A NEW OPERATION FOR THE TREATMENT OF COMMUNICATING HYDROCEPHALUS

REPORT OF A CASE SECONDARY TO GENERALIZED MENINGITIS*

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Patients suffering from severe purulent meningitis may survive with the aid of modern antibiotic therapy only to face an equally disastrous complication, namely, obliteration of the subarachnoid fluid pathways by an adhesive process involving particularly the cisternae at the base of the brain and the subarachnoid spaces over the cerebral and cerebellar hemispheres. This chronic adhesive process may prevent access to, or virtually destroy, the normal absorptive surface provided by the vascular bed of the pia-arachnoid. The circulation of spinal fluid is therefore interrupted and progressive hydrocephalus ensues.

Hydrocephalus of this origin may or may not be of the so-called "communicating" variety, depending upon where interruption of the subarachnoid fluid pathways occurs. Several locations are involved commonly, and treatment varies accordingly:

1. If one foramen of Monro is occluded, unilateral hydrocephalus may occur; this has been successfully treated by making an opening through the septum pellucidum.

2. If the Sylvian aqueduct becomes blocked by scarring, but the subarachnoid cisternae remain open, subfrontal or subtemporal 3rd ventriculostomy may be performed, or even more satisfactorily, a shunting procedure of the type introduced by Torkildsen9 which connects the lateral ventricle with the cisterna magna.

3. If obstruction occurs in the posterior fossa alone with obliteration of the cisterna magna and occlusion of the caudal and lateral recesses of the 4th ventricle, then suboccipital craniectomy with lysis of these adhesions and removal of the thickened membrane which seals the 4th ventricle may be sufficient to re-establish normal fluid circulation.

4. If, however, a more extensive adhesive process has taken place, causing obstruction of the basilar cisternae or the subarachnoid bed generally over the cerebral and cerebellar hemispheres, either alone or in addition to the locations already mentioned, then treatment becomes much more difficult. The operative procedures mentioned are of no avail since they fail to provide access to an absorptive surface. The problem becomes essentially the same as in congenital idiopathic communicating hydrocephalus where no

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obstruction can be demonstrated but there is apparently a simple failure of
spinal fluid resorption.

Partial choroid plexectomy—for this can never be a complete operation—is
the only procedure generally used in the treatment of communicating
hydrocephalus. This involves at least two transcortical operations and the
results are satisfactory probably only in patients where spinal fluid resorp-
tion is impaired to a minor degree.

Diversion of spinal fluid to a wide variety of locations has been carried
out in the attempt to find an alternative absorptive surface. These locations
include the subcutaneous tissues, the paranasal air sinuses, the pleura, the
peritoneum, the thoracic duct and the blood stream itself, including both the
intracranial venous sinuses and the veins of the scalp and neck. To date
none of these has demonstrated any significant success either in hydroce-
phalic animals or in human patients.

If the search for a new absorptive area is abandoned, the possibility of
shunting fluid into an excretory channel instead naturally comes to mind.
With the exception of one or two disastrous attempts to lead fluid from the
ventricles into the oro-pharynx and one attempt to suture a loop of bowel
directly to the lumbar dura, the gastrointestinal tract has not been em-
ployed.2

The urinary tract has proved somewhat more attractive. Heile, in 1925,4
first reported ureterodural anastomosis following unilateral nephrectomy.
He operated on 4 patients; 1 died during the operation and the other 3
apparently were at least temporarily improved. Christopher in 19291 trans-
planted the ureter to the sac of a lumbar meningocele in 2 patients; 1 of
these died at operation and the other 3 weeks later. Davidoff and Bancroft3
reported 1 ureterodural anastomosis in 1932, the patient succumbing 1 week
after surgery.

In 1934, Lehman7 described 3 cases in which he had performed uretero-
arachnoid anastomosis. The anastomosis no longer functioned at 7 1/2 weeks in
1, 1 died of meningitis at 17 days, and the third succumbed suddenly of un-
known causes on the day of leaving the hospital. This same author collected
reports of 13 individual cases from the Russian and German literature and
estimated that 4 of them were in some measure successful. In 1942, Sachs8
described 3 instances of uretero-arachnoid anastomosis performed following
unsatisfactory results from choroid plexectomy; there was 1 death and the
other 2 patients are reported improved. Torkildsen, in his recent monograph
on ventriculocisternostomy,10 dismisses uretero-arachnoid anastomosis as
follows: "This ingenious operation is connected with a very high mortality
and has never gained considerable practical importance because of its opera-
tive and post-operative complications."

This report presents an operative procedure which is an adaptation of
the principle introduced by Heile, designed to shunt spinal fluid from the
lumbar subarachnoid space to the urinary tract. Based upon considerable
laboratory experience in the diversion of spinal fluid through various types
of channels a method was adopted in this case which proved technically simple and which appeared to overcome many of the drawbacks of Heile's operation. The ease with which the procedure was carried out, the striking immediate recovery of this critically ill patient, and the uneventful post-operative course, with demonstration at 2½ months that the excretion of spinal fluid by way of the bladder was still completely satisfactory, seemed to warrant preliminary presentation of this case in some detail.

