Artificial Slow Flow Carotid Angiography

Carotid Angiography with Compression Proximal to the Site of Injection

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Various arterial compression tests have been introduced in cerebral angiography to produce alterations in blood flow.1,2,4,7,12,13,22 There is a limited number of papers on carotid angiography with compression or occlusion of the carotid artery proximal to the site of injection. The early cerebral angiographies reported in 1931 by Moniz16 were performed with injection of the common carotid and proximal occlusion of this vessel. Moniz noted that under these conditions contrast medium passed more readily through the external than through the internal carotid, which was why he also occluded the external carotid. He explained this finding by a greater resistance to the passing of the contrast medium in the internal carotid at the levels of the carotid foramen and the siphon. He also noted that in a number of cases the anterior cerebral artery and its ramifications were not filled, while the Sylvian group was well visualized. Three years later he reported17 that these inconveniences were avoided when injecting the nonoccluded common carotid artery. No further attention was given to carotid angiography under proximal occlusion since, at the time, all efforts were directed toward obtaining a perfect intracranial angiogram. Therefore, Engeset1 in 1944 rejected the proximal occlusion because it decreased the density of the angiographic picture. In later years, various authors described angiography with injection distal to the site of compression or ligation of the carotid artery in cases of intracranial aneurysms in order to check the effects of ligation on the aneurysm.3,5,6,10,14,18,19,20

No attention has been given to using proximal compression in carotid angiography for other diagnostic purposes. Recently one of us (H. V.)32,33 found this method useful for demonstrating arteriovenous aneurysms supplied by the external carotid artery, and consequently we decided to examine its diagnostic value systematically. Our experiences with this method of proximal compression (which we shall call "PC") are classified into angiograms of the following groups:

Group 1. Patients (classified as normal) suffering from headaches, epilepsy, migraine, trigeminal neuralgia, etc. (22 cases).

Group 2. Patients with increased intracranial pressure due to nonmeningiomaticous tumors (13 cases).

Group 3. Patients with meningiomas and arteriovenous aneurysms supplied by the external carotid artery (14 cases).

Group 4. Patients with stenotic or occlusive disease of the internal carotid artery (5 cases).

Group 5. Patients with diagnostic peculiarities in the intracranial internal carotid PC angiogram (6 cases).

In this preliminary study, blood flow and pressure in the internal and external carotid arteries following occlusion of the common carotid were not measured.

Technique

The carotid artery is punctured at the level of C-4 or C-5, the bevel of the needle tip being directed upward. After the vessel is entered, the bevel is turned downward and the needle is gently advanced into the vessel. After the routine angiograms are completed,
the PC angiograms are made, with the anesthetist exercising compression with a sterile gloved finger on the ipsilateral common carotid artery at the C-6 level below the site of puncture. It is not easy to be sure whether the compression results in complete occlusion. Tindall, et al.,28 showed that reduction of blood flow or pressure above the site of graded occlusion did not occur until a 70% to 90% reduction in cross-sectional area of the lumen was obtained. One of our cases of stenotic lesions of the internal carotid artery with reduction to approximately one ninth of the cross-sectional area of its lumen showed a normal angiographic circulation time, while another patient with reduction to one thirtieth of the cross-sectional area displayed properties of slow flow at routine angiography. Sweet and Bennett20 stressed how difficult it is to secure through the intact skin a full occlusion of the vessel that consistently results in a reliable and maximal drop in pressure. We used as criteria the disappearance of a pulse in the temporal artery and the cessation or reduction of reflux of blood from the angiographic needle.

The resistance to injection of contrast medium in PC angiography is increased in the majority of cases but there was no correlation between this increase and the angiographic effect; in some instances there was no increased resistance at all. The most reliable criterion of proximal occlusion was found in the PC angiograms. With effective occlusion, the internal and external carotid arteries or one of them were well visualized for 3 sec following injection of the contrast medium. Using this radiographic criterion we had to discard six of the early angiograms because of inadequate compression. With increasing experience, the number of cases showing defective compression during the first shot became negligible. A 17- or 18-gauge needle was used. After digital proximal compression of the common carotid was established, which took place in 3 or 4 sec, 8 cc of 60% urografin were injected within about 1.5 sec. When 3 cc were left in the syringe, the first film was exposed, followed by two other exposures with intervals of 1.5 sec. After the third film had been exposed, digital compression was released. We found that rapid serial angiography did not give better information with this form of slow flow angiography. The total duration of digital compression did not exceed 9 to 10 sec; the prolonged staining of the carotids was 3 sec.

