Ventriculosagittal-Sinus Shunt

PAUL C. SHARKEY, M.D.
Division of Neurological Surgery, Baylor University College of Medicine, Houston, Texas

In an effort to palliate or correct progressing hydrocephalus with its diverse etiologies, numerous and often ingenious methods have been devised to by-pass the obstruction to the passage of cerebrospinal fluid or to divert the fluid to a new bed of absorption. Although some of these procedures are now a part of the history of neurological surgery, many still are being used but often they are limited or restricted to a specific set of factors such as: sex (fallopin-tube shunt); normal or adequate bed for absorption of cerebrospinal fluid after by-passing the block (Torkildsen shunt); two normal kidneys, and an intelligent informed family (ventriculo-ureteral and lumbar subarachnoid ureteral shunts). In addition, a major problem common to almost all shunts utilizing a foreign-body tube for transmission of the fluid has been obliteration or obstruction of its working ends, requiring patience and perseverance on the part of the patient and the surgeon and often terminating in an unsuccessful result. As early as 1908, Payt reported on 3 patients in whom he had connected the lateral ventricle to the longitudinal sinus with a segment of saphenous vein. Even though these patients all died within 4 months, autopsy showed that blood had not refluxed into the ventricle and the sinus was not thrombosed. Haynes, in 1913, reported on connecting the occipital sinus to the cisterna magna in 1 patient and connecting the cisterna magna to an emissary vein. Both attempts were unsuccessful. Cushing referred, in 1926, to an attempted connection of the 3rd ventricle to the longitudinal sinus with a tube passed through the corpus callosum. He observed that blood did not reflux into the 3rd ventricle. In 1948 Ingraham et al. reported their experience with polyethylene shunts from ventricle to sagittal sinus in dogs. When the shunts were observed 6 to 42 days later all tubes were clotted from refluxed blood. However, with the advent of the modern ventriculovenous shunts, a new era has been entered and the treatment of hydrocephalus, regardless of cause, is carried out actively in most clinics. It would appear from the current literature that the utilization of the distal-valve (Pudenz-Heyer) shunt or the proximal-valve (Spitz-Holter) shunt has increased significantly the chances for useful survival of these patients over those for a comparable group of patients and has provided the neurosurgeon with a relatively simple operative technique.

It has been pointed out by Strenger that in spite of an almost universal application of ventriculovenous shunting, relatively little has been published pertaining to the complications or difficulties encountered utilizing these procedures. Although the ventricular portion of the shunt, regardless of the type used, may occasionally become obstructed by fragments of brain, blood clot or debris from a previous ventriculitis, or the occasional unusual problem when a tube migrates proximally or distally, the usual source of difficulty is at the delivering end of the shunt. This is usually a result of obstruction by reactive tissue or of dislodgment of the shunt with active linear growth of the patient. The ventriculovenous shunts have presented a number of complications or technical problems during operation or in the postoperative period. These problems have ranged from folding of the tube upon itself, diversion into the subclavian vessels, difficulties in accurate placement into the auricle, formation of atrial ulcerations, mural thrombi or similar lesions of the tricuspid valve which have led to embolization, or, when infected, to a bacterial endocarditis, as well as the unusual complication
reported by Strenger, whereby the cardiac limb of the shunt perforated the ventricle. These shunts have been handicapped by the linear growth of the patient, especially if the procedure was instituted in early infancy with a progressive cephalad migration of the tube.

In an effort to utilize a shunting procedure which would be affected minimally by factors of growth and yet maintain the desirable delivery point of cerebrospinal fluid in the vascular system and utilize available materials for shunts, the ventriculosagittal-sinus shunts were done.

