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Tanweer Ahmed,  
Rabail Akbar,  
Anas Ahmed,  
Sana Akbar,  
Lal Rehman,  
Amjad Ali



# Role of intrathecal and topical vancomycin in prevention of ventriculoperitoneal shunt infections

Tanweer Ahmed<sup>1</sup>, Rabail Akbar<sup>1</sup>, Anas Ahmed<sup>1</sup>,  
Sana Akbar<sup>2</sup>, Lal Rehman<sup>1</sup>, Amjad Ali<sup>1</sup>

<sup>1</sup> Neurosurgery Department, Jinnah Postgraduate Medical Centre,  
Karachi, Sindh, PAKISTAN

<sup>2</sup> Sindh Services Hospital, Karachi, Sindh, PAKISTAN

## ABSTRACT

The objective of this study is to assess the role of intrathecal and topical vancomycin in the prevention of ventriculoperitoneal shunt infection. Infections of the ventriculoperitoneal (VP) shunt are a frequent consequence of shunt surgery. Different strategies, and protocols in addition to prophylactic intravenous antibiotic administration have been described to limit the infection rate, but the burden still remains high. The use of intrathecal Vancomycin along with topical application can be implemented as an additional measure to limit shunt-related infections.

The study includes 105 patients who underwent ventriculoperitoneal shunt insertions for different reasons. Apart from the standard operative protocols used for shunt surgeries, intraoperatively intrathecal and topical vancomycin were administered to all the patients. Postoperatively, all the patients were followed for three months to assess shunt-related infections

The study showed that the infection rate after administration of intrathecal and topical Vancomycin was found to be low, which is 4.7%, which shows a reduction of 5.8% from our baseline infection rate of 10.5%. We also found that patients having tuberculous meningitis were more at risk of developing shunt-related infections, the p-value being significant (0.001\*).

Therefore, we conclude that as part of a standardized shunt operation routine, Intrathecal and topical vancomycin treatment may be an appropriate option for preventing pediatric shunt infections.

## INTRODUCTION

Hydrocephalus is one of the most common clinical conditions presenting in a neurosurgical unit. Different surgical methods have evolved overtime to counteract this, with ventriculoperitoneal shunt insertions gaining widespread popularity [10].

Ventriculoperitoneal shunts provide a sterile, alternate route to the CSF into the peritoneal cavity, however the efficacy of these devices have been hampered by the challenges of shunt infections and obstructions [2]. As with any foreign body, there is a propensity for bacteria to colonize the shunt and develop infection. These biofilm

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**Keywords**  
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Corresponding author:  
**Tanweer Ahmed**

Neurosurgery Department, Jinnah  
Postgraduate Medical Centre,  
Karachi, Sindh, Pakistan

dr\_shezi@yahoo.com

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forming bacteria then can transmit this infection to both the intracranial and intraperitoneal cavities leading to significant morbidity. The culprits in most of the cases are organisms of the normal skin flora like staphylococcus aureus, staph epidermidis and propionobacter acnes [4, 16, and 31].

The shunt infection rate ranges from 5-15% on average [5, 13, and 14] but is higher in the pediatric population approximating at 20% [6, 31]. This higher incidence in children can be attributed to preterm birth, low birth weight, inadequately developed immune system and exposure to certain intrauterine pathogens among other factors [16, 18]. Multiple revision surgeries secondary to shunt obstruction is also an important cause [11] of shunt infections as well as hemorrhage as the primary cause leading to the development of hydrocephalus [8, 26]. Some surgeons argue that open neural tube defects, with communication of the skin flora with the subarachnoid spaces are a potential risk factor predisposing to shunt infections [8, 30]. While others believe that having a meningomyelocele may confer protection from the development of infections [26].

These shunt infections are notorious for being resistant to common antibiotic therapies, in part due to poor CSF penetration, and lead to significant decline in quality of life of the patients, prolonged hospital stays and overuse of resources. They ultimately result in shunt malfunction and high shunt failure rates [2]. These failure rates have been estimated to be around 6% per procedure [28]. This complication can lead to altered level of consciousness, neurological deficits, and seizures as well as reduced IQ levels in the pediatric population [23, 28].

Although the etiological factors cannot be controlled, there are certain modifiable factors that can be taken under consideration to reduce the infection rate. This includes impeccable sterile techniques and abstinence from direct handling of shunt apparatus during surgery, reduced duration of surgical procedure, limited traffic in and out of OR as well as diligent use of antibiotics prophylactically. Intravenous antibiotics have been used widespread as a prophylactic agent owing to its good response against staphylococcal organisms and better CSF penetration. However, recent reports have focused more on intraoperative intrathecal vancomycin administration and have demonstrated a significant impact in decreasing the VP shunt infection rates [3,

20, and 27]. These promising results have convinced our institution to use intrathecal and topical vancomycin intraoperatively in VP shunt placement surgeries in order to control the troubling infection rates.

