Antibiotic impregnated catheter (AIC)

Antibiotic impregnated catheters are antimicrobial catheter that have been introduced with the primary objective of reducing the incidence of shunt related infections.

The incidence of shunt infection is still high despite routine administration of perioperative antibiotics. A lower incidence of shunt infection was observed when antibiotic impregnated shunts (AIS) were used to treat hydrocephalus and a rapid cure was reported in cases of ventriculitis when antibiotics were injected into external ventricular drain (EVD).

Mechanism of action

Designed to reduce the colonization of gram positive bacteria. Laboratory tests show these antibiotic-impregnated catheters provide antimicrobial activity for at least the first 31 days, the time when patients are most susceptible to shunt infections 1) 2) 3) 4)

AIC catheters slowly release antibiotics over several weeks to prevent the colonization of shunt systems by gram-positive bacteria, which account for most shunt infections 5) 6) 7) 8) 9) 10).

Costs

The bulk of the literature to date has demonstrated a reduction in shunt-associated infections associated with the use of AICs; however, there has been some reluctance to adopt these systems because of their increased cost compared with conventional catheters 11) 12) 13) 14) 15) 16).

AI catheters were found to be associated with a significant reduction in infection incidence, resulting in tremendous cost savings. AI catheters were associated with a cost savings of $42,125 and $230,390 per 100 de novo shunts placed in adult and pediatric patients, respectively 17).

Antibiotic-impregnated shunts have yet to find widespread use in the developing world, largely due to cost. Given potential differences in the microbial spectrum, their effectiveness in preventing shunt infection for populations in low-income countries may differ and has not been demonstrated 18).

Types

Bactiseal C and NC

Ventriclear

Ares Antibiotic Impregnated Catheter

Duration

A study determined the protective effect of antibacterial processing of cerebrospinal fluid (CSF) shunt catheters against infection with staphylococci, which is an important complication following CSF shunt placement for hydrocephalus. Also examined is the effect of a conditioning film such as that seen on the luminal surface of shunts used in posthemorrhagic hydrocephalus. Conventional preventative measures, including antimicrobial prophylaxis, confer a temporary or unproven benefit. Bayston et al.
have therefore developed a process for impregnation of CSF shunts with rifampicin and clindamycin, and this has been shown previously to achieve the target duration of 28 days of protective activity in vitro. The present study demonstrates the limit of the period of protection and the efficacy of the processing against a wide range of staphylococci, particularly in the presence of a plasma protein conditioning film. Five strains of Staphylococcus aureus and 17 coagulase-negative staphylococci, all clinical isolates, were inoculated into the shunts at 2-week intervals until failure of antimicrobial protection occurred. The results showed that the process protected against all strains for between 42 and 56 days and that the conditioning film did not diminish the protection.

CSF culture for diagnosis of ventriculitis

Concern has arisen over the effect of released antimicrobial agents from antibiotic-impregnated external ventricular drainage (EVD) catheters on the reliability of CSF culture for diagnosis of ventriculitis.

Bayston et al. designed a laboratory study to investigate this possibility, and to determine whether there was also a risk of loss of bacterial viability when CSF samples were delayed in transport to the laboratory. METHODS Three types of commercially available antibiotic-impregnated EVD catheters were perfused with a suspension of bacteria (Staphylococcus epidermidis) over 21 days. Samples were analyzed for bacterial viability and for concentrations of antibiotics released from the catheters. The authors also investigated the effect on bacterial viability in samples stored at 18°C and 4°C to simulate delay in CSF samples reaching the laboratory for analysis. RESULTS Bacterial viability was significantly reduced in all 3 catheter types when sampled on Day 1, but this effect was not observed in later samples. The results were reflected in stored samples, with significant loss of viability in Day 1 samples but with little further loss of viable bacteria in samples obtained after this time point. All samples stored for 18 hours showed significant loss of viable bacteria. CONCLUSIONS While there were differences between the catheters, only samples taken on Day 1 showed a significant reduction in the numbers of viable bacteria after passing through the catheters. This reduction coincided with higher concentrations of antimicrobial agents in the first few hours after perfusion began. Similarly, bacterial viability declined significantly after storage of Day 1 samples, but only slightly in samples obtained thereafter. The results indicate that drugs released from these antimicrobial catheters are unlikely to affect the diagnosis of ventriculitis, as sampling for this purpose is not usually conducted in the first 24 hours of EVD.

Metaanalysis

2015

The majority of data derive from studies on the effectiveness of AICs, followed by studies on the effectiveness of silver impregnated catheter SCCs. Statistical heterogeneity was observed in several analyses. Antimicrobial shunt catheters (AICs, SCCs) were associated with lower risk for CSF catheter-associated infections than conventional catheters (CCs) (RR 0.44, 95% CI 0.35-0.56). Fewer infections developed in the patients treated with antimicrobial catheters regardless of randomization, number of participating centers, funding, shunting or ventricular drainage, definition of infections, de novo implantation, and rate of infections in the study. There was no difference regarding gram-positive bacteria, all staphylococci, coagulase-negative streptococci, and Staphylococcus aureus, when analyzed separately. On the contrary, the risk for methicillin-resistant S. aureus (MRSA, RR 2.64, 95% CI 1.26-5.51), nonstaphylococcal (RR 1.75, 95% CI 1.22-2.52), and gram-negative bacterial (RR 2.13, 95% CI 1.33-3.43) infections increased with antimicrobial shunt catheters.

