Microsurgery for Aneurysms on the Circle of Willis

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SUMMARY

A description of a microsurgical approach for aneurysms on the anterior part of the circle of Willis is given.

Certain practical points are stressed. The operative results obtained in 37 consecutive aneurysms operated on in 30 patients are discussed.

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Aneurysms of the cerebral vessels have interested clinicians for more than a century. Some of the earlier descriptions of the clinical presentation of cerebral aneurysms could hardly be bettered today, either in their accuracy or brevity.[1-3] With the introduction of cerebral angiography by Moniz[4] in 1927 it became possible to visually localise the aneurysms and also to incorporate more facts into the formula for their treatment.

While little could be added to the original clinical descriptions of years ago, the treatment of these aneurysms has undergone a constant evolution. In the earlier series, mortality rates of 21%[5] to 38%[6] for all risk patients were reported. More recent publications pointed out the benefit of publishing separate figures for good and bad risk cases.[7,8] Many factors are responsible for this improvement in the over-all outlook for patients with a cerebral aneurysm.[9,10] In a review of 250 aneurysms operated on by Yasargil, using microsurgical techniques, the over-all mortality rate was 5%, and the mortality in 112 consecutive grade I and II cases was 0%.[11] In this series, they gave recognition to all the modern methods used, and stressed the added advantage of consistency in operative technique as well as the advantage of binocular magnification. The advantages of binocular magnification, especially with the use of the operating microscope, are numerous, and clearly set out in standard references.[12,13]

In spite of all these convincing reports, many neurosurgeons are still reluctant to make use of this technical aid. This is usually due to difficulties encountered in the handling of the instrument. In order to be able to cope with certain difficulties encountered during microsurgery in neurosurgery, the surgeon should first prepare himself in the laboratory.[14]

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This article describes the technique used and results obtained in the operative treatment of 37 consecutive aneurysms on the circle of Willis.

OPERATIVE TECHNIQUE

Instrumentation

We prefer the Zeiss binocular type I operating microscope, with standard manual magnification selection, because of its manoeuvrability and simplicity, which are essential in neurosurgery. Because of the obvious advantages of maximum distance between microscope and the operating area, a 300-mm objective is used in combination with 12,5× oculars set at a 10-fold magnification. A magnification of 16-fold is only used during certain stages of the operation.

Positioning of the Patient

All patients are operated on in the supine position with the head turned 45° away from the side of the osteoplastic craniotomy. The head and thorax are elevated slightly above the horizontal. The head alone is then only minimally lowered. In subfrontal surgery without the use of the operating microscope, lowering of the head usually supplements retraction of the frontal lobes because of the tendency of these lobes to fall away from the anterior fossa floor. Lowering to this degree in microsurgery is not recommended, as the edge of the frontal bone will throw a very troublesome shadow over the operating field.

Osteoplastic Craniotomy

Unless special attention is given to certain important points during this stage of the operation, the surgeon will have his vision obstructed during the later stages. In this series an identical craniotomy was used in all cases. The craniotomy is performed on the relevant side and all anterior communicating aneurysms are operated on from the right. As an assistant's hands obstruct the view, the surgeon has to use mechanical, self-retaining cerebral retractors mounted on the skull. This in itself necessitates a larger craniotomy than in non-microsurgical approaches.

