Control of shunt infection

Report of 150 consecutive cases

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The author analyzes 150 consecutive ventriculovenous, ventriculoperitoneal, and lumboperitoneal shunt procedures with particular attention to shunt colonization by Staphylococcus epidermidis. There was one primary infection with Staphylococcus epidermidis early in the series, and in two other cases, the organism was felt to be a secondary invader. In those procedures involving either primary placement or revision of a ventriculovenous shunt, there was not a single infection. The operative protocol that has virtually eliminated Staphylococcus epidermidis is outlined.

KEY WORDS □9 hydrocephalus □9 shunt, ventriculoperitoneal □9 shunt, ventriculoatrial □9 shunt, lumboperitoneal □9 ventriculitis

Infection remains a major complication of cerebrospinal fluid (CSF) shunting procedures. The infection rate following ventriculoatrial shunting has been reported at about 15%.1,6 Although generally conceded to be less liable to infection, ventriculoperitoneal shunting has been associated with infection rates ranging from 5%2 to 15%.3 Staphylococcus epidermidis remains the commonest infecting organism.3

This report surveys 150 consecutive placements of both venous and peritoneal shunts done either by or under the direct supervision of the author. An antibiotic regimen and operative protocol that has allowed significant reduction in the rate of shunt infection is outlined.

Summary of Cases

Case Material

The diagnosis of hydrocephalus was determined by the usual physical, neurological, and neuroradiological criteria. Shunt malfunction was diagnosed by a tap of the Rickham reservoir that usually established the site of shunt malfunction and, in the absence of ventricular catheter obstruction, allowed for the recovery of ventricular fluid for preoperative analysis and culture. Non-elective revisions were done whenever possible within 12 hours of admission. Elective revisions for ventriculoatrial shunts were done when the distal catheter reached the T4-5 level on the x-ray study. Ventriculoperitoneal shunts were revised electively when it was felt that the catheter was too short to allow free mobility with peristalsis.

A ventriculoperitoneal shunt was the initial procedure in 36 infants. In older children a ventriculoatrial shunt was often the initial procedure (18 patients), although the efficacy of peritoneal shunting has led us to use this procedure more frequently in all age groups.

Antibiotic Coverage

All children received 50 mg/kg of oxacillin as an intravenous bolus during induction of
anesthesia. Two intravenous doses of 25 mg/kg were given approximately 6 and 12 hours following the initial dose, and then antibiotics were discontinued. Initially, only ventriculoatrial shunts and non-elective ventriculoperitoneal shunt revisions were treated in this manner. However, the single primary Staphylococcus epidermidis infection occurred early in this series in the initial placement of a ventriculoperitoneal shunt. Subsequent to this infection, all patients have received the same antibiotic coverage.

Operative Technique

The following method of prepping and draping has been strictly adhered to:

1. A 5-minute pHisoHex scrub followed by the application of 2% Amphyll (a phenolic germicide) was allowed to air dry. (The use of Amphyll for skin preparation is no longer approved by the FDA. This has been replaced with a Betadine (povidone-iodine complex) scrub followed by the application of Betadine solution. In vitro and in vivo studies demonstrate a 99.5% reduction in colony counts maintained for hours using full strength aqueous solutions of Betadine."

2. The operative field is draped with towels in the usual manner and a plastic drape holding the towels in position is then placed over the field.

3. Incisions are protected by Telfa gauze secured in position with Michel clips. The exclusion of skin areas from the operative field is an essential part of the procedure. Every effort is made to avoid contact between the shunt tubing and the patient's skin.

All operations have been performed either by or under the direct supervision of the author. The technique for ventriculovenous shunt placement is as described by Matson, save that the burr hole is placed more posteriorly and medially and no craniectomy is performed to seat the valve. Care is taken to ensure that no more than 3 to 5 cc of ventricular fluid is lost during the procedure. In ventriculoperitoneal shunts a soft Silastic catheter with a single distal opening is placed by way of an anterior transverse paramedian right subcostal incision and a muscle splitting technique. Sufficient catheter is threaded in the direction of the right lateral gutter to extend approximately into the pelvis and across to the other side. X-ray films taken at various times following the operation show the catheter to move freely within the abdominal cavity. The lumboperitoneal shunt is performed with the child on his side. An L2-3 hemilaminectomy is performed, and an anterior incision as described above is used to enter the peritoneal cavity.

A Hakim medium-pressure valve of either the pediatric or adult type is used in all cases. In an occasional newborn baby, following repair of a large myelomeningocele with consequent increased intraabdominal tension, a low-pressure valve may be necessary. This has been a rare occurrence in our experience. The more direct access to the ventricular system given by the Rickham reservoir is preferred. The Hakim reservoir is removed. No change in valve dynamics or ease of application has been encountered with this method.

The peritoneum is closed with a 4-0 chromic purse-string suture and all wounds are closed in layers with interrupted 4-0 Tevdek suture.

Bacitracin (50,000 units/100 cc saline) is used as the irrigating solution throughout the procedure. Exposed wounds and tubing are covered with Bacitracin sponges during x-ray procedures. Copious irrigation during closure and meticulous attention to hemostasis ensures a minimal amount of dead space postoperatively.