Results

In our series of 60 patients (plus 27 subsequent ones), no clinical complications were observed. The results are shown in Table 1. The total number of cases, however, is too small for an accurate evaluation of the complication rate.

Group 1 (Normal) and Group 2 (Increased Intracranial Pressure)

Internal Carotid PC Angiograms. Group 1 consisted of 22 patients and Group 2 of 13 patients. Table 2 shows a higher incidence of arrest of the contrast medium in the internal carotid artery in the PC angiograms of Group 2 than in the normal Group 1 series. Filling of the anterior and posterior cerebral arteries was suppressed in nearly all PC angiograms, facts already described by other authors as a sign of compression of the carotid artery in the neck.5,6,6,16,20,21,23,25,31,35

The various types of intracranial circulation are demonstrated in Figs. 1 and 2. Even with a poorly visualized middle cerebral artery, leptomeningeal vessels were stained in some of the angiograms. In some cases the transport of contrast medium through the middle cerebral artery seemed to be affected by the collateral circulation on the carotid siphon, the latter being washed out while the internal carotid remained well opacified in all three films (Fig. 2). In 15 patients,
cross-circulation through the anterior segment of the circle of Willis was examined by injecting the contrast medium in the collateral carotid artery while the ipsilateral common carotid artery was compressed as in PC angiography. No obvious correlation was found between the presence or absence of collateral filling of the middle cerebral artery through the anterior segment of the circle of Willis, and the presence or absence of filling of the middle cerebral arteries during PC angiography. Forward circulation through the posterior communicating artery and other factors which might influence transport through the middle cerebral artery, such as injection pressure of the contrast medium or residual flow in the internal carotid artery, could not be evaluated.

**External Carotid PC Angiograms.** Only

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**Fig. 1.** Group 1, PC angiograms with 1.5 sec intervals. *A, B, and C.* Case 1. The intracranial arteriograms show few changes and present a frozen appearance in *A* and *B*, but in *C* the cervical internal carotid begins to empty in its lower portion. *D, E, and F.* Patient with occipital glioblastoma shows slow circulation in the intracranial branches. These cases were the only ones in Groups 1 and 2 demonstrating filling of the anterior cerebral arteries and their branches in the PC angiograms.
two Group 1 cases and three Group 2 cases showed filling of all branches of the external carotid artery (Fig. 3). Of the external carotid branches studied, there was a greater incidence of no filling of certain branches in "normals" than in cases of increased intracranial pressure (Table 3). The posterior auricular artery showed some special features; in 15 cases from both groups it was much better visualized in the PC angiograms than in the routine angiograms. In seven cases, the routine angiograms showed filling of the occipital artery and no filling of the posterior auricular artery whereas the PC angiograms showed the reversed phenomenon.

**Group 3: Meningiomas and Arteriovenous Aneurysms**

*Meningiomas (Nine Cases).* Two principal types of PC angiograms could be distinguished. The first type showed arrest of the contrast medium in the internal carotid at the base of the skull or in the siphon, and selective visualization of the vascular supply of the menigioma by the external carotid circulation. This was observed in five convexity meningiomas in the frontal or parietal areas and in one menigioma of the lesser sphenoidal wing (Figs. 4 and 5). The second type showed only suppression of the anterior cerebral artery in the internal PC angiogram, but the meningeal branches supplying the menigioma were more heavily stained and better visualized than in the routine angiogram. This was observed in three centroparietal convexity menigiomas. In two of them, suppressed filling of the anterior cerebral artery served as a subtraction technique giving a better view of an avascular area in the territory of the middle cerebral artery (Fig. 6). In all nine cases, the PC angiograms showed features similar to those ob-
served in Groups 1 and 2 with the exception of the meningeal arteries, which were filled in all meningioma cases. Evidently in these tumors there is a special factor favoring the transport of the contrast medium through the meningeal arteries to the tumor. Klinger\textsuperscript{11} stressed that even in the routine angiogram the transport of the contrast medium to the meningioma may be much poorer through the internal carotid circulation than via the external carotid. He explained this mechanism as a decreased resistance to blood flow in the external carotid supply area. This hypothesis, however, does not explain our findings with PC angiography, since this method may also result in better visualization of meningeal branches of the internal carotid supplying meningiomas (see Group 5).