The skin incision is a curvilinear one, extending from 2 cm off the midline just within the hairline, to above the zygoma. The osteoplastic craniotomy is based across the pterion and hinged on the temporalis muscle. The burrholes are placed so as not to enter the frontal sinus. A very important part of the bone work is to remove the sphenoid wing over at least half the distance to the anterior clinoid process. In cases with an anterior communicating aneurysm, only the outer third or less needs to be removed. This part of the operation is usually haemorrhagic and the haemorrhage should be well controlled before opening the dura. The bone at the superior angle of the eye, and 1 cm of bone medial to it, should also be cut away, even if the orbit is entered. This is essential, as this area could be a very troublesome obstruction to a clear view. The self-retaining retractor is mounted opposite the sphenoid ridge. The dura is opened transversely across the Sylvian fissure. The centre part of the dural flap is about 1,5 cm above the edge of the bone and extends to about 0,5 cm from the bone edges. This triangular dural flap is folded over the muscle and sutured against it. This enables blood coming from the area of the craniotomy at the base of the skull and the muscle to run along a gutter from the end of which it can be sucked away. Thus, both the blood and the sucker are kept out of the operating field. In this series the temporal muscle and skin were infiltrated before craniotomy, with Ornipressin (POR. 8; Sandoz) to aid haemostasis. An indwelling catheter was placed in the frontal horn of the relevant lateral ventricle and mannitol 1,5 g/kg mass administered after induction of anaesthesia.

Once the dura is opened, the microscope is set up with its stand to the left of the surgeon, and the theatre sister on the right of a right-handed surgeon.

One blade of the retractor is placed on the frontal lobe and the other on the temporal lobe. Blood running into the operating field from a bleeding point outside the field of vision or area in focus, is a source of frustration during microsurgical operations. The bridging veins between the Sylvian fissure veins or the tip of the temporal lobe and the dural sinuses, could be the origin of such bleeding. This is often precipitated by the temporal lobe retraction. As it is time-consuming and difficult to manipulate the microscope into such a position as to enable the surgeon to focus on the bleeding point, it is easier to inspect this area without magnification before starting the retraction. Veins that will obviously tear once retraction is applied, can then be clipped and cut. The retraction puts stretch on the arachnoid overlying the Sylvian fissure. Using a bipolar coagulating forceps, the arachnoid is freed, coagulated, and then cut with a sharp arachnoid knife. Blunt dissection should be kept at a minimum. The entire fissure is opened, up to and including the area overlying the optic nerve and carotid artery. As the brain adapts to the retraction by displacing cerebrospinal fluid through the drain, the retractor blades are advanced in small increments. After identifying the proximal part of the middle cerebral artery, the actual dissection and preparation of the aneurysm commences. All middle cerebral aneurysms in this series were either at the trifurcation or bifurcation of the parent vessel. With magnification the exact relation between the vessels and the aneurysm can be determined. Vessels that seem to be incorporated into the aneurysm should be inspected under 16-fold magnification. They are often separate from, but adherent to, the aneurysm and can be freed, making it possible to clip the aneurysm. Should this not be possible, a more accurate wrapping can be performed. Only one middle cerebral aneurysm in this series ruptured during surgery. This is in keeping with the experience of other surgeons as regards manipulation of the middle cerebral aneurysms.

Internal Carotid Aneurysms

The same approach is used as in the previous group. In this series 18 aneurysms were in the classic posterior communicating (ICPC) position, 4 at the terminal carotid, and one had an infraclinoid origin and extended medially below the optic nerve to present in the area of the pituitary fossa (Figs 1 and 2). This aneurysm ruptured during preparation but was successfully clipped. The anterior clinoid process and a small area of sphenoid wing lateral to it were removed before isolating the aneurysm. Visual fields were intact but pituitary function slightly depressed, and this returned to normal postoperatively. Similar cases have been described before.[15] Three of the supraclinoid carotid aneurysms could not be clipped. All three had subsequent staged carotid ligations at their initial intracranial exploration.

