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CAROTID ANGIOGRAPHY

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Our diagnostic equipment had been improved in an extremely fruitful way, since 30 years ago encephalography and ventriculography were introduced into neurology and neurosurgery by Dandy. Since then, cerebral pneumography has been commonly used, and at the present, ventriculograms are considered indispensable by most neurosurgeons in cases of intracranial neoplasm.

Moniz [20], in 1927, introduced carotid angiography, which was a diagnostic contribution not less valuable. The radiological demonstration of the cerebral blood vessels enables us to draw conclusions concerning their position and type as well as, to detect many vascular dislocations and abnormalities, including the visualization of intracranial neoplasms. Since then, Moniz and his associate Almeida Lima [13] have published several papers describing the technique and findings in different pathological conditions.

The widespread use of carotid angiography was soon accepted in some countries, as for instance, in Germany, where Löhr [17], Löhr and Jacobi [18], Riechert [23], Tönnis and others have published valuable contributions. This procedure however was received with limited enthusiasm in other countries, as for instance, in North America, where the first paper was published nearly ten years later by Loman and Myerson [19]. They were followed by Elvidge [2], Turnbull [27] and, recently by List and Burge [15], List and Hodges [16], Hodes, Perryman and Chamberlain [10]. All these authors described carotid angiography with the thorotrast.

There was some hesitation in using angiography for practical diagnostic purposes for several reasons. It was first pointed out that the contrast (thorotrast) used for cerebral angiography might be noxious. The thorotrast has been employed by Moniz and Lima since 1931. The danger which might be connected to the injection of this substance into the vascular system has been pointed out by several authors (Northfield and Russel [21], Stuck and Reeves [26], Ekström and Lindgren [1]). Other authors meanwhile have published that they have succeeded in producing sarcomas in rats and mice after subcutaneous injection of thorotrast (Roussy, Oberling and Guerin [24], Selbie [25]). These observations are important since it is not to be avoided that occasional periarterial injection of the contrast substance may occur in angiography. Busch has observed that leukopenia occurred 8 years or more, after angiography with thorotrast.

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When I first realized carotid angiography, I felt that the examination should be carried out with caution, but in 1938 I started to use perabrodil in a 35% solution as *routine* contrast substance. There was no longer need for limiting the use of the examination for fear of the toxicity of the contrast substance, especially after Kristiansen and Cammermeyer [11] investigated its possible ill effect on the central nervous system, being unable to demonstrate any harmful pathological alterations. Our experience is that the perabrodil should be used in a 35% solution and not in a 50% solution as preconized by others (Gross [9]). Using a 35% solution, complications (epileptic fits, transitory hemiparesis) which occasionally follow the use of a 50% concentration, are avoided. The experiments which have been carried out lately by Olsson and Broman [22] give convincing physio-pathological evidence of the endothelial changes provoked by such strong concentrations.

Engeseth [3] analysed our experience with perabrodil as contrast substance in carotid angiography up to the end of 1944. In a monograph which is now in print (supplementum to Acta Psychiatrica et Neurologica) I have analysed our cases for the last 4 years (1945-1948), selecting the verified hemispherical gliomas for discussion. Thus, for more than ten years we have now routinely employed satisfactorily perabrodil for carotid angiography. A monograph by Wickbom [29] dealing with a large number of angiographic examinations carried out in Stockholm, shows that in this center, for the last four or five years, thorotrast has also been substituted by perabrodil as contrast substance for cerebral angiography.

Contraindications — At present, the contraindications, depend upon the type of contrast substance used. From what has been mentione above, due to the toxicity of the thorotrast its use should be limited as far as possible. Our experience has shown that even in a 35% solution, perabrodil is contraindicated to patients with a high blood urea as 70 mgr.% and much care with hypertense subjects must be taken, because this drug even in such a solution, acts on a moderate arterial hypertension, determining a considerable elevation, for a long time, of the sistolic and diastolic pressure.

Practice has shown us that it is not necessary to test our patients on hypersensitivenes to iodine. In a few cases much a reaction has been observed but never with serious consequences. Only in one case of our 2000 we have seen severe alergic reaction with swelling og of the lips, eyelids and face, and slightly strained respiration. The reaction subsided in 25 minutes. Nowadays we have adrenaline ready for injection, if similar symptoms should occur. In cases of known hypersensitivenes to iodine we prefer thorotrast as contrast substance.

In cases of spontaneous subarachnoid bleeding the angiographic examination should be postponed for a couple of weeks.

Complications — In most instances some homolateral pain follows the injection of perabrodil. However the pain is never severe, and only lasts for a few seconds. Periarterial injection of the contrast is followed by considerable pain lasting for some hours. In most cases a small hematoma takes place following the puncture of the artery, a slightly hoarse voice may occur, and the patient may experience slight pain on swallowing the food. In our material only in one cases the hematoma has been large enough to indicate surgical evacuation of the blood.

The injection of 50% solution of perabrodil may occasionally cause epileptic fits which we do not see using a 35% solution. Angiography carried out with a 50% solution may also cause transitory hemiparesis, which we have not observed using a 35% solution for the examination.

The injection of the perabrodil into the carotid artery is always followed by a sensation of heat in the homolateral side of the head. This sensation starts in the eye corresponding to the ophtalmic artery, first branch the internal carotid artery, then follows flushing of the homolateral side of the face and of the conjunctiva. Injection into the external carotid artery is followed by a sensation of burning heat starting in the jaw on the same side (corresponding to contrast substance entering the maxillary arterial

