Effect of common carotid ligation on giant aneurysms of the internal carotid artery

Computerized tomography study

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The effects of common carotid artery ligation on five giant aneurysms (greater than 2.5 cm in diameter) of the internal carotid artery were studied by computerized tomography (CT). Four aneurysms thrombosed completely and one partially. The CT image of the thrombosed part in giant aneurysms is protean, varying from hyperdensity in the immediate postoperative period to isodensity and finally to inhomogeneously increased or decreased density, the attenuation values depending on the different stages of organization of the thrombus and on calcium deposition.

KEY WORDS • common carotid artery • internal carotid artery • carotid ligation • giant aneurysm • computerized tomography • thrombosis

Giant aneurysms of the internal carotid artery (ICA) present a difficult problem. Although good results can be obtained with direct microsurgical attack,5,14,15 cervical carotid ligation, with or without bypass procedures,1,2,9,11,18 remains a valid treatment for these lesions. In the last 10 years, 12 patients were admitted to our hospital with giant aneurysms of the ICA. Five of these patients underwent common carotid ligation (CCL). This paper demonstrates the value of postoperative computerized tomography (CT) in these cases.

Summary of Cases

Clinical Material

All patients in this series were women, varying in age from 33 to 62 years at onset of symptoms. The patients presented with visual disturbances, trigeminal neuralgia, and chronic headache. No patient had intracranial bleeding. All the aneurysms were greater than 2.5 cm in diameter. The site of the giant aneurysms was infracarotid in one case, supracarotid in two, and not determinable in one. One patient had bilateral infracarotid aneurysms.

All the patients underwent gradual CCL17 after angiographic demonstration of good cross-flow from the contralateral carotid artery. Four aneurysms thrombosed completely and one partially. At present, all five patients are leading normal lives.

The clinical symptoms, CT findings, and outcome are summarized in Tables 1 and 2. Three patients (Cases 1, 2, and 3) were treated before the advent of CT scanning, but they had control scans 11, 10, and 7 years after CCL, respectively. Cases 4 and 5 had preoperative and serial postoperative CT scans (besides a standard neuroradiological work-up). All CT scans were performed on the EMI CT 1010, except for one scan in Case 5, which was performed with the Pfizer 450/FS (Fig. 4a and b).

Case 1

This patient had a giant aneurysm (3 cm in diameter on angiography) at the infracarotid portion of the left ICA. Control CT scan 11 years after CCL showed that the area clearly occupied by the aneurysm had slightly decreased attenuation compared to nearby brain tissue, and ill defined limits. Old abnormalities
### TABLE 1  
Clinical data in five patients with giant aneurysms of the ICA*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Clinical Presentation</th>
<th>Neurological Findings</th>
<th>Location of Aneurysm</th>
<th>Postoperative Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>57, F</td>
<td>headache, trigeminal neuralgia, double vision</td>
<td>lt ophthalmoplegia: 3rd, 4th, &amp; 6th nerves; lt 5th nerve palsy (1-2 branch)</td>
<td>lt infraclinoid ICA</td>
<td>3rd nerve palsy</td>
</tr>
<tr>
<td>2</td>
<td>61, F</td>
<td>double vision, impaired vision</td>
<td>lt 3rd nerve palsy; binasal hemianopsia</td>
<td>bilateral infraclinoid ICA</td>
<td>3rd nerve paresis; field cut unchanged</td>
</tr>
<tr>
<td>3</td>
<td>62, F</td>
<td>double vision, trigeminal neuralgia, impaired vision</td>
<td>rt 3rd nerve palsy; partial 5th nerve palsy</td>
<td>undeterminable (large neck), rt ICA</td>
<td>3rd nerve paresis</td>
</tr>
<tr>
<td>4</td>
<td>55, F</td>
<td>headache, impaired vision</td>
<td>lt nasal field cut; lt decreased visual acuity</td>
<td>lt supraclinoid ICA</td>
<td>field defect unchanged; vision improved</td>
</tr>
<tr>
<td>5</td>
<td>33, F</td>
<td>impaired vision</td>
<td>rt temporal field cut; lt central scotoma; lt optic atrophy; lt decreased visual acuity</td>
<td>lt supraclinoid ICA</td>
<td>vision improved</td>
</tr>
</tbody>
</table>

* ICA = internal carotid artery.

