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The impact of antibiotic-impregnated catheters on ventriculoperitoneal shunt infection

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Background/aim: Ventriculoperitoneal shunt infections remain an important problem and result mainly from perioperative colonization of shunt components by skin flora. Antibiotic-impregnated shunts have been designed to prevent such colonization. This study evaluates the incidence of shunt infection after the insertion of antibiotic-impregnated shunts in a population of children with hydrocephalus.

Materials and methods: All pediatric patients who had undergone cerebrospinal fluid shunt insertion retrospectively were reviewed over a 6-year period between May 2004 and December 2010. The primary outcome measure was the rate of shunt infections. Patients were followed up with for an average of 26.2 months after shunt surgery, and shunt infections were evaluated.

Results: A total of 123 pediatric patients underwent 211 shunt placement procedures. Of these operations, 193 (91%) were performed with nonimpregnated catheters and 18 shunts (9%) were placed with antibiotic-impregnated shunt catheters. Of the patients with nonimpregnated catheters, 12 (6%) experienced shunt infection, whereas none of the patients with antibiotic-impregnated catheters experienced shunt infection within the 26.2-month follow-up period ($P < 0.01$).

Conclusion: The antibiotic-impregnated catheters significantly reduced the incidence of shunt infection in children with hydrocephalus during the postoperative period. Antibiotic-impregnated catheters are effective devices to prevent perioperative colonization of shunt components.

Key words: Antibiotic-impregnated catheter, cerebrospinal fluid diversion, ventriculoperitoneal shunt infection, ventricular catheter, ventriculoperitoneal shunt

1. Introduction

Infections due to insertion of a ventriculoperitoneal (VP) shunt remain a most important problem and are related to notable morbidities like mental, motor, and psychological retardation; convulsive states; and the results of severe infectious complications such as septicemia (1). At the same time, some patients with central nervous system infections require VP shunts during their illness process (2). Shunt infections among small children and low-birth-weight and premature infants may occur at higher percentages than in older children. In the relevant literature, reported infection rates range from 3% to 27% among children implanted with a VP shunt before the age of 6 months (3,4). Prematurity is also a risk factor for VP shunt infections. Premature children with a birth weight of less than 1000 g have the maximum rate of infection; the rate of shunt infection in this group of patients is 71% (4).

Skin flora, especially gram-positive organisms, play a major part in the developing of infections. The majority of VP shunt infections take place with gram-positive organisms accounting for over 90% of infections (5). That the origin of the etiological microorganisms is cutaneous flora has been shown by interim studies. They have demonstrated that up to 80% of the etiological bacteria come from naturally occurring cutaneous flora and are inoculated during the shunt operation. Some other factors such as surgical technique, duration of operation, surgeon's experience, and no-touch technique were studied widely in the literature. Even with wide research into contributing issues, very low infection rates have not been attained constantly (6,7).

Antibiotic-impregnated shunt (AIS) catheters were designed for prevention of VP shunt infections. AIS catheters have been tested comprehensively in vitro before use in a patient, showing promising sustained antibacterial activity. In the literature, there are no uniform results of these kinds of shunts; decisions for using them are distinctive. Although there have been reports of the

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effect of these catheters on the infection rate in vivo, the published data differ in their conclusions and most studies do not report a considerable decline in infection rates (8–10).

The aim of this study is to evaluate the incidence of VP shunt infection after introduction of AIS catheters in comparison with nonimpregnated catheters in a population of children with hydrocephalus.

2. Materials and methods

2.1. Study design

Pediatric patients who had undergone cerebrospinal fluid shunt insertion at a tertiary referral center over a 6-year period, between May 2004 and December 2010, were included in the study. All patients were followed for an average of 26.2 ± 24.1 months after shunt surgery, and shunt infections were evaluated.

All the patients had undergone the shunt procedure under prophylactic antibiotic cover.

