

Development of Protocol for Ventriculoperitoneal Shunt Surgery in Paediatric Patients to Reduce Shunt Infection

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Abstract

Original Research Article

Background: Ventriculoperitoneal shunt (VPS) is the most common treatment modality for hydrocephalus. However, VPS infection is a common and serious complication with high rates of mortality and morbidity and there is some emerging evidence suggesting that adherence to a strict protocol may be important in reducing the rate of shunt infection. **Objectives:** To develop a protocol for initial ventriculoperitoneal shunt surgery and assess the efficacy of this protocol in reducing ventriculoperitoneal shunt infection rate. **Materials and Methods:** This study was a comparative study was carried out in the Department of Neurosurgery, Bangabandhu Sheikh Mujib Medical University, Dhaka from December 2021 to March 2023. Total 100 patients were included in this study. Patients < 18 years of age undergoing initial ventriculoperitoneal shunt surgery for hydrocephalus due to various etiologies in the Department of Neurosurgery, Bangabandhu Sheikh Mujib Medical University. Data collection sheet was used to collect the necessary information. Voluntary written informed consent was taken from the patients and/or the legal guardian/responsible family members after completely explaining to them the procedure and the purpose of the study. Using simple random sampling by lottery method, the patients were divided into a study group and a control group. Patients in the study group underwent ventriculoperitoneal shunt surgery as per the proposed surgery protocol and strict adherence to the protocol by the operating surgeon was ensured. Patients in the control group underwent ventriculoperitoneal shunt surgery as per the current standard practice. Post-operative care of the patient was carried out as per the standard practice in both the groups. Follow-up of the patients were done on an outpatient department basis at 1 month and at 3 months postoperatively, where they were examined thoroughly for signs and symptoms of shunt infection. Patients not showing up at the outpatient department were telephoned and inquired about the condition of the patient. If any patient was suspected to have any shunt related complication during telephone conversation, he/she was asked to visit the outpatient department for formal assessment and relevant investigations. In patients presenting with suspected of shunt infection, some laboratory tests like complete blood count, Gram stain of cerebrospinal fluid, wound swab/discharge or pseudocyst fluid, cytology and biochemistry (sugar, protein) of cerebrospinal fluid and imaging study (if necessary), in the concerned departments in Bangabandhu Sheikh Mujib Medical University, to confirm the diagnosis of shunt infection. Statistical analysis of the results of the study was performed and the data processed by utilizing IBM SPSS Statistics program (version 21.0) Results were described in frequencies or percentage. Statistical comparisons were done using Chi-square test. P-value < 0.05 was considered statistically significant. **Results:** The overall rate of infection was 3% with 0% infection rate in the study population and 6.4% infection rate in the control population, but no statistically significant (p= 0.062) benefit in reducing the rate of shunt infection was found using a protocol based surgery. In this study, no significant associations were found between the rate of shunt infection age of patient (p= 0.31), scheduling of shunt procedure (p=0.051), subsequent surgery (p=0.151), number of personnel in the surgical team (p=0.465), use of adhesive drape (p=0.557), clipping of hair (p=0.421), double gloving (p= 0.465), change of outer gloves (p=0.111), and the use of antimicrobial suture (p=0.488). **Conclusion:** No significant correlation between the use of protocol-based shunt surgery and reduction in the rate of shunt infection, which is most likely due to the small sample size.

Keywords: Development of protocol, ventriculoperitoneal shunt, paediatric patients, Shunt infection.

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INTRODUCTION

Ventriculoperitoneal shunt (VPS) is the most common treatment modality for hydrocephalus. However, VPS infection is a common and serious complication with high rates of mortality and morbidity [1].

Identification of risk factors for shunt infection and predictors of infectious pathogens may improve current methods to prevent and treat shunt infections [2]. Shunt-related infections are associated with reduced intellectual performance, seizure, neurological disability, longer duration of hospitalization, shunt failure, increased treatment costs and even mortality [3]. Reported infection rates vary from 5% to 18% [4, 5], with significantly higher rates in specific subgroups, such as premature infants and post-haemorrhagic hydrocephalus [6]. Infections of VPS are common, with reports ranging from 1%-22% [7].

Re-infection of VPS has been reported to occur at a rate of approximately 26%. Multiple factors, including age at first shunt insertion, being younger than 6 months, male gender, nonsurgical management, intracranial haemorrhage and surgical technique, contribute to the occurrence of re-infection [7].

VPS infections have a substantial impact on patient outcomes. Patients with shunt infections suffer significant morbidity and have a higher mortality than those without infection. Infections have been associated with decreased intelligence quotient, seizures, and decreased quality of life [8]. Reduction of VPS infections is essential to achieving improved patient-oriented outcomes. Postoperative VPS infection reduction may reduce patient morbidity, mortality, and health care expenditures in addition to improving quality of life. Perioperative protocols to reduce the incidence of postoperative cerebrospinal fluid (CSF) shunt infections have been increasingly investigated and used by the neurosurgical community in recent years [9, 10].

