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 ascites.

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 November, 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