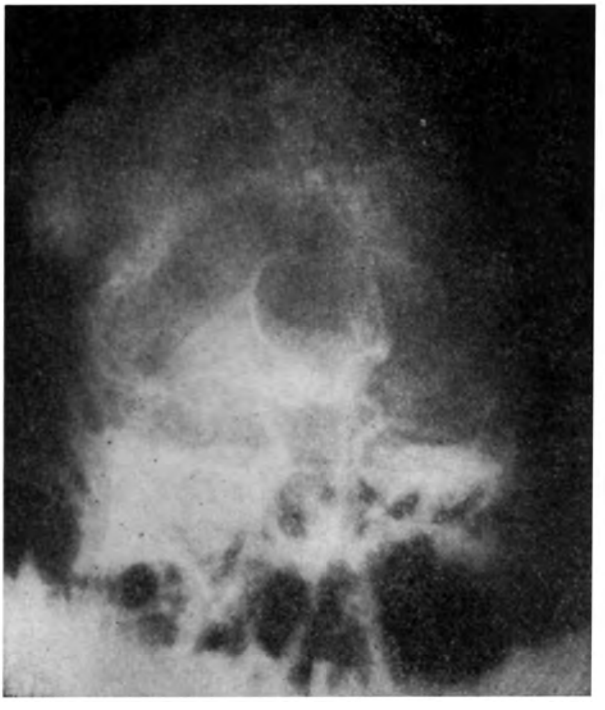

Fig. 1 — Lpnr. 87931/48. Astrocytoma of the right frontal lobe. In order to obtain filling with contrast of both right and left carotid intracranial branches, digital compression of the common carotid artery on the side opposite to the injection should be carried out. The above picture illustrates the result which may be obtained: the injection has taken place on the right side, and the left common carotid artery has been compressed during the injection. The right carotid syphon is clearly seen, and arterial blood containing perabrodil has entered the internal carotid artery as well as the anterior and middle cerebral artery also on the left side.

branch). By examining the patient as to where he first feels the heat, one can judge whether the injection has been successful or not.

In clinics where cerebral angiography is frequently carried out, great care should be taken to guard the doctors and the nurses against a noxious dose of the X-rays. In some instances our doctors have suffered from general fatigue, headaches and marked leukopenia. In order to prevent such reactions we take careful precautions to protect the staff against the X-rays by means of moveable lead aprons and lead shields (fig. 5) which are brought into position before the exposure (Engeset [5]).

Pre-medication — To patients showing signs of intracranial hypertension are given injections of 50 cc. of 50% solution of succrosi one hour before the examination. In cases of restlessnes and disorientation we give from 7 cc. to 10 cc. of a 10% solution of sodium evipan by intramuscular injection. To patients showing no signs of intracranial hypertension are given 0,5 gr. of barbituric acid subcutaneously; if they are of a nervous and apprehensive type, a moderate dose of thebaicin may be added, or given instead of the barbituric acid.

Before the patient is brought to the X-ray room local anaesthesia is given by injection of 1% solution of novocain (with adrenalin added to it in ordinary surgical proportion). The novocain is injected close to the

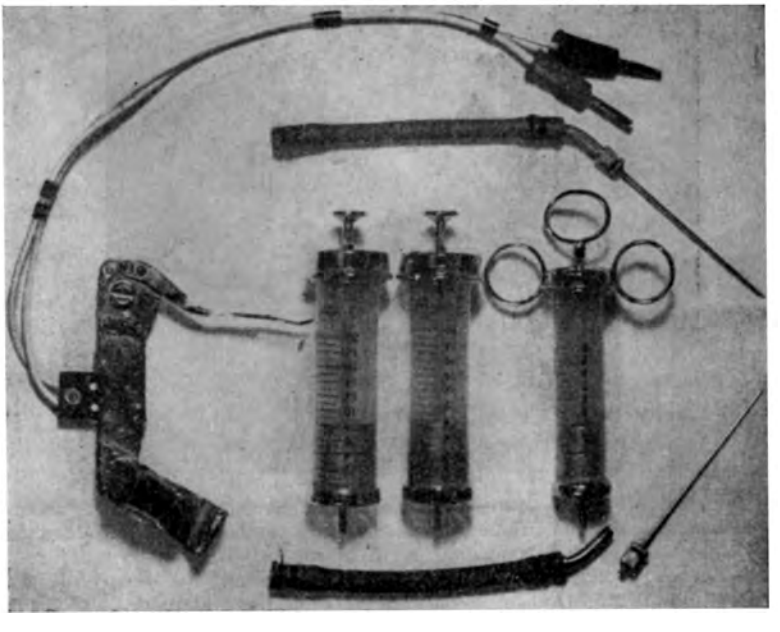

Fig. 2 — Syringes and needles which we use for angiography. The picture also illustrates our attachment to the syringe which automatically releases the exposure of the film by the movement of the piston of the syringe.

wall of the carotid artery just below and near the bifurcation. A good local anaesthesia is important for a successfull result of the examination.

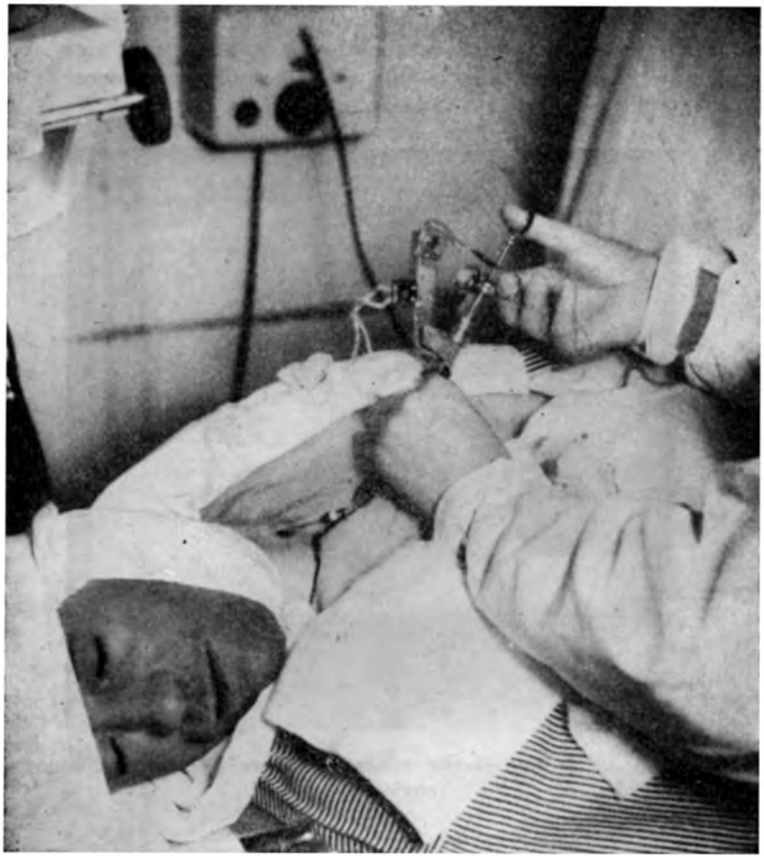

Fig. 3 — Attachment fixed on the syringe

Instruments and technical data — The needle which we use for the percutaneous angiography is about 8-9 cm. long and has an external diameter of 1.5-1.6 mm. giving to the lumen a diameter of about 1.2 mm. An angulated nipple is welded to the needle allowing a rubber tube with an attachment for a syringe to be screwed on to it. The walls of the rubber tube should be firm, with little elasticity. The syringe is of the ordinary type used for any surgical purpose, but having a good gripp for the fingers so that the injection may take place under firm and constant pressure (fig. 2 and 3).