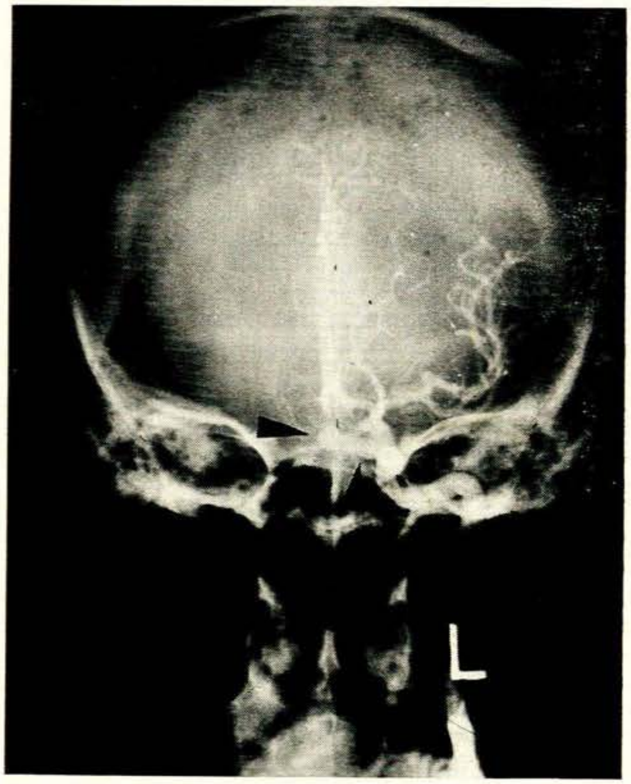

Fig. 1. Carotid-ophthalmic aneurysm extending into the area of pituitary fossa, pre-operative angiography.

All except one of the ICPC aneurysms could be clipped. This aneurysm had a broad neck partly obstructed by a clot. This was responsible for the angiographic suggestion

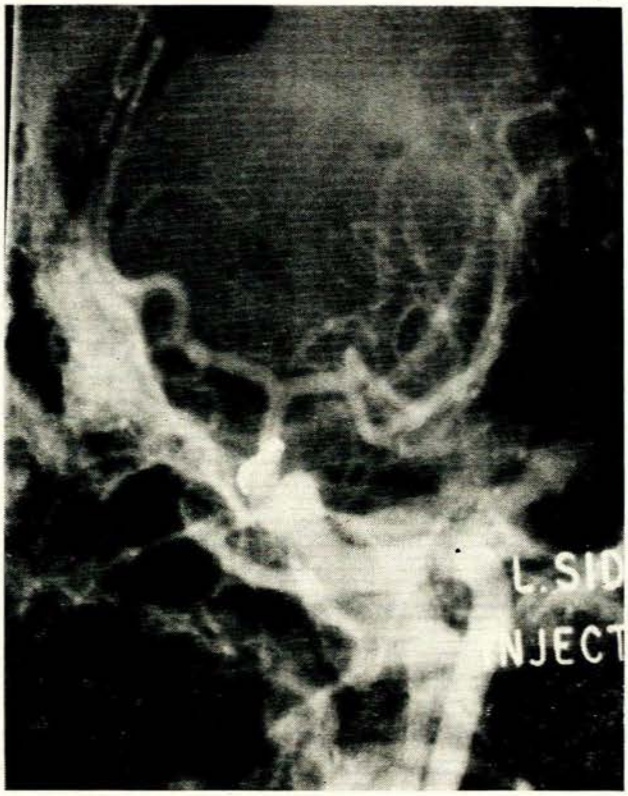

Fig. 2. Same case as Fig. 1, postoperative angiography.

of a narrow neck. Carotid ligation was also performed. In two instances the anterior clinoid was removed to provide additional space for the proximal limb of the aneurysm clip. In all cases it was possible to identify the posterior communicating artery. As we did not set out to identify the anterior choroidal artery and oculomotor nerve, these structures were not always seen. Unless an unusually long clip is used, and is angled superiorly, these structures will not be damaged.

All aneurysms in this position, except one case, extended inferiorly to the free edge of the tentorium. In one case the aneurysm pointed directly laterally, lying above the free edge of the tentorium and partly embedded in the temporal lobe. Should angiography suggest this relationship, retraction of the temporal lobe should be kept to a minimum, lest this manoeuvre should rupture the aneurysm.

