Combined Stereotaxic Operation for Treatment of Deep-Seated Angiomas and Aneurysms

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The total extirpation of an arteriovenous angioma has so far proved to be the best method of treatment. It is possible in about 30 to 50 per cent of the cases. In addition to other factors (diffuse spreading, location in functionally important areas of the brain, inoperable condition of the patient), one of the most serious hindrances is a deep position of the angioma, e.g. as in cases of mesodiencephalic tumors, which have been described by French and Peyton and others.

If extirpation is not possible, ligation of the supplying arteries still offers the best chance of success. Unfortunately this method also causes difficulties in many patients, and ligation is not always possible. The vessels are located either subcortically or too deeply within brain tissue that is particularly important functionally, e.g. in the motor or speech regions. Serious functional deficits are easily caused by a resection of brain tissue and by a search for the vessels. Apart from this, subsequent angiography may show that erroneously an adjacent vessel has been clipped. Failures of this kind are reported in the literature. In these cases the stereotaxic operating procedure offers new technical possibilities.

Technique

Our operative procedure was based on the following scheme. First of all the vascular tumor is presented angiographically on a lateral and an anteroposterior series of films, whereby a good filling of the supplying vessels is very important. During the vascular filling a metal measuring rod of the same kind that we use in our other stereotaxic operations is radiographed simultaneously in order to effect an accurate calculation of the roentgen-ray magnification. If merely a ligation of the supplying vessels seems advisable according to the angiographic findings, it is determined which of the supplying arteries will be ligated and, furthermore, at which point of the vascular system and from which approach this may be performed best. The construction of our stereotaxic apparatus enables us to choose the operative approach to the vessel beforehand and to alter it if subsequently different findings make it necessary. In case several vessels have to be ligated it is possible to focus them successively by means of the stereotaxic apparatus and to ligate them from the same or an altered approach. Difficulties may originate in identifying the same vessel on the anteroposterior and lateral views for the determination of the target points, but they can be avoided by technical measures.

The actual operation is performed in the following way: After lateral and anteroposterior films have been taken in the antecedent angiography, the base ring of our stereotaxic apparatus is fixed as far basally as possible in order to leave space on the convexity of the skull for the subsequent trepanation. Roentgenograms having been taken in two planes, the target points are marked at the place at which the separately supplying arteries are to be ligated. For this procedure it is necessary to translate the target point (point of ligation) from the arteriogram to the roentgenogram taken with applied base ring on the day of operation. Thus we are able to determine the coordinates of the target point with reference to the midpoint of our base ring. These coordinates are adjusted at the phantom ring (identical with the base ring) and in this way the target point is ascertained at the phantom ring, too. If the roentgen-ray magnification of the arteriogram is different from that of the picture taken with applied base ring on the day of operation (which phenomenon is caused by different distances from the roentgen-ray tube to the plate), it can be corrected easily by means of the measuring rod described. Thereupon it is de-
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Tendence at which point the trepanation is performed most suitably in order to expose the region of the brain concerned. After removal of the bone, the target arc with the needle fixation is transferred to the patient's base ring, and then the target needle is moved up to the dura mater. At this place the dura mater is opened. After a small cortical resection around the target needle has been performed, the needle is introduced into the brain up to a point about 5 mm. from the focused depth in order to avoid injuries of the artery by the tip of the needle. Now the layer of cerebral tissue around the needle and above the artery is carefully sucked out, so that a channel is produced through which the supplying blood vessel can be exposed and ligated. Thereafter the target needle can be withdrawn. The clip holder and clip serving for the ligation of the vessel are introduced through this sucked-out channel. In this manner further deep-seated supplying vessels also can be focused and ligated by different approaches in case such a measure proves to be necessary. If it is planned to perform the total extirpation of the deep-seated angioma, the target needle has to be focused to the surface of the angioma.

So far we have operated on 4 patients with lasting effect by means of the method described. The following case, in which we applied this operation for the first time, illustrates the specific procedure of ligation of vessels in a case of deep-seated tumor of the basal ganglia.