## METHODOLOGY

This is a prospective cohort study, carried out in the department of Neurosurgery, Jinnah Postgraduate Medical Centre, Karachi, Pakistan from 15th November 2021 till 31st July 2022 for a period of 8 months. A total of 105 patients were enrolled in the study. Before this study was carried out, we determined a baseline infection rate by retrospectively analyzing previous data of patients who had undergone VP shunt placement in the past one year. We assessed for the incidence of infection and determined the rate to be 10.5%.

After obtaining ethical board approval, a proforma was designed and patient data was collected which included, demographics, the type and etiology of hydrocephalus and other details with regards to the ventriculoperitoneal shunt placement. The inclusion criteria defined patients of both genders, pediatric as well as adult population who required a VP shunt placement. Patients already having an infected CSF DR, which would preclude VP shunt insertion were excluded, so were patients who did not adhere to the follow up protocol and those not giving consent to be part of the study.

The patients were divided into 5 age groups, with Group A comprising of children 6 months or less, Group B: More than 6 months till 1 year of age, Group C: More than 1 year till 5 years of age, Group D: More than 5 years till 18 years of age and Group E: More than 18 years of age i.e. the adult population.

Different etiologies resulting in hydrocephalus were included in the study and associations identified. Patients having meningomyelocele, who also had concurrent hydrocephalus which needed ventriculoperitoneal shunting, were also included in the study. Radiological parameters such as Evan's ratio, ballooning of the frontal horns and prominent temporal horns along with Fronto-occipital circumference of the patient were used to determine whether there was a need of shunting in these children.

## Surgical protocol and antibiotic administration

The surgeries were carried out in standard operation

theatres which strictly adhere to the sterility protocols. The surgical site was cleaned using povidone iodine solution thrice, followed by swabs of sterilium. Then opsite was used to cover the cranial and abdominal surgical sites as well as the probable subcutaneous track area. Double gloving was done in all surgeries and once the dissection was complete to expose the burrhole proximally and the peritoneal cavity distally, the top glove was removed before handling the shunt catheters and tubing. Prior to insertion of shunt parts, they were soaked in normal saline impregnated with Gentamicin. Peroperatively a single dose of 2g ceftriaxone is given intravenous, which is followed by three more 2g IV doses administered for three days. This had also been the standard protocol in all patients having ventriculoperitoneal insertions in our institute even before this study was carried out. The only new difference was introduction of intrathecal and topical Vancomycin prophylactically which was not previously practiced.

Once the Proximal catheter was introduced into the ventricular cavity, it was used to inject 10mg of Vancomycin intrathecally. The catheter was then quickly connected to the chamber. Prior to skin closure, additional 10mg of Vancomycin was sprayed onto the site of the Proximal catheter insertion in the dura, as well as the surrounding tissues and then the skin was closed using prolene sutures.

#### Follow up protocol

The patients were then followed for a period of 3 months to assess for any ventriculoperitoneal shunt infections as well as any superficial wound infections. Any erythema, edema and Pus discharge from the wound with no infective elements of infection in the CSF DR was labeled as a 'superficial wound infection'. Whereas CSF D/R with increased WBC count (increased neutrophil counts) and abnormal glucose and protein levels, with or without positive CSF cultures, and with or without shunt blockage was labeled as 'Shunt infection'.

Patients having superficial wound infections, were given appropriate antibiotics (culture sensitive in case of positive pus cultures), and then followed for resolution of symptoms. For patients having infected CSF, with clinical symptoms of infection, the VP shunt was removed and an external ventricular drain placed. Cultures were sent and appropriate antibiotics started (IV vancomycin and Meroneum in

case of negative cultures), and patients were regularly followed by daily CSF D/R reports and cultures after every 48 hours. Normal WBC Count and protein and glucose parameters on D/R and three consecutively negative cultures would denote resolution of infection.

## RESULTS

### Age and gender

A total of 105 patients were a part of the study, with the ratio comprising 59 (56.2%) males and 46 (43.8%) females.

The frequency according to the age group distribution is depicted in Table 1, with 44.8% of the patients in the adult age group and remainder in the pediatric age group.

**Table 1.** Age distribution of the patients.

Age Groups	Frequency	Percentage
6 months and less	25	23.8%
>6 months - 1 year	2	1.9%
>1 year - 5 years	11	10.5%
>5 years - 18 years	20	19.0%
>18 years	47	44.8%

### Etiology of hydrocephalus

Communicating hydrocephalus was seen in 59 (56.2%) patients and 46 (43.8%) had an obstructive type of hydrocephalus. However, the etiologies were very variable and have been summarized in Table 2.

