Complications of Ventriculovenous Shunts

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The history of ventriculovenous shunts began with Gärtnert who suggested the concept in 1895, at the National Science Convention at Lübeck. Payr announced the results of his initial attempts at this problem in 1908. The further history of ventriculovenous shunts has been reviewed in the recent past. Ingraham et al. expressed the necessity for a sensitive one-way valve to cope with the problem, but it was not until after the work of Nulsen and Spitz in 1951, and that of Pudenz et al. in 1957 that the procedure met with any degree of success. It has been estimated that over five thousand procedures of this type had been performed by 1960. Little has been published in the English literature about the difficulties which have been, or may be, encountered in the management of the “proximal”-valve (Spitz-Holter) or “distal”-valve (Pudenz-Heyer) ventriculovenous shunts in their various modifications.

As has been suggested, ventriculovenous shunting is fairly universal in applicability to palliate hydrocephalus, obstructive and communicating, acquired and congenital. Situations that may lead to unfavorable results are those of hydrocephalus associated with increased right atrial and venous pressure from any cause. Thus a higher than desired intraventricular pressure may be necessary to have a sufficient gradient of pressure to initiate flow through the valve. No reports of failure to install a ventriculovenous shunt have been encountered. This possibility could have arisen if one considers a case described by Hooper, when hydrocephalus developed as a manifestation of thrombosis of the superior vena cava.

The mechanically intact device must be placed properly to function successfully. Operators are advised to introduce a 6–8 cm. ventricular segment. This portion may be obstructed by fragments of brain or blood clot incident to the trauma of introduction.

The placement of the intravenous portion of the shunt can become involved. Considering the cervical anatomy to be normal, and the isolation of the cervical veins accomplished, placement of the auricular segment may be guided by electrocardiographic or roentgenographic techniques. The passage of this limb may be complicated by deviations into the subclavian vessels or the tube folding upon itself. The latter circumstance would provide a confusing picture to the operator dependent solely upon electrocardiographic guidance. Roentgenography usually requires the use of a contrast medium, with its attendant dangers, to insure accurate positioning. With placement of the shunt as recommended, in the right heart, inadvertent entry into the right ventricle may precipitate cardiac arrhythmias leading to ventricular fibrillation. Fortunately this rarely occurs as noted in several series of right-sided cardiac catheterizations. Fixation of the system at various points (dura mater, vein, joints, and valve) may lead to disruption or occlusion of the shunt.

Immediate postoperative difficulties may arise with the rapid conduction of cerebrospinal fluid into the intravascular compartment. In a small hydrocephalic infant this conceivably could precipitate acute heart failure. The rapid changes in the dynamics of the intracranial fluid may result in symptoms of intracranial hypotension. In a child the rapid collapse of the ventricles may be accompanied, as suggested by Dandy, by injury to the bridging veins with the subsequent development of a subdural hematoma. McNab reported 2 deaths with the loss of large amounts of fluid during a shunting procedure. Conversely the valve mechanism may have too high an opening pressure and

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intracranial hypertension may persist.\textsuperscript{11} Most of the literature regarding complications deals with the more remote postoperative period. Delayed occlusion of the proximal limb may occur\textsuperscript{1,6,8,26} from becoming embedded in the ventricular wall, brain fragments occluding the lumen, plugging by the choroid plexus, delayed hemorrhage and formation of clots.

Placement of the ventricular tube may incite a ventriculitis\textsuperscript{26} or rekindle a dormant meningitis.\textsuperscript{1} Organisms present then may be widely disseminated through the blood by direct introduction into the right atrium.\textsuperscript{1,6,11,15,26}

Infections of the wound in the presence of a foreign body may be stubborn in resolving. The delayed breakdown of thin skin or intertriginous tissues over the implanted tubes, valve and pump occurs occasionally. These lesions may resist healing until the shunt is removed, and the area may act as a focus of infection leading to a devastating bacte-remia.\textsuperscript{6,25}

The valve may become incompetent. Clotting of blood refluxing into the system leads to occlusion. With the shunt occluded, cerebrospinal fluid may escape along the course of the system, forming smoothly lined pseudocysts in communication with the ventricle.\textsuperscript{11}

The Spitz-Holter valve has been shown to act on occasion as a site for bacterial colonization.\textsuperscript{2,4,25} The ensuing bacte remia is highly resistant to therapy. Cohen and Callaghan\textsuperscript{2,4} have defined a syndrome characterized by pyrexia, splenomegaly, progressive anemia and positive blood cultures associated with Spitz-Holter shunts. Similar studies have not been performed with Pudenz-Heyer valves, but cases of septicemia developing in their presence are known.\textsuperscript{1}

The venous limb appears to be the principal site of postoperative complications. The cephalad migration of the cardiac segment with growth of the infant has been commented upon.\textsuperscript{1,8,19} Emphasis\textsuperscript{1,4,18,19,23,26,28} has been placed upon positioning the orifice into the atrium to assure function for the longest possible time. Atrial mural thrombi and ulceration are known to occur,\textsuperscript{1,7,11,26} as well as lesions involving the tricuspid valve. These\textsuperscript{6,7} may lead to embolization\textsuperscript{1,7} or serve as a nidus for bacterial colonization leading to a clinical picture resembling bacterial endocarditis.\textsuperscript{2,4,6,26} Techniques had been pro-posed\textsuperscript{19} to allow for caudad migration of the entire system with growth of the infant. The shunt may shift prematurely, passing into the right ventricle with untoward consequences.

The response of tissues along the course of the plastic system is variable.\textsuperscript{1,6,7,11,26} Thin membranes may invest the entire subcutaneous and intravascular portions of the shunt. Fibrinous sleeves may form or other reactive changes of variable intensity.\textsuperscript{1,7,26} Thrombi may develop along the shunt and propagate, partially or completely occluding the superior vena cava\textsuperscript{2,11} or its tributaries. A local pericarditis was noted by Emery and Hilton\textsuperscript{7} over an area of vegetation possibly resulting from trauma by the catheter. Johnson\textsuperscript{1} reported a transitory pericardial effusion of cerebrospinal fluid relieved by aspiration.

Revision of the system carries additional hazards. The scarified tissues are more difficult to manipulate, especially the fibroed vessels. Adjustment of the venous segment may require removal and replacement. The Holter vein-bore* when mishandled could result in perforation of a major vessel. A dislodged thrombus could result in massive pulmonary infarction. Transporting the shunt to the opposite side is not without hazard. Depending upon the collateral vessels present, interruption of the second jugular vein may lead to an untoward result.

Pappas\textsuperscript{25} has reported craniosynostosis developing with the approximation of the parietes after a successful ventriculo-atrios-tomy.

The mortality, incidence of septicemia and venous thrombosis, and the number of initial revisions reported in various series are given in Table 1.

**Case Report**

The patient, a male child, weighed 3 lbs. 15 oz. at birth on Nov. 15, 1960. The circumference of

* Holter Surgical Specialties and Precision Instruments, Catalog #VC-440.