BILATERAL CEREBRAL CIRCULATION CURVES
OBTAINED BY INTRAVENOUS INJECTION
OF RADIOISOTOPES*

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Estimation of the circulation of several organs of the body has been achieved successfully by monitoring the passage of radioisotopes in the blood with external counting techniques. Well-established methods now exist for the heart, liver, and kidney. From an anatomical viewpoint, the brain would appear to be particularly suitable for such studies. It is relatively isolated in position; that is, the neck and body can be shielded from a detection system directed at the head. The test to be used must be able to reflect the relatively large volume and rapid flow. Since the brain has bilaterally symmetrical cerebral hemispheres, one can make a comparison between the two. It is well known that the vascular system of each side is quite symmetrical on the arterial side, and that the only variations that do occur are not likely to affect the volume of the arterial network. On the venous side, however, there is commonly a predominance of blood flow to one side in the dural venous sinuses. Cerebral blood flow is unique anatomically from other organs with respect to its situation in a partially vented cranial vault. These circumstances have been expressed in the Munro-Kellie theory which indicates that cerebral blood flow is greatly influenced by changes in the nature of the intracranial contents within such a chamber.

We have sought a method by the external counting technique because 1) the brain is relatively inaccessible to direct methods, 2) it may be easily traumatized, and 3) any method to be used must not interfere with blood flow that is critical for the organ. The method herein reported using intravenous injection is atraumatic, is repeatable at intervals as short as 2 hours, and measures blood flow without influencing the physiological status of the patient.

Present methods of studying cerebral blood flow include angiography by arterial injection of radiopaque materials which give radiographic visualization of the anatomical features of the system. Rapid serial angiograms were made by Greitz to study circulation time, but this method is expensive and is influenced inevitably by the carotid puncture. Intracarotid injections of dye and radioisotopes also are hampered by the necessity of carotid injection. The nitrous oxide, krypton gas, and chromium-labelled erythrocyte methods are not carried out easily for common clinical use. Electromagnetic flow meters are of use in surgical situations and for individual arteries but again are not readily applicable to patients.

We have issued a preliminary report on the results of a first method used about 189 years ago. Very soon, we were able to make considerable improvements by the construction of different apparatus and by the use of I\textsuperscript{131} in a more desirable chemical form.

METHOD OF THE TEST

The radioisotope used was I\textsuperscript{131}-labelled hippuric acid (Hippuran-Squibb). This iso-
The scintillation detectors register through scalers to a rate meter. On the rate meter, pens are mounted to record simultaneous, nearly overlapping curves with individually colored ink for each side so that easy comparison of the curves is seen at once. The time constant of the detection, counting, and display apparatus should not exceed 1 second if the rapidly changing rate of count is to be followed usefully.

ADMINISTRATION OF THE TEST

The test is administered in the following manner (Fig. 1). The patient is placed supine with his head aligned in a true anteroposterior position by means of a plastic headrest of 2 plates at an angle of 150°. The counter-balanced head unit is lowered until the lower edge of the detector aperture is just above the supraorbital ridges. A notch in the inferior edge of the head unit allows a fitting with the nasion enabling better positioning. This positioning of the head must be performed carefully.

A Velero sphygmomanometer cuff is applied to the arm, the blood pressure is obtained, and the cuff is left distended at 10 mm. below the diastolic arterial pressure for at least 1 min. Venipuncture and injection of the radioisotope are done with the cuff inflated to above systolic values. To make the injection relatively standardized, the exact time of injection is taken at the instant the cuff is removed from the arm releasing the distended veins.

The tracing is run for 60 sec. After release of the cuff, there usually is a small rise, probably caused by the passage of the bolus through the axilla and thorax. The curve rises sharply 6 to 10 sec. after injection, it peaks in 5 to 10 sec., and then drops off rapidly. The final plateau is produced by recirculation of the radioisotope. Shown in Fig. 3 are characteristic normal curves.

INTERPRETATION OF CURVES

For the purpose of discussion of the test, the blood contained within the cranium may be thought of as a network, consisting of arterial, capillary, and venous fractions of which the venous is the largest. At any instant the height of the curve represents the amount of radioisotope in the system.

Three features of the curve may be evaluated (Fig. 2). The interval AB represents the arm to circulation time of the brain.

The upgoing slope of the curve represents the rate of blood flow into each hemisphere.