The films are 24 cm. by 30 cm. The exposure of the arteriogram takes place automatically by the movements of the plunger of the syringe which is connected by electrical outfit so that a release mechanism carries out the exposure when about 7 or 8 cc. of the contens of the syringe has been injected (figs. 1 and 2). The phlebobram takes place routinely 4 seconds later by an automatical electric timer, which however can be adjusted to carry out the second exposure after any length of time according to individual demand. The exposure is done at 55 kilovolt in the lateral view and 60 to 65 kilovolt in the frontal view. We use 200 milliampere-seconds amounting to about 0.8 seconds pr. exposure.

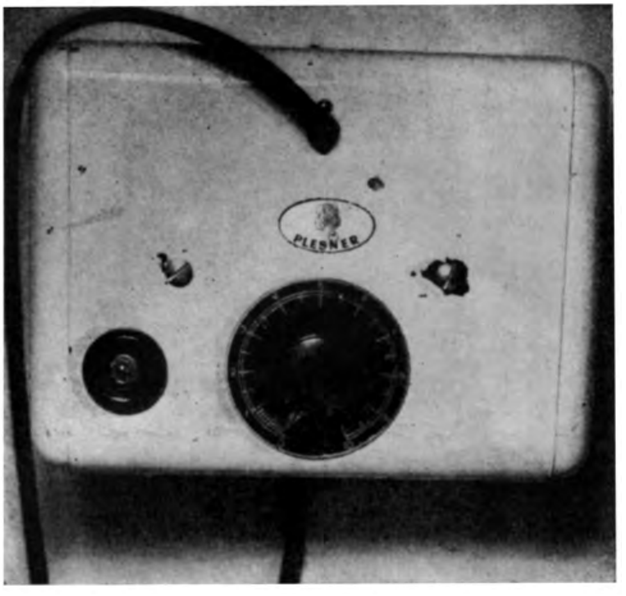

Fig. 4 — The adjustable electric timer which we use for the exposures in angiography.

A double cassette contains two films. The top film is removed by a specially trained nurse after the exposure of the arteriogram, after which the second film automatically comes into position for the exposure of the phlebogram (Lysholm skull table with sliding drawers for two cassettes).

Routinely we take pictures in two frontal views: the first with the X-ray tube in a 10 degree angulation with the cranial direction, and the second with the tube in a 35 degree angulation with the line that goes from the lateral corner of the orbit to the external auditory meatus, this line being in vertical position.

Points concerning the flow of the blood through the cerebral vessels — A contrast substance injected into the carotid artery on a corpse, reaches the vascular system of both cerebral hemispheres. When injected into a living person nearly all the contrast substance flows through the homolateral hemisphere, and only a very small amount (if any) enters the blood vessels of the contralateral hemisphere. If bilateral filling of the intracranial vessels is intended, compression should be excersised on carotid artery opposite to the injection (fig. 1). The diminuished blood stream through the compressed artery is compensated by supply from the patent artery through the communicating arteries. Compression or ligation below the point of injection should consequently not be carried out, since it provokes an ascendent rush of the blood from the contralateral carotid artery through the communicating arteries, diluting the delayed blood stream, carrying the contrast substance and decreasing the density of the shadows of the blood vessels on the angiogram.

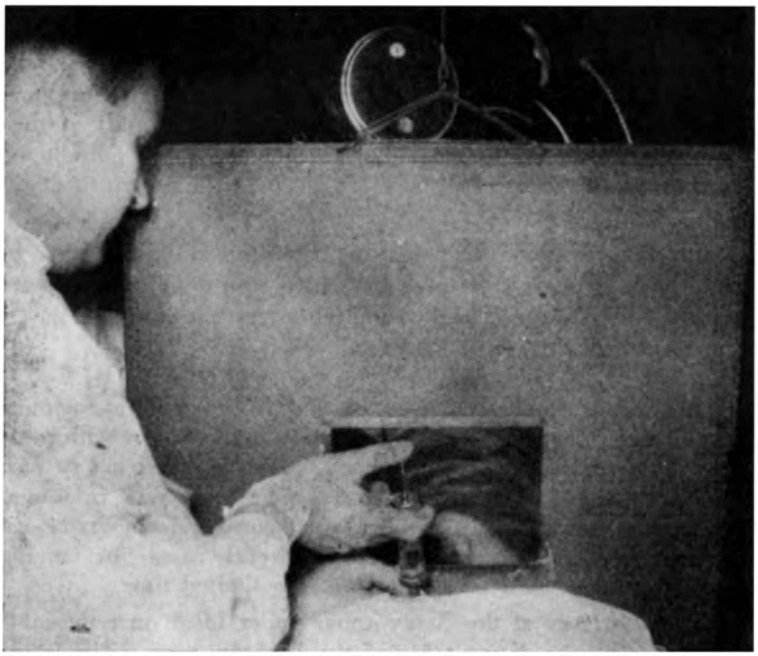

Fig. 5 — The lead shield protecting the doctors from the exposure to the x-rays. The shield is lowered into position immediately before the exposure. A semicircular piece has been cut in the shield fitting the neck of the patients.

In order to obtain satisfactory pictures of the cerebral vessels, the moment of the exposure must to some extent vary with the nature and the location of the lesion. In a case of a paraclinoid aneurysm an earlier exposure is needed than in a case of a lesion near the longitudinal sinus. Similarly, venous changes appear more clearly on a delayed phlebogram than immediately after the injection of the contrast substance. The smaller the amount of the contrast substance the more important is the correct timing of the exposure of the film. If the exposure takes place while the contrast substance is dispersed in the numerous capilary vessels of the brain, no vascular outlines will appear on the film even if the examination is otherwise corretly carried out.