CASE REPORT

An 8-year-old colored girl was injured in an automobile accident in May, 1947, at which time she suffered an extensive frontoparietal skull fracture. She was hospitalized for 3 months with gradual recovery, following which she was asymptomatic except for intermittent mild headache for 10 months—that is, until March, 1948. At that time she experienced the onset of severe headache, irritability, vomiting and fever; 36 hours later, she was admitted to a hospital in the midst of a generalized convulsion. She was subsequently transferred to the Neurosurgical Service of Duke University Hospital. On admission she was found to have staphylococcus meningitis, osteomyelitis of the frontal bone, and CSF rhinorrhea. A radical extirpation of the infected bone and frontal sinuses was carried out (Fig. 1) and the dural defect repaired with a pericranial graft.

After a stormy postoperative course, the infection cleared, but evidence of increasing intracranial pressure appeared and ventriculography demonstrated marked ventricular dilatation (Fig. 2). Posterior fossa exploration was therefore performed at which time the cisterna magna was found to be obliterated and the 4th ventricle obstructed by adhesive arachnoiditis (Fig. 3).

Following this operation the child did well, but after the 5th postoperative day the frontal decompression again bulged and the patient became drowsy and apa-
Fig. 2. Ventriculogram showing symmetrical dilatation of the entire ventricular system. There is no air in the basal cisternae or subarachnoid spaces over the cerebral hemispheres.

thetic. Removal of fluid by lumbar puncture always decreased the protrusion of the decompression. Phenolsulphonphthalein injected into the lateral ventricle appeared in the lumbar spinal fluid in good concentration in 5 minutes. However, only 7.5 per cent of the dye was excreted in 2 hours and less than 30 per cent in 12 hours.

An intravenous urogram demonstrated good excretion of diodrast by both kidneys. During this period it was necessary to perform lumbar removal of spinal fluid

Fig. 3. Cross section of the membrane which sealed the 4th ventricle.
every 12 to 24 hours to relieve the patient of severe headache, semi-stupor, vomiting, and extreme bulging of the frontal decompression (Fig. 4). Immediately after each lumbar puncture she was much brighter and more comfortable but it became necessary to tap her at more and more frequent intervals. Since no absorptive surface within the central nervous system remained accessible, more radical measures were decided upon to relieve the increasing hydrocephalus.

![Fig. 4. Extreme bulging of the intracranial contents through the bony decompression.](image)

**Operation**

Choroid plexectomy was considered but the rapidity with which severe intracranial hypertension recurred following each lumbar spinal fluid drainage indicated a degree of obstruction which, it was felt, precluded any possibility of lasting benefit from partial plexectomy. On April 30, under ether anesthesia, the left kidney was removed through a flank incision by Dr. John Dees of the Urological Department. Leaving this incision open, the patient was rolled forward slightly and a laminectomy of L2 and L3 was carried out. The dura was opened in the midline. The arachnoid was punctured, and a polyethylene plastic tube,5 about the size of a #8F catheter, was introduced and directed downward to lie among the cords of the cauda equina; approximately 6 cm. of the tube was placed intrathecally. The tube was fastened securely to the dura by silk sutures. It was brought upward and laterally toward the left in a gentle curve, tunneled through the psoas muscle to the peri-nephric space and introduced into the ureter for about 6 cm. The margins of the upper end of the ureter were then sutured securely to the fascia of the psoas muscle. No sutures were placed around the ureter. Both operative wounds were closed without drainage (Fig. 5).
Fig. 5. (A) Detail of suture of the upper end of ureter to the fascia of the psoas muscle.
(B) Detail of the plastic tube lying within the lumen of the ureter.
(C) Cross section showing pathway of the tube from the spinal canal to the retroperitoneal space.
(D) Laminectomy at L2 and L3, showing position of tube after insertion.
(E) Detail of the end of the plastic tube inserted into the subarachnoid reservoir.
(F) Relation of the tube to the dura and cords of the cauda equina.
(G) General diagram of the completed operation.
The *postoperative course* was afebrile. The patient was incontinent for about 36 hours and after that had complete urinary control. The decompression remained depressed at all times (Fig. 6). It was never necessary to tap the patient after this operation because of increased pressure. One lumbar puncture was carried out on the 5th postoperative day, at which time the initial pressure was 90 mm. of water.

Recovery was remarkably rapid. All wounds healed per primam and the patient, for the first time in over 8 weeks, took a real interest in her surroundings, laughed, ate well and wanted to get up. Her voided urine showed rbc. for 10 days and none thereafter. It continually showed 5–20 wbc./high power field in a centrifuged specimen. It showed no sugar, a 1+ albumin, and a specific gravity varying between 1.002 and 1.014.

On May 18, the coronal scalp flap was re-elevated and a preformed tantalum plate inserted to close the defect in the frontal bones (Figs. 7 and 8). The postoperative course was uneventful. She was up and about the ward by the 5th day and was discharged home on her 76th hospital day, 30 days after anastomosis of the lumbar subarachnoid space to the ureter and 10 days after insertion of the tantalum plate. At this time she was alert, afebrile and symptom-free.