Case 1. F. O. was born on Sept. 5, 1933. At the age of 12 attacks of headache, vomiting, stiffness of the neck, considerable weakness of the left half of the body with numb feeling appeared for the first time. These complaints recurred at intervals of several years. In 1956 there occurred loss of consciousness for several hours, clouding of consciousness for weeks, mental confusion and complete paralysis of the left half of the body with slow recovery.

Examination. On his first admission to our clinic, an intensification of the tendon reflexes of the left arm and a left-sided hemiparesis combined with hypalgalia and hypesthesia were found.

Angiograms visualized a very compact arteriovenous angioma on the right side, which started on the anteroposterior picture from the midline and had a lateral extent of 4 cm. A comparison with the lateral view showed that the tumor occupied nearly the entire thalamus and parts of the hypothalamus and bordered on the internal capsule. This would explain the deficiency of motor and sensory symptoms on one side. The blood supply was kept up primarily by the dis-

tended anterior choroid artery and by deep branches of the posterior communicating artery.

1st Operation, Jan. 4, 1957 (extract from the operative report). Right-sided frontal bone flap was performed by the method of Dandy. Below the tractus opticus in the region of the substantia perforata the vessels of the tumor from the choroid and posterior communicating arteries were found, part of which were clipped. From this approach it was not possible to clip the vessels located in the depth. In a second intervention an attempt will be made to reduce the angioma further by means of a ventricular approach and to clip the supplying vessels after localization with the stereotaxic apparatus.

Course. As the paresis improved a little, the patient declined the planned second operation and returned home.

Four years afterwards, in November 1961, an acute and serious hemorrhage with severe symptoms occurred. The repeated angiography showed the angioma in nearly unaltered extent.

2nd Operation, Dec. 12, 1961. The procedure planned in 1957 was carried out. After application of the base ring the coordinates of the two deep-seated arteries supplying the tumor were determined in the same manner as described above and the phantom ring was adjusted. Thereupon the target needle focused at the first supplying artery was moved forward until it touched the dura mater. Here the dura mater was opened and a small resection of cortex and white matter was performed in the forebrain in the direction of the target needle (Fig. 1). In the course of this, the enlarged lateral ventricle was opened. The angioma was of rusty brown color, a sign of hemorrhages having occurred (later confirmed histologically). The interventricular foramen was enlarged. Then the target needle was moved through the ventricle and introduced into the caudate nucleus up to a point 5 mm. in front of the first main artery supplying the angioma. The covering tissue in the prolonged axis of the target needle was sucked out carefully and the artery was exposed. Thus after withdrawal of the target needle a clip following the sucked-out channel could be applied to the vessel without difficulties. The second supplying artery was clipped in the same way.

Course. The patient was fully conscious even during the first postoperative phase, and healing of the wound was free from complications. Three weeks after operation, as a result of the ligature of the arteries supplying the tumor, no tumor could be recognized at the control angiography despite good filling of the remaining cerebral arteries. This finding was in all phases ascertainable on the lateral as well as on the anteroposterior pictures. Two weeks after operation the patient left the clinic in good condition.
The following case will illustrate briefly that by the method described it also is possible to remove totally angiomas immediately adjoining important cerebral structures, in this case the central region, without neurologic deficits occurring.

**Case 2.** D.I. was born on March 7, 1937. In July 1962 patient had flash-like pain in the cervical region, with stiffness of the neck, and later on was unconscious for 2 days.

**Examination.** There were sensory disturbances of the right thigh.

Right-sided angiography showed an arteriovenous angioma supplied by the middle cerebral artery and the angular artery with outflow over the straight sinus (Figs. 2 and 3).

Left-sided angiography, through the anterior communicating artery, also demonstrated the angioma.