Cultures of CSF are obtained in all cases, and replaced valves and ventricular, cardiac, and peritoneal catheters are sent for aerobic and anaerobic cultures.

Postoperative Course

Bandages are removed 24 to 36 hours postoperatively. Abdominal incisions in children who must be on their abdomen for protracted periods such as in cases of myelomeningocele repair are covered with a light dressing that is changed daily or more frequently as needed. In cases of severe hydrocephalus, the child is kept flat for 24 hours and then elevated slowly over 2 to 3 days. In the majority of cases, children are discharged on the second postoperative day.
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**Diagnosis and Management of Infection**

There were no infections following the initial placement or revision of ventriculovenous shunts in patients followed up to 2 years under this protocol. One patient had primary *Staphylococcus epidermidis* infection following placement of a ventriculoperitoneal shunt early in the series and two had secondary infections in this group (Table 1). The remainder of the infections were caused by either Gram-negative organisms (four) or *Staphylococcus aureus* (two).

All children with a history of a febrile episode without apparent cause who are seen in the emergency room or referred to the Spina Bifida Clinic have cultures of CSF, blood, and urine. Cultures of CSF are also obtained on children treated for infection elsewhere, for instance in the urinary tract, who do not respond to antibiotic therapy within 48 hours. This procedure has enabled us to initiate therapy in three children prior to the appearance of a cellular response in the CSF. Early diagnosis has perhaps been the reason that there have been detectable neurological sequelae in only one case of shunt infection. All children in whom a positive culture is obtained are treated with intraventricular and intravenous antibiotics for 7 days, followed by 1 week of oral or intramuscular antibiotics. Shunt replacement is done within 24 hours of beginning intraventricular therapy. Although this method has been effective in those cases in which *Staphylococcus aureus* and *Staphylococcus epidermidis* have been the infecting organisms, three infections caused by Gram-negative organisms required ventricular drainage for control. Cultures of blood and CSF are obtained in all cases 48 to 72 hours after the last dose of antibiotics.

Because of the occasional presence of *Staphylococcus epidermidis* as a secondary invader it is suggested that intraventricular oxacillin be added to the treatment regimen in cases of infection with Gram-negative organisms.

**Discussion**

The single case of primary *Staphylococcus epidermidis* infection occurred early in the series prior to the use of prophylactic antibiotics in elective ventriculoperitoneal shunt procedures. A second case of *Staphylococcus albus* meningitis and subsequent ventriculitis occurred in a child with a partially treated otitis media. Although *Haemophilus influenzae* was never cultured from the CSF, the presenting complaint of meningitis and the initial lack of an intraventricular cellular response suggests that *Staphylococcus albus* was a secondary invader. The two cases of *Staphylococcus aureus* infection occurred secondary to skin infections (furuncle, infected eczema), and although the organism was cultured from ventricular fluid neither child was clinically ill.

Two of the Gram-negative infections have occurred in children with chronic urinary tract infections on suppressive therapy (Pseudomonas, enterococci). A third infection (Proteus) occurred in the presence of a massively infected meningomyelocele repair. The fourth infection occurred in a child with an intraoperative anesthesia catastrophe resulting in aspiration, massive atelectasis, and *Escherichia coli* sepsis. This child was neurologically devastated and developed a *Staphylococcus epidermidis* infection, which was probably secondary to prolonged ventricular drainage.
One child was seen for depression in level of consciousness occurring during treatment with oral antibiotics for a paronychia. *Staphylococcus aureus* was cultured from the ventricular fluid and the child responded well to the treatment protocol outlined in the previous section. Approximately 2 months later he was seen for low-grade fever and somnolence. A tap of the Rickham reservoir demonstrated ventricular catheter obstruction. Operative removal of the ventricular catheter disclosed a loculated abscess cavity from which several Gram-negative aerobic and anaerobic organisms were recovered. The shunt apparatus was removed and a tap of the left frontal horn demonstrated sterile, crystal-clear CSF. Although perforation of an intraabdominal viscus was suspected, the child never had signs or symptoms referable to the peritoneal cavity and radiological studies failed to confirm the diagnosis.

Prevention of *Staphylococcus epidermidis* shunt infection appears possible with the techniques now available. Reports of the effectiveness of prophylactic antibiotic coverage vary widely; however, prolonged coverage appears to be unnecessary. Oxacillin remains the drug of choice in our hands. Choice of a prep solution, strict avoidance of contact between shunt tubing and the patient’s skin, careful attention to hemostasis, and meticulous wound closure all contribute to the eradication of *Staphylococcus epidermidis* contamination of shunt apparatus. The use of copious irrigation is a well-established technique for decreasing the size of a wound inoculum and the addition of Bacitracin is predicated on its known bactericidal effect against Gram-positive organisms.

**Summary**

The elimination of *Staphylococcus epidermidis* infection in patients with ventriculo-venous shunts and the decreased incidence in patients with peritoneal shunts has been demonstrated in a series of 150 consecutive shunt procedures. Infection by Gram-negative organisms occurring in peritoneal shunts continues to be a recurring problem.

**References**

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