We have found it advantageous to take routinely an arteriogram and a phlebogram 4 seconds later. In certain cases a phlebogram of an earlier phase is to be prefered and we then change the time of the second exposure accordingly. According to individual demand, one should not follow the rules too strictly.

In describing the angiographic findings we follow the terminology of Fischer [8]. Starting at the point of division of the internal carotid artery into the anterior cerebral and the middle cerebral branch, he divides each of these vessels into numbers attached to the letter "A" for the anterior cerebral artery and "M" for the middle cerebral artery. A_1 is the horizontal part of the vessel running in the medial direction. This part of the vessel is visible only in the anterior view, as is the part of the middle cerebral artery which runs on the base of the brain in lateral direction to the Sylvian fissure (M_1).

The anterior cerebral artery, on reaching the middline, runs forward upward (A_2 and A_3) before it turns backward on the surface of the corpus callosum (A_4 — A_5). The middle cerebral artery on reaching the Sylvian fissure runs upward (M_2) and backward (M_3 — M_4).

The percutaneous technique — It should be stressed that percutaneous carotid angiography can not be carried out satisfactorily, nor with perfection, unless it is done regularly. The puncture of the artery is not easy, neither is the interpretation of the angiograms. We have made a rule of having one of the internes on the neurological or neurosurgical service carrying out the punctures. As we usually have several cases for angiography every day the personal skill is acquired after a limited time.

The patient arrives at the X-ray room under local anaesthesia. He is placed on his back on a X-ray table of the Lysholm type. The head is adjusted to the correct position for the exposure of the film before the arterial puncture is attempted. The film should be large enough to comprise also the neck with the bifurcation of the carotid artery. The head rest is then lowered until the doctor, who palpates the carotid artery, feels its pulsation ad maximum. In that position the puncture is attempted.

The site of the puncture of the skin varies to some extent with the neck's shape. In patients with a long and thin neck, the skin is punctured closely above the articulatio sterno-clavicularis, nearly in the midline. In patients having a short and thick neck the puncture should take place somewhat higher up and the needle should then be directed more in lateral direction and more perpendicularly on the arterial wall than in case of a lower puncture when the longitudinal axis of the needle is more parallel to that of the artery.

The puncture may be done with a syringe half filled with normal saline solution attached to the rubber tube. An assistant should aspirate under slight pressure during the puncture, in order to detect as early as possible when the needle has entered the artery. The puncture may also be performed without the syringe attached to the rubber tube and in such a case the flow of arterial blood through the rubber tube clearly indicates that the needle is in situ.

Once the artery has been punctured, one should continously inject normal saline, room temperature, through the rubber tube in order to prevent coagulation of the blood in the needle. The head of the patient is now elevated to the correct level for the exposure of the film and a supporting belt should be fixed over the brow in order to keep it in the correct position.

The injection of the contrast medium usually takes place over a period of 1.5 to 3 seconds. The injection should take place under a steady and even pressure by the thumb. The injection time should be shorter if the patient is restless. In most cases we use an injection time from 2.5 seconds to 3 seconds. An automatic mechanism medium has been injected (the syringe takes 10 cc.). When the arteriogram and the phlebogram has been taken in the anterior view, the head is turned to the side (healthy side up) and similar exposures are done in the lateral view, after which the patient is allowed to rest in a more comfortable position, normal saline all the time being injected into the artery in order to prevent clothing of the blood in the needle. We carry on, doing so until examination of the pictures show that the result of the examination is satisfactory.

MATERIAL AND RESULTS

When we started doing, here, carotid angiography, it was done entirely by exposure of the carotid artery and injection of the contrast under direct vision. With increased experience we gradually have found the examination so valuable that we found indications to perform it more frequently and we had to look for a more practical technique, as well as a harmless contrast substance.

Having selected perabrodil in a 35% solution as our routine contrast substance, there was no longer need for limiting the use of angiography for fear of the toxicity of the contrast substance. In order to overcome the extensive number of cases, in 1945 we changed from the surgical exposure of the artery to the percutaneous technique which has been changed to its present modification mainly by the work of Kristiansen [12], Emblem [6]. Koppang and Engeset [4, 5].

With the increased experience we have performed a steadily increasing number of angiographies as seen by the following table:

1945	....	114 angiographies
1946	....	350 "
1947	....	420 "
1948	....	626 "

These numbers do not include attemps of angiography which have failed, but concern only cases of concluded examinations with visible contrast in the cerebral blood vessels.

During the past years the examination has proved to be steadily more valuable and, presently in my neurosurgical practice, I even favor the angiogram in preference to the pneumogram for diagnostic purpose, both in neoplastic and non-neoplastic diseases. Angiography also has the advantage that most patients tolerate the examination better than the pneumography. It is followed by no subsequent headaches. Hospitalization of the patient is not necessary and, in tumor cases, the angiography demands no preparation for immediate operation as is frequently the case with cerebral pneumography.

One important advantage with the angiographic examination is that the pictures may carry definite proof of the differential diagnosis of intracranial neoplasms. In cases of meningeoma the neurosurgeon may learn the exact localization besides the nature of the neoplasm. Special angiograms of the external carotid artery rarely fail to disclose the differential nature of the tumor; the neurosurgeon may see the exact size of the neoplasm and obtain valuable information concerning its vascular supply making it possible to ligate important afferent vessels and cut down the blood supply (fig. 9).

In cases of cerebral glioma the angiograms may show the differential nature on most cases of glioblastoma and astrocytoma. The examination makes it possible to exclude from operation malignant gliomas infiltrating the hemispheres. During the recent years I have, with increasing frequency, taken the advantage of this diagnostic development. At present I refuse many cases showing angiographic signs of doubtless malignant infiltration of the cerebrum for operation.

For this paper I have selected only histologically verified cases of glioma of the hemispheres. Concerning the topographical division of the cases, I have deviated to some extent from the standard anatomical terminology, in as much as I have considered the coronal suture as the border between the frontal and the parietal lobe. I have done so because this analysis is a neurosurgical consideration, and a different surgical technique is employed by most neurosurgeons for turning down a convenient flap in order to remove a glioma in front of and behind this line.