Based on data mainly from nonrandomized studies, AICs and SCCs reduce the risk for infection in
patients undergoing CSF shunting. Future studies should evaluate the higher risk for MRSA and gram-negative infections. Additional trials are needed to investigate the comparative effectiveness of the different types of antimicrobial catheters.\(^{21}\)

Cui et al. evaluated the efficacy of antibiotic impregnated catheter (AIC) and silver impregnated catheter compared with plain catheters for the prevention of catheter related infections (CRI).

The authors performed an independent search of Medline, Embase, and the Cochrane Library to identify eligible studies published between January 2002 and August 2014.

They searched all relevant literature using an exhaustive search strategy. Randomized controlled trials or observational studies that compared (AIC) catheters with plain catheters for the prevention of CRI were included. The quality of each included study was assessed using a risk of bias assessment tool and the Newcastle-Ottawa Scale. RevMan5.3 software (The Cochrane Collaboration, Oxford, UK) was used to perform this meta-analysis, and publication bias was investigated using funnel plot constructions and Egger test.

A total of 4 randomized and 10 observational studies involving 4,399 patients were included in this meta-analysis. Pooled results comparing AIC catheters with plain EVD catheters in the management of patients with acute high intracranial pressure demonstrated the superiority of antimicrobial EVDs for the prevention of CRI with a risk induction of 62% (95% confidence interval [CI], 0.25-0.58; \(P < .00001\)). Subgroup analyses of pooled data from separate analyses of AIC and SIC showed the efficacy of both measures for CRI prevention, with a risk ratio (RR) of 0.31 (95% CI, 0.18-0.55; \(P < .0001\)) and an RR of 0.59 (95% CI, 0.40-0.88; \(P = .010\)), respectively. The protective effects of these AIC catheters remained significant in the subgroup of randomized controlled trials with an RR of 0.48 (95% CI, 0.25-0.90; \(P = .02\)). A similar result was also seen after a pooled analysis of observational studies with an RR of 0.35 (95% CI, 0.21-0.60; \(P = .0001\)). The heterogeneity among studies was moderate (I\(^2\) = 49%) and was primarily attributed to the inclusion of 1 large, positive cohort study. Publication bias was unlikely in the current meta-analysis.

The results indicate that both AIC and SIC are more effective than plain EVDs for the prevention of CRI. There is no conclusive evidence on the preference of AIC vs SIC because of insufficient data. Further well-designed, multicenter randomized controlled trials are required to confirm the findings of this meta-analysis.\(^{22}\)

**Cost analysis**

The current value analysis demonstrates that evidence supports the use of AICs as effective and potentially cost-saving treatment.\(^{23}\)

see Antibiotic impregnated shunt

**Case series**

**2015**

One hundred and fifteen patients underwent insertion of EVDs from January 2000 to March 2008. Data were collected for 99 patients with a total of 146 EVD insertions. The parameters studied were age, gender, ASA score, seniority of the surgeon, significant medical history, presence of trauma, concurrent surgeries, revisional surgery, use of peri-operative systemic antibiotic, use of antibiotic-
impregnated external ventricular catheter, tunnelling of the catheter, duration of drainage and VRIs.

Eleven patients developed new VRI (12%). Analysis comparing infection incidence for various co-morbidities shows that systemic sepsis was associated with higher infection rates ($p = 0.037$). Revisinal surgery ($p = 0.036$) and longer duration of catheterization ($p = 0.001$) were also found to be associated with VRI. The Standard catheters and the antibiotic-impregnated catheters had similar infection rates. The antibiotic-impregnated catheters tended to be infection-free for longer but these differences were not statistically significant. The duration of catheterization was significantly higher for the antibiotic-impregnated catheter group. In both groups, the majority of infections were caused by Gram-positive bacteria.

The study demonstrates that there was no statistically significant difference in the infection rates for the Standard and antibiotic-impregnated external ventriculostomy catheters. The duration of catheterization was significantly higher for the Antibiotic-impregnated catheter group. The antibiotic-impregnated catheter infections tended to occur later as compared with the Standard catheter group.

2011

Demetriades and Bassi present the experience of 52 months of Bactiseal catheters in all consecutive patients who underwent a ventriculoperitoneal (VP) shunt from July 2004 to November 2008, under the care of one neurosurgeon. This was a prospective study with outcome measures of infection, blockage, intra and postoperative complications and revision surgery.

One hundred and twenty-five patients underwent VP shunting with Bactiseal catheters, with a combination of NSC, Strata and Burr Hole valves. The age range of the patients was from 1 week premature to 64-years old. Forty-two of the patients were paediatric. The aetiology for hydrocephalus included posterior fossa tumoursto intra-ventricular haemorrhage, post-meningitic hydrocephalus and aqueduct stenosis. The overall complication rate was 12%. The following complications occurred: blockage in two cases; haemorrhage and blockage in two cases; CSF leak in one case; infection in four cases; other in three cases (peritoneal adhesions, wound erosion and postoperative peritonitis). There were four infections in total (3.2%). All of these occurred within six months of implantation. All infections were caused by rifampicin resistant Staphylococcus epidermidis.

In an era of increasing methicillin-resistant Staphylococcus aureus (MRSA) resistance and ‘superbugs’, is the use of antibiotic-laced catheters adding to the pool of resistant bacteria which may be harder to treat? Vigilance is required, as rare and resistant staphylococci strains occasionally can emerge as causative agents for VP shunt infections, in both adults and children, and their treatment can be difficult.


5) L.F. Borges Cerebrospinal fluid shunts interfere with host defenses Neurosurgery, 10 (1982), pp. 55–60