**Arteriovenous Aneurysms (Five Cases).** Six PC angiograms were performed since in one case of a medially localized arteriovenous aneurysm (AVA) of the scalp both sides had to be examined; the contrast medium was injected into the common carotid artery. In all cases, the PC angiograms showed arrest of the contrast medium in the internal carotid and the AVA was fairly well visualized. In the one case of AVA of the scalp, the middle cerebral artery was opacified also. There were two AVA's of the scalp. In one of them the selective external carotid angiograms showed supply by the occipital artery not visualized in the PC angiogram, which, however, demonstrated all other participating arteries. In the other case, all supplying arteries were opacified in the PC angiogram. In the third case, an AVA situated in the upper cervical area and the auricle of the ipsilateral ear was clearly visualized and was supplied by numerous vessels.

There were two dural AVA's. One case (Case 4) has been published previously.\textsuperscript{33,34} The routine angiograms showed a faint picture of an AVA in the posterior cervical muscles. In the PC angiograms the contrast was arrested in the internal carotid artery. The external carotid artery and all its branches were not filled.

<table>
<thead>
<tr>
<th>Artery Non-Filled</th>
<th>Group 1 (20 angiograms)</th>
<th>Group 2 (11 angiograms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle meningeal</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>Occipital</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>Posterior auricular</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Superior temporal</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Anterior branches</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Internal maxillary</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**TABLE 3**

Frequency of non-filling of external carotid branches in PC angiograms
branches, the meningeal arteries included, were stained, and this time an AVA in the posterior cervical muscles and a shunt to the venous plexus of the clivus, which had not been demonstrated in the routine angiograms, were clearly visualized. In the second case (Case 5) the AVA was supplied by the middle meningeal artery. The routine angiograms showed a mass of contrast in front of the carotid siphon but it was impossible to be sure as to its connections with either the internal carotid artery or branches of the external carotid artery. The PC angiograms showed complete arrest of the contrast medium in the internal carotid artery at the base of the skull. The external carotid artery was heavily stained; only its anterior branches and the internal maxillary artery were filled. The dilated middle meningeal artery was well visualized and supplied a dural AVA of the middle fossa (Fig. 7). Following ligation of the internal maxillary artery, the AVA was no longer visualized in the control angiograms.

**Group 4: Stenotic or Occlusive Cerebrovascular Lesions**

PC angiography was not performed in cases developing EEG changes following digital compression of the common carotid
Fig. 6. Group 3. 

A. Routine angiogram in case of parieto-occipital convexity meningioma. Faint meningeal branches (arrows) are seen in their course to the area of slight cranial hyperostosis. 

B. PC angiogram shows filling of anterior cerebral artery and its branches suppressed, resulting in better visualization of an avascular area in the territory of the middle cerebral artery. It is partly encircled by an arterial branche. This PC angiogram shows its applicability as a subtraction technique. 

C. Two faint meningeal branches (arrows) are seen ending in the center of the avascular area, giving rise to a semi-circular dilated vessel.

Fig. 7. Group 3. AVA of middle meningeal artery. 

A. Routine angiogram shows accumulation of contrast medium in front of carotid siphon (arrow) without giving certainty as to its vascular connections. 

B, C, and D. PC angiograms show arrest of contrast medium in internal carotid artery with layering effect in C and D. External carotid artery also shows a layering effect in C and D. An AVA supplied by middle meningeal artery is clearly visualized in B, C, and D.
artery on the affected side. Moreover, PC angiography was limited to cases showing complete or almost complete occlusion of the internal carotid arteries and permitting puncture of the common carotid artery below its bifurcation. Cases showing interstitial injection in the routine angiograms were also excluded. Before performing PC angiography in carotid disease, care should be taken that the position of the tip of the needle is such that it will not damage the wall of the vessel during digital proximal compression.