Anterior Communicating Aneurysms

A microsurgical approach to these aneurysms is from the right through the previously described craniotomy. This approach is possible whether the aneurysm points to the right or to the left, inferiorly or superiorly.[16] Should the patient, in addition to the anterior communicating aneurysm, have an aneurysm on the anterior circle of Willis on the left, both aneurysms can be approached from the left at the same operation. In this series the approach was slightly different from the microsurgical approach described by other authors.[11] Both retractor blades are placed under the frontal lobe. After the optic nerve is identified, the arachnoid over the nerve and the carotid artery is opened. The rest of the Sylvian fissure arachnoid is not opened. It is also not necessary to follow the anterior cerebral artery from its origin to the anterior communicating artery. The anterior cerebral artery need only be identified close to the aneurysm. In this way dissection along the area where this vessel gives off its perforating branches is kept to a minimum. Under 10- or 16-fold magnification these vessels are clearly identified. Damage to these vessels was, most probably, the reason for the poor results obtained with this approach before the aid of microtechniques.

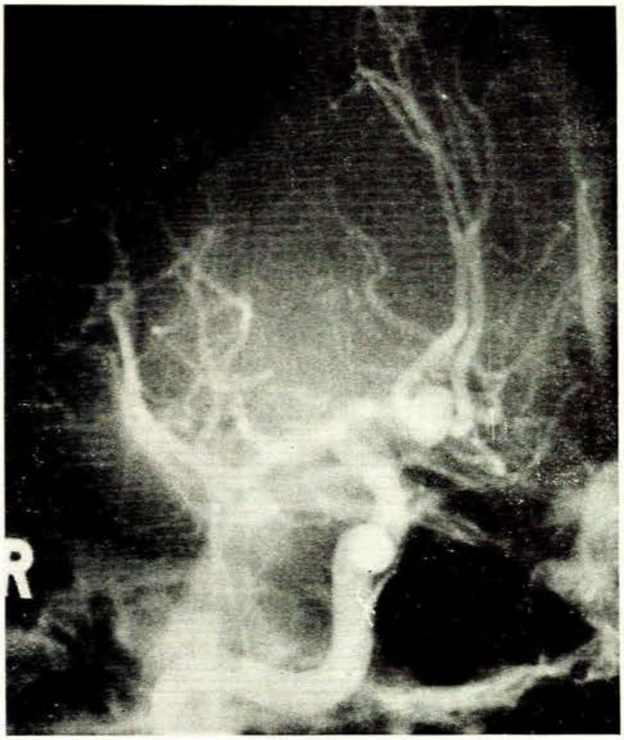

Fig. 3. Anterior communicating aneurysm, pre-operative angiography. Note value of oblique views.

A small area of gyrus rectus (± 0,5 - 1 cm) is removed on both sides of the midline and the anterior cerebral vessels identified distal to the anterior communicating area. Only then is the opposite proximal anterior cerebral artery identified. All the aneurysms in this position could be clipped. Other authors in much larger series have also mentioned a high incidence of clip application in these aneurysms[12] (Figs 3 and 4).

DISCUSSION OF CLINICAL MATERIAL

Microsurgical techniques offer great advantages to the surgeon during cerebrovascular surgery. The intense uni-

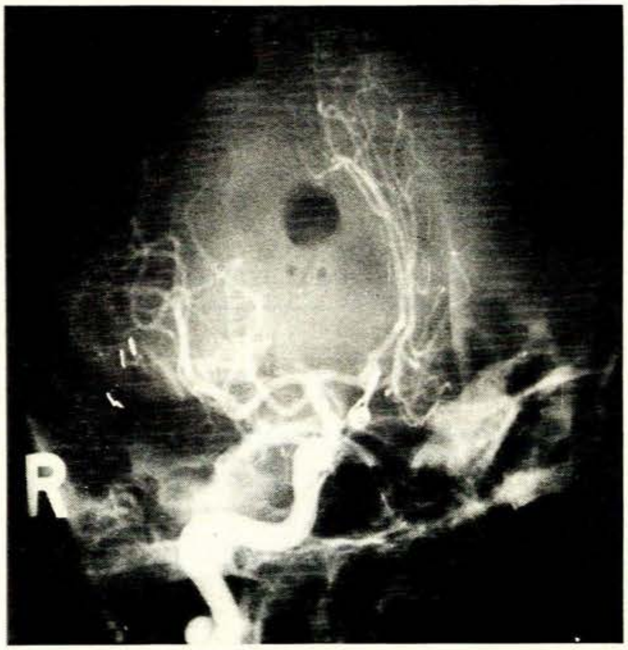

Fig. 4. Same case as Fig. 3, postoperative angiography.