Procedure

The hydrocephalic infant has a complete examination similar to that advocated by Ingraham and Matson. During this evaluation a sinogram is done by percutaneous technique utilizing a pediatric scalp-vein needle and plastic set-up and one of the contrast media. Anteroposterior and lateral films are made with the injection timed so that the outline and size of the superior sagittal sinus, torcular, lateral sinuses, sigmoid sinuses, and usually the beginning portions of the jugular vein are well visualized. During the course of evaluation, the hydration and nutritional status of the infant are observed carefully and any necessary corrections are made before actual surgical intervention. Of the two, proper hydration of the infant is the more important. On the day of operation, the total head is prepared and the infant is placed on its back on the operating table with a small folded towel placed beneath one shoulder in order to place the head adequately in a three-fourths lateral position without twisting the neck excessively. The procedure can be done adequately under local anesthesia supported by the usual appropriate preoperative medications. A small curved flap is made with its apex directed towards the midline, but 3.0 cm. lateral to this point and posterior to the anterior fontanelle. This flap is planned in such a manner that it will be larger than the underlying flushing device on the infant type of Pudenz-Heyer shunt. This same flap may be placed more posteriorly if a shorter than standard infant type of shunt is used. Pericranium underlying the midpoint of this flap is incised and a small Burr hole is placed and adequately enlarged to accommodate the flushing device. The desired length of the ventricular portion of the shunt is cut, tied with ligatures to the flushing device, and after incision of the dura mater and pia mater is carefully inserted into the ventricular system. In order to prevent excessive loss of fluid, a small portion of the cut tubing is placed on the vascular end of the flushing device and clamped with a rubber-shod clamp. A small transverse incision is made overlying the midline, usually at a point 6.0-8.0 cm. anterior from the torcular Herophilus, and careful dissection is carried down to the sagittal sinus. Whatever bone necessary to allow adequate exposure of the sinus is removed at this time. The vascular end of the shunt is checked with normal saline to determine competency as well as the approximate resistance of the valve. This portion of the shunt is then filled with saline or contrast medium and clamped with a rubber-shod hemostat in order to prevent loss of the fluid. The sagittal sinus is incised with a #11 blade, spread carefully with a small curved mosquito hemostat and the valve is placed into the sagittal sinus and advanced to the predetermined distance so that the valve will lie at the torcular Herophilus. This can be checked by lateral roentgenograms and compared with the sinogram when contrast medium is in the shunt. If care has been used upon placement of the valve safely into the sinus, the hemostat usually is removed and the remaining portion of the tube advanced so that there is no bleeding nor any need for suture materials. Any minor ooze can be controlled readily with one of the standard hemostatic agents or muscle. The vascular catheter is passed under the scalp and joined to the flushing device. The flushing device is then fixed by suture to the pericranium. The galea and skin are closed in the usual manner (Figs. 1 and 2). Postoperatively the hydration of the patient is watched carefully to prevent any
She was readmitted at age of 3 months because of lethargy and persistent vomiting. The frontal to occipital measurement was 48.5 cm.; the fontanelle was large, tense and bulging. The Torkildsen shunt was opened. A ventriculopleural shunt was placed, but migrated intracranially. She had a sagittal sinogram and repeated ventriculogram. On Dec. 10, 1963, at age of 4 months, she had a right ventricular-osagittal-sinus shunt.

She did well for 5 weeks, when diarrhea, otitis and meningitis developed, and she died 7 weeks after the shunting procedure. The shunt functioned at all times. Autopsy showed the shunt to be placed properly and the sagittal sinus, other intracranial venous sinuses and cortical veins were patent.

**Case 2. S.C.,** was a 7-month-old boy in whom hydrocephalus developed following an upper respiratory infection and meningitis at age of 2 months. During the acute stage, he was treated with lumbar intrathecal and intraventricular instillation of medication as well as parenteral and intramuscular dosages. The developing hydrocephalus was partially controlled by removal of cerebrospinal fluid on ventricular taps. After sterilization of the fluid he had a ventriculoperitoneal shunt which had to be revised 2 months later, obstructing again after 7 weeks. At examination the frontal to occipital measurement was 47.6 cm., and the fontanelle was tense and bulging. Sagittal sinography and oxygen ventriculography were done. On Dec. 22, 1963 he had a right ventricular-osagittal-sinus shunt which continues to function satisfactorily. He has reduction in the size of his head (frontal to occipital measurement 46.0 cm.), decreasing fontanelle, clinical and

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**Fig. 1.** Diagrammatic representation of the skull, lateral ventricle and sagittal sinus demonstrating the relative positions of the shunt: (1) ventricular tube, (2) flushing device, and (3) cardiac or venous tube.

**Fig. 2.** Lateral outline of the skull, lateral ventricle and major venous sinuses showing the relative positions of the ventricular tube (1), flushing device (2), and cardiac or venous tube (3).
radiographic improvement of the separated sutures, and satisfactory neurologic development to date.

Case 3. H.S.W., a 3-month-old girl, was well until age of 2 months when she had onset of an upper respiratory infection and diarrhea, followed several days later by meningitis. *Hemophilus influenzae* was cultured from blood, spinal and ventricular fluid. The infection responded to treatment and antibiotics were stopped. On admission the frontal to occipital measurement was 37.5 cm. and 4 weeks later was 41 cm., with a tense, bulging fontanelle. A sagittal sinogram was made. On Feb. 17, 1964, she had a right ventriculo-sagittal-sinus shunt which continues to function satisfactorily. She has had an initial reduction in the size of her head, with normal-appearing fontanelle and satisfactory neurologic development to date.