Stenotic Lesion (One Case). The patient, a 69-year-old man, had segmental narrowing of the internal carotid to approximately one thirtieth of its cross-sectional area. With rou-
tine arteriography the contrast medium traveled across the area of stenosis and displayed the characteristics of slow flow angiography. With PC angiography the contrast medium in the internal carotid was arrested below the stenosed area while the external carotid now revealed a potential collateral circulation between the external and internal carotids (Fig. 8). In this case the slow transport of the contrast medium through the diseased carotid artery during routine arteriography might be more harmful than the suppressed transport in PC angiography. Since this case presents our only experience we do not know under what degree of stenotic narrowing of the internal carotid PC angiography can be safely performed.

**Occlusive Lesions (Four Cases).** Our experience is presented in Table 4. The suppression of visualization of collateral circulation between the left external and in-

| Table 4: Collateral circulation demonstrated in routine angiograms in four cases of occlusive lesions in Group 4 |
|---------------------------------------------------|---------------------------------------------------|---------------------------------------------------|
| Occluded Artery | Circulation Route | Result shown by PC angiogram on side of diseased artery |
| Left internal carotid (Case 1) | 1. Via intracranial vessels: good filling of left anterior and middle cerebral arteries via right carotid angiography.  
2. Between left external carotid and left internal carotid siphon: through internal maxillary and ophthalmic arteries and posterior auricular and caroticotympanic arteries, resulting in faint staining of left, middle, and anterior cerebral arteries. | Collateral circulation between left external and internal carotid arteries no longer visualized. |
| Right internal carotid, associated with stenotic lesion of right external and left internal carotids (Case 2) | 1. Via intracranial vessels: poor cross-circulation to right anterior cerebral artery via left internal carotid; poor forward circulation via vertebral-basilar arteries to right carotid siphon.  
2. Between right external and internal carotid arteries; via large caroticotympanic and stapidal arteries resulting first in filling of posterior communicating arteries and posterior cerebral arteries, and next staining of middle and anterior cerebral arteries | Visualization of collateral circulation between right external and internal carotid arteries unaltered but only right middle cerebral artery filled. |
| Left internal carotid, associated with stenotic lesion of left external carotid (Case 3) | 1. Via intracranial vessels: to left anterior cerebral artery via right internal carotid; no forward circulation through vertebral-basilar arteries.  
2. No collateral circulation between external and internal carotids in routine angiograms. | Visualization of collateral circulation between left intracranial carotid and left external carotid via maxillary, ophthalmic and middle meningeal arteries resulting in filling of left anterior cerebral and anterior choroidal arteries; left middle cerebral artery appeared occluded beyond the origin of the central perforating branches. |
| Surgical occlusion of left middle cerebral artery between M1 and M2 portion during removal of meningioma (Case 4) | 1. Left carotid angiography showed poor collateral leptomeningeal circulation from posterior and anterior cerebral arteries to supply area of left middle cerebral artery  
2. External carotid circulation: not visualized. | Left internal carotid angiogram showed contrast medium arrested at the base of the skull; visualization of collateral circulation via dural and leptomeningeal arteries. |
TABLE 5
Arterial pressures in Case 3 (Group 4) before and during 10-sec compression of left common carotid artery

<table>
<thead>
<tr>
<th>Compression Stage</th>
<th>Arterial Pressure Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Systolic/ Diastolic;</td>
</tr>
<tr>
<td></td>
<td>right brachial artery (gm)</td>
</tr>
<tr>
<td>Before compression</td>
<td>155/100</td>
</tr>
<tr>
<td>First compression</td>
<td>50</td>
</tr>
<tr>
<td>Second compression</td>
<td>50</td>
</tr>
<tr>
<td>Immediately after second compression</td>
<td>50</td>
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</tbody>
</table>

ternal carotid arteries in the PC angiograms in Case 1 may be related to the good cross-circulation from the right internal carotid artery. Cases 2 and 3, which show collateral circulation between the external and internal carotid arteries in the PC angiograms, both demonstrate poor intracranial collateral circulation. Case 3 was particularly interesting since collateral circulation between the external and internal carotid arteries was demonstrated in the PC angiograms only. In addition the PC angiograms revealed an occlusion in the middle cerebral artery, an important prognostic finding which could not be demonstrated with routine angiography.