form illumination, magnification of the whole area within the visual field and depth of vision, are the most important factors. This enables the surgeon to identify and protect small vital vessels. The aneurysm's exact origin and relation to the surrounding structures can be identified before clip application. Because of the factors mentioned, the arachnoid can be cut instead of torn open with a blunt hook. This in itself reduces tension and pulling on the dome of the aneurysm, which could precipitate intra-operative rupture. Under magnification rupture of the aneurysm can be better controlled. Surgeons are often inclined to move the microscope away once the aneurysm ruptures. This should not be done, as the operator then has to reorientate himself in an almost completely new operation field. During rupture, the magnification should be increased to 16-fold or more if necessary. With the tip of the suction apparatus on the hole, a temporary clip can be applied to the aneurysm or the feeding vessel, while the dissection is completed. Collapse of the aneurysm after rupture often facilitates the dissection. In this series, there was intra-operative rupture in 5 instances. All these cases could be clipped without mortality. Because of the possibility of intra-operative rupture, under no circumstances should a type of clip be used that cannot easily be removed.

This series covers the period May 1972 to October 1973. All cases with cerebral aneurysms admitted under the care of the senior author were treated operatively and to maintain uniformity in the technique all cases were operated on by one surgeon (D. J. J. de K.)

The following cases were turned down for surgery: one case with three aneurysms, of which the terminal basilar aneurysm, which included both posterior cerebral arteries, had bled according to clinical and radiological criteria. One patient refused operation. She died from a rebleed of her anterior communicating aneurysm while still in hospital. In two instances the patients rebled shortly after arriving from distant hospitals and were deeply comatose. One diabetic, hypertensive and emphysematous patient admitted as a grade IV subarachnoid bleed, died two days after admission. Two cases admitted from distant hospitals with inadequate angiographic pictures died because of a rebleed during or shortly after angiography in our department.

Fig. 5. Case of multiple aneurysms. Terminal carotid. Also anterior communicating aneurysm, filiing from left.

The remaining 30 cases had 40 aneurysms. Eight patients had multiple aneurysms (Figs 5 and 6). In 4 cases with two aneurysms, both were clipped. One patient refused to have the second aneurysm operated. There were 2 cases who each had three aneurysms. One patient had two clipped and the other treated by carotid ligation. The other had one clipped and one wrapped with muslin gauze. She died before the third aneurysm could be attended to.

Twenty cases were female and 10 male. The ages ranged between 21 and 54 years, with an average of 39,6 years.

The anatomical sights of occurrence are shown in Table I. All patients were classified according to the Hunt and Hess[17] system of classification of subarachnoid haemorrhages (Table II).

