisted of making an oblique incision along the anterior border of the sternomastoid muscle to expose the distal part of the common carotid artery with its two terminal branches which were ex-
posed as high as possible in the neck. The branches of the external carotid were ligated and divided along with the terminal trunk so as to provide adequate mobility and permit the two main arteries to lie side by side without distortion (Fig. 3). After cutting an ellipse out of adjacent portions of the two arteries and joining them by four equidistant sutures the anastomosis was completed with an over-and-over suture which everted the edges of the elliptical openings (Fig. 4).

The operations were carried out under hypothermia (86°F) because in each case the internal carotid artery was still supplying a substantial part of the circulatory needs of the hemisphere and it was hoped to avoid addi-

### TABLE 2

Two cases of incomplete carotid occlusion treated by side-to-side anastomosis of internal and external carotid arteries

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Mode of Onset</th>
<th>First Symptom</th>
<th>Other Symptoms</th>
<th>Onset to Operation</th>
<th>Site of Occlusion</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. G.S.</td>
<td>58</td>
<td>Apoplectic</td>
<td>Left hemiplegia</td>
<td>Left sensory diminution, slurring of speech, defect in recent memory Recurring attacks of hemiparesis, slurring of speech</td>
<td>21 days</td>
<td>Carotid bulb</td>
<td>Early thrombosis of common: slight improvement of hemiplegia Relief of hemiplegic attacks; partial recovery from hemiparesis</td>
</tr>
<tr>
<td>6. K.A.</td>
<td>53</td>
<td>Stuttering (3 attacks)</td>
<td>Left hemiparesis</td>
<td></td>
<td>9 days</td>
<td>Carotid bulb</td>
<td></td>
</tr>
</tbody>
</table>

tional neurologic damage while the vessels were clamped off during the anastomosis. No harm arose from clamping the vessels even though the anastomosis consumed over an hour in each case. The avoidance of harm may have been the result of hypothermia, or it may only mean that the collateral circulation was adequate. However, it would appear on the basis of animal experiments that under hypothermia one may occlude the carotid artery much longer than was previously considered safe even with reduced temperatures.

When the carotid clamps were released after the first operation there was a strong flow of blood through the internal carotid. However, before the wound was closed the pulsations began to diminish and it is thought that complete thrombosis occurred in the first 24 hours. Perhaps regional heparinization as described by Freeman et al. might have prevented this, or one could operate under general anticoagulation as we did in the later thrombectomies, it being found that prothrombin times of 20 to 25 seconds produced no significant increase in wound bleeding. In the second patient the result was more satisfactory and the anastomosis remained open as shown by a subsequent arteriogram (Fig. 5). When last examined it was still functioning approximately 9 months after surgery.

Both patients showed improvement in their one-sided weakness, the second much more than the first. Although the functioning anastomosis in the second case may have influenced the degree of recovery, yet one cannot assert this with confidence because the natural course of untreated patients is also to show improvement. However, since operation this patient has re-
Fig. 1. Case 5. Partial occlusion of internal carotid artery just above bifurcation.

Fig. 2. Case 6. Partial occlusion of internal carotid artery just above bifurcation.
mained free of recurring attacks of hemiparesis and it would seem that this could reasonably be attributed to the anastomosis.

DISCUSSION

Miller Fisher's suggestion to anastomose the external carotid artery to the internal in order to by-pass an obstruction is thus shown to be a feasible
procedure, but is it the best way to deal with the problem? To me it would seem that the method has some inherent defects. In the first place, the external carotid branches so freely that its size diminishes rapidly and so the length of usable artery is quite short and the anastomosis must be close to the bifurcation of the common carotid. Perhaps a more serious objection is the need to divide the branches and terminal trunk of the artery in order to have it lie easily beside the internal carotid. This destroys any collateral circulation that may be reaching the ipsilateral hemisphere through the ophthalmic artery, which may be quite important.\textsuperscript{14}

As for the effectiveness of a side-to-side anastomosis, this, too, is open to question. Such an anastomosis inevitably reduces the lumen of the involved vessels by the amount of the wall used up in evertting the edges of the stoma. In vessels the size of the external and internal carotid such a loss is significant and the variation in the lumen of the vessel may be conducive to thrombosis. Linton and Menendez\textsuperscript{7} have shown that in the iliac vessels an end-to-side anastomosis is much more likely to remain patent than is an end-to-end anastomosis, and it seems likely that this will also hold true for vessels as small as the carotids. But the rapidly diminishing terminal trunk of the external carotid artery is not adapted to making an end-to-side anastomosis. It would therefore seem that the problem of partial occlusion of the internal carotid artery at or near the carotid bulb could be most effectively answered.