**Table 2.** Etiology of Hydrocephalus.

Etiology	Patients	Percentage
Congenital HCP only	5	4.8%
MMC Associated	24	22.9%
Aqueductal Stenosis	8	7.6%
Infectious	15	14.3%
Traumatic SAH/IVH	4	3.8%
Hypertensive IVH	2	1.9%
Tumors	37	35.2%
Postoperative	1	1.0%
Unknown	9	8.6%

Majority of the patients (35.2%) included in the study, had hydrocephalus secondary to brain tumors, both supratentorial and infratentorial. This was followed by Hydrocephalus associated with a meningomyelocele in 22.9% of the cases. 15 of the patients developed hydrocephalus as a result of

infective sequelae i.e. Tuberculosis, with the CSF D/R not showing an active infection. One patient who had undergone prior evacuation of a posterior fossa bleed, developed hydrocephalus 1 month postoperatively and was labeled as 'postoperative'. In 9 cases, the cause of hydrocephalus remained inconclusive.

**Type of VP shunts**

None of the patients had past history of VP shunt placements. Only non programmable shunts were used, with a cylindrical type of chamber used in 90 cases, and spherical ones in the rest.

**Shunt Infections**

Of the 105 patients enrolled in the study, 5 developed infections, denoting an infection rate of 4.7% per procedure.

Out of these five, one patient had a superficial wound infection which developed on the 3rd postoperative day. Shunt was passed secondary to history of tuberculous meningitis. The patient was managed on oral antibiotics and daily dressings. There was resolution of infection within 5 days and he was discharged

Rest of the four patients developed shunt infections with associated ventriculitis and meningitis. The demographics of these patients are discussed in Table 3 below.

**Table 3.** Demographics and etiology of patients who developed shunt infections.

	Age	Gender	Etiology	Type of Shunt	Organism
Patient 1	23	Female	TBM	Cylindrical	None
Patient 2	12	Male	TBM	Cylindrical	None
Patient 3	18	Male	TBM	Cylindrical	Staph. Aureus
Patient 4	14	Male	Tumor	Cylindrical	None

Patient 1 and 4 were brought to ER initially with a low GCS and emergency VP shunt placement was done. The VP shunt blocked almost immediately post op with both patients developing fever and neck rigidity. The shunt was removed and EVD placed. IV antibiotics started. However, the patients were unable to recover and expired within 2 weeks of developing ventriculitis.

Patient 2 developed wound infection with CSF leak at the surgical site. The CSF D/R showed an infective etiology, however the lab was unable to culture an organism. The right sided shunt was removed and EVD placed. Within 2 weeks her infection was resolved and new VP shunt was placed on the left side. On the three month follow up, the patient did not have any active issues.

Patient 3 also developed infection at 2 week follow up with culture showing growth of staph aureus, however, he was successfully managed on antibiotics and did not show any signs of infection at the 3 month follow up.

Table 4 shows in detail the relationship of the outcome with different patient parameters.

**Table 4.** Analysis of outcomes in comparison with different patient parameters.

Variable	No. of surgeries	Infection	No infection	P Value
<b>Gender</b>				
Male	59 (56.1%)	4 (6.7%)	55 (93.2%)	0.26
Female	46 (43.8%)	1 (2.17%)	45 (97.8%)	
<b>Age</b>				
≤ 6 months	25 (23.8%)	0 (0%)	25 (100%)	0.59
>6 months - 1 year	2 (1.9%)	0 (0%)	2 (100%)	
>1 year - 5 yrs	11 (10.4%)	0 (0%)	11 (100%)	
>5 yrs - 18 yrs	20 (19.0%)	2 (10%)	18 (90%)	
>18 yrs	47 (44.7%)	3 (6.38%)	44 (93.6%)	
<b>Etiology</b>				
Congenital HCP only	5 (4.7%)	0 (0%)	5 (100%)	0.07
MMC Associated	24 (22.8%)	0 (0%)	24 (100%)	
Aqueductal Stenosis	8 (7.6%)	0 (0%)	8 (100%)	
Infectious	15 (14.2%)	4 (26.6%)	11 (73.3%)	
Traumatic	4 (3.8%)	0 (0%)	4 (100%)	
SAH/IVH	2 (1.9%)	0 (0%)	2 (100%)	
Hypertensive IVH	37 (35.2%)	0 (0%)	36 (97.2%)	
Tumors	1 (0.95%)	1 (2.7%)	0 (0%)	
Postoperative	9 (8.57%)	0 (0%)	1 (100%)	
Unknown			9 (100%)	
<b>CSF Leak after shunt</b>				
Yes	3 (2.8%)	1 (33.3%)	2 (66.6%)	0.137
No	102 (97.1%)	4 (3.9%)	98 (96.0%)	

Males were more likely to develop shunt infection as compared to females (6.7% vs. 2.17%) in our study; however the p value is not significant ( $p$  Value > 0.5). Three patients out of 5 were adults; the other two were in Group D. None of the children less than 10 years of age developed an infection. Hydrocephalus associated with tuberculous meningitis was most commonly associated with shunt infections (in 80% of the cases). Cylindrical chambers were more prone to getting infected, however there is no significant data supporting this claim. There were two adverse outcomes i.e. death. Three patients recovered and did not show any signs of infection on monthly follow up visit.

