became maximum one week after, and these changes were milder comparing to other types of hydrocephalus. There was little change in the subarachnoid space.

At the case of experimental hydrocephalus, one should make consideration of chronological changes and localized ventricular dilatation in each group.

B-28. Shunt Revision: Percutaneous Management of Ventricular Catheter Obstruction and Fogarty Catheter Technique for Release of Atrial Obstruction

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Ventriculoatrial shunt has been widely used for the treatment of hydrocephalus. Among complications of the procedure, mechanical obstruction of the shunt system especially in a ventricular catheter was reported to be the most common cause of functional failure of the system. It has been general practice to release mechanical obstruction of the system surgically under general anesthesia. However, frequent revision on a patient presents many problems associated with surgery such as pulmonary complications, trachitis, wouud infection and economical burdens on the patient's family. We have tried to develop a technique to revise this mechanical obstruction by non-surgical percutaneous management of the obstructed ventricular catheter which requires minimal sedation and no serious morbidity. This paper is to present the procedure of the technique in detail and results of follow-up investigation. In addition, experience with Fogarty catheter technique for release of atrial obstruction is reported.

Method: 1) technique for placement of a ventricular catheter through 8-figured burr hole

A horseshoe scalp incision is placed 2–3 cm lateral to the bregma.

One of these holes is made by a 1/4 inch (6 mm) drill used for stabilization of the Rickham reservoir and the larger adjacient burr hole allows satisfactory dural openning and hemostatic control in the smaller hole, as well as a later route for emergency ventriculostomy and the outflow CSF pathway during the ventricular catheter irrigation procedure. A straight ventricular catheter with holes at the tip is connected to Rickham reservoir and inserted into the ventricle anterior to Foramen Monroe. Optimal ventricular catheter length is determined using the preoperative air study. Distal to the Rickham reservoir, any of various pressure control valve mechanism may be connected

2) technique for management of obstructed ventricular catheter. Following light

sedation and under fluoroscopic control, a 20 gaze modified spinal needle is passed percutaneously into the Rickham reservoir and through the entire length of the ventricular catheter. A standard sharp stylet is used for penetration of the oberlying scalp and silastic cap of the reservoir. Once the needle is passed the cap, a blunt stylet replaces the sharp stylet and fluoroscopic control aids in avoiding extremes of pressure or position change as the needle is passed the length of the in place ventricular catheter. Aspiration through the needle in the ventricular catheter is enough to remove obstruction and reopen the catheter. If not, a spinal needle is positioned in the lateral ventricle via the previously placed larger burr hole. Volume from the high pressure ventricle may flow out as well as allowing egress of irrigant saline solution injected through the needle in the ventricular catheter. Aspiration and irrigation through the needles accomplish removal of particulate obstruction. Instillation of a few cc of air may aid demonstration of the exact position of the ventricular catheter.

3) technique for removal of obstruction in the atrial end using Fogarty Catheter.

After an atrial tube is removed from the internal jugular vein, a Fogarty catheter is passed and advanced until the tip of the catheter reaches obstructed site. Gentle aspiration is followed by instillation of saline solution into the tip balloon and this is repeated until dilatation of the area breaks fibrous adhesive tissue. Aspiration through the catheter should be continued in the course of the dilation procedure to avoid distal migration of broken tissue particles and subsequent pulmonary embolism. Contrast medium is injected frequently to visualize the condition of the area.

Result: We have used this ventricular catheter placement with frontal Rickham reservoir system on 58 patients since July 1970. During 2 to 26 months follow up period, 11 ventricular catheter obstruction in 9 patients have presented the clinically nonfunctioning system. Percutaneous removal of obstruction by needle aspiration and irrigation as described has prevented the need for operative revision in all cases. No serious complication rather than a small subcutaneous hematoma is noted. Successful removal of the atrial obstruction with Fograty catheter technique has been obtained on 3 patients in 5 patients attempted. No clinical complication has been presented.

Summary: Techniques for shunt revision are presented in detail. Percutaneous management of the obstructed ventricular end prevented the operative revision with minimal morbidity. Fogarty catheter technique is described for removal of atrial end obstruction.

B-29. Experiences with Ventriculoatrial and Ventriculoperitoneal Shunt Operations, with Special Reference to Different Shunt Apparatuses

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