Ventriculo-Peritoneal Shunts in the Management of Hydrocephalus*

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Between 1950 and 1957, we performed a number of polyethylene tubing ventriculo-peritoneal shunts. The results were almost uniformly unsatisfactory, obstruction occurring within a matter of days or weeks, usually at the peritoneal end of the shunt. When these shunts were revised it would be found either that the distal end of the tube was encased in a dense mat of omentum and bowel or that the distal inch or two of the tube was filled with a thick coagulum. However, during this discouraging period an occasional shunt worked well enough and long enough to suggest that the abdominal cavity might indeed be a satisfactory shunt receptacle.

Realizing that the newer techniques of shunting into the blood stream involved certain inherent problems, we decided to try the abdominal cavity once more, this time using silicone tubing because of its inert properties, along with a slit valve at the distal end to prevent reflux of fluid from the abdominal cavity. The first such shunt was done in 1958. It soon became obvious that the peritoneal cavity was admirably suited for cerebrospinal fluid shunting. Nothing has occurred since that time to alter this impression.

It was found quite early that the lumbar subarachnoid peritoneal shunt could not be relied on in infants because of the small size of the spinal canal. Therefore, the ventricle has been used exclusively for infants although several successful lumbar subarachnoid peritoneal shunts have been carried out in older children and adults.

During the past 9 years we have performed approximately 120 ventriculo-peritoneal shunts. There have been four deaths attributable to the operative procedure itself, all due to infection. In one case the infection appeared after the initial procedure; the other infections developed after revisions.

There has been only one case in which the peritoneum lost its absorptive capacity. This was in a child who underwent peritoneal shunt at age 3 months. The shunt functioned well for the next 2 years. The child then developed an acute febrile illness characterized by vomiting, diarrhea, abdominal pain, and leukopenia. This illness cleared promptly on symptomatic treatment but 3 weeks later he returned because of abdominal distension, which proved to be cerebrospinal fluid ascites. Repeated paracenteses failed to relieve the situation and ultimately a ventriculo-atrial shunt was done; this functioned well some 6 months later at his last examination.

Failure of the peritoneum to absorb fluids following even a mild peritonitis has been observed in connection with peritoneal dialysis. It has further been noted that following complete subsidence of all post-inflammatory reaction the peritoneum regains its absorptive capacity.1

Except for the case above, no instance is known in which the peritoneal cavity has "rejected" the shunt. Obstruction of the distal end of the tubing has not occurred, in spite of the fact that omentum is not resected and no attempt is made to place the distal tubing at any specific location within the abdomen. The longest known time that a shunt has functioned satisfactorily is 6 years. Before 1962, our shunts did not incorporate a pumping device. It is therefore impossible to determine if the earlier cases which continue to do well represent simply spontaneous arrest of the hydrocephalus.

A number of problems were encountered during the gradual evolution of the present

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operative technique. These have been largely mechanical and have consisted of:

1. Migration of shunt or components
2. Separation of components
3. Plugging of ventricular catheter, notably at the connector “bottleneck.”
4. Distal end of shunt pulling out of peritoneal cavity. This problem occurred in earlier cases due to unwarranted timidity in introducing a sufficient length of tubing into the abdomen.
5. Slit valve too small. It has been found that the opening pressure should not exceed 3 or 4 cm of water and that lower opening pressures are satisfactory as long as the valve is competent. The mechanism by which intracranial pressure adjusts after a shunt is not clear but it is apparent that back pressure from the valve itself is not a significant factor.

A reasonably satisfactory technique was evolved and used without modification from November, 1963, until December, 1965. Twenty-eight cases were operated on during this period, with no deaths. One shunt was replaced because of infection and three were revised due to obstruction of the ventricular catheter. One child, as previously described, developed asceites.