\textbf{Fig. 5. Case 6. Functioning anastomotic shunt between the external and internal carotid arteries.}
by an arterial graft which would be united to the common carotid and to a point on the internal carotid distal to the obstruction by end-to-side anastomosis. Thus the external carotid circulation would not be disturbed and the obstruction in the internal carotid would be by-passed effectively.

**SUMMARY**

1. Six cases of partial or complete obstruction of the internal carotid artery are presented. All of the patients were treated by surgery.
2. Of the 4 patients having complete obstruction none was helped by attempted thrombectomy.
3. The 2 patients with partial obstruction were treated by joining the external carotid artery to the internal carotid by side-by-side anastomosis. One of these was relieved of recurring attacks of hemiplegia during the 9 months of observation; the other was not benefited.
4. The disadvantages of a side-to-side anastomosis between the external and internal carotid arteries are enumerated, and a better method of by-passing an obstruction is suggested.

**REFERENCES**

8. Meyer, J. S. Personal communication.

**DISCUSSION**

**Dr. Francis Murphrey:** Dr. Wegner is to be congratulated on his efforts to correct one of the most common abnormalities in the circulation of the brain. We have been interested in this problem for some time and we feel it is an extremely urgent one. In our experience at least, it seems to be one of the most common, if not the most common cause of cerebrovascular accidents.
TREATMENT OF CAROTID INSUFFICIENCY

At the present time, as Dr. Wegner stated, it is certainly not possible to say whether the procedure that he demonstrated or a graft or resection with end-to-end anastomosis or thromboendarterectomy is going to turn out to be the best procedure. We have attempted 14 thromboendarterectomies and in 8 of these we have been unable to obtain a retrograde flow, presumably because of an organized clot. In 6 cases we did obtain a good retrograde flow and in 4 of these patients (five arteries) the arteries have remained patent as proven by arteriography weeks or months later. In 2 cases thrombosis occurred and anticoagulants were used in neither of these.

[Slide] This is the arteriogram of a white male, aged 45, who had sudden onset of hemiplegia and aphasia a week before we saw him. It shows a complete occlusion of the internal carotid artery just above the bifurcation in the neck and an embolus to the ascending frontoparietal branch of the middle cerebral artery. We were, of course, aware that nothing could be done in the neck to alleviate the condition in the head, but we felt he might make a fairly good recovery if further emboli were prevented. This was discussed with the family and it was decided to do an endarterectomy. However, before we did so, an arteriogram on the other side was carried out. [Slide] This showed marked stenosis on the right side. Thromboendarterectomy was carried out on the left and a month later [slide] this arteriogram showed the artery to be patent.

The patient wanted to push his luck and have the other side operated upon. This was carried out about a month after the first operation and [slide] this arteriogram was made a month after the second operation showing that this artery was also patent.

The second patient is a 65-year-old man who for several months had been deteriorating mentally and had had attacks of transitory right hemiparesis. Examination showed that the right carotid was occluded all the way from the clavicle to the base of the skull. There was a bruit over the carotid bifurcation on the left and when this artery was occluded by pressure, the patient lost consciousness. An arteriogram on the left side [slide] showed marked stenosis of this vessel. [Slide] This is a vertebral arteriogram which shows he is getting most of his blood into the carotid circulation by way of the vertebral artery.

It was believed that this man would probably improve if we could increase the total volume of blood going into the carotid circulation, and thromboendarterectomy was advised and carried out. [Slide] One month later this is the arteriogram showing the patent artery. [Slide] One-half second later shows adequate filling of the circulation on this side. This man has had no more transitory attacks of hemiparesis. He is now normal mentally and is an effective human being. I understand he has gone back to work.