The present series contains 127 cases of verified glioma. The table below shows the differential nature and the location of the neoplasm:

Total number	Location	Astro-cytoma	Glioblas-toma	Oligoden-droglioma	Astroblas-toma	Ependy-moma	Not classi-fied. glioma
31	Frontal	16	7	4	1	1	2
33	Parietal	16	14	3			
39	Temporal	15	23			1	
13	Occipital	4	8	1			
11	"Central"	5	3	1			2
127		56	55	9	1	2	4

The characteristic angiographic findings in each of these groups will be summarized below after which some points concerning the differential diagnosis between the two main groups, the glioblastoma and the astrocytoma, will be discussed.

Frontal gliomas — In 28 of the 31 cases the angiograms allowed the localization of the neoplasm, in 6 of which the diagnosis was made under slight doubt. The main findings consisted in a contralateral dislocation of the anterior cerebral artery most marked in cases of glioma in the lateral part of the lobe: 15 of the gliomas occupied mainly the medial part of the lobe, 6 mainly the lateral half, while the rest infiltrated diffusely the frontal lobe. Gliomas near the base simultaneously caused the anterior cerebral artery to be dislocated upward, polar tumors pushed it backward, while the gliomas in the parasagittal region pressed it down.

Depression of the vessels of the Sylvian fissure (branches of the middle cerebral artery) was seen in 19 instances. This was the case in 5 of 7 glioblastomas, in 7 of 16 astrocytomas, and in all the 4 cases of oligodendroglioma. In 3 cases the anterior cerebral artery or its branches curved around the neoplasm and outlined its location and size. In 3 cases the neoplasm received arterial supply by branches from the middle cerebral artery. Vascular findings indicating a pathological circulation within the neoplasm and showing abnormal types of blood vessels were seen in 1 case of astrocytoma, 2 cases of oligodendroglioma and 4 cases of glioblastoma.

Parietal gliomas — In 27 of the 33 cases the angiograms revealed vascular alterations which clearly allowed the diagnosis of a parietal neoplasm. The characteristic findings consisted in a contralateral dislocation of the anterior cerebral artery which generally was less marked than in cases of frontal gliomas, and also less marked the further posteriorly the glioma was located in the lobe. In parasagittal gliomas the branches of the anterior cerebral artery (the paricallosal and the marginal branch) were pressed down and, in some of the parietal gliomas low down in the hemisphere, these branches were pushed upward. Simultaneously with these findings concerning the anterior cerebral artery, the branches of middle cerebral artery running in the Sylvian fissure appeared depressed in 22 cases.

Neoplastic blood vessels were seen in 8 cases of glioblastoma, 2 cases of astrocytoma and one case of oligodendroglioma. Contralateral dislocation of the anterior cerebral artery was present in 21 cases. In 3 cases the artery was not clearly seen. In 6 cases there was no definite lateral displacement of that artery when seen in the anterior view.

In some cases of parietal glioma the findings which concern separate changes of the anterior on the middle cerebral artery may be negligeble and leave doubt concerning the diagnosis. In many cases it is therefore necessary to evaluate both groups of vessels seen in the anterior and in the lateral view in order to arrive at the diagnosis.

Temporal gliomas — Of 39 cases of glioma in the temporal lobe the angiograms allowed the diagnosis of the tumor in 38 cases. In one case the picture did not show the neoplasm clearly because of errouneous timing, so that the arteriogram only showed the carotid artery and the carotid syphon, while the supposed phlebogram showed only the very last phase of the arterial circulation and no veins. Further pictures were not taken. The characteristic findings consist, first of all, in an elevation of the vessels of the Sylvian fissure when seen both in the lateral and in the anterior view. Tumors near the temporal pole caused such elevation of that part of the middle cerebral artery which is close to the point of bifurcation from the temporal lobe did not necessarily change the course of M_1, and if far back in the lobe not even of the M_2.

In 6 cases the anterior cerebral artery was not clearly visible in the frontal view, but in all the other cases some dislocation of the anterior cerebral artery to the side contralateral to the tumor was present. In many cases of temporal lobe tumor the dislocation of the anterior cerebral artery concerns mostly (or only) the basal portion of the vessels, while the upper portion is seen vertically in the midline or slightly pushed over to the other side. In 34 of the cases the curve of the carotid syphon was stretched, while it was normal in 4 cases. In 10 cases the pericallosal artery was pushed upward. The anterior choroid artery was visible in 27 of the cases. In 12 cases it was normal as to shape and position, in 7 cases it was displaced upward, in 3 cases there was a displacement in medial direction; a downward displacement was seen in 5 cases. Tumor vessels could be seen in 7 cases of gliobastoma and 2 cases of astrocytoma. In one additional case of glioblastoma questionable tumor vessels were present.

Gliomas of the temporal lobe usually change the arteriographic picture of the anterior cerebral artery in such a way that, when seen in the frontal view, the part of the vessel which runs horizontal-lateral becomes pushed upward, making less marked the angulation between the horizontal part (M_1) and the part that runs vertically (M_2). Large gliomas may even cause these portions of the vessel to appear on the angiogram as a straight line (fig. 7).