MATERIALS AND METHODS

This study was a comparative study was carried out in the Department of Neurosurgery, Bangabandhu Sheikh Mujib Medical University, Dhaka from December 2021 to March 2023. Total 100 patients were included in this study. Patients < 18 years of age undergoing initial ventriculoperitoneal shunt surgery for hydrocephalus due to various etiologies in the Department of Neurosurgery, Bangabandhu Sheikh Mujib Medical University. Data collection sheet was used to collect the necessary information. Voluntary written informed consent was taken from the patients and/or the legal guardian/responsible family members after completely explaining to them the procedure and the purpose of the study. Using simple random sampling by lottery method, the patients were divided

into a study group and a control group. Patients in the study group underwent ventriculoperitoneal shunt surgery as per the proposed surgery protocol and strict adherence to the protocol by the operating surgeon was ensured. Patients in the control group underwent ventriculoperitoneal shunt surgery as per the current standard practice. Post-operative care of the patient was carried out as per the standard practice in both the groups. Follow-up of the patients were done on an outpatient department basis at 1 month and at 3 months postoperatively, where they were examined thoroughly for signs and symptoms of shunt infection. Patients not showing up at the outpatient department were telephoned and inquired about the condition of the patient. If any patient was suspected to have any shunt related complication during telephone conversation, he/she was asked to visit the outpatient department for formal assessment and relevant investigations. In patients presenting with suspected of shunt infection, some laboratory tests like complete blood count, Gram stain of cerebrospinal fluid, wound swab/discharge or pseudocyst fluid, cytology and biochemistry (sugar,protein) of cerebrospinal fluid and imaging study (if necessary), in the concerned departments in Bangabandhu Sheikh Mujib Medical University, to confirm the diagnosis of shunt infection.

Statistical analysis of the results of the study was performed and the data processed by utilizing IBM SPSS Statistics program (version 21.0) Results were described in frequencies or percentage. Statistical comparisons were done using Chi-square test. P- value < 0.05 was considered statistically significant.

Ventriculoperitoneal Shunt Surgery Protocol

1. Number of personnel in the operation theatre was kept to a minimum (maximum 5 personnel including the surgeon and assistant, the anesthesiologist, and circulating nurse).
2. Clipping of the hair was carried out, instead of shaving, in the operating room after induction of anaesthesia.
3. Primary wash of the scalp and the skin was carried out using chlorhexidine scrub solution.
4. The scalp and skin were prepared with 10% povidon iodine solution and left to dry out.
5. Administration of prophylactic antibiotic (intravenous ceftazidime and flucloxacillin) prior to incision was ensured.
6. All members of the surgical team wore two pairs of gloves after performing a formal scrub/wash.
7. Adhesive drape was used to cover the operative field.
8. Surgical drapes were fixed to the skin using skin staplers and not using sutures. Because of the availability of shunt drapes widely in the market, the procedure of fixing the drapes to the skin was abandoned completely. The

drapes were instead fixed with the adhesive drape provided in the shunt drape.

9. After surgical exposure, the outer gloves were changed prior to handling the shunt.
10. The shunt package was opened and the shunt components removed from the package just prior to implantation.
11. The shunt was immersed in a gentamicin bath prior to insertion.
12. Upon completion of shunt introduction and prior to wound closure adequate hemostasis was ensured to avoid subcutaneous hemorrhage and hematoma formation.
13. Closure of the galea and the fascia were done using triclosan-coated polyglactin 910 suture
14. Skin closure was carried out using monofilament suture (e.g. nylon, polypropylene) or multifilament braided suture (e.g. silk).
15. Dressing was applied over the wound.

Factors common in the control group: Include all per-operative steps except clipping of hair, wearing of two pairs of gloves, changing of outer gloves prior to handling the shunt.

RESULTS

Table 1 shows that majority (39.0%) subjects belonged to age <6 months and 59(59.0%) were male. Male female ratio was 1.4:1. Table 2 shows that overall rate of infection was 3.0% patients among them 0.0% infection rate in study group and 6.4% in control group. The level of significance according to chi square test was 0.062. Majority infection were found < 6 months 2(66.67%) and 1(3.33%) were found 7-12 month of age. Table 3 shows that the shunt infection in the study occurred in the patient who underwent surgery in the afternoon between 2.00 pm and 8.00 pm. The level of significance according to the Chi-square test was 0.051. Table 6 shows that out of the 25 surgeries carried out by 2 personnel (25.8%) there was no shunt infection (0.0%). The level of significance according to Chi-square test was 0.309. Out of the 44 surgeries carried out by 3 personnel (45.4%) there was on the shunt infection (66.7%). The level of significance according to Chi-square test was 0.465. Out of the 22 surgeries carried out by 4 personnel (22.7%) there was on the shunt infection (33.3%). The level of significance according to Chi-square test was 0.665. Table 7 shows the different components of the shunt surgery procedure studied in this current study.