The patient was readmitted to the hospital for evaluation 2½ months after the shunting operation. She had gained several pounds in weight, was happy and active. She had complete control of her urine, voided 4 to 6 times during each day and not at all during the night. Her neurological examination was normal. Her urine showed a specific gravity of 1.006, no albumin or sugar, and 6-10 wbc./high power field in a voided specimen. Lumbar puncture revealed an initial pressure of 50 mm. of water in the lateral position. Ventricular puncture was then carried out and the pressure in the dependent ventricle in the lateral position was also 50 mm. of water; 1 cc. of neutral phenolsulphophthalein was injected into the ventricle. This dye appeared in the bladder urine in between 15 and 20 minutes; 75 per cent of the dye was excreted within 2 hours and approximately 95 per cent in 12 hours. Six months after operation, the patient is still symptom-free and leading a normal active life.
DISCUSSION

This procedure was designed to provide several features felt to be desirable: first of all, ureteral peristalsis should remain unimpaired since the nerve and blood supply of the ureter was left intact; secondly, the normal valvular action of the uretero-vesical junction should also remain unimpaired since this region was not even approached; thirdly, the possibility of retrograde infection travelling from the bladder to the subarachnoid space by way of the lymphatics in the wall of the ureter should be obviated by the interpolation of a loop of polyethylene tubing at least 6 cm. in length between the ureter and the arachnoid. In the fourth place, the possibility of arachnoid adhesions occluding the junction of an artificial opening made into the subarachnoid space—which was frequently the fate of direct uretero-arachnoid anastomosis—was counteracted by placing a full 6 cm. of a fairly large size plastic tube containing several openings well into the lumbo-sacral subarachnoid reservoir and well away from any points of operative interference with the arachnoid. In the fifth place, a large enough loop of polyethylene tube was used, and a sufficient length of the tube inserted both into the ureter and into the subarachnoid space to allow any type of motion or position-
ing of the patient without danger of the tube being dislodged or put under tension.

There was no evidence that this patient's electrolyte, carbohydrate, or protein metabolism was significantly disturbed by the continual excretion of large amounts of spinal fluid. This amount was not determined quantitatively since it was not felt justified to run the risk of ureteral catheterization. The consistently low specific gravity of the voided urine, the rapid excretion of the dye injected into the ventricular system, and more important perhaps, the clinical course of the patient seemed ample proof of the continued flow of spinal fluid through the artificial shunt.

There was no evidence that the persistent reduction in the pressure in the subarachnoid fluid spaces, measured at 50–90 mm. of water on two occasions, had any deleterious effect. Because of the rather alarming manner in which the frontal decompression sank in when the patient assumed an erect position, especially after she had just voided, it was felt that repair of the cranial defect at the earliest possible date might be desirable to lessen, perhaps, the possibility of subdural or subarachnoid hemorrhage. Therefore, not without some misgivings, tantalum cranioplasty was carried out only 60 days after the original removal of the osteomyelitic bone, exenteration of the frontal sinuses and grafting of the large dural defect. A satisfactory result was achieved and to date there has been no evidence of unusual reaction to the plate.

The history of the treatment of hydrocephalus is replete with reports of individual cases in which some new surgical procedure resulted in temporary improvement, only to have failure ensue later. Therefore, this should be viewed strictly as a preliminary observation. The subsequent course of this patient will be followed with considerable interest and care before any final conclusion is reached.

The following opinions, however, seem tentatively justified on the basis of the case presented:

(1) Combined nephrectomy and laminectomy for this purpose is not technically difficult or unduly shocking to the patient when the proper supportive measures are anticipated. In the case reported it was apparently a life-saving procedure.

(2) There was no undesirable disturbance in electrolyte, protein or carbohydrate metabolism as a result of the continual excretion of spinal fluid.

(3) No urinary dysfunction such as incontinence, frequency, nocturia, or painful urination has resulted from the mixture of spinal fluid and urine in the bladder.

(4) No abnormal neurological symptoms or signs have resulted to date from the presence of the plastic tube in the subarachnoid space amid the cords of the cauda equina.

(5) There is no evidence that any reflux of urine from the bladder to the subarachnoid space through this system has taken place in a patient who has been very active and led an apparently normal existence.
(6) If this patient’s course continues as satisfactorily as it has proceeded to date, without evidence of increased intracranial pressure, foreign body reaction or meningeal infection, it is felt that this procedure should be explored further and applied to selected patients with communicating hydrocephalus of all types, especially those who have persistent increased pressure following choroid plexectomy.

REFERENCES


ADDENDUM

Since the preparation of this report, this operation has been performed without difficulty on 3 hydrocephalic infants, 3 to 5 months of age, at The Children’s Hospital, Boston. Preliminary observations indicate that in infants 2–3 grams of salt daily should be added to the diet to prevent excessive chloride loss.