Efficacy of Hydromer-Coated and Antibiotic-Impregnated Shunt Systems in Reducing Early Shunt Infections in the Pediatric Population

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Objective: Shunt infection is the most common complication following a Cerebrospinal fluid (CSF) diversion procedure with devastating consequences. This study analyzes the efficacy of different shunt systems in reducing early shunt infections in the pediatric population.

Methods: Retrospective case study analysis of 177 pediatric patients with hydrocephalus de novo shunted using hydromer-coated (HC) shunt systems, antibiotic-impregnated (AI) shunt systems and standard non-impregnated shunt systems was performed and compared for the incidence of shunt infection in the early postoperative period.

Results: Group A consisted of standard shunt systems with 63 patients, Group B were HC shunt systems with 67 patients and group C consisted of 47 patients with antibiotic-impregnated shunt systems. Mean age in Group A was 1.36 +/- 3.36 years Mean age in Group B was 2.32 +/- 4.69 years. Mean age in Group C: 0.64 +/- 1.70 years. In terms of shunt infections, HC group had 4 shunt infections (6.25%), as compared to the control group, where 7 patients (10.45%) had infections. The AI group had 1 infection (2.13%). When comparing HC systems versus Standard Non-Impregnated There were 3 shunt malfunction in Group A (4.8%), 2 shunt malfunction in group B (3.3%) and 0 shunt malfunction in Group C (0%).

Conclusion: Hydromer-coated shunt systems and antibiotic-impregnated shunt system represent a superior alternative to standard shunt systems for the reduction of shunt infection in the early post operative period. [*P R Health Sci J 2019;38:244-247*]

Key words: Hydromer coated, Antibiotic-impregnated, Shunt infections

Shunt infection remains the most common complication following a cerebrospinal fluid (CSF) diversion procedure, with an incidence rate of up to 39% and 90% of infections occurring in the first 6 months (1). Despite advances in the treatment of shunt infections, patients are at risk of severe intellectual and neurological deficits after successful treatment (2,3,4,5). Furthermore, shunt infection carries a significant financial burden, being considered the most costly implant-related infection in the United States (6,7,8).

Advances in surgical techniques have demonstrated a consistent decrease in the incidence of shunt infection (8). New systems such as antibiotic-impregnated (AI) shunt components have shown promise in reducing the rate of infection, but at the expense of increased material costs. Nonetheless, when cost-analysis are performed the amount of money invested to avoid a shunt infection using new systems outweighs the cost of treating a shunt infection economically and socially. (8)

Biomaterial engineering has developed materials that inhibit bacterial adherence in shunt systems. Such systems include the Bioglide catheters (Medtronic, Inc., Minneapolis, MN) that consist of a hydrophilic surface that is intended to lower bacterial colonization. This hydrophilic polymer catheter when soaked in antibiotic solution absorbs the antibiotic and is later released after insertion, thus theoretically lowering the risk of infection (9). This assertion has not been reproduced in vitro (10). However clinical data regarding the efficacy of hydromer-coated catheter effect on shunt infections has not been consistently documented, especially in the pediatric population (11).

In this clinical study the primary objective was to determine if the incidence of early shunt infection was reduced in a pediatric patient population after the introduction of hydromer-coated shunt system and antibiotic-impregnated shunt systems for the treatment of hydrocephalus.

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Patient and Methods

A retrospective case series analysis of 177 pediatric patients with hydrocephalus who underwent de novo CSF diversion procedure from July 2005 to June 2014 was performed. Information was obtained from patient's hospital chart. From July 2005 until July 2007 all patients were treated with standard shunt system by the two senior pediatric neurosurgeons at University Pediatric Hospital (UPH) and at Administracion de Servicios Medicos de Puerto Rico (ASEM). Following this time-period, patients were treated either with antibiotic-impregnated shunt systems or hydromer-coated shunt system, this decision was made by the attending surgeon. This analysis was divided into patients who had been treated with standard shunt systems (Group A), hydromer-coated shunt systems (Group B) and antibiotic-impregnated (Rifampin and Clindamycin) shunt systems (Group C). Group A consisted of standard shunt systems with 63 patients, Group B were HC shunt systems with 67 patients and group C consisted of 47 patients with antibiotic-impregnated shunt systems Patient demographics, hydrocephalus etiology, complications, infectious organism were reviewed in all cases. Institution Review Board was obtained to perform this study.

