Electrically Induced Thrombosis in Intracranial Aneurysms*

S. Mullan, M.D., A. J. Raimondi, M.D., G. Dobben, M.D., G. Vailati, M.D., and J. Hermatpanah, M.D.

Division of Neurological Surgery and Department of Radiology, University of Chicago Clinics and Hospitals, Chicago, Illinois

The occasional observation of spontaneous occlusion of an intracranial aneurysm has suggested the possibility of a surgically induced thrombosis (Fig. 1). Laboratory studies have shown that thrombosis could be produced very easily in artificial aneurysms of the femoral artery of the dog by passage of a small direct electrical current across the sac. Thrombosis in an intact femoral artery required the insertion of an intra-arterial anode and a current of 50 to 2,000 μA, for a period of about 1 to 2 hrs. This clot lasted only a few days and in the course of its development it was subject to embolization if the current was too strong, if the negative electrode was too close, or if the animal moved its leg while the needle was in place. Epsilon-aminocaproic acid prolonged the duration of the clot.1,2

As one of us had punctured, without hemorrhage, two aneurysms exposed at open operation by inserting into them a needle 20 mils in diameter (25 gauge), it seemed that puncture by an extremely fine electrode 4 mils in diameter would be safe. Withdrawal offered no problem since it was known that the steel tip would erode during passage of a current of sufficient strength and duration to produce thrombosis.

It was believed that the electrode could be inserted through a burr hole and guided to the aneurysm by biplane radiography and thus a major craniotomy in the early period following hemorrhage could be avoided. Because of the dangers of embolism and of thrombosis of the parent vessel, serial angiography during the procedure seemed indicated. It was felt also that the operation should be done under local anesthesia so that any clinical deterioration as the result of excessive contrast material or excessive thrombosis or embolization could be determined at the earliest possible moment.

Successful thrombosis by this relatively simple technic might be expected to carry the patient safely through the critical early weeks without fear of recurrent hemorrhage and enable definitive surgery to be undertaken at the time of election. The possibility that permanent thrombosis might occur in some instances was entertained.

Technic

The special steel electrodes* had an insulated shaft 10 mils in diameter and an uninsulated end 4 mils in diameter. The length of the uninsulated end was determined by pre-operative study of the aneurysm. It was usually 4 to 7 mm in length and was made exquisitely sharp.

After shaving the patient's head, a burr hole was made (under local anesthesia) at a site convenient to the aneurysm. The skin and muscle were closed. Next the head was fixed by a three-pronged head-holder which gripped the bone. This holder was fairly firm but not so firm as desirable. One copper grid was fastened on the skin of the lateral surface of the skull remote from the aneurysm, and a second was attached to the occiput. The common carotid artery was punctured and a catheter was threaded up to the bifurcation. Occasionally a simple needle puncture was used and on two occasions the carotid artery was catheterized through the femoral artery. Biplane arteriography outlined the aneurysm on the two surface grids. The introducing needle (usually gauge 22) was inserted manually through the skin overlying the burr hole and was advanced and repositioned until its image fell upon the exact point of the grids occupied by the aneurysm. Each movement was checked by biplane radiography (without contrast).† Finally biplane angiog-

Received for publication May 21, 1964.

* Aided by the United States Public Health Service General Research Support Grant 1-S01-FR-50367-01, and MO 1-F.R.-55.

† Supplied by courtesy of Polaroid Corporation X-ray Technical Service Department.
raphy was taken to make sure the grids or head-holder had not moved (and sometimes they had). If necessary, further adjustments and further angiography were undertaken. Usually it took 5 or 6 movements of the needle, but sometimes it took 10 or 12, and once only 2 movements were necessary. It was not difficult to get the needle to within 2–3 mm. of the target, but it took time to get it to the exact fraction of an mm. that was necessary. As the lengths of the introducing needle and of the electrode were known, the position of the point of the electrode relative to the aneurysm could be determined by measuring the amount that protruded beyond the introducing needle. When the sharp electrode touched the aneurysm, a sensation of resistance was encountered. Sometimes a slight flick of pain was experienced. The position was checked again by measurement and the needle was then inserted to the desired depth. In most instances this produced a slight pain, but as the patients were warned of this and as it was only slight, there were no problems. The current was turned on and serial angiograms were taken every 30 min. until satisfactory thrombosis was achieved (Fig. 2).

As the point of the needle wears away within 15 min. or so, the thrombotic process may be accelerated by replacing needles, but this was done no oftener than every 30 min. to make sure that an intact needle was not being pulled out. The tips of the needle are too fine to be seen radiographically. Angiography was sometimes performed at increasingly frequent intervals towards the end of thrombosis.

**Results**

The case histories of 12 patients who have been treated by this method are partly summarized in Table 1. They were unselected, since no other method was used to treat aneurysms in patients who were admitted to our service during this period of time. The last 3 patients were too ill to treat by conventional surgical methods. There were 7 aneurysms of the internal carotid artery at the posterior communicating junction, 2 on the anterior communicating artery, 2 on the anterior cerebral artery at the genu, and 1 on the middle cerebral artery. Ten patients had suffered one or more subarachnoid hemorrhages and 8 of these had been in coma. In 1 (Case 9) palsy of the 3rd nerve developed and 1 (Case 4) had sudden loss of consciousness. The follow-up interval ranges between 6 and 14 months. None has bled in the interval. Follow-up angiography has been provided for Cases 2, 3, 4, 5, 6 and 8. This shows that in those in whom thrombosis was complete (Cases 2 and 3) subtotal thrombosis persisted over the duration of the follow-up, but that in those in whom it was subtotal, it disappeared quite early. Three patients (Cases 1, 3 and 4) had subsequent clipping of their aneurysms.

Brief case histories of 6 patients will serve to illustrate the method and some of its problems.

**Case Reports**

**Case 1.** S.J., a 42-year-old woman, had a subarachnoid hemorrhage 10 days before admission. There was a large aneurysm on the right internal carotid artery at the posterior communicating...