**1st Operation.** First of all it was attempted to remove the tumor by an open operation. It was found that localization of the deep-seated tumor could be made only by a large resection of cortex, which would have led to serious functional deficits because of the immediately adjacent motor region. Therefore the intervention was restricted to the resection of an artery located on the surface.

**Course.** Subsequent angiography showed that, as foreseen, only a small part of the vascular tumor had been eliminated.

**2nd Operation.** Therefore 9 weeks after the open operation a stereotaxic intervention ensued in the manner described above. The tumor could be located from a small sucked-out channel in the parietal lobe and was extirpated completely, as shown by the postoperative angiograms (Figs. 4 and 5).

By this procedure it was possible to avoid functional deficits despite close adjacency to the motor region. No motor deficits or pathologic reflexes were present in the phase of postoperative swelling. (The exact neurologic status and the absence of any symptoms of deficiency caused by the operation could be demonstrated by a motion picture.\(^{11,16}\))

In the 2 remaining cases the lesions also proved to be deep-seated vascular tumors, the operations for which were performed without complications. The operation for a tumor located in the caudal part of the basal ganglia was also carried out through the lateral ventricle. In this case less importance was attached to the ligation of the tumor vessels, because a papilloma of the plexus was found also, probably in direct connection.

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**Fig. 1.** In the depth of the sucked-out channel, which is 1.5 cm. in diameter, the pulsating angioma is visible (1). It has been reached by the tip of the electrode (2), which is supported by the guide tract (3) of the stereotaxic apparatus.
with the tumor. It was extirpated. As a result of this misinterpretation of the preoperative situation, the postoperative angiogram showed the actual angioma only partially removed.

**Indications**

In 1960 Guiot and others, using a different technical method and operative procedure, reported on 2 successful operations for deep-seated malformations with the stereotaxic apparatus. The possibility of combining stereotaxic intervention and open operation had been indicated by us previously in 1957. Using the procedure described above we have observed meanwhile a complete postoperative vanishing of epileptic seizures in a patient with a calcified subcortical tumor of the motor region and in another with a calcified deep-located cerebral scar with epilepsy. The
open operation and total extirpation of vascular tumors will continue to be the method of choice. The stereotaxic procedure described is particularly appropriate for vascular malformations including aneurysms, which were so far difficult to find during operation and inoperable on account of their deep position, especially in case of the not-at-all unusual mesodiencaphalic situation. If, according to the angiographic finding, a total extirpation is not possible, the supplying vessels may be traced and ligated in the manner described. The stereotaxic procedure is of high value because of the possibility of determining exactly beforehand the points at which the blood vessels have to be clipped. These may be chosen so that the ligature is performed distally from the point of outflow of vessels possibly important for the normal brain tissue. It is intended to ligate the vessels from a trephine hole by means of an instrument which will simultaneously serve as clipping device and target needle.

A second indication for employing the stereotaxic procedure is the subcortical position of the tumor in a functionally important part of the brain, as in our Case 2. In this case only a small cortical incision was necessary. The point of insertion of the target needle can be chosen so that as few deficits of brain function as possible are produced. The accuracy of locating the vascular lesion is not as reliable as in these combined open operations as in the closed interventions, e.g. in elimination of structures in the region of the basal ganglia or in operations of the hypophysis. This fact results from the outflow of liquor and the subsequent displacement of the brain. Since adhesions are no hindrance to stereotaxic interventions, a repeated operation is possible if the control angiography still shows residual vessels or parts of tumor.

Summary

A method is reported for treatment of hitherto inoperable deep-seated arteriovenous angiomas, for which, because of their deep position (as in case of mesodiencaphalic situation), an extirpation or a ligation of the supplying vessels is indicated. After the trepanation, the malformation, having been localized and calculated on the basis of the angiogram, is traced by means of the stereotaxic operating technique. The accuracy of the procedure permits of finding reliably the most appropriate point of ligation at the artery even in the depth, so that the covering brain tissue is largely spared. The technical procedure is illustrated by 4 patients who have been operated on successfully to the present time.

References

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