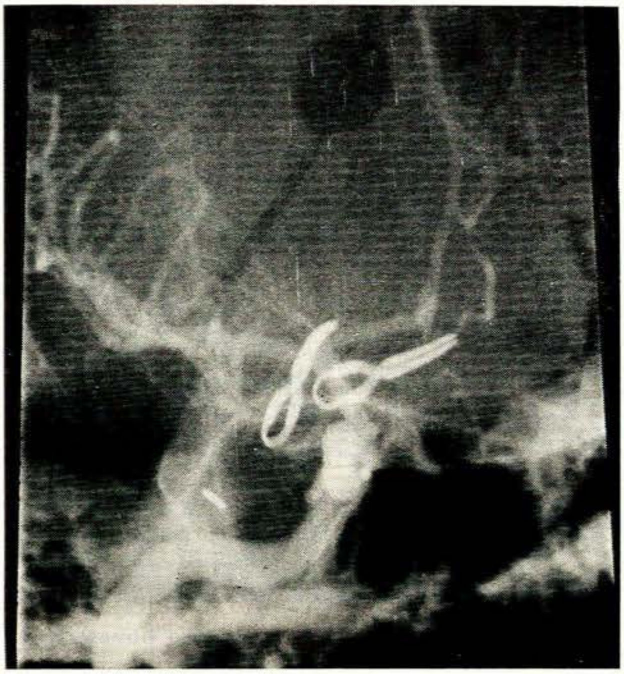

Fig. 6. Postoperative angiogram of case shown in Fig. 5. Both aneurysms clipped.

TABLE I. OPERATED ANEURYSMS

Anatomical		Localisation
Anterior communicating		7
Middle cerebral		7
Internal carotid		18
Posterior communicating		
Internal carotid		5
	Total	37

TABLE II. GRADING AND DEATHS

Grading		No. of cases	Deaths
I		14	0
II		9	2
III		5	1
IV		2	0
	Total	30	3

POSTOPERATIVE DEATHS

There were three postoperative deaths (Table II). One other case had a massive bleed either during induction of anaesthesia or during the initial stages of craniotomy. The operation was abandoned before the opening of the dura. As this article concerns the technique and results of a microsurgical approach, this case is not regarded as a death related to the technique.

In a 38-year-old patient with two aneurysms, both of which were treated operatively, a deep vein thrombosis developed pre-operatively. He died suddenly 8 weeks postoperatively from a pulmonary embolism, after insertion of a ventriculo-atrial shunt for his hydrocephalus.

A 35-year-old female with an anterior communicating aneurysm died 36 hours postoperatively. She was hypertensive, 180/105 mmHg pre-operatively, and was kept at a mean blood pressure of 45 mmHg for 1 hour 35 min during surgery. The patency of her major vessels was confirmed during postoperative angiography and at autopsy. She was the only anterior communicating aneurysm treated by the trapping procedure. This method is no longer recommended.[11]

The third mortality was a 38-year-old female with an anterior communicating aneurysm and bilateral middle cerebral aneurysms. The middle cerebral aneurysm on the right was wrapped with muslin gauze and the anterior communicating aneurysm clipped. Postoperatively she responded to commands and gave her name on request. She had a severe, long-standing hypertension which was difficult to control. She died on the 4th postoperative day and at autopsy had a massive rebleed of the wrapped middle cerebral aneurysm.

RESULTS

All patients admitted had strict bedrest, were sedated with Aterax 50 mg every 6 hours and received epsilon aminocaproic acid 24 g/24 hours (except the first 6 cases), once the presence of an aneurysm had been confirmed radiologically. In 10 cases there was evidence to suggest that they had had more than one pre-operative bleed.

There was one death not related to the immediate postoperative period. She was a 54-year-old female patient who had both middle cerebral aneurysms wrapped, and she died 11 months postoperatively from a rebleed while at work.

During surgery the blood pressure was lowered to a mean arterial pressure between 40 and 55 mmHg during the final stages of aneurysm preparation and clipping. This was varied according to the time duration of the operation and the pre-operative blood pressure. As hypotensive agents, halothane, trimetaphan or pentolinium were employed.

On an average the patients were operated on on the 14th post-bleed day. This was often beyond the surgeon's control because of the large number of cases referred from distant hospitals. In a trial at present being conducted in a large centre in the USA, all cases are electively operated on day 14 post-bleed.[18] In all cases postoperative control angiography was performed, usually between day 5 and day 10 postoperatively. This is highly recommended. It not only confirms the total obliteration of the aneurysm neck, but is of great value in determining postoperative spasm and complications. In two instances, where the patients were drowsy postoperatively, and diagnosed as postoperative spasm, the angiography revealed small subdural haematomas, the evacuation of which led to improvement in the patients' condition (Figs 7 and 8).