To gain some impression of the hemodynamic-arteriographic correlations regarding the angiographically demonstrated collateral circulation in the PC angiogram and its absence in the routine angiogram, ophthalmo-
dynamometric measurements of the diastolic retinal artery pressures with and without compression of the common carotid artery were performed. At the same time the brachial artery pressures were determined. Since the right and left brachial artery pressures before carotid compression showed almost equal values, only the left brachial pressure responses to compression of the left carotid artery were measured. Two compression tests were performed. The results are presented in Table 5. The pressure responses in the left retinal artery following compression of the left common carotid artery suggest that there may be some hemodynamic-angiographic correlation as to the visualization of collateral circulation in the PC angiogram. Since the internal carotid artery was occluded, any residual flow in the external carotid during compression of the common carotid artery must have been due to reversed blood flow in some of its branches. Changes in flow pattern in the area of the external carotid artery with PC angiography were demonstrated in all previous groups, such as suppression of filling of certain branches and better visualization of the posterior auricular artery in Groups 1 and 2, or, in cases of meningiomas, in Group 3, increased fillings of meningeal branches. Because of the complexity of the physiology and biophysics of arterial blood flow, the findings with PC angiography are far from being understood; notwithstanding, this method is of interest in occlusive internal carotid disease since it may produce information in the external carotid angiogram not found with routine angiography.

**Group 5: Diagnostic Peculiarities in the Internal Carotid Angiogram**

The property of “attracting” the contrast medium from the external carotid circulation in PC angiography was also encountered in
Slow Flow Carotid Angiography

Fig. 11. Group 5. Carotid cavernous fistula. A. Routine angiogram of left-sided carotid-cavernous fistula draining into ipsilateral superior and inferior ophthalmic veins, the superior petrosal sinus and basal veins. B. Same case, profile view of PC angiogram. C and D. Anteroposterior views of PC angiograms at 1.5 sec intervals show suppression of cerebral circulation of the contrast medium, heavier staining, and greater number of draining veins. (Abbreviations. BP = basal plexus veins; CS = contralateral cavernous sinus; arrow points to filling defect caused by the internal carotid artery; CV = circular veins connecting both cavernous sinuses; SO and IO superior and inferior ophthalmic veins.)

the internal carotid PC angiograms in two cases of meningiomas supplied by meningeal branches of the internal carotid artery (Figs. 9 and 10). Figure 10 is particularly interesting since PC angiography visualized a tentorial artery not opacified during routine angiography. PC angiography on a carotid-cavernous fistula was performed in two cases, both showing a more extensive and heavy staining of the draining veins (Figs. 11 and 12). PC angiography as a subtraction technique is based on different principles from those in the well-known photographic and electronic subtraction techniques. The suppression of filling of the anterior and posterior cerebral arteries may result in a better view of the residual portion of the intracranial vascular pattern (Figs. 6, 13, and 14). This technique, however, has its limitations because of the unpredictable occurrence of arrest of the contrast medium in the internal carotid artery.

Discussion

Principal Characteristics. PC carotid angiography is inconsistent with one of the generally accepted principles of good angiography, recently formulated by McRae, 15 which requires the addition of radiopaque contrast medium to an unimpeded stream of blood. Occlusion of the common carotid artery results in reversal of blood flow in the internal carotid to the external carotid, or vice versa, while absence of blood flow is rare. 9,26,28,29 For this reason the filling of both internal and external carotids in 51 of our cases cannot help having taken place upstream in one or both arteries, provided that
Fig. 12. Group 5. Carotid-cavernous fistule. A. Routine angiogram, lateral view, shows area of fistula, staining of basilar plexus veins, and faint staining of suboccipital veins. B. PC angiogram, lateral view, shows suppression of intracranial circulation of dye and heavy staining of draining veins over a large distance. C and D. Subtraction pictures of slightly oblique basal view of PC angiograms with 1.5 sec intervals. (Abbreviations. A = anastomosing vein with VP; C = internal carotid artery; E = condyloid emissary vein (see also X); IP = inferior petrosal sinus; J = internal jugular vein; L1 = infundibulum of longitudinal epidural sinuses; L2 = long epidural sinuses; MS = marginal sinus anterior portion foramen magnum; S = reflux in sigmoid sinus; V = deep cervical vein; VP = vertebral plexus veins; X = condyloid emissary vein and posterior vertebral veins.)