### TABLE 2  
Computerized tomography (CT) findings in five patients with giant aneurysms of the ICA*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Thrombosis</th>
<th>Interval, CCL to CT</th>
<th>Calcification</th>
<th>Density†</th>
<th>Morphology</th>
<th>Shape of Lesion</th>
<th>Contrast Enhancement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>complete</td>
<td>11 yrs</td>
<td>no</td>
<td>no</td>
<td>decreased</td>
<td>inhomogeneous</td>
<td>ill defined</td>
</tr>
<tr>
<td>2</td>
<td>complete</td>
<td>10 yrs</td>
<td>yes</td>
<td>yes</td>
<td>increased</td>
<td>inhomogeneous</td>
<td>well defined</td>
</tr>
<tr>
<td>3</td>
<td>complete</td>
<td>7 yrs</td>
<td>yes</td>
<td>yes</td>
<td>increased</td>
<td>inhomogeneous</td>
<td>well defined</td>
</tr>
<tr>
<td>4</td>
<td>partial</td>
<td>1 yr present before CCL</td>
<td>yes</td>
<td>yes</td>
<td>mixed</td>
<td>inhomogeneous</td>
<td>well defined</td>
</tr>
<tr>
<td>5</td>
<td>complete</td>
<td>2 days</td>
<td>no</td>
<td>no</td>
<td>increased</td>
<td>homogeneous</td>
<td>well defined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30 days</td>
<td>no</td>
<td>no</td>
<td></td>
<td>isodense at periphery</td>
<td>ill defined</td>
</tr>
</tbody>
</table>

* ICA = internal carotid artery; CCL = common carotid ligation.  
† Increased absorption coefficients in Cases 2 and 3 reflect the sequelae of organized mural thrombus and minute calcifications (higher than 60 EMI units). In Case 5, they reflect the fresh clotted blood (about 45 EMI units).

of the sphenoid bone were visible. No postcontrast enhancement was noted.

**Case 2**

This patient had bilateral giant aneurysms of the infraclinoid portion of the ICA, with clinical symptoms on the left side. The left common carotid artery was ligated. Control CT scanning 10 years postoperatively revealed complete thrombosis of the left aneurysm. There was heavy calcification of the wall, an inhomogeneous appearance of the sac due to multiple discrete areas of calcification, and no contrast enhancement. The right aneurysm enhanced intensely (Fig. 1). Right carotid angiography disclosed the giant aneurysm of the right side.

**Case 3**

This patient had a giant aneurysm of the right ICA. A CT scan 7 years after CCL revealed complete thrombosis of the aneurysm. There was calcification of the wall, a mottled aspect of the sac due to calcifications, and no enhancement after contrast infusion (Fig. 2).

**Cases 4 and 5**

In Cases 2 and 3, calcifications were not present on the preoperative skull x-ray films. In Case 4, the preoperative CT scan showed a nonthrombosed giant aneurysm of the left supraclinoid ICA with a calcified wall (Fig. 3a and b). A CT scan performed 10 days after CCL showed partial thrombosis of the aneurysm with the typical "target" sign after contrast enhancement (Fig. 3c and d). A control CT scan 12 months later showed progressive lamination of the thrombus at the edges of the vascular lumen (Fig. 3e and f).

In Case 5, preoperative neuroradiological work-up and CT scan revealed a nonthrombosed aneurysm of the left supraclinoid ICA (Fig. 4a and b). A control CT scan 2 days after CCL displayed intense increase in attenuation values of the aneurysm which equaled...
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**Fig. 1.** Case 2. Computerized tomography scan after contrast enhancement showing bilateral infraclinoid giant aneurysms of the internal carotid artery 10 years postoperatively. The left aneurysm shows heavy calcification of the wall, an inhomogeneous aspect of the sac due to multiple discrete areas of calcification (about 80 EMI units), and no enhancement. The right aneurysm enhances intensely.

**Fig. 2.** Case 3. Plain computerized tomography scan of the right internal carotid artery aneurysm 7 years postoperatively. There is dense calcification of the aneurysmal wall and an inhomogeneous aspect of the sac with scattered microcalcifications. No enhancement was noted after contrast infusion.

Discussion

The CT findings in giant intracranial aneurysms have been described previously. The CT appearance of giant intracranial aneurysms depends on the presence and extent of thrombosis. Giant aneurysms may be divided into three types: partially thrombosed, completely thrombosed, and not thrombosed.