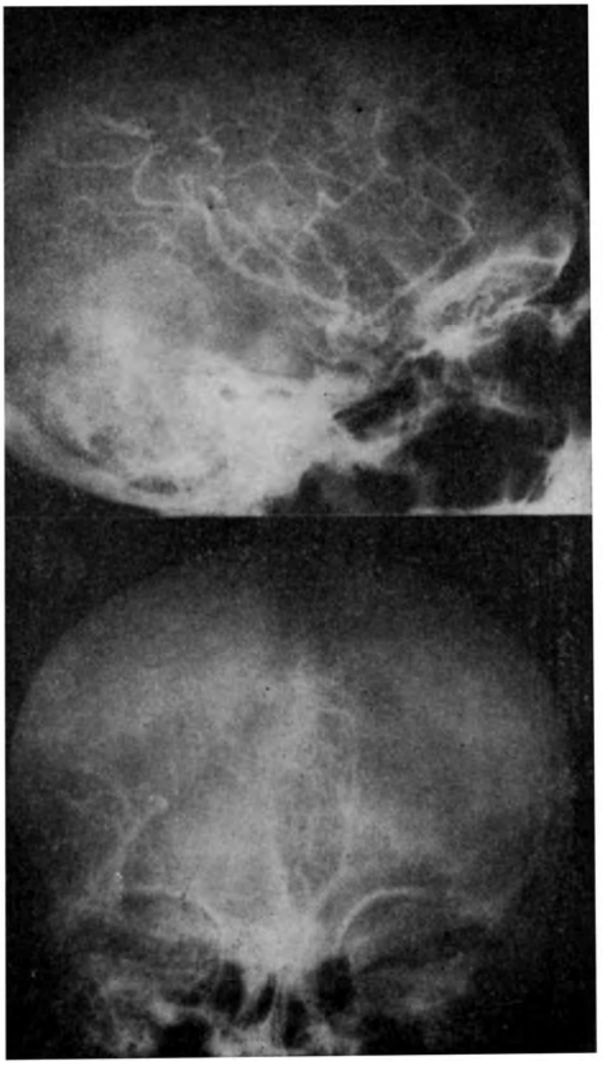

Fig. 6 — Lpnr. 8679/47. Glioblastoma of the right frontal lobe. On the anterior picture a contralateral dislocation of the anterior cerebral artery is seen. The lateral picture shows depression of the anterior cerebral artery and its branches. The tumor contains numerous neoplastic vessels. A probably newly formed branch of the middle cerebral artery is seen running up to the neoplastic area in the frontal lobe as if additional blood supply were needed. Normally the middle cerebral artery does not supply this area with blood.

In my experience no temporal lobe glioma ever causes the middle cerebral artery to appear as a lateral-concave line, and if present, such findings indicate a meningeoma of the sphenoidal ridge. In the presence of such a marked dislocation of the vessel as seen in the anterior view and the moderate change of its course when seen in the lateral view.

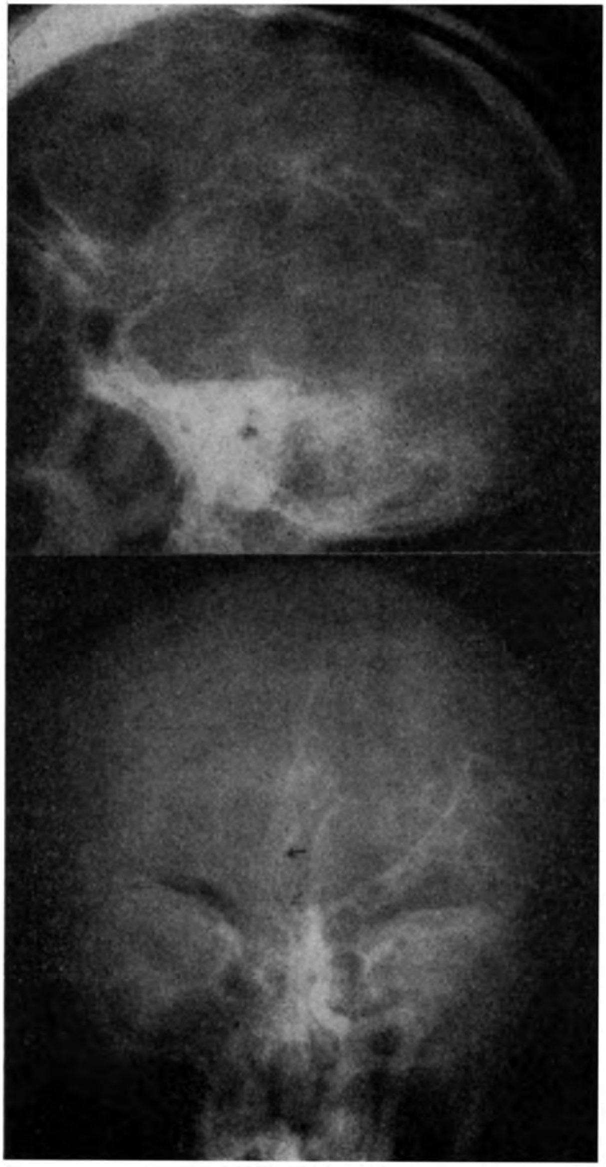

Fig. 7 — Lpnr. 2572/45. Ependymoma of the temporal lobe. There is a marked elevation of the vessels of the Sylvian fissure. The anterior choroidal artery is abnormally large and appears stretched. On the frontal picture, M_1 from its beginning takes an upward lateral course indicating that the tumor occupies the anterior part of the lobe and the arched dislocation of the anterior choroidal artery (arrows) indicates that the tumor comprises the medial portion of the temporal lobe.

Occipital gliomas — In this series there were 13 tumors of occipital location. Generally speaking it is my experience that tumors of the occipital lobe or of the parietal-occipital region offer greater diagnostic difficulties than do the frontal ones. This experience is in some disagreement with that of Wickbom [29]. As a general observation it should be stressed that the further back in the hemisphere the tumor is located, the less is the contralateral dislocation of the anterior cerebral artery and the less is the curved appearance of the artery, when seen in the frontal view. In this series the anterior cerebral artery, in 7 of the 13 cases, showed a contralateral displacement more or less parallel to the midline without any marked curve, such being seen in only 2 cases, while in the other 4 the artery did not show any definite displacement but appeared somewhat wavy and curly. The pericallosal branch was pushed upward in 9 cases, in 3 of which it was simultaneously pushed forward. In 4 cases the carotid syphon appeared stretched. The terminal branches of the middle cerebral artery were pushed upward and appeared stretched in 9 cases.

Fig. 8 — Lpnr. 9126/45. Glioblastoma of the occipital region. Multiple neo-plastic vessels arranged in a parallel way are seen in occipito-parietal region. Enlarged branches of the middle cerebral artery supply the neoplasm with blood.

A change of the Sylvian fissure vessels course (when seen in the lateral view), may be the most stricking finding in many cases of glioma of the occipital lobe. These vessels may be elevated and simulate the picture of gliomas of the temporal lobe, but when seen in the frontal view, this elevation does not affect the horizontal part of the middle cerebral artery (M_1). This finding serves to differentiate neoplasms in these two different locations.

New formed vessels within the neoplasm were seen in 3 cases of glioblastoma, and in one, not typical case of oligodendroglioma, which presented traits commonly seen in glioblastomas.