The pre-operative and peri-operative protocol was identical for HC, AI, and standard non-impregnated systems. All patients underwent preoperative clinical assessments, computerized tomography and/or magnetic resonance imaging studies, routine hematological and biochemical blood laboratories. All patients were given cefazolin 30mg/kg intravenously at anesthesia induction, if patient were allergic to penicillin, vancomycin 10mg/kg was given, three postoperative doses were later given 8 hours apart if cefazolin was administered, if vancomycin was administered two post operative doses were given 12 hours apart. Only essential personnel was allowed in the operating theatre. The surgical procedure consisted of a standard implantation of a shunt system. The scalp and skin were cleansed first with alcohol and then prep with povidone–iodine solution. The abdominal and cranial components of the surgical procedure were made and worked on simultaneously to minimize the length of surgery. The shunt system was kept soaked in a 1-liter solution of 0.9% saline solution with 1 gram of vancomycin and 50,000 units of bacitracin until implanted. Operating time was kept to less than 45 minutes.

At the time of shunt insertion, ventricular CSF was collected and sent to the laboratory for biochemical and microbiological analysis.

All patients were followed up for 12 months after shunt surgery. Shunt-related complications were recorded. Shunt malfunction was defined as an event leading to hardware removal, replacement, or revision. Shunt infection was defined as patients with clinical symptoms of infection with positive cultures from CSF and/ or hardware.

Results

In total, 177 patients with hydrocephalus were treated with a ventricular-peritoneal shunt. 63 received standard shunts, 67 received the hydromer-coated shunt systems (HC), and 67 received Antibiotic-impregnated shunt systems (AI). All patients underwent the procedure for the first time. Population characteristics were well matched (Table 1,2,3), with 36 males (58%) in the standard group, 38 males (57%) in HC shunt group, and 26 males (25%) in the AI group (P = 0.80). Median ages of 6 months in the AI group and 12 months in the standard shunt group and 24 months in the HC group (P = 0.32). In the standard shunt group 39% had congenital hydrocephalus, 40% of patients had a history of Myelomeningocele In the HC group 39% had congenital hydrocephalus and 39 % had a history of Myelomeningocele. In the AI group 38 % had history of Myelomeningocele and 29% had congenital hydrocephalus.

Table 1. Demographics - Standard Shunt system

# of patients	63
Age	1.36 years (SD + 3.36 years)
Sex	
M	36
F	27
Diagnosis	
Myelomeningocele	25
Congenital	24
Intraventricular hemorraghe	9
Aqueductal stenosis	3
Meningitis	1
Encephalocele	1

Table 2. Demographics – Hydromer-coated Shunt system

# of patients	67
Age	2.32 years (SD + 4.69 years)
Sex	
M	38
F	29
Diagnosis	
Myelomeningocele	26
Congenital	26
Intraventricular hemorraghe	5
Posterior fossa tumor	5
Meningitis	2
Holoprocencephaly	2
Encephalocele	1

Overall, there was a reduction in infections in the HC and AI group. There were 7 (10.45%) patients with shunt infections in the standard shunt system group, 4 in the HC group (6.25%), 1 (2.13%) in the AI groups, while there was no statistical significance, a trend toward less infections was observed in the HC and AI groups. The most common causative organism in all groups was Staphylococcus Aureus (HC - 75%, Standard - 70%), in the AI group the only infection was caused by Klebsiella

Pnemonia. The relative risk of infection with HC versus standard shunt system was 0.60 (95% CI: 0.18, 1.95) and the relative risk of infection with AI vs. versus standard shunt system was 0.20 (95% CI: 0.03, 1.60). In patients with shunt infections, a history of Myelomeningocele was prevalent with 4 in group A (57%), 2 in group B (50%) and 1 in Group C (100%).

The average time to presentation of shunt infection was 1.5 months in the standard shunt groups versus 1 months in the HC and AI groups (P >0.05).

The number of malfunctions between the two groups was similar, with 2 malfunctions in the HC group (3%) compared to 3 malfunctions in the control group (4.8%) and none in the AI group (P >0.05).

