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Prospective Study of Ventriculoperitoneal Shunt Complications in Tertiary Care Centre

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A B S T R A C T

***Background*:** Ventriculoperitoneal shunt procedures remain the mainstay of hydrocephalus treatment despite significant complication rates. This study analyzed the patterns and risk factors for shunt complications in a tertiary care setting. ***Methods*:** A prospective observational study of 80 patients undergoing VP shunt surgery was conducted. Patient demographics, etiology, and complications were analyzed using standardized protocols. ***Results*:** The study included 50 males (62.5%) and 30 females (37.5%), with 57.5% under one year of age. Congenital hydrocephalus (37.5%) and tubercular meningitis (18.75%) were the predominant etiologies. Overall complication rate was 20%, with obstruction (11.25%), infection (6.25%), and displacement (2.5%) being the main complications. Ventriculitis cases showed the highest complication rate (37.5%, $p<0.05$). ***Conclusion*:** While VP shunt complications remain significant, certain etiologies carry higher risks. Understanding these patterns can improve patient selection and management protocols.

Keywords: Ventriculoperitoneal shunt; Hydrocephalus; Shunt complications; Congenital hydrocephalus; Tubercular meningitis; Surgical outcomes.

INTRODUCTION

Hydrocephalus represents a significant neurosurgical challenge affecting approximately 1-1.5 per 1,000 live births and carrying substantial morbidity across all age groups [1]. The introduction of ventriculoperitoneal (VP) shunts in the 1950s revolutionized the management of hydrocephalus, offering a reliable method for cerebrospinal fluid (CSF) diversion [2]. Despite technological advances over the past seven decades, VP shunt procedures continue to be associated with significant complication rates among neurosurgical interventions, presenting ongoing challenges for healthcare providers and significant impact on patient outcomes [3].

The reported incidence of VP shunt complications varies widely in literature, ranging from 20% to 40% within the first year of placement [4]. These complications encompass a spectrum of mechanical failures, infections, and functional inadequacies that often necessitate surgical revision. A multicenter study by Williams *et al*., demonstrated that approximately 40% of shunts fail within two years of placement, with the rate increasing to 50% within five years [5]. The economic burden associated with shunt complications is substantial, with estimates suggesting that revision surgeries account for more than $1 billion annually in healthcare costs in the United States alone [6].

Infection remains one of the most dreaded complications of VP shunt surgery, occurring in 5-15% of cases, with higher rates observed in pediatric populations [7]. These infections not only result in prolonged hospital stays and increased healthcare costs but also contribute significantly to patient morbidity and mortality. The causative organisms typically include skin flora, predominantly Staphylococcus epidermidis and Staphylococcus aureus, highlighting the critical importance of perioperative protocols and sterile technique [8].

Mechanical complications, including obstruction, disconnection, and migration, represent another significant category of shunt failure. Recent studies suggest that proximal catheter obstruction accounts for approximately 30% of all shunt malfunctions, while distal failure occurs in about 20% of cases [9]. Understanding the timing and patterns of these complications is crucial for developing preventive strategies and improving patient outcomes [3].

The evaluation and management of VP shunt complications present unique challenges in tertiary care settings, where centers often handle both primary cases and revisions referred from other facilities. This complexity is further compounded by the diverse patient population, varying surgical techniques, and the need for long-term follow-up. A systematic analysis of shunt complications in a tertiary care setting can provide valuable insights into risk factors, management strategies, and outcomes that could inform clinical practice and potentially reduce complication rates [10].

Given the significant impact of VP shunt complications on patient outcomes and healthcare resources, there is a pressing need for prospective studies that can better characterize these complications in contemporary practice. Our study aims to evaluate the incidence, patterns, and risk factors associated with VP shunt complications in a tertiary care setting, with particular attention to timing, presentation, and management outcomes. This information will be crucial for developing evidence-based protocols for prevention, early detection, and optimal management of shunt-related complications.

Aims and Objectives

The primary aim of this study was to evaluate the outcomes and complications associated with ventriculoperitoneal shunt procedures performed at Chengalpattu Medical College. The specific objectives included assessment of the procedural effectiveness, comprehensive analysis of post-operative complications, and identification of factors contributing to shunt malfunction. The study sought to establish patterns of complications and determine potential risk factors that might influence surgical outcomes in the tertiary care setting.

Materials and methods

Study Design and Ethical Considerations

This investigation was designed as a prospective observational study conducted over an 18-month period. Prior to commencement, ethical clearance was obtained from the Institutional Ethics Committee of Chengalpattu Medical College. The study adhered to the principles outlined in the Declaration of Helsinki and followed Good Clinical Practice guidelines.

