

# A Modified Shunt System for the Management of Pyogenic Hydrocephalus

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## ABSTRACT

**BACKGROUND:** To describe the structure and efficacy of a modified cerebrospinal fluid (CSF) shunt system with Bhatti CSF access chamber and ventriculoperitoneal shunt, for the management of hydrocephalus associated with pyogenic ventriculitis.

**METHODS:** This was an observational study performed at the National Medical Center and Ziauddin Medical University, Karachi, Pakistan. Chemically bonded Bhatti CSF access chamber and ventriculoperitoneal shunt was inserted into 443 patients with hydrocephalus and pyogenic ventriculitis to allow injection of antibiotics into the lateral ventricles.

**RESULTS:** In all patients, symptoms and signs of hydrocephalus were relieved immediately after shunt insertion and infection brought under control within two weeks of intraventricular injection of

antibiotics (vancomycin or linezolid), via the CSF access chamber. In two patients peritoneal catheter was blocked by a precipitate of vancomycin. Reduction in the dose of intraventricular vancomycin from 50mg to 20mg and increased dilution (additional 2ml of 0.9% N/S solution) prevented recurrence of this complication. All patients recovered from ventriculitis within two weeks of initiating this treatment. Follow-up was from 3 months to 2 years to monitor continued relief of hydrocephalus and absence of recurrence of ventriculitis.

**CONCLUSION:** Bhatti CSF access chamber and the ventriculoperitoneal shunt is the only system available at present that fulfills the management of hydrocephalus associated with pyogenic ventriculitis. It provides continuous internal drainage of CSF combined with access to the ventricles for injection of antibiotics.

Keywords: CSF Access Device; Hydrocephalus; Intra-ventricular Antibiotics; Ventriculitis; Ventriculoperitoneal Shunt; External Ventricular Drain

## INTRODUCTION

Hydrocephalus associated with pyogenic ventriculitis poses a serious problem in management in patients of all ages [1, 2]. Systemic antibiotics often fail to control ventriculitis because of low penetration in the CSF [3]. Insertion of a conventional ventriculoperitoneal shunt relieves hydrocephalus but does not help in controlling infection, which often worsens [4]. Pyogenic ventriculitis, that begins with a shunt in place, necessitates the removal of shunt because of bacterial colonization within the shunt system [1]. Acute hydrocephalus that follows shunt removal may become life threatening [2]. Intermittent

ventricular tapping via patent fontanelle, a burr hole or a CSF access device, with or without intraventricular instillation of antibiotics, does not eliminate the risk of acute hydrocephalus and its serious effects in the intervals between tapping [2, 4]. Continuous external ventricular drainage (EVD) relieves hydrocephalus temporarily [5, 6] and repeated intraventricular injection of antibiotics may control ventriculitis, but the process prolongs hospital stay without offering any degree of certainty of sustained control of infection or a long term relief of hydrocephalus [1, 3, 7]. Secondary infection often complicates EVD [3, 7, 8]. Intraventricular instillation of antibiotics is cited as an important step in the control of pyogenic ventriculitis [6, 9].

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To allow such treatment, the original Bhatti ventriculoperitoneal shunt [10] was modified by adding a CSF access chamber proximal to the flushing chamber and placing the unilateral flow control valve between the two chambers. The modified shunt allows continuous internal drainage of CSF without the risk of bacterial colonization as the antibiotics injected into the access chamber course through the entire system. Bhatti CSF access chamber and the ventriculoperitoneal shunt are made of silicone elastomer, chemically bonded in a tubular design for placement beneath the galea. It comprises a separate ventricular catheter, a CSF access and flushing chambers unit with a chemically bonded peritoneal catheter (Figure 1-3). In conventional ventriculoperitoneal shunts, antibiotics injected in the flushing chamber flow only distal to the chamber without entering the ventricles because of the presence of oneway flow control valve at the inlet of the chamber [11].

**Figure 1:** Complete Bhatti CSF Access Chamber and Ventriculoperitoneal shunt system with ventricular catheter



**Figure 2:** Bhatti Shunt with Access Chamber



In the modified Bhatti shunt system, the flow control valves are placed between the two chambers and allow materials injected in the CSF access chamber to flow preferentially into the ventricles. Antibiotics diffuse in the ventricular CSF and flow back through the entire shunt system, at a rate, controlled by the flow control valves, into the peritoneal cavity thereby minimizing the risk of bacterial colonization of the entire shunt system. To ensure that maximum quantity of material injected, enters the ventricle, the flushing chamber is occluded with external digital pressure while the injection is being made into the access chamber. The effectiveness of the modified Bhatti shunt system has not been reported in our setting, therefore, we are reviewing the outcomes of patients who underwent implantation of the modified Bhatti shunt system for pyogenic hydrocephalus.

## METHODS

The diagnosis of hydrocephalus was made on imaging, usually CT scan [7, 9]. For the diagnosis of pyogenic ventriculitis, at least three of the following four criteria were fulfilled in all patients (CSF glucose < 40 mg/dL, CSF protein >50 mg/dL, CSF WBC count of > 11/uL with > 50% neutrophils, or positive CSF culture). The patients or their parents/guardians were briefed about the shunt system and their consent was taken before shunt insertion.

