CEREBRAL ANGIOGRAPHY: A TECHNIQUE USING DILUTE DIODRAST

FRANC D. INGRAHAM, M.D., AND CULLY A. COBB, JR., M.D.*

Neurosurgical Service, The Children's Hospital, Surgical Service, Peter Bent Brigham Hospital, and Department of Surgery, Harvard Medical School, Boston, Massachusetts

(Received for publication April 5, 1947)

The introduction of radio-opaque materials into the fluid-filled cavities of the body has accompanied the development of radiology since its early days. Injection of the vascular system is desirable as a diagnostic measure since blood vessels reach all organs and form there a regular pattern. However, there are two serious disadvantages. First, no material may be injected which can serve as an embolus or which is irritating to the vessels themselves; second, the rapid movement of blood makes the timing of X-rays difficult. Numerous variations in contrast media and techniques have been suggested to meet these difficulties in angiography of different structures.

The brain is especially well suited to study by angiography. It is invested with a system of quite large vessels, displacement of which can be recognized without difficulty; the vessels themselves may be affected by disease; and arteries carrying the entire blood supply are easily reached in the neck. The value of cerebral angiography in diagnosis has been well shown in the work of Moniz,17,18 Elvidge,5 Gross,9 List,14 and many others. Yet the rather tedious procedures requiring special X-ray equipment, the lack of an entirely satisfactory contrast medium, and the possible danger to patients have barred the method from general acceptance. These subjects: contrast media for angiography, and the technique of cerebral angiography, will be reviewed and a method which has been safe and satisfactory in our hands will be presented.

CONTRAST MEDIA FOR ANGIOGRAPHY

The choice among contrast media has been a difficult one, for each material has had certain definite faults. Moniz first used strontium bromide and then sodium iodide, both of which caused serious reactions. In 1931 he adopted thorotrast, a material which produced X-ray films of excellent diagnostic quality and caused little or no immediate reaction. Its drawback lay in its high and lasting radioactivity, together with almost quantitative storage in the reticuloendothelial system.29 Despite this it has been chosen for almost all cerebral angiograms and is looked upon favorably by most of those who have published reports of their work in this field.5,13,18

"Thorotrast" is the trade name for a colloidal preparation of thorium

---

* Resident Neurosurgeon, The Children's Hospital, Harvey Cushing Fellow in Neurosurgery, Peter Bent Brigham Hospital, Assistant in Surgery, Harvard Medical School.
dioxide. When studied by the Council on Pharmacy and Chemistry of the American Medical Association in 1932,\(^1\) it was rejected for intravenous injection because of its radioactivity. The thorium which causes this is an unstable element having a pattern of decomposition like that of uranium. It produces a series of daughter elements, each existing in equilibrium with the ones above and below in the series of decomposition, so that the radioactivity remains approximately unchanged. Three emanations are produced by this decomposition, alpha particles or rays, beta rays, and gamma rays. Radium therapy of tumors is accomplished largely by the effect of the beta rays. In toxicity for normal tissues, however, the alpha rays are much the strongest, in ratio with beta and gamma rays as 10,000 is to 100 and to 1. Since their penetration is weak, the alpha rays are easily filtered out when radium is used for therapy. Alpha rays form the predominant emanation of thorium and thus a high toxicity is to be expected.

Two general types of tissue damage have been shown to be caused by the radioactivity of thorium: necrosis which is followed by scarring, and sarcomatosis.\(^2\) Both of these reactions were first observed in watch workers who painted luminous dials. Careful studies of these patients were made by Martland\(^16\) and the insidious nature of the thorium poisoning was brought to light. In experimental animals thorotrast injected intravenously is deposited in the liver, spleen, bone marrow and lymph nodes, and the changes of irradiation damage develop slowly over a period of several years.\(^3,19,25\) Sarcoma of the peritoneum was produced in rats by Roussy, Oberling and Guérin\(^21\) with intraperitoneal injections of thorotrast. Selbie\(^27\) was able to cause peritoneal sarcoma with as little as 0.6 cc. of thorotrast.

The ultimate danger of sarcoma in man has been stressed by those who have conducted studies in animals. This complication has failed to appear among patients, however, and those who prefer to use thorotrast have allowed this to outweigh the experimental evidence. The recent case of McMahon, Murphy and Bates,\(^12\) one of the first patients studied a number of years after thorotrast injection, shows that man is no exception. This patient died at the age of 70 of hemorrhage from a primary endothelial-cell sarcoma of the liver. Seventy-five cc. of thorotrast had been injected 12 years earlier to outline a gumma of the liver. There was widespread irradiation injury, especially in the liver and the hematopoietic system. The greatest concentration of thorotrast lay in the liver and the tumor had originated "in immediate association with the largest single deposition of this material in the body." The other changes of irradiation are well shown in this case. The liver parenchyma was damaged and extensive fibrosis had occurred in the portal areas. Thorotrast was present in the reticuloendothelial system of bone marrow, spleen, liver and lymph nodes, and all of these structures showed damage. The smooth muscle and elastica of blood vessels were affected.

Findings similar to these were reported earlier by Jacobson and Rosenbaum\(^11\) in a patient who had received thorotrast 5 years before death. Their