In 1965, a shunt incorporating one-piece fabrication of ventricular catheter and a twin-chambered flushing device was developed in cooperation with the Medical Products Division, Dow Corning Corporation (Figs. 1–3). Since December, 1965, 24 cases have been operated upon using this shunt; 19 were infants with hydrocephalus and the remaining five were adults, the majority with inoperable tumors who needed palliative procedures. One death has occurred, due to infection. One revision has been necessary because of obstruction of the ventricular catheter and flushing device by fresh clot; this was in a shunt which had functioned well for 4 months. In one other case, the original intraperitoneal tubing was too short; the infant outgrew the shunt after 7 months. An additional length of peritoneal catheter was attached and reinserted into the abdominal cavity. The revised shunt is presently working well.

Of the 52 cases operated on since Novem-

ber, 1963, 10 were adults and 42 were infants. A break-down of these cases is given below:

**Adult Group:**

4 Metastatic brain tumors, multiple or inoperable
1 Increased intracranial pressure of unknown etiology
1 Diffuse meningeal gliomatosis
1 Recurrent astrocytoma, solid, cerebellum
1 Midbrain glioblastoma with aqueduct obstruction
2 Mental deterioration with ventricular enlargement

**Infant Group:**

21 Hydrocephalus in conjunction with myelomeningocele and presumed due to Arnold-Chiari malformation (preoperative air studies were not done routinely in these cases) 4 Hydrocephalus due to aqueduct obstruction 5 Hydrocephalus due to membranous obstruction of foramen of Magendie (Dandy-Walker) 12 Communicating hydrocephalus.

Only those adults who did not have tumors remain alive. The shunts have functioned well up to 1 year of follow-up. In the tumor cases, pressure was controlled during survival periods of from 5 to 12 months. Autopsy examination of three of these shunts after intervals of 5, 6, and 11 months disclosed each to be patent and functioning.

All infants underwent the initial shunting procedure during the first 6 months of life. The majority were operated on before the age of 3 months, the youngest being 8 days old. Of the entire group, only three could be classified as “borderline” hydrocephalic patients. Brain thickness in the majority of cases was less than 3 cm. The only criterion for shunting was the presence of progressive hydrocephalus. No infant was refused operation unless multiple anomalies or other conditions existed which made prolonged survival impossible. Of the 42 infants, 8 were known to have died including the one who died with postoperative infection. Although information as to exact cause of death is
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FIG. 1. Assembled apparatus for silastic ventriculo-peritoneal shunt.

inadequate, we noted that most of these were badly crippled individuals who had shown little in the way of satisfactory mental or physical development.

Of the survivors, a certain number have been lost to follow-up. The remainder are seen at 6-month intervals and are doing well from a mechanical standpoint. Mental development varies greatly. We are impressed with the fact that there is no consistent, predictable correlation between brain thickness at the time of initial shunting and future intelligence.

Inspection of the abdominal cavity in infants with functioning shunts has been possible in two cases. In one, a hernia repair 4 months after lengthening of the peritoneal catheter and 2 years after the original shunt allowed us to see that no free fluid was present in the abdomen. In the second case a laparotomy for cystectomy and creation of an ileal conduit 28 months after a ventriculo-peritoneal shunt showed no free fluid in the peritoneal cavity; the catheter lay free among loops of small intestine and cerebrospinal fluid dripped from the slit valve at a

FIG. 2. Silastic ventriculo-peritoneal shunt showing single unit construction.

FIG. 3. Silastic ventriculo-peritoneal shunt showing double chamber flushing device.
rate of four drops per minute.

Two of the cases involving membranous obstruction of the foramen of Magendie have been explored and the membrane removed. It is likely that the remaining cases will be explored at some future date.