Study Population and Sample Size

The study enrolled 80 consecutive patients who met the predetermined inclusion criteria at Chengalpattu Medical College. The sample size was calculated based on previous literature reporting complication rates of VP shunts, with allowance for adequate statistical power. The study population comprised patients of all age groups and both genders who presented with CT-proven hydrocephalus requiring CSF diversion.

Selection Criteria

Patient selection followed strict inclusion and exclusion criteria. The study included patients across all age groups and both genders who presented with radiologically confirmed hydrocephalus on computed tomography. Exclusion criteria were carefully implemented to maintain homogeneity of the study population. Patients with active bacterial or tubercular meningitis presenting as hydrocephalus were also included. Additionally, patients with previous CSF diversion procedures were excluded to ensure evaluation of primary interventions only. Patients with altered coagulation profiles were also excluded due to increased surgical risk.

Materials and Methods

All patients underwent comprehensive preoperative evaluation following a standardized protocol. Detailed medical histories were obtained, and thorough neurological examinations were performed for each participant. The surgical intervention utilized the Chhabra "slit n spring" medium pressure hydrocephalus shunt system uniformly across all procedures to maintain consistency in treatment.

Preoperative assessment included a comprehensive panel of laboratory investigations. Complete blood count, erythrocyte sedimentation rate, renal function tests, serum electrolytes, and liver function tests were performed for all

patients. Complete urinalysis was conducted to rule out underlying infections. Cerebrospinal fluid analysis, including culture and sensitivity testing, was performed to ensure absence of active infection.

Radiological evaluation comprised multiple imaging modalities. All patients underwent chest radiography, non-contrast computed tomography of the head or magnetic resonance imaging as clinically indicated. The choice of imaging modality was based on clinical requirements and patient-specific factors.

Surgical intervention was performed under standardized conditions, and postoperative outcomes were systematically documented. Complications were classified and recorded according to predetermined criteria, including mechanical failures, infections, and functional inadequacies.

Data Collection and Analysis

Data collection utilized a preformed proforma that captured demographic information, clinical parameters, investigation results, surgical details, and outcomes. The statistical analysis was conducted using IBM SPSS Statistics for Windows, Version 20. Continuous variables were expressed as mean ± standard deviation with ranges, while categorical data were presented as frequencies and percentages. Statistical significance was set at $p < 0.05$ for all analyses.

The study methodology was designed to ensure comprehensive evaluation of VP shunt outcomes while minimizing potential sources of bias. Regular monitoring and documentation of complications were maintained throughout the follow-up period to ensure complete data capture and accurate assessment of outcomes.

RESULTS

The present study analyzed data from 80 patients who underwent ventriculoperitoneal shunt procedures. The demographic analysis revealed a predominance of male patients (n=50, 62.5%) compared to females (n=30, 37.5%), with a male-to-female ratio of 1.67:1. The age distribution demonstrated that the majority of patients were infants and young children, with 57.5% (n=46) of cases occurring in patients under one year of age. Specifically, 25% (n=20) were aged 0-2 months, and 32.5% (n=26) were between 2 months and 1 year. The remaining age distribution showed equal proportions (16.25%, n=13 each) in the 1-5 years and 20-30 years age groups, while patients aged 50-60 years constituted 10% (n=8) of the study population.

Analysis of the underlying etiology revealed congenital hydrocephalus as the most common cause, accounting for 37.5% (n=30) of all cases. Tubercular meningitis was the second most frequent etiology at 18.75% (n=15), followed by post-traumatic hydrocephalus at 12.5% (n=10). Ventriculitis was observed in 10% (n=8) of cases, while aqueductal stenosis accounted for 7.5% (n=6). Posterior fossa tumors and cerebellopontine angle masses represented 6.25% (n=5) and 5% (n=4) of cases, respectively. Normal pressure hydrocephalus was the least common etiology, present in only 2.5% (n=2) of cases.

Complications were observed in 20% (n=16) of the total cases, with varying distributions across different etiologies. The most frequent complication was obstruction, occurring in 11.25% (n=9) of all cases, followed by infection in 6.25% (n=5) and displacement in 2.5% (n=2). The complication rates showed significant variation among different etiological groups. Patients with ventriculitis demonstrated the highest complication rate at 37.5%, with 25% experiencing obstruction and 12.5% developing infections. Among tubercular meningitis cases, 26.7% developed complications, including obstruction (13.3%), infection (6.7%), and displacement (6.7%).

The analysis of complication-free outcomes showed that 80% (n=64) of all procedures were successful without any immediate complications. CPA mass cases and NPH patients showed 100% success rates with no complications. However, success rates varied significantly among other etiologies, with ventriculitis showing the lowest success rate at 62.5%, followed by tubercular meningitis at 73.3%. Congenital hydrocephalus cases demonstrated a relatively high success rate of 83.3%, similar to that observed in aqueductal stenosis cases.

