Control of Hydrocephalus by Valve-Regulated Venous Shunt: Avoidance of Complications in Prolonged Shunt Maintenance

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In a previous paper the technical measures necessary for ideal placement of the Holter valve-controlled shunt from ventricle to venous system were described. Our accumulated experience with 140 venous shunts for progressive hydrocephalus in infancy from 1956 to 1966 now provides a basis for understanding and preventing shunt dysfunction or infection which often necessitate shunt removal. Cases in which shunts were used in the management of a known neoplasm are not included in this series.

Prior experience with simple check valves for venous shunts first performed in 1949 had pointed up the problems resulting from over-drainage of ventricular fluid. Check valves of proper resistance were simultaneously developed by Pudenz, et al., and Spitz.

In considering this artificial but mechanically effective method for controlling ventricular pressure and size, three principles have gradually established themselves and now form the basis of our philosophy and plan of management. First, severe uncomplicated infantile hydrocephalus, when properly treated, clearly can be followed by normal brain development much more frequently than has been taught in the past. Second, the ultimate result, although related in part to the original cause and severity of the hydrocephalus, is strongly affected by the adequacy of continued mechanical palliation. Even children who are apparently tolerating a shunt blockade will often be found to have re-enlarged ventricles with sufficient elevation of pressure to prevent optimal development. Third, the many technical problems posed by continuous maintenance of shunt function in the rapidly growing infant can be minimized by expert planning.

In this paper we will deal primarily with the pitfalls and complications we have encountered, considering any degree of shunt dysfunction as a complication. We will also review the measures we have instituted to avoid these complications, document their effectiveness, and point out the continuing problems in prolonged shunt maintenance.

Pneumography

Regardless of each surgeon's individual criteria for treatment, evaluation of each case of hydrocephalus must include pneumography. The study must be adequate to reveal that the extent and nature of the hydrocephalus, as well as the characteristics of the CSF are suitable for palliation by venous shunt. One must have a base line measurement of ventricular size and cerebral mantle thickness before treatment.

Treatable mass lesion causing hydrocephalus must not be overlooked. We made this error four times prior to 1960. A 6-week-old infant died suddenly from rupture of an undiagnosed cerebellar abscess after good response to shunt. Two malignant posterior fossa gliomas and a frontal ependymoma were ultimately recognized and received definitive surgical treatment.

Delineation of communicating porencephalic cysts and of Dandy-Walker cysts arising from the fourth ventricle is of prognostic importance, but experience suggests that these conditions respond well to treatment by shunt and that a direct surgical attack on the cyst offers no advantages.

The introduction of large amounts of air, on the other hand, increases morbidity. From 1956 through 1961, this factor was responsible for six instances of contamination and bacteremia following shunt placement in patients subjected to multiple ventricular taps between pneumography and surgery. The incidence of this complication can be reduced by limit-
ing the amount of air injected. Figure 1 illustrates the adequacy of delineation obtained, by proper positioning, after a 10-cc air injection.

In the child depressed by increased intracranial pressure, the shunt can be instituted immediately after a bubble of air confirms the presence of large ventricles. Gradual delivery of a small amount of air to the atrium by shunt carries no hazards. A more definitive study can be undertaken when the patient’s general condition has improved through the control of pressure. The important point is not to create additional brain insults by excessive diagnostic air injection.

Finally, analysis of our problems with infection suggests that a venous shunt should not be undertaken in the presence of CSF contamination, whether from multiple taps or from an open or necrotic myelomeningocele sac.17

Dysfunction from Venous Catheter Block

Without planned revision, catheter blockade is an inevitable complication in the growing infant, since a catheter anchored above the clavicle will project an ever shorter distance into the growing chest as each month passes. The problem was clarified by x-ray visualization of barium-impregnated catheters in the chest.27 Radiographic techniques designed to define bony rather than pulmonary detail may be necessary to show the catheter. When films show a blurred rather than a sharply defined catheter tip (Fig. 2 left), a shorter, higher intensity exposure, use of fluoroscopy, or provision of increased contrast by Hypaque injection will define its true position (Fig. 2 right). Correct placement of the catheter tip in the chest is important because of the striking correlation between its anatomical position and complications (Table 1).

The empirical data in Table 1 indicate that catheter tip obstruction begins at T-4 (with one lower exception) and becomes very frequent at the T-3 level. Yet any attempt to prolong catheter function by placing the tip at T-7 or below is correlated with a 22% incidence of bacteremia. An x-ray of one of the early cases (1957) that developed bacteremia with the catheter tip at the T-9 level is shown in Fig. 3. At autopsy we found that this catheter had penetrated the tricuspid valve and was enmeshed in infected vegetations and thrombus.

Evidence for anatomic correlation with bac-