Pre- and Postoperative Measurements of Regional Cerebral Blood Flow in Three Cases of Intracranial Arteriovenous Aneurysms

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Modern treatment of intracranial vascular malformations requires information not only about the general morphology of the malformation but also about the hemodynamics of arteriovenous shunts. This information is obtained mainly by serial angiographic studies in which the size, form and localization of the aneurysm can be established, as well as its major arteries and veins.⁴⁶⁷¹¹⁻¹² Although angiography gives some information about the blood flow through the aneurysm and the cerebral tissue surrounding the malformation, more precise quantitative measurements of the flow in these different parts of the brain have hitherto not been possible. Available clinical methods measure flow of blood only in the brain as a whole and only gross side differences may be demonstrated with such methods.⁴⁵⁹⁻¹⁵

In the present investigation we have used a new technique for quantitative measurement of regional cerebral blood flow in three cases of arteriovenous aneurysms within the carotid system. It will be shown that measurements made before and after neurosurgery made it possible to assess the hemodynamic implications of the cerebrovascular malformation, and also to gain some information on the flow of blood through the cerebral tissue surrounding the malformation.

Material and Methods

Regional cerebral circulation was measured according to the method of Lassen et al.⁴ An inert and freely diffusible radioactive gas (krypton⁸⁵ or xenon¹³³), dissolved in 2–10 ml. saline, is injected into one of the carotid arteries, preferably the internal carotid artery if intracranial structures are to be examined. The uptake and subsequent clearance of the isotope are recorded extracranially through the intact skull by means of a scintillation detector coupled to a suitable rate meter and writing unit. The blood flow of the region which is “seen” by the detector is calculated from the clearance curve in terms of ml. blood per 100 gm. of tissue per min. By suitable collimation and choice of isotope the blood flow of regions of various size and depth can be measured. In the present series a wide-angle collimator was used.

Case Reports

Case 1. A 33-year-old farmer, at the age of 9 years, was hit accidentally by a stiff straw in the left orbit, medial to the left eye. The straw penetrated the bony structures at the bottom of the orbit. The wound was treated at a regional hospital and healed without complications. Some months after the accident the patient heard an intracranial murmur which was synchronous with his cardiac rhythm. Some years later the patient noticed irregularities of the cardiac activity with extrasystoles, and he also became easily fatigued during physical effort. In 1961 he started to suffer from a dull ache in the occipital part of the head, which usually came in attacks lasting some hours. Attacks of headache could be provoked easily by pressure over the left carotid artery.

Examination. When admitted to hospital in 1961 the patient had a right-sided exophthalmos and a slight diplopia when looking to the left. An homonymous hemianopia of the lower quadrant was also present. There was an augmented cardiac volume and high minute-volume values (9.2/ l./min.) as well as a precordial systolic and di-
astolic murmur. His blood pressure was 120/80 mm Hg, and the electrocardiogram showed interference with the propagation of the intraventricular impulse.

Electroencephalography demonstrated a continuous slow-wave abnormality on the right side. Auscultation over the head revealed a systolic murmur, maximal over the left ear.

Left carotid angiography showed a large arteriovenous aneurysm between the carotid artery and the cavernous sinus with a great number of distended veins (Fig. 1).

Measurement of the cerebral blood flow by means of krypton was carried out pre- and post-operatively. In the 1st investigation the injection of the isotope was made into the left common carotid artery. The curve obtained was found to consist of two components, a large peak, followed by a slower falling phase (Fig. 2A). The rate of counting at the peak was found to be about 300,000 counts per min. and it fell within 5 sec. to a level of about 50,000 counts, i.e. the slower phase of clearance following the peak started at a concentration of about one-seventh of the maximal concentration of the peak. The phenomenon of the peak was studied in several injections with smaller amounts as seen in Fig. 2A. It was found that the ratio between the peak and the initial value of the slower phase of clearance was closer to 9 to 1. Calculation of the flow represented by the slow phase gave a value of 23 ml. per 100 gm. per min. (normal for cerebral tissue 50.2 ml. (± 7.2) per 100 gm. per min.).

The conclusion reached from this preoperative investigation was that the left carotid artery supplied the arteriovenous aneurysm through which the blood passed rapidly, giving the marked peak on the record. The remainder of the curve showed a slower clearance than expected for cerebral tissue, and it probably represented extracerebral tissue (diploic vessels and tissue supplied by the external carotid artery). This indicated that the left hemisphere was supplied by the right carotid artery, a fact also shown on the angiograms performed on the right side.

Operations. The patient was submitted to neurosurgical treatment. In the 1st stage an intracranial ligature was applied on the left internal carotid artery, proximal to the origin of the posterior communicating artery. The ophthalmic artery was ligated separately. Renewed injection of the isotope into the left carotid artery revealed a simplified curve consisting of only one large peak (Fig. 2B). This indicated that following the ligations described, the blood from the left carotid artery passed almost exclusively through the aneurysm and that the tissues which previously had been responsible for the slow phase of clearance had been excluded by the ligations performed.

It was now established that the left hemisphere was adequately supplied with blood by an injection of isotope into the right carotid artery and by recording with the detector over the left hemi-