Table 1: Demographic characteristics of the study patients (n=100)

	Frequency	Percentage
Age		
<6 months	39	39.0
7-12 months	34	34.0
13-24 months	16	16.0
>24 months	11	11.0
Sex		
Male	59	59.0
Female	41	41.0

Table 2: Infection in the study and control groups (n=100)

Infection	Study group (n=53)	Control group (n=47)	P value
Present	0 (0.0%)	3 (6.4%)	0.062
Absent	53 (100.0%)	44 (93.6%)	

Here Chi-square test was done to measure the level of significance. Overall rate of infection was 3% among them 0.0% in study group and 6.4% in control

group. Level of significance according to chi-square test was 0.062.

Table 3: Rate of infection according to age

Age	Infection at 3 rd follow up		p-value
	Present (n=3)	Absent (n=97)	
<6 months	02(66.67)	37(38.14)	0.31
7-12 months	01(33.3)	33(34.02)	0.98
13-24 months	0	16(16.49)	--
>24 months	0	11(11.4)	--
Total	03(100)	97(100)	

Majority of infection were found in < 6 months in 2(66.67%) and 1(3.33%) patient was infected in 7-12 month of age.

Table 4: Impact of time schedule of surgery on the rate of infection

Time of day	Infection at 3 rd follow up		P-value
	Present (n=3)	Absent(n=97)	
	n (%)	n (%)	
Morning between 8.00 am to 2.00 pm	0 (0.0)	41 (42.3)	0.143
Afternoon between 2.00 am to 8.00 pm	3 (100.0)	42 (43.3)	0.051
Night between 8.00 pm to 8.00 am	0 (0.0)	14 (14.4)	0.478

Chi- square test was done to measure the level of significance. Here shunt infection in study occurred in those patients who underwent surgery in the

afternoon between 2.00 to 8.00 p.m. Level of significance was 0.051.

Table 5: Impact of subsequent surgery on the rate of infection

Subsequent Surgery	Infection at 3 rd follow up		P-value
	Present(n=3)	Absent(n=97)	
	n (%)	n (%)	
Yes	0 (0.0)	40 (41.2)	0.151
No	3 (100.0)	57 (58.8)	

Chi- square test was done to measure the level of significance. Out of 40(41.2%) patients who underwent subsequent surgery for hydrocephalus , none

(0%) had shunt infection.The level of significance according to chi- square test was 0.151.

Table 6: Impact of number of personal in the surgical team on the rate of infection

Number of personnel in the surgical team	Infection at 3 rd follow up		P-value
	Present (n=3)	Absent (n=97)	
	n (%)	n (%)	
Two	0 (0.0)	25 (25.8)	0.309
Three	2 (66.7)	44 (45.4)	0.465
Four	1 (33.3)	22 (22.7)	0.665
Five	0 (0.0)	6 (6.2)	0.656

Chi- square test was done to measure the level of significance. Out of 25 surgeries carried out by 2 personnel (25.8%) there was no shunt infection (0.0%). The level of significance according to chi-square test was 0.309. Out of 44 surgeries carried out by 3 personnel

(45.4%) there was shunt infection (66.7%). The level of significance according to chi- square test was 0.465. Out of 22 surgeries carried out by 4 personnel (22.7%) there was shunt infection (33.3%). The level of significance according to chi- square test was 0.665.

Table 7: Individual components of shunt surgery

Factors of per- operative steps	Group				P- value
	Factor present		Factor absent		
	No of procedure	Infection	No of procedure	Infection	
Clipping of hair	56	1	44	2	0.421
Shaving of hair	48	2	52	1	0.511
Scalp preparation with povidone iodine	100	3	0	0	-
Prophylactic antibiotic	100	3	0	0	-
Use of double gloves	54	1	46	2	0.465
Use of adhesive drape	90	3	10	0	0.557
Drape fixation using staples	15	0	85	3	0.460
Change of outer gloves	45	0	55	3	0.111
Immersion of shunt hardware in gentamicin bath	100	3	0	0	-
Use of antibiotic impregnated suture for wound closure	53	1	47	2	0.488

Chi- square test was done to measure the level of significance. Different components of shunt surgery procedure were studied in this current study.