Majority of the patients who developed a shunt infection (4/5) had an infective etiology as a cause. Of these 4 patients, all were diagnosed cases of tuberculous meningitis. 4 out of 15 cases of tuberculous meningitis developed a shunt associated infection, with the p value being significant ( $p$  value= 0.001)\*. The last patient had VP shunt surgery done to treat hydrocephalus secondary to a craniopharyngioma.

Out of 3 patients who developed a CSF leak, only one went on to develop a shunt infection. The p value is not significant.

## DISCUSSION

In the past, multiple studies have put weightage behind the use of a standard protocol to reduce shunt related infections with strict measures to control potential environmental, iatrogenic and patient related factors [13, 17]. Nevertheless, with the ever increasing use of foreign materials, such as VP shunts, as well increasing antimicrobial resistance, in addition to the emergence of more pathologically virulent organisms, there is a need for a dynamic and evolving process of strategies to contain the infection rates to acceptable levels.

Multiple studies have been conducted recently to study the role of intrathecal and/or topical vancomycin in preventing shunt infections [20, 29]. The results have been promising with one large clinical series showing a favorable outcome where prophylactic antibiotics were used [20]. The study showed that the infection rate was limited to 3.2% in comparison to multiple studies without the use of intrathecal and topical antibiotics in which the reported infection rates remained higher [7, 21]. Our study also showed an infection rate of 4.7% per

procedure, this shows a 5.8% decrease in the infection rate when compared with the reported baseline incidence of shunt infection in our institute which is 10.5% without the use of prophylactic vancomycin. Other studies have also reproduced this effect, showing a significant net decrease of shunt infection rates with the use of intrathecal vancomycin [3, 19].

In our single institution study, shunt infection was seen in ages 10 and older. This is in contrast to other studies showing higher rates of shunt infections in pediatric patients [9, 13 and 15]. Also, we found the male population to be more prone to develop shunt infections. A large series elsewhere showed that females had a higher preponderance [20].

Tuberculosis is endemic to Pakistan and as such, we do get a lot of patients in our Neurosurgical department having tuberculous meningitis and their sequelae, such as hydrocephalus. In our study, 4 out of 5 patients who developed shunt infections were diagnosed cases of tuberculous meningitis. This finding is significant ( $p$  Value= 0.001) and shows the trend that patients having tuberculous meningitis are more prone to develop shunt related infections. This has also been well documented in other studies [22, 24]. Although the patients were diagnosed as having tuberculous meningitis, no other organism was cultured as a cause of infection. Tuberculosis is also associated with thick exudates which might block the VP shunt [1]. None of the patients have tuberculous meningitis in our study were visibly cachexic. However, in 3 out of 4 patients, the BMI was in the underweight category and all of them developed shunt infections. The one patient having a normal BMI also developed infection.

CSF leak is considered an adverse factor with strong associations with subsequent shunt infections, as seen in the literature [20]. However, in our study, only one patient out of 3 developed an infection.

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## Limitations

This study is a single institution study comprising of both adult and pediatric population with a sample size of 105. This small size may not be fully

representative of the large population of hydrocephalus patients. Another potential limitation is the use of the same intrathecal and topical vancomycin dose in both the adult and pediatric population, which might potentially explain that none of the patients less than 10 years of age developed an infection, but the older population did. In patients having tuberculous etiology, a larger sample size with association to the weight should be carried out to determine a more solid relationship.

### CONCLUSION

Based on our findings, it is safe to say that intrathecal and topical vancomycin with strict adherence to the standard shunt protocol have a good impact on reducing shunt infections and should be practiced in all VP shunt procedures. Even though, the rate of infection still remained high in patients having tuberculous meningitis, larger studies on this particular etiology with dose adjustments is recommended so that a proper and efficient protocol could be generated to minimize shunt related complications in the future.

Although Vancomycin is known to prevent shunt related infections and has been well studied, there are only limited studies carried out in our region. The diversity of the organisms causing these infections as well as high rate of tuberculosis deemed it necessary to conduct a study to document the efficacy.

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