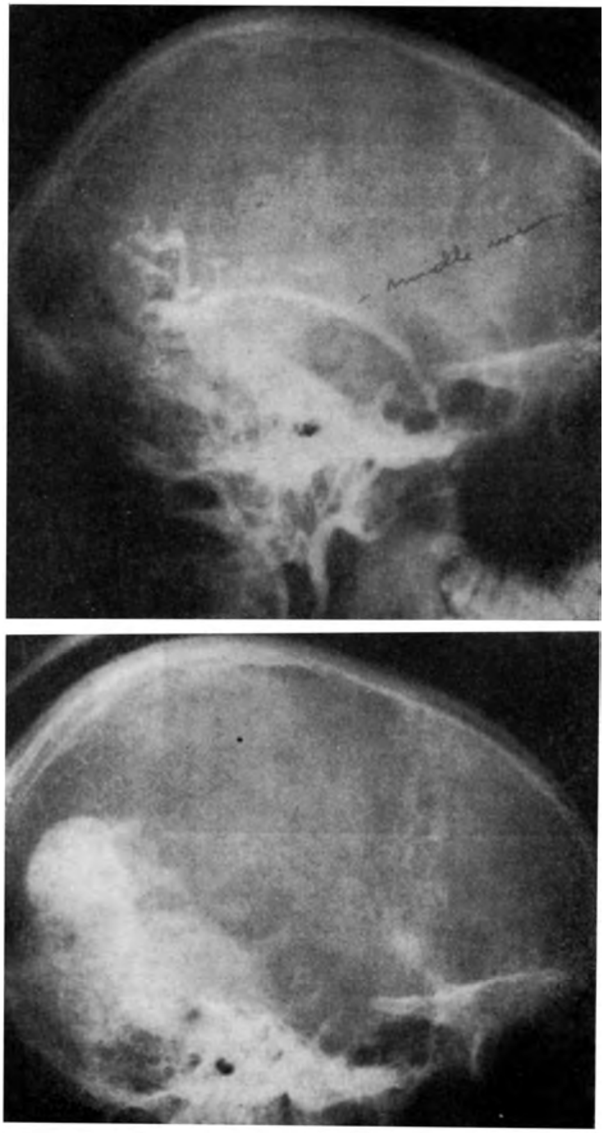

Fig. 9 — Lpnr. 2197/46. Angiograms in a case of meningioma. The arteriogram shows great enlargement of the occipital and the middle meningeal artery carrying blood to the neoplasm. The phlebogram shows retention of contrast in the tumor outlining its size and shape.

"Central" gliomas — By this term is here understood gliomas primarely arising from the basal ganglia and (or) the corpus callosum. In this series there were 11 cases of such locations. Only in 3 cases of this group could the angiograms serve satisfactorily for the diagnosis. In these 3 cases a glioma of the corpus callosum was present. In one case strio-thalamic vessels of unusual appearance gave rise to definite suspicion.

DIFFERENTIAL DIAGNOSIS

Meningiomas, with few exceptions, receive arterial blood supply by way of the middle meningeal artery. The visualization of this artery should therefore not be omitted in suspected cases, if necessary by separate injection into the external carotid artery. In the arterial phase small curly vessels may be seen in the neoplasm and in the venous phase a sharply outlined homogenous saturation with the contrast substance may outline clearly the location and size of the neoplasm (fig. 9).

Subdural hematomas are characterized by an avascular zone between the surface of the hemisphere and the inner table of the skull, as a rule most clearly seen late in the arterial phase.

A cerebral abscess is characterized by its central avascular field while the surrounding capsule may disclose retention of the contrast in the small arteries and veins. Usually there is, simultaneously, a well marked displacement syndrom of the normal vessels.

Cholesteatomas may impress by the lack of blood vessels; sometimes it might be difficult to distinguish these tumors from gliomas poor in blood vessels such as astrocytomas.

Cerebral metastases are recognized by the richness in blood vessels of a similar type as those seen in glioblastomas. They differ from the latter by the limited size, the sharp outline and eventual multiplicity. Sometimes it may be very difficult to distinguish with security, cerebral metastases from glioblastoma. Primary neoplasm localized in other places of the body may solve the problem.

Tuberculoma and gumma are in this country nearly extinct types of tumors, so I have no experience as to their angiographic appearance. The same is true of cerebral parasites.

The great majority of intracranial tumors are glioblastomas and astrocytomas. As these two kinds of gliomas represent extremities as to their histobiological activity and energy, it is important to recognize their differential character previous to any operation. A few words should be mentioned concerning the special picture each one may present. For their recognition it is of importance to keep in mind the systematic difference as to the blood supply of the two types of glioma, as pointed out by Elsberg [7] and utilized for the angiographic interpretation by Almeida Lima [13]. In the astrocytomas the largest number of vessels occur in the center of the new growth and there is no increase in the number of arteries in the adjacent white matter of the brain. In the glioblastomas, the peripheral areas of the neoplasm contain the largest number of arteries, and the adjacent areas of the brain tissue contain a larger number of blood vessels than the normal white matter, and a larger number of vessels than is seen in the white matter adjacent to astrocytomas. This "peripheral irrigation" in glioblastomas and "central irrigation" in astrocytomas is important for the distinction of the two types of gliomas by the angiographic examination.

Corresponding to the histological structure the astrocytoma when seen on the engiogram, as a rule, is rather poor in blood vessels and the vessels which are seen appear more or less normal.

The glioblastomas, on the contrary, show as a rule abundant alterations of the blood vessels. Endothelial proliferations occur spotwise in the vascular walls and may cause sudden constrictions or occlusions of the lumen. At other places degenerative changes take place, causing hemorrhages, arterio-venous fistulas and aneurysms, sometimes associated with enlargement of the vascular lumen. Regional undernurishement of the brain may cause secondary degeneration and cyst formation.