2.2. Diagnosis and patients

Diagnosis of hydrocephalus (HCP) was reached by computed tomography (CT). If the ratio of frontal horn to maximal biparietal diameter was greater than 0.3 and there was periventricular low density on CT, the diagnosis of HCP was accepted. Fifty percent of patients had HCP alone, 40% had HCP with myelomeningocele, and 10% had an intracranial mass lesion with HCP. Patients requiring revision for shunt infection had an AIS inserted. The rest of the patients had a nonantibiotic impregnated device inserted.

2.3. Antibiotic-impregnated shunt catheter

The Bactiseal catheter (Bactiseal Codman, Johnson & Johnson, Boston, MA, USA), which consists of a silicone elastomer permeated with barium, was used as a shunt catheter. The silicone matrix is elongated with chloroform allowing dissolution of the antibiotics rifampicin and clindamycin, resulting in impregnation with a concentration of 0.15% clindamycin and 0.054% rifampicin. After inserting the catheter, the antibiotics were released both into the catheter lumen and into the surrounding tissue for at least a 50-day period. The choice of antibiotics covered the most common germs that arise in shunt infections, *Staphylococcus aureus* and *Staphylococcus epidermidis*, which together cause around 80% of the infections.

2.4. Outcome measures

The primary outcome measure was the shunt infection rate. VP shunt infection was diagnosed if a patient had signs and symptoms of shunt infection with either an organism cultured from cerebrospinal fluid or the shunt apparatus, or a raised cerebrospinal fluid white cell count and a clinical response to treatment for infection following shunt removal and appropriate antibiotic therapy.

2.5. Surgeon and operation room team

All operations were performed by the same surgeon. Only 1 assistant, 1 nurse, 1 operating room employee, and 1 anesthesiologist were found in the operating room. All operations were performed as the first operation of the day.

2.6. Statistical analysis

Data were analyzed using the SPSS 16.0 for Windows (SPSS Inc., Chicago, IL, USA). The results for all items were expressed as mean ± SD, assessed within 95% reliance and at a level of $P < 0.05$ significance.

3. Results

A total of 123 pediatric patients underwent 211 VP shunt placement procedures, 55 males and 68 females (M/F = 0.8). The age of the patients was 0–192 months with a mean of 33.6 ± 43.3 months and a median of 5 months. The median age of the infection group was 3 months, lower than the general patient population of this study.

The Table details the distribution of patients having VP shunt by year of operation. The follow-up observation period averaged 26.2 ± 24.1 months. One hundred and ninety-three shunts (91%) were placed with nonimpregnated catheters and 18 shunts (9%) were placed with AIS catheters. Of the patients with nonimpregnated catheters, 12 (6%) experienced shunt infection, whereas none of the patients with antibiotic-impregnated catheters experienced shunt infection within the 6-month follow-up period ($P < 0.01$).

Of the 12 patients (5.7%) who became infected, 6 were male and 6 female. The underlying condition in the infected cases above were hydrocephalus of unknown etiology in 6 patients, meningomyelocele with hydrocephalus in 5 patients, and intracranial mass with hydrocephalus in 1 patient. Of the 12 infections, 4 occurred within 30 days

Table. The distribution of patients having ventriculoperitoneal shunt by year of operation.

Years	Patient n (%)
2004	30 (14.2%)
2005	37 (17.5%)
2006	28 (13.4%)
2007	18 (8.5%)
2008	19 (9.0%)
2009	24 (11.4%)
2010	55 (26.0%)
Total	211 (100%)

of the shunt procedure, which was either the primary shunt operation or a procedure to revise the shunt. Late infections occurred in 8 cases, about 1 month or 3 months after shunt revision, respectively. However, no deaths occurred as a result of shunt infection and all the patients survived after the infected shunts were removed.

4. Discussion

In the current study we compared our experience of AIS versus non-AIS catheter systems and demonstrated a significant decrease in shunt infection after our institutional conversion to AIS catheters.

