Test for Patency of Ventriculovascular Shunt for Hydrocephalus with Radioactive Iodinated Serum Albumin*

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Although the presence of a "pump" often makes it easy to determine if a ventriculovascular shunt is functioning, there are occasions when there is some doubt as to its function. Tests of the patency of the valve system in vivo have therefore been undertaken, using radioactive iodinated serum albumin (RISA). Bell injected RISA into the ventricular system in 30 adults, and followed the passage of the radioactive material in the tubing of ventriculoperitoneal shunts, using a Geiger counter. The abstract of Schlesinger et al. deals with much the same type of study, but details have not yet appeared. Atkinson and Foltz (p. 165) have also used RISA in testing patency of the shunt: "... the levels in blood are very helpful if a sudden surge of isotope activity can be picked up to indicate functioning of the shunt." This method appeared to depend on the time of sampling and the rate of flow in the shunt, and was apparently considered secondary to the determination of clearance of the isotope in ventricular fluid over a period of 24 hours. Migliore et al. have used a technic similar to that described in the present investigation, injecting 50-200 μc. of RISA into the lateral ventricle, and sampling radioactivity of blood and radioactivity of residual cerebrospinal fluid. Specific technical details were not given in this brief clinical note.

Methods

Ten hydrocephalic children, aged 1 to 18 months, have been studied before and after ventriculojugular shunting procedures. The diagnosis was made clinically on the basis of progressive enlargement of the head, and verified by diagnostic air study, study of passage of dye from ventricle to lumbar subarachnoid space, and by absence of subdural collections. Either before or a few days after the air study, the child was prepared with 2 drops of Lugol's iodine-potassium iodide solution, given orally to protect the thyroid gland against pickup of radioactive iodine. RISA was instilled into one lateral ventricle several hours after administration of the Lugol's solution. The total dose of RISA was 4 to 7 μc., calculated as ½ μc. per pound body weight. Blood samples were taken at 1, 2, and 24 hours after injection of RISA, using tubes containing anticoagulants. After centrifugation, the serum was collected, and the counting was done with a deepwell scintillometer† on 1 cc. of serum. Each infant acted as its own control, with pre- and postoperative surveys. When the procedure was repeated 2 days to 2 weeks after operation, the only variation was collection of a sample of blood just before instillation of the RISA to permit evaluation of the background activity as a residue of the earlier injection. Early in the investigation, surface counts with flat-field (nonfocussed) and focussed collimation were made over the cerebral hemispheres, heart, liver, and thigh in a few babies. With the doses of RISA used, there was insufficient evidence of increased radioactivity over these areas to permit substitution of these pools of blood for the peripheral blood samples. Direct body counts therefore were abandoned.

A major concern was the possibility of allergic responses to repeated use of radioactive iodinated serum albumin, especially since microbiologists use animal serum albumin as a basic allergen to produce antibodies. Search of the literature failed to reveal previous studies directed at this point, although Crispell et al. mentioned specifically no adverse reactions with multiple doses of RISA in study of plasma volume.

† The well counter was Picker's model 8804A, using a sodium iodide crystal, 2" thick and 2" in diameter, activated by thallium. Corrections were made for background radioactivity and for physical decay of the isotope.

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* Preliminary results indicating the usefulness of the present technic were presented to the Chicago Neurological Society on May 3, 1960. A short abstract appeared in the Society Transactions in the Archives of Neurology in 1961.
Antihuman serum albumin antibodies were produced in rabbits using 3 weekly injections of antigen, consisting of human serum albumin to which had been added a few mg. of RISA and Freund's adjuvant. The anti-human serum albumin antibody was then used as a control in the complement fixation test as described by Boyden.\textsuperscript{3} The antigen was adsorbed on red blood cells of the sheep treated with tannic acid, then used with known antibodies and compared with unknown sera, which might contain antibodies.

In 3 patients, serum was collected prior to carrying out the second RISA study, usually 2 to 3 weeks after the first injection of RISA. In none of these sera were antibodies found, using concentrations of antisera of up to 1:10. There was no evidence in the clinical course of these patients to indicate any antibody-antigen reaction.

**Results**

Fig. 1 shows typical graphs from a hydrocephalic baby (D.E.). The lowermost curve shows the slow pickup of radioactivity from the ventricular system found in an untreated hydrocephalic baby. The most rapid rate of uptake is in the first hour, with a slowly rising slope of the curve of radioactivity (ordinate) plotted against time (abscissa). The uppermost curve was made 7 days after insertion of a Heyer-Pudenz shunt: it shows a striking increase in uptake of radioactivity in the serum, amounting to 3000 units (corrected counts) in a half hour, and 5000 units in 1 hour. After several weeks, the valve was inoperative clinically, and the system was revised at the cardiac end. Fourteen days later, the fontanelle was depressed and the shunt appeared to be working. The isotope study was repeated (middle curve). Although the transfer of radioactivity into the blood stream was lower than the rate in the first postoperative series, it was still distinctly higher than before operation. The implication was that the shunt was working, although at a level below optimum. The shunt was still effective clinically when the child was seen 1 and 9 months later.

Even when circumstances do not permit pre- and postoperative studies, a single curve (Fig. 2) may be of considerable value in determining if a shunting system is effective. This child (T.R.) was seen in our clinic because of doubt if the shunt put in at another hospital was effective. The fontanelle had closed, and clinical data (size of head, irritability, etc.) were equivocal. The RISA study indicated the presence of a nonfunctioning shunt.

The child (G.O.) whose studies are graphed in Fig. 3 had the first shunt put in at age 1 month. About 2.5 months later, the fontanelle became full again, the child became irritable, and appetite declined. Two weeks later, the RISA study (lowest curve) indicated a nonfunctioning tube. Operation revealed that the tube had become too short to function well. A new one was put in place.

![Fig. 1](image1.png) **Fig. 1.** Radioactivity (counts per min.) in blood after injection of radioactive iodinated serum albumin into the lateral ventricle (½ µc, per pound body weight). Curve marked "post revision" was taken a month after the one marked "post-op.," 2 weeks after revision of the shunt because of failure of proper drainage.

![Fig. 2](image2.png) **Fig. 2.** Curve of radioactivity in blood of hydrocephalic child who had had ventriculo-atrial shunt done elsewhere, whose fontanelle was closed, and in whom the question of functioning shunt was raised.