The present series contains 56 cases of astrocytoma. In 3 cases the picture are not satisfactory for a detailed analysis, leaving 54 for discussion. In 35 of the cases typical vascular dislocations of an expanding lesion allowed only the regional diagnosis. In 5 (possibly 7) cases, small curly vessels were seen in the neoplasm; in 3 cases normal arteries of enlarged size were seen running to the neoplastic area, in 2 cases the area of the neoplasm was seen to be slightly hyperemic without presenting abnormal types of blood vessels. In 3 cases sudden constriction of the diameter of small arteries were observed (caused by spasm due to the contrast substance?). In 9 cases the field of the suspected neoplasm appeared devoid of blood vessels as seen in cases of cyst formation: in 4 of these a cyst was found at operation and in 5 a neoplastic tissue very poor in blood vessels was removed.

These series of angiograms, with few exceptions, allowed a definite regional diagnosis of the neoplasm, but it was rarely characteristic concerning the positive points to permit a differential diagnosis of a possible astrocytoma. The differential diagnostic conclusions had to be guided by the abscence of vascular signs of a specific tumor circulation, and the angiographic pictures had to be seen in relation to the history of the illness, the neurological findings, and other points of importance for the clinical differential diagnosis.

The glioblastomas more frequently betrayed their differential diagnosis by positive angiographic findings. In the present series of 55 cases of glioblastoma, the angiographic pictures in 3 cases were incomplete for a satisfactory evaluation. In 16 the angiograms allowed only a localizing diagnosis, but in the others, positive points allowed a differential diagnosis of a glioblastoma. The presence of small arteriovenous aneurysms as a specific sign of glioblastoma has been pointed out by various authors such as Moniz [20], Almeida Lima [13], Lorenz [14] and Wickbom [29]. Such direct transition of the contrast from the arterial into the venous system was seen in 12 cases in this series. Moniz has pointed out that in some cases of glioblastoma it is possible to see small veins and arteries arranged as parallel stripes on the angiogram. Such arrangement could be seen in no less than 14 (possibly in 17) cases in this series. Hypervascular zones of small new formed vessels with no special such arrangement were seen in 9 cases. In some cases these zones were of a nodular type, in others, they appeared more extensive and covered a continous field. Sudden changes of the caliber of the vessels, sometimes in the form of sudden constriction, at other times in the form of dilatation, were seen in 19 cases. Enlarged branches of otherwise normal arteries were seen running to the neoplastic field in 23 cases in this series.

SUMMARY AND CONCLUSIONS

After a brief review of the history of cerebral angiography, some of the most important points concerning the percutaneous angiographic technique have been described. The value of the angiographic examination in cases of cerebral gliomas has been studied, based upon a consecutive series of 127 verified cases of hemispherical gliomas.

Of 31 cases of frontal glioma, 28 could be diagnosed by the angiographic method; of 33 cases of parietal glioma, the angiograms revealed the neoplasm in 27 instances; of 39 cases of temporal glioma, the tumor could be localized in 38 cases; of 13 cases of occipital glioma, the angiographic localization of the tumor was successfull in 9 instances; of 11 cases of glioma infiltrating the corpus callosum and (or) the basal ganglia, the angiographic examination was successful in only 3 cases.

The angiographic examination in cases of cerebral glioma, in my experience, yields a more satisfactory result as to the localization than does the pneumography. The only exception concerns the gliomas growing in the thalamus or in the basal ganglia. These are more easily localized by means of ventriculography.

As to the differential diagnosis of the gliomas, tumor vessels could be seen both in astrocytomas and in glioblastomas. Most cases of astrocytomas were however devoid of specific tumor vessels. When present they could not be definitely distinguished from those seen in glioblastomas, but the abnormal findings were far less numerous and definitely less pronounced in astrocytomas than in glioblastomas.

In most cases the astrocytomas were characterized only by displacement of blood vessels of normal appearance, while the glioblastomas frequently presented both displacement of normal appearing blood vessels and new formed blood vessels within the neoplasm itself. The pathological blood vessels in the tumor were frequently abnormal both regarding their topographical appearance and their type. Frequent findings were arterio-venous aneurysms, sudden variation of the caliber, parallel arrangement of the small tumor vesesls and fields of hypervascularization. In 37 of 55 cases of glioblastoma such vascular changes indicated the differential nature of the neoplasm.

SUMÁRIO E CONCLUSÕES

Após breve revisão histórica da angiografia cerebral, são descritas algumas das mais importantes questões relativas à técnica angiográfica percutânea. E' estudado o valor da angiografia para o diagnóstico dos gliomas cerebrais, baseando-se o autor em 127 casos de gliomas hemisféricos.

De 31 casos de glioma frontal, 28 puderam ser diagnosticados pelo método angiográfico; em 33 casos de glioma parietal, os angiogramas revelaram a neoplasia em 27 vêzes; entre 39 casos de glioma temporal, o tumor pôde ser diagnosticado em 38; de 13 casos de glioma occipital, a localização angiográfica da neoplasia foi bem sucedida em 9 vêzes; em 11 casos de glioma infiltrando o corpo caloso e (ou) os gânglios basais, o exame angiográfico deu bons resultados em apenas 3 casos.

Na opinião do autor, o exame angiográfico em casos de glioma cerebral fornece resultados mais satisfatórios, no que respeita à localização, que a pneumencefalografia. A única exceção diz respeito aos gliomas que se desenvolvem no tálamo ou nos gânglios basais. Êstes são mais fàcilmente localizáveis pela ventriculografia.

No que concerne ao diagnóstico diferencial dos gliomas, vasos neoformados podem ser visualizados tanto nos astrocitomas como nos glioblastomas. A maioria dos astrocitomas são, entretanto, desprovidos de vasos neoformados; quando presentes, êles não podem ser seguramente diferenciados daqueles encontrados nos glioblastomas, mas as anormalidades são menos numerosas e menos pronunciadas nos astrocitomas que nos glioblastomas.

Na maioria dos casos, os astrocitomas são caracterizados sòmente pelo deslocamento dos vasos sangüíneos de aparência normal, ao passo que os glioblastomas freqüentemente apresentam tanto o deslocamento de vasos normais como rica vascularização neoformada. Os vasos sangüíneos patológicos são anormais tanto quanto à topografia como quanto ao tipo. Freqüentes são os aneurismas arteriovenosos, as bruscas variações do calibre vascular, os arranjos paralelos de pequenos vasos tumorais e campos de hipervascularização. Em 37 dos 55 casos de glioblastoma, tais modificações vasculares permitiram o diagnóstico da natureza da neoplasia.

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