Continuing HCP is another critical factor for VP shunt infections. These infections persist to be a crucial cause of morbidity and mortality for patients with continuing HCP (3,6). The most susceptible group of patients for VP shunt infections is the pediatric population. Infection rates of up to 15% in children of less than 6 months of age have been reported (3,4). The infection can be treated conservatively with antibiotics, but often requires removal of the shunt. For continuation of treatment of HCP, inserting an extraventricular drainage system is strongly recommended. After a suitable antibiotic treatment, insertion of a new shunt is necessary. A prolonged stay in the hospital, typically 1–3 weeks, is often involved. There are discrete fiscal implications of a shunt infection, such as the hospital stay, surgery, and implants, as well as physical, emotional, and social costs. Efforts to confine this is an expected part of neurosurgical practice and include meticulous operative protocols, including duration of operative time, number of staff in the operating suite, operating list order (earliest on the list), surgeon supremacy, operating system (non-touch), and prophylactic antibiotics (8–10).

In a prior study it was noted that the organisms responsible for shunt infection were infrequently detected in the operative wound at the time of shunt insertion. The principal authors assume that the susceptible period for bacterial colonization of shunts may not be limited to the operative procedure as is usually considered, but may lengthen throughout the postoperative phase of wound healing (11,12). The leading bacterial agent of a shunt infection is widely accepted as *Staphylococcus epidermidis*, with *Staphylococcus aureus* and other types of bacteria and fungi implicated, as well. Shunt colonization with *Staphylococcus* is challenging to eradicate once begun owing to the production of biofilm (5).

AIS catheters have been used to avoid infection, primarily in the early postoperative phase when the largest amount of infections take place (13). On the other hand, their clinical effectiveness in drastically reducing shunt infections in clinical practice is doubtful and there remains a reluctance to apply AIS catheters because of their increased price not unavoidably translating into obvious patient advantage (14,15). There have been several studies with varying conclusions reported in the literature. Govender et al.'s report is compatible with present results. They found a significant reduction of infections with AIS catheters, from 16.7% to 6% (8). However, they also reported the absence of any staphylococci in any of their AIS infections, which was in contrast to other published reports. In a retrospective review, Sciubba et al. reported a 2.4-fold diminished pediatric shunt infection percentage when changing from standard to impregnated catheters with a follow-up period of 6 months (14). A statistically significant diminution of 6.5% to 1.2% in infection rates has also been stated by Pattavilakom et al. (16). A single-center study by Eymann et al. compared 171 adults and 26 pediatric patients who had AIS catheters against 98 adults and 22 pediatric patients who had ordinary catheters (17). The overall infection rate dropped from 5.8% to 1% and this was statistically significant. Kan and Kestle described a study in children where converting from regular to AIS catheters diminished the shunt infection rate from 8.8% to 5.0% (10). In a similar, smaller study, Aryan et al. found a reduction in infection rate in children from 15.2% to 3.1% (18). Richards et al. published a retrospective review comparing AIS catheters against usual shunts (19). Their data demonstrated a 4.7% infection rate in standard shunts and an infection rate of 3% in AIS implantations.

The presented study has several limitations. First, it is a retrospective study; therefore, not all the potentially pertinent information was available to us, such as severity of illness and duration of immunosuppression. Second, it is a single-center study. Third, we are comparing outcomes from different time periods. This allows the data to be influenced by various confounding factors and interventions that occurred during these different time phases. Furthermore, statistically significant conclusions would require a larger patient population with AIS catheters. Although this study strongly suggests an association between AIS catheter use and a decrease in shunt infection, because of other multiple concurrent interventions, the results should be interpreted cautiously until a prospective study is conducted.

This study provides further evidence of the positive effect of AIS catheters in reducing infection rates in children with HCP. A larger group on the infection side of this study would strengthen opinions on this topic. Despite the significant caveats related to the study design, we feel that the data presented can serve to guide practice until a multiunit prospective, randomized controlled trial provides more robust evidence.

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