DISCUSSION

In this study showed that majority (39.0%) subjects belonged to age <6 months and 59(59.0%)

were male. Male female ratio was 1.4:1. Pan *et al.*, reported the median age of the patients at the time of VP shunt placement was 20.7 months (range 1.5 months to 8.5 years) [11]. Bawa *et al.*, reported the majority (65.8%) of the patients belonged to the 0 to 6 month age group [12]. Gupta (2011) states that the most consistent factor to affect shunt infection rates is patient age, with neonates and very young children at greatest risk [13].

In this study, 59.0% patients were male and 41% were female. Male female ratio was 1.4:1. Pan study observed there were 78 male and 59 female patients. Bawa *et al.*, reported a total of 278 patients were included, of which 203 were males and the remaining 75 were females.

In the present study, shunt infection occurred in the patient who underwent surgery in the afternoon between 2:00 pm and 8: pm. Statistically, scheduling of the shunt procedure was not significant ($p=0.051$). Forty (41.2%) of the patients underwent subsequent surgery for the etiology of hydrocephalus after undergoing ventriculoperitoneal shunt. No shunt infection was found in these patients. The association between subsequent surgery and the rate of infection was not statistically significant ($p=0.151$).

In this present study, out of the 25 surgeries carried out by 2 personnel (25.8%) there was no shunt infection. When shunt surgery was carried out by 3 or more personnel (74.2%), there was three incidence of shunt infection. Statistically, the association between the number of personnel in the surgical team and shunt infection was not significant. In this current study, shunt infection occurred in the patient even when adhesive drapes were used. The association between the use of adhesive drape and shunt infection was not found statistically significant ($p=0.557$). Blount states that it preferable to remove the hair in a gentle fashion with clippers rather than with a razor because small nicks and cuts in unprepared skin can increase the risk for infection [14]. Kestle *et al.*, (2011) found no significant association ($p=1.00$) between the method of hair removal (clipping of hair vs. shaving of hair) and the rate of shunt infection [9]. In present study, hair clipping was carried out in the study group and shaving of the hair before surgery was performed in the control group. Based on the method of hair removal before surgery, clipping of hair ($p=0.421$) or shaving of hair ($p=0.511$) had no statistically significant association with shunt infection. Tulipan and Cleves reported that the odds of developing an infection were almost 2.5-fold greater in cases in which shunts were inserted by personnel wearing a single glove on each hand [15]. Kestle *et al.*, (2011) in their prospective study found a significant association ($p=0.043$) between double gloving by all team members and reduction in the rate of shunt infection [9]. In this present study, all members of the surgical team in the study group used double gloves and the association between double gloving and

the rate of shunt infection was not found significant ($p=0.465$).

Rehman *et al.*, reported a statistically significant ($p=0.0458$) reduction of ventriculoperitoneal shunt infection rate by changing of gloves before handling the shunt catheter [16]. In the present study, after initially double gloving, the outer pair of gloves was changed prior to handling the shunt catheter. The association between change of outer gloves prior to handling the shunt catheter and the rate of shunt infection was not found significant ($p=0.111$).

Rozzelle *et al.*, reported that the shunt infection rate was significantly ($p=0.038$) reduced from 21% to 4.3% with the use of antimicrobial sutures [17]. Kestle *et al.*, in a multicenter, prospective study also found that the use of antibiotic –impregnated sutures were associated with a significantly lower risk of infection ($p=0.026$) [9]. In this present study, triclosan-coated polyglactin -910 sutures were used for closure of galea and fascia during shunt surgery in the study group. During statistical analysis, the association between antimicrobial suture and reduction in shunt infection was not found significant ($p=0.488$).

Choux *et al.*, showed a dramatic reduction in shunt infection rate to 0.33% following the initiation of a protocol for shunt procedures [18]. Choksey and Malik reported a shunt infection rate of 0.57% after a rigidly applied and strict adherence to sterile technique [19]. Kestle *et al.*, has shown a significant reduction from 8.8% to 5.7% in shunt infection by adherence to a standardized protocol ($p=0.0028$) [9]. In the present study, the overall rate of infection was 3.0% in the study population. The association between protocol based shunt surgery and shunt infection was not found statistically significantly.

CONCLUSION

Ventriculoperitoneal shunt infections are thought to occur as a result of microbial inoculation of the shunt during insertion, so meticulous attention to detail in prophylaxis is required. This study found no significant correlation between the use of protocol-based shunt surgery and a reduction in the rate of shunt infection, which is most likely due to the small sample size.

LIMITATIONS

1. Shorter period of study
2. Small sample size
3. Loss of patients before completion of study
4. Multiple surgeons performing surgeries; the level of experience of the operating surgeon and its association with shunt infection was not addressed.

RECOMMENDATIONS

Based on the available published literatures, protocol based surgery for ventriculoperitoneal shunt should be initiated and strict adherence to the sterile technique can reduce the rate of shunt infection. This simple protocol, which does not include uses of more expensive devices like antibiotic – impregnated shunt, should be continued to include a larger population and assess the end result.

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