**Technique**

The patient is positioned supine with the right shoulder elevated and the head extended and rotated to the left. Plastic draping is useful. A straight or slightly curved incision is made in the parieto-occipital region and a burr hole placed. A dural nick is made and the exposed cortex coagulated. A cannula is inserted, and a note is made of the depth at which the ventricle is entered. On this basis a shunt assembly having the desired length of ventricular catheter is selected. The scalp is undermined by blunt dissection to create a subgaleal pocket of proper size and position to accommodate the flushing device. The distal end of the connector tubing is grasped with a suitable instrument (the Carroll tendon forceps has been found very satisfactory) and passed subcutaneously as far as possible. A small incision is then made over the tip of the instrument and the connector tubing withdrawn. An upper right rectus incision is made and an instrument passed from it subcutaneously until the connector tubing can be grasped and drawn down. By traction on the connector tubing the flushing device is well seated in the subgaleal pocket. If properly positioned, there will be no kinking or stretching of the ventricular catheter as it passes into the ventricle. The flushing device may be anchored to the pericranium by one or two sutures. The ventricular catheter is inserted along the cannula tract into the ventricle. The tract makes the use of a stylet unnecessary.

After free flow of cerebrospinal fluid has been observed, the connector tubing is clamped to prevent excess fluid loss at this stage and divided an inch or so distal to the clamp. A suitable length of peritoneal catheter is joined to the connector tubing by means of the metal connector provided. Encircling silk ties afford added protection against component separation. The clamp is removed and satisfactory flow of cerebro-

spinal fluid established. It is sometimes necessary to manually separate the edges of the slit valve in order to initiate flow; this is due to a tendency for dry silicone surfaces to adhere. Once flow has been started this cohesiveness is no longer a problem.

The rectus sheath is incised and the rectus muscle split. A small incision is made through the posterior rectus sheath and the peritoneum and the peritoneal catheter introduced. It is recommended that the length of the shunt be such that a minimum of 6 inches of catheter lie within the peritoneal cavity.

Incisions are closed in layers with fine silk. No special postoperative measures are needed except in the case of infants, who are maintained in a horizontal position for the first 12 hours after surgery.

In infants, the twin domes of the flushing device are easily palpated through the overlying scalp at all times. In adults, the combination of greater scalp thickness and edema renders satisfactory palpation and identification impossible until a week or 10 days has elapsed.

The design of the flushing device is such that firm digital pressure over either chamber collapses that chamber and prevents flow of fluid through it. Palpation of the other chamber then readily determines if there is free flow through that section of the shunt. By occluding either the proximal or distal chamber first, it is possible to test the patency of the ventricular or the peritoneal end of the shunt selectively. The ability to test for patency of the ventricular catheter is particularly valuable in that group of individuals in whom the chambers of the flushing device, when compressed, remain collapsed for an extended period of time.

**Summary and Conclusions**

Properly designed ventriculo-peritoneal shunts have proven to be both practical and satisfactory in the management of hydrocephalus. Technical problems encountered in the past have led to the design and adoption of the shunt assembly currently in use. We have described our apparatus and the technique involved, and have discussed our clinical experience with 120 cases treated by this method.
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Reference
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Discussion
Drs. Alexander, Davis, and I have performed 18 ventriculo-peritoneal shunts over the past 1½ years at the North Carolina Baptist Hospital and, in general, have been pleased with the results.

Our procedure at the present time is to do a ventriculo-atrial shunt with the Holter valve on uncomplicated cases of hydrocephalus. However, we have resorted to ventriculo-peritoneal shunts when other factors such as the following are involved: 1) recent meningitis or ventriculitis, with or without previous shunt; 2) recent septicemia secondary to infected ventriculo-atrial shunt; 3) crusting and infected myelomeningocele; and 4) superior vena caval obstruction or thrombosis of the jugular veins.

Primarily we have used the Holter valve in the assembly because in this way the distal tubing can be pumped. We have not used the slit valve and have placed the distal tube over the liver to avoid the omentum. We have the distinct impression that the added feature of the valve in the ventriculo-peritoneal shunt assembly, using silicone tubing, is superior to the previously employed ventriculo-peritoneal shunt without valve and with rubber and/or polyethylene tubing. It certainly has a place in the current armamentarium against hydrocephalus and has been successful in the hands of Dr. Ames.

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