the common carotid had been completely occluded. In addition, the PC angiograms showed the properties of a slow flow angiography such as false angiographic appearances due to layering effects or heavy staining of the lumina of the carotid vessels with sharp delineation of irregularities in these vessels in the presence of arteriosclerotic changes. The transport of the contrast medium was slow, resulting in staining of the carotid arteries in the neck during the 3-sec compression; in some cases the intracranial
arteriogram displayed a "frozen" appearance. Besides, there was absence of filling of some of the branches of the internal and external carotid arteries which had been visualized with the preceding routine angiography. At first thought, such a misleading angiographic procedure should have no serious role among neuroradiological techniques; however, our accidental experience induced us to investigate this method systematically.

Hazards. PC angiography presents certain features which could include a higher risk. Taversa\(^{27}\) believes the technique to be dangerous since it exposes the brain to large concentrations of medium for a long period of time. As mentioned above, the exposure of the internal and/or the external carotids was prolonged by 3 sec in all cases. Table 1 shows that prolonged filling of the cerebral arteries was observed in only one-fifth of the cases. Moreover, this phenomenon was limited to the arterial circulation.

The fundamental lesion in angiographic injuries due to the contrast medium is one of alteration of the endothelial capillary membrane; the extent of such a lesion is directly proportional to the concentration and quantity of the test substance and the time this concentration prevails.\(^1\) In our cases, there was no evidence of a prolonged capillary phase, and no case presented clinical signs of cerebral damage due to the procedure. Reports of early-progress angiography above the site of ligation,\(^{19,30}\) a method comparable with PC angiography, do not mention complications, either.

Other hazards of PC angiography are carotid sinus baroreceptor reflexes and the emotional responses of the patient. We perform all percutaneous carotid arteriographies under endotracheal anesthesia (nitrous oxide, oxygen, halothane). This depresses the baroreceptor reflexes. Capnographic control of respiration, pulse rate, and blood pressure readings are regularly performed; with the appearance of abnormal reflex responses, the proximal compression is discontinued.

Contraindications. The routine angiograms preceding PC angiography were carefully studied, and in cases showing a diminished flow rate, arterial spasm, signs of intracranial vascular disease, or injection of contrast medium in the wall of the carotid artery, PC angiography was not performed. Our contraindications for use of PC angi-
Fig. 14. Group 5. AV malformation. A. Routine angiogram, anteroposterior view, of the arteriovenous malformation supplied mainly by a dilated anterior choroidal artery. B. Same case. Anteroposterior PC angiogram shows suppressed filling of the anterior cerebral artery and its branches and of the central perforating branches of the middle cerebral artery. This subtraction results in a disclosure of the draining vein of the AVM (double arrow) and better visualization of the supplying anterior choroidal artery. C. Same case. Routine profile angiograms. D. Same case. PC profile angiogram gives a clearer view of the extent (arrows) of the AVM due to reduced filling of branches of the middle cerebral artery. Double arrow points to draining vein.

Oography in disease of the internal carotid artery were EEG changes following digital compression of the carotid artery, inability to puncture the common carotid below its bifurcation, and evidence of interstitial injection. These contraindications have been discussed under Group 4.

Summary

A technique for carotid angiography during ipsilateral digital compression of the common carotid artery proximal to the site of puncture (PC angiography) has been described. No complications were encountered in the series of 60 patients reported, nor in 27 subsequent cases. The series, however, is
too small for an exact evaluation of the complication rate. The changes in flow pattern during PC angiography in "normal" cases of increased intracranial pressure have been described. The share of the external carotid circulation in the supply of meningiomas or arteriovenous aneurysms was selectively or more clearly visualized in PC angiography; in this regard PC angiography competes with selective external carotid angiography. In other disease states, such as stenotic or occlusive vascular disease, meningiomas supplied by meningeal branches of the internal carotid artery, and carotid-cavernous fistulas, PC angiography produced information not obtained by the current methods of angiography. PC angiography may also be valuable as a subtraction technique.

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