Statistical analysis revealed a significant association between etiology and complication rates ($p<0.05$). Age stratification showed that patients under one year had a higher likelihood of developing complications compared to other age groups, though this did not reach statistical significance ($p=0.068$). No significant gender-based differences were observed in complication rates ($p=0.42$).

Table 1: Age-Wise Distribution of Patients Undergoing Ventriculoperitoneal Shunt

Age Group	Frequency	Percentage (%)
0 to 2 months	20	25.0
2m to 1 year	26	32.5
1 to 5 years	13	16.25

20 to 30 years	13	16.25
50 to 60 years	8	10.0
Total	80	100.0

Table 2: Etiology-Wise Distribution of Patients

Etiology	Frequency	Percentage (%)
Congenital Hydrocephalus	30	37.5
Tubercular Meningitis	15	18.75
Post Traumatic Hydrocephalus	10	12.5
Ventriculitis	8	10.0
Aqueductal Stenosis	6	7.5
Posterior Fossa Tumor	5	6.25
CPA Mass	4	5.0
Normal Pressure Hydrocephalus	2	2.5
Total	80	100.0

Table 3: Gender-Wise Patient Distribution

Gender	Frequency	Percentage (%)
Male	50	62.5
Female	30	37.5
Total	80	100.0

Table 4: Etiology/Complications Related to VP Shunt Procedures

Etiology	NIL	Obstruction	Infection	Displacement	Total
Congenital	25 (83.3%)	2 (6.7%)	2 (6.7%)	1 (3.3%)	30 (100%)
Tubercular Meningitis	11 (73.3%)	2 (13.3%)	1 (6.7%)	1 (6.7%)	15 (100%)
Post Traumatic	8 (80%)	1 (10%)	1 (10%)	0 (0%)	10 (100%)
Ventriculitis	5 (62.5%)	2 (25%)	1 (12.5%)	0 (0%)	8 (100%)
Aqueductal Stenosis	5 (83.3%)	1 (16.7%)	0 (0%)	0 (0%)	6 (100%)
Posterior Fossa Tumor	4 (80%)	1 (20%)	0 (0%)	0 (0%)	5 (100%)
CPA Mass	4 (100%)	0 (0%)	0 (0%)	0 (0%)	4 (100%)
NPH	2 (100%)	0 (0%)	0 (0%)	0 (0%)	2 (100%)
Total	64 (80%)	9 (11.25%)	5 (6.25%)	2 (2.5%)	80 (100%)

DISCUSSION

This study's findings regarding VP shunt complications align with several key trends reported in the neurosurgical literature while also highlighting some unique patterns. The overall complication rate of 20% observed in this study falls within the range reported by major series, though on the lower end of the spectrum. Reddy *et al*., reported complication rates between 20-30% in their long-term analysis of VP shunt outcomes [11].

The male predominance (62.5%) in our study population mirrors the gender distribution reported by Khan and colleagues, who found a 60.8% male prevalence in their 5-year retrospective analysis [12]. The high proportion of patients under one year of age (57.5%) in our series reflects the typical age distribution in hydrocephalus management, supported by Kulkarni's multicenter study that reported 55% of initial shunt placements occurring in infants [13].

Our finding that congenital hydrocephalus (37.5%) represents the most common etiology is consistent with Kestle's registry data, though their reported percentage was slightly higher at 42% [14]. However, the relatively high proportion of tubercular meningitis cases (18.75%) in our series differs from Western literature, where this etiology is less common. This likely reflects regional variations in disease patterns and is consistent with findings from other developing nations [15].

The complication profile observed shows obstruction (11.25%) as the predominant issue, followed by infection (6.25%). This pattern aligns with Stone's meta-analysis, though their reported obstruction rates were higher at 16.7% [16]. The infection rate in our series is notably lower than the 8-12% range reported in most large series, possibly reflecting strict adherence to antiseptic protocols [17].

The higher complication rates observed in ventriculitis (37.5%) and tubercular meningitis (26.7%) cases align with McGirt's findings that inflammatory conditions predispose to shunt failure [18]. Their series reported a 31.8% complication rate in inflammatory conditions, suggesting similar risk patterns.

The study's limitations include its relatively small sample size and single-center design. Additionally, the follow-up period may not capture all delayed complications.

CONCLUSION

Ventriculoperitoneal shunt surgery remains a fundamental neurosurgical procedure with significant complication rates. This study demonstrates that while overall complication rates align with published literature, certain patient groups - particularly those with inflammatory conditions - face higher risks. The predominance of obstruction and infection as primary complications emphasizes the need for careful patient selection and meticulous surgical technique. The findings support the need for specialized protocols for high-risk groups and suggest that regional factors may influence outcomes.

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