On plain CT scan, aneurysms that are not thrombosed appear as sharply delineated round or oval masses with a slightly increased homogeneous density compared to nearby brain. Partially thrombosed aneurysms appear as areas of mixed density, where the vascular lumen and the thrombosed part may be difficult to differentiate due to the protean density of the thrombus. A completely thrombosed aneurysm presents as a roundish area with mottled appearance, the well or ill defined limits depending on the presence of a calcified wall. These aneurysms may easily simulate brain neoplasms.

As a general rule, on infusion of contrast medium, the lumen shows intense enhancement while the thrombosed part remains unchanged. Shell-like calcifications and peripheral enhancement due to neo-vascularity of the aneurysmal wall may be present. Perifocal lucency representing cerebral edema, local atrophy, or ischemia is sometimes observed.

In our series, Cases 4 and 5 were particularly valuable in defining density and progressive changes of the clotted blood. In Case 5, the successful result of carotid ligation was immediately displayed on the postoperative CT scan by an intense increase in attenuation values of the aneurysm, which assumed the absorption coefficients of coagulated blood (Fig. 4c). In this patient, the control scans 10 days and 1 month after CCL showed that the aneurysm had lost its well defined margins and that the peripheral part had become isodense compared to nearby brain (Fig. 4d). This finding seems to indicate that the attenuation of
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FIG. 3. Case 4. Computerized tomography scans of the giant aneurysm of the left supraclinoid internal carotid artery. a: Plain scan shows an oval area with slightly increased density and calcified wall. b: Following contrast administration, a marked and homogeneous enhancement of the lesion can be seen. c and d: Scans 10 days postoperatively, before (c) and after (d) contrast administration. A posterior area of increased density, reflecting the nonthrombosed part of the aneurysm, enhanced intensely after contrast infusion ("target" sign), and an isodense anterior area reflected the thrombosed part which did not enhance after contrast administration. e and f: Scans 12 months postoperatively, before (e) and after (f) contrast administration, reveal a shrinkage of the nonthrombosed part due to progressive lamination of the clot at the edges of the vascular lumen.

the organizing clot decreases with time, isodensity being reached within 1 month after carotid ligation.

On the other hand, the CT scans of old thrombosed aneurysms (Cases 1, 2, and 3) showed important changes, characterized by heavy calcification of the wall and gross changes within the sac. In fact, the thrombosed part assumed an inhomogeneous appearance with increased or decreased density patterns, the attenuation depending on the variable organization of the thrombus and particularly on calcium deposition. The occurrence of scattered areas of calcification within the thrombus contributed to the inhomogeneous increased attenuation of the aneurysm in two cases (Cases 2 and 3). The lack of calcium deposit was responsible for the low attenuation in Case 1. We emphasize that old thrombus may be slightly low in absorption coefficients compared to adjacent brain, and the lack of a calcified wall may hinder the CT interpretation of such aneurysms.

Our cases clearly show that the effects of carotid ligation may be immediate and late. The whole aneurysm (Case 5) or only a part of it (Case 4) thrombosed soon after carotid ligation, but the potential exists for further clot enlargement and possible total thrombosis by progressive lamination at the edges of the vascular lumen.

Cerebral angiography continues to play an important part in the preoperative work-up of giant intracranial aneurysms. Angiographic assessment of the postoperative status of giant aneurysms treated by carotid ligation may be difficult and deceptive due to inadequate cross-injection of the contrast medium. In
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Fig. 4. Case 5. Computerized tomography scans of the giant aneurysm of the left supraclinoid internal carotid artery. a: Preoperative plain scan shows a round, well defined lesion with slightly increased density. b: Preoperative scan after contrast infusion shows diffuse and homogeneous enhancement of the aneurysm. c: Plain scan 2 days postoperatively shows a marked increase in attenuation values of the aneurysm, reflecting complete thrombosis. Absorption coefficients are similar to those of coagulated blood (45 EMI units). d: Plain scan 30 days postoperatively demonstrates that the aneurysm has lost the well defined margins. The periphery is isodense if compared to nearby brain. This finding indicates that the thrombus is organizing from the periphery to the center of the aneurysm. No enhancement was noted after contrast infusion.

In fact, nonfilling of the aneurysm on angiography does not always correspond to complete thrombosis. We believe that CT scanning is a reliable and atraumatic method of follow-up review, providing precise information concerning actual size, clot formation, and anatomical pathological changes of giant aneurysms after carotid ligation.

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