Table 3. Demographics – Antibiotic-impregnated Shunt system

# of patients	47
Age	0.64 years (SD + 1.70 years)
Sex	
M	26
F	21
Diagnosis	
Myelomeningocele	18
Congenital	14
Intraventricular hemorraghe	10
Aqueductal stenosis	2
Meningitis	2
Holoprocencephaly	1

Discussion

Hydrocephalus remains a common neurological entity that neurosurgeons must deal with daily, associated complications such as CSF infection remains a major cause of morbidity and mortality among patients (11,12,13,14,15,16,17,18, 19).

In our present study we sought to investigate the efficacy of two different shunt systems after introduction in clinical practice. The efficacy of antibiotic-impregnated shunt system has been established (5,20), however the associated cost of implementation remains a burden, especially in countries where significant shortage of budget is a common scenario. Hydromer-coated systems such as Medtronic Bioglide after introduction demonstrated a trend toward reducing the incidence of early shunt infections. Although our results were not statistically significant they demonstrated a trend, it is difficult to achieve statistical significance due to the rare instances of shunt infections and malfunctions and the sample needed to achieve adequate study power. Our results also showed similar trend of reduction of shunt infections and malfunctions between AI and HC shunt systems.

In the past, in-vitro investigation failed to obtain any reduction in bacterial colonization of hydromer-coated catheters, thus predicting that the efficacy of such catheters to prevent infection would be no different that standard shunt systems (9,10). However our present results contradicts such findings, demonstrating a significant reduction in the incidence of infections. It is postulated that the hydrophilic surface reduces bacterial adhesion and thus prevents early colonization (20).

Among patients with shunt infection the most common organisms was Staphylococcus Aureus, not in accordance with the current literature in which coagulase-negative staphylococcus species tends to be the most common infecting organism. This finding could be explained by the increase incidence of Staphylococcus Aureus in our institution, favoring inoculation in the implantation procedure.

Patients treated with hydromer-coated catheter and antibiotic-impregnated shunt systems were less prone to malfunctions, however this proved not to be of statistical significance. The hydrophilic surface of HC could explain a lower incidence of shunt malfunctions as the possibility of debris adherence would be lower. Theoretically hydrophilic surfaces tend to maintain a constant flow of fluid thus diminishing the possibility that debris such as choroid plexus could adhere to it.

Conclusion

Shunt infection remains a significant cause of morbidity in patients undergoing CSF diversion procedures. The introduction of hydromer-coated shunt system catheter and antibiotic shunt system demonstrated a significant reduction in early shunt infections while also showing a trend toward less shunt malfunctions, thus offering an alternative for neurosurgeons to minimize such complications..

Resumen

Objetivo: La complicación más común luego de una derivación de liquido cerebro espinal es infección. Este estudio analiza y compara la eficacia de diferentes sistemas de derivación para prevenir infecciónes temprana en la población pediátrica. Métodos: Estudio retrospectivo donde se analiza 177 pacientes pediátricos con hidrocefalia de novo cuyos sistema de derivación usados fueron sistemas: recubiertos con hidrómero (HC), impregnados con antibióticos (AI) y no impregnados. Para así comparar y contrastar la incidencia de infección en el periodo post operatorio temprano dependiendo del sistema usado. Resultados: Grupo A consistió de sistemas estándar con 63 pacientes, Grupo B de sistemas recubiertos con hidrómero (HC) con 67 pacientes y Grupo C con 47 pacientes con sistemas impregnados con antibióticos (AI). Edad promedio en Grupo A fue 1.36 +/- 3.36 años, en Grupo B fue 2.32 +/- 4.69 años y en el Grupo C fue 0.64 +/- 1.70 años. Grupo A tuvo 7 pacientes (10.45%) con infecciones Grupo B tuvo 4 infecciones (6.25%) El Grupo C tuvo 1 infección(2.13). Ocurrieron 3 mal-funcionamientos de derivación en el grupo A (4,8%), 2 en el grupo B (3%) y 0 en el grupo C (0%). Conclusiones: Los sistemas de derivación recubiertos de hidrómero y el sistema de derivación impregnado de antibióticos representan una alternativa superior a los sistemas estándar de derivación para la reducción de la infección por derivación en el período postoperatorio temprano.

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