Case 4. D.J.R., a 5½-week-old girl, had surgical repair of a lumbar myelomeningocele at age of 4 days because of leakage of cerebrospinal fluid. The frontal to occipital measurement was 35.5 cm. and the fontanelle was full and somewhat tense. Postoperatively the head was noted to be increasing in size beyond normal. Ventricular tap with removal of cerebrospinal fluid was done on 3 occasions. At discharge 3 weeks after operation, the frontal to occipital measurement was 37.0 cm. On readmission, at 5 weeks of age, the frontal to occipital measurement was 39.0 cm., and the fontanelle was tense and bulging. Examination revealed aqueductal stenosis, associated with the likely Arnold-Chiari malformation. The sinogram showed a somewhat unusual configuration of the anterior two-thirds of the sagittal sinus. On March 26, 1964 a right ventriculosagittal-sinus shunt was placed and function continues satisfactory to date.

**Discussion**

Certainly the ventriculo-venous shunts have added greatly to the neurosurgeon’s ability to treat hydrocephalus,26 and have helped to overcome many of the serious objections to the various other methods of shunting though they present their own unique complications. Perhaps one of the most exasperating problems common to most shunts has been the tendency for migration of the catheter17,18 with linear growth, reducing a previously functioning shunt to a nonfunctional status. A shunt confined to the head would offer perhaps the best way to overcome this problem because, although there will be growth of the head in all axes, this will be minimal as compared to linear growth of the body. A shunt of this type is unaffected by movements of the head or neck. This procedure offers the advantage of the shunt not being in contact with any moving parts such as the wall of the heart or the tricuspid valve, and the shunt may be placed on either side of the skull since the vascular end will terminate in a midline structure and is not as dependent on variabilities of the vascular tree.

A number of questions remains to be answered from a practical and philosophical standpoint. It would seem that placement of the valve in or at the site of the torcula Herophilus would be efficacious since it would be in a relatively large fast-moving pool of blood, but this may not be necessary.

Even though this shunting technique circumvents some of the possible complications of the ventriculocardiace shunts, the specter of possible thrombosis of the longitudinal sinus2 is present and may, with larger experience, prove to be a significant hazard, as it doubtlessly has been in the past. Whether temporary or long-term use of anticoagulants would be useful or necessary needs to be determined. Such agents have not been used in this small series of cases. Since thrombosis of the superior sagittal sinus or its main tributaries can follow an insidious course2 at times, rather than the more common acute catastrophic illness, it is uncertain as to how long a shunt must function successfully before the hazard of venous obstruction would be unlikely. In order to minimize the possibility of thrombosis, meticulous attention to the hydration of the infant in the preoperative, operative, and postoperative period is imperative. During operation, gentle dissection of the tissue in relation to the sagittal sinus should be carried out, with considerable attention directed toward protecting the valve (vascular end) so as not to deform it upon its insertion and not to scratch or roughen any part of the tube which will lie in the sagittal sinus during the actual manipulation and placement of the
tube during this critical portion of the shunting procedure.

Whether the over-all success of this type of shunt would be less in the premature or newborn infant under 5 or 6 weeks of age, because of the more diminutive size of all structures, needs evaluation. Even smaller valves than the standard small cardiac valve with shorter cardiac ends, could be made if this should prove necessary. If the technical handling of this shunt should prove to be unsatisfactory in the very young infant, but satisfactory or desirable in the older infant, he or she might be tided over readily, to that period, by utilizing a temporary shunting procedure such as a ventriculopleural\(^1\) or ventriculoperitoneal\(^2\) shunt modified by interposing the flushing device in an effort to promote longevity of the shunt against distal obstruction.

Although this report is based on a small number of patients with short-term follow-up, the ventriculosagittal-sinus shunt has shown promise and it is reported at this time with the hope that other neurosurgeons with a larger series of hydrocephalic patients might become interested in evaluating this procedure. A follow-up report on these patients and any other patients added to this series will be made at a later date.

**Summary**

A simple shunting technique has been outlined utilizing the principles of ventriculovenous techniques, but placing the distal tract of outflow into the sagittal sinus. The advantages for this particular shunting technique are outlined; some of the possible complications are discussed briefly.

**References**