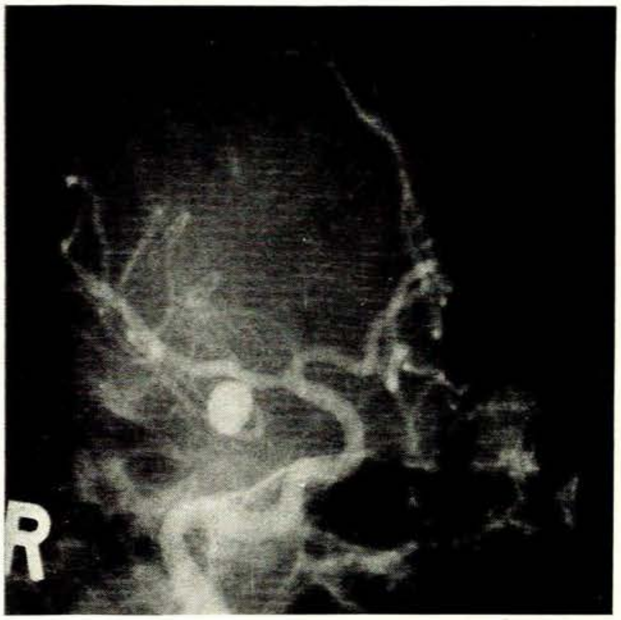

Fig. 7. Middle cerebral aneurysm.

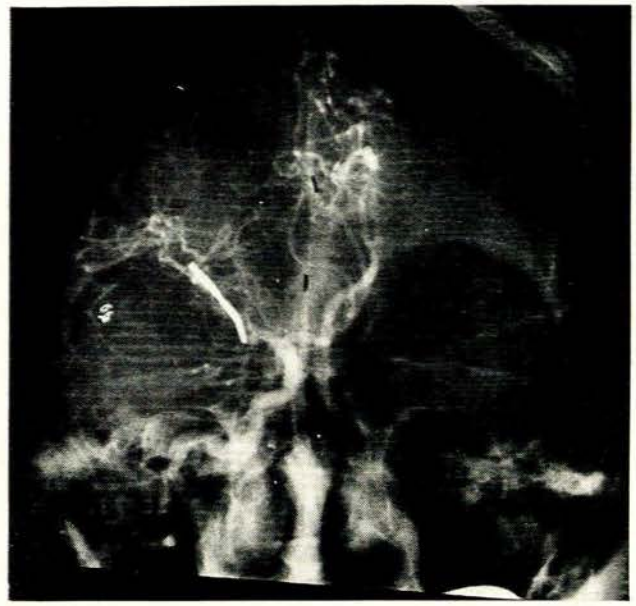

Fig. 8. Same case as in Fig. 7, showing postoperative subdural haematoma and vessel spasm.

In 17 instances, the patients returned to their pre-operative employment, or, where the patients were housewives, they were able to manage their homes as before. Of the remaining 10 cases, four were re-employed in less demanding occupations. Two housewives had to have constant aid in the management of their daily routines. The other four cases could not be re-employed, and are treated as invalids.

Although 11 patients had radiological evidence of an initial hydrocephalus shortly after their subarachnoid bleeds, only two patients had to have ventriculo-atrial shunts at a later stage. It is quite possible that this number may increase during the months of follow-up.

There was one instance of postoperative sepsis, necessitating removal of the bone flap.

Three patients complained postoperatively about the cosmetic appearance of the craniotomy wounds. This was related to the area of bone removed at the angle of the orbit. In another three patients, there was loss of frontalis muscle action, probably due to damage of the nerve by the incision extending towards the zygoma. In one of these patients, this has since been recovered.

This series is too small to express certain findings as percentages. It is large enough, however, to show certain tendencies, when compared with larger series. We are of the opinion that microsurgical technique is the method of choice in the surgery of cerebral aneurysms when used in combination with the other well-established criteria of patient selection and pre-operative treatment.

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