## RESULTS

The modified shunt was inserted in 443 patients, with hydrocephalus and ventriculitis of varied severity. The age of patients ranged from 3 months to 90 years with 213 (48%) patients between the ages of 3 and 6 months. In most patients, CSF glucose level was below 25mg/ml

**Figure 3:** Ventricular Catheter



and CSF protein elevated above 50 mg/ml (Table 1). Microscopic or culture evidence of pyogenic organisms was available in only five patients. The severity of ventriculitis was taken as a reflection of the degree of polymorphonuclear pleocytosis in the CSF with neutrophils exceeding 50% in all cases.

In 86 (19.4%) patients, ventriculitis was secondary to a CSF shunt in place or a recent EVD [5, 12]. In addition to systemic antibiotics, intraventricular vancomycin (20 mg/dl) was given daily or at longer intervals via the CSF access chamber for at least two weeks in all patients [3].

Following insertion of the CSF access chamber and ventriculoperitoneal shunt system, hydrocephalus was relieved in all 443 patients and none suffered any effects or consequences of raised ICP in the early postoperative period. All were discharged home within three days of shunt placement. Infection was also controlled in all patients, in less than two weeks, with a combination of systemic antibiotics and intraventricular vancomycin given via the shunt system. The intraventricular vancomycin was given initially in inpatient and then as an outpatient; daily or at less frequent intervals depending on the severity of ventriculitis and patient's response to treatment.

There were two deaths in the study. In one patient, a 10-year old boy who was admitted initially in the severely debilitated state, after one month of shunt insertion. The shunt system was removed on readmission because of erosion of scalp over the chambers of the shunt system. Ventriculitis and hydrocephalus, however, did not recur following shunt removal. He died of septicemia from extra cranial infection. In the other patient, a four-month-old baby in whom hydrocephalus was controlled initially, the shunt malfunctioned during outpatient intraventricular vancomycin therapy via the CSF access chamber. The baby was readmitted with severe acute hydrocephalus. On shunt revision, the slit valves at the lower end of the peritoneal catheter were found blocked with precipitated vancomycin. The baby was admitted in a coma and did not improve after revision of shunt and died of brain damage. CSF taken at shunt revision was however normal. To obviate the risk of shunt obstruction from drug precipitation, intraventricular vancomycin was reduced from 50 mg at a concentration of 100 mg/ml to 20mg at a concentration of 50 mg/ml [1]. Decreased dose and increased dilution of the antibiotic has since prevented this complication. The follow-up

period of the remaining 441 patients' ranged from two months to two years. All patients at follow-up had been found to have control of hydrocephalus with the absence of ventricular infection.

## DISCUSSION

Pyogenic ventriculitis refers to inflammation of the ventricular ependymal lining accompanied by pus in the ventricular system [1]. Pyogenic ventriculitis is uncommonly reported in adults and is almost exclusively seen in patients who have undergone cranial surgery, placement of a ventricular drain shunt, or had sustained head trauma [1, 5, 11, 13]. It is most commonly seen in neonates and children [14]. Pyogenic ventriculitis can complicate central nervous system (CNS) infections such as meningitis or brain abscesses and may even occur as a spontaneous infection in significantly immunocompromised patients [1]. Ventriculitis without hydrocephalus is associated with high mortality; from 30 to 70 percent [15]. Mortality is much higher when the infection occurs in association with hydrocephalus.

Ventriculitis associated with ventricular drains is the form most often discussed in the literature [12, 17]. The most common organisms isolated from patients who have undergone neurosurgical procedures (including shunt placement) include coagulase-negative *Staphylococcus* and *S. aureus*. Nonetheless, gram-negative organisms, such as *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Enterobacter cloacae*, and *Enterobacter aerogenes* are becoming increasingly common [8].

In most patients, however, bacterial cultures were negative because of early use of antibiotics as was the case in our patients. Diagnosis of pyogenic ventriculitis was based on the CSF findings of polymorphonuclear pleocytosis, reduced glucose and elevated protein, according to defined criteria [2], in majority of patients. Diagnosis of hydrocephalus was made on CT or MRI of the head [7, 9].

**Table 1:** CSF characteristics of Patients

No of Patients	W.B.C count	Glucose (mg/dl)	Protein (mg/dl)
21	5000 to -8000	10—20	>50
94	1000---<5000	10—20	>50
116	100---<1000	20—30	>50
213	11---<100	30--40	>50

## CONCLUSION

Bhatti CSF access chamber and ventriculoperitoneal shunt insertion have given satisfactory results in the management of patients with hydrocephalus and associated pyogenic ventriculitis. It relieves hydrocephalus by providing continuous internal drainage of CSF and controls infection by giving access to the ventricular system for antibiotic instillation. The use of this modified shunt in uncomplicated hydrocephalus may be justified in those surgical units that have a high incidence of shunt infection, as the modified shunt would allow intraventricular antibiotic therapy and control of infection obviating the need for removal of shunt and insertion of EVD.

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