MAK HILL Publications Research Journal of Medical Sciences

Research Article
doi: 10.36478/makrjms.2024.12.261.266

OPEN ACCESS

Key Words
Ventriculoperitoneal shunt, hydrocephalus, chhabra shunt, complications, clinical outcomes, risk factors, neurosurgery, cerebrospinal fluid diversion, shunt failure, tertiary care

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Received: 20 August 2024
Accepted: 13 November 2024
Published: 23 November 2024

Citation: Dr. Suresh Kumar Choudhary, Dr. Madhur, Rahul Singh, Dr. Mukesh Kumar, Dr. Sanjeev Chopra, Dr. Ashok Gupta and Dr. Manish Agrawal, 2024. A Prospective Study and Analysis of Ventriculoperitoneal Shunt Surgery: their Indication and Complication in a Single Tertiary Care Centre. Res. J. Med. Sci., 18: 261-266, doi: 10.36478/makrjms.2024.12.261.266

A Prospective Study and Analysis of Ventriculoperitoneal Shunt Surgery: their Indication and Complication in a Single Tertiary Care Centre

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ABSTRACT
Ventriculoperitoneal (VP) shunt surgery remains the standard treatment for hydrocephalus, yet complications and outcomes vary significantly across different healthcare settings. To analyze the indications, complications and outcomes of VP shunt surgeries using the Chhabra shunt system at a single tertiary care center. This prospective study included 245 patients who underwent VP shunt surgery between June 2020 and November 2021. All procedures utilized Chhabra's shunt system with Keen's point entry. Patients were followed for six months post-surgery with regular clinical and radiological evaluations. The study population included 58.4% males, with a mean age of 19.4±15.2 years. Congenital hydrocephalus (29.8%) was the most common etiology, followed by post-meningitis (21.2%) and tumor-related (18.4%) causes. Medium pressure shunts were predominantly used (80.8%, p<0.001). The overall complication rate was 32.7%, with mechanical complications being most frequent (15.5%). At six-month follow-up, 68.6% of patients showed good recovery (GOS 5) and 82.0% of shunts remained functional. Multi variate analysis identified age <1 year (OR 2.34, p=0.001) and prior CNS infection (OR 2.15, p=0.002) as significant risk factors for shunt failure. VP shunt surgery using the Chhabra shunt system demonstrates favorable outcomes with acceptable complication rates. Early identification of high-risk patients and standardized surgical protocols contribute to improved success rates.

INTRODUCTION

Hydrocephalus remains one of the most challenging neurosurgical conditions, affecting approximately 1-2 per 1,000 births and presenting across all age groups[1]. The management of this condition has evolved significantly since the introduction of the first ventriculoperitoneal (VP) shunt by John Holter in 1956, yet it continues to be associated with notable complications and revision rates[2]. VP shunting represents the gold standard treatment for hydrocephalus, serving as a crucial intervention for cerebrospinal fluid (CSF) diversion in patients where natural drainage pathways are compromised[3]. The indications for VP shunt placement encompass a broad spectrum of pathologies, including congenital hydrocephalus, post-hemorrhagic hydrocephalus, normal pressure hydrocephalus (NPH) and hydrocephalus secondary to tumors or infections[4]. Despite technological advancements in shunt design and surgical techniques over the past decades, complications remain a significant concern, with reported failure rates ranging from 30-40% within the first year of placement[5]. Understanding these complications and their risk factors is crucial for improving patient outcomes and developing strategies for their prevention. Recent literature suggests that approximately 50% of shunted patients require at least one revision surgery during their lifetime, with many requiring multiple revisions[6]. The most common complications include mechanical failure, infection and over drainage or under drainage syndromes. Shunt infection rates, although decreased with improved surgical techniques and prophylactic protocols, still occur in 5-8% of cases and represent a significant source of morbidity and mortality[7]. The timing of complications varies considerably, with mechanical failures typically occurring within the first two years of placement, while infections usually present within the first few months post-surgery[8]. Long-term follow-up studies have demonstrated that even after successful initial placement, patients require ongoing monitoring and may develop complications years after the original surgery. This highlights the importance of establishing standardized protocols for both early detection of complications and long-term surveillance. The economic burden of VP shunt surgeries and their complications is substantial, with each revision surgery adding significantly to healthcare costs. Studies estimate that the direct medical costs associated with shunt revisions in the United States alone exceed $1 billion annually[9]. This financial impact, combined with the psychological burden on patients and their families, underscores the importance of identifying factors that may predict or prevent complications. In developing nations, the challenges associated with VP shunt surgery are often magnified by limited resources, delayed presentation and difficulties in long-term follow-up. These factors can significantly impact outcomes and complicate management strategies[10]. Understanding the specific challenges and outcomes in different healthcare settings is crucial for developing context-appropriate protocols and improving global standards of care. The present study aims to analyze the indications, complications and outcomes of VP shunt surgeries at our tertiary care center, with a particular focus on identifying patterns that may help predict and prevent complications. By examining our institutional experience, we hope to contribute to the growing body of knowledge regarding optimal management strategies for patients requiring VP shunt placement. This analysis will not only serve to audit our current practices but also provide valuable insights that may help improve patient care and outcomes in similar healthcare settings.

Aims and Objectives: The primary aim of this study was to analyze the indications, complications and outcomes of ventriculoperitoneal shunt surgeries performed at the Department of Neurosurgery, Sawai Man Singh Medical College and Hospital, Jaipur, Rajasthan, India. The study specifically focused on evaluating the efficacy of Chhabra's shunt system in managing hydrocephalus, identifying the timing and nature of post-operative complications and assessing the factors influencing shunt survival rates in the Indian tertiary care setting.

MATERIALS AND METHODS

Study Design and Setting: This prospective observational study was conducted at the Department of Neurosurgery, Sawai Man Singh Medical College and Hospital, Jaipur, from June 2020 to November 2021. The study protocol was approved by the Institutional Ethics Committee and informed consent was obtained from all patients or their legal guardians prior to enrollment.

Study Population: The study included 245 consecutive patients who underwent ventriculoperitoneal shunt surgery during the study period. All patients presenting with hydrocephalus of various etiologies who required CSF diversion were considered for inclusion. The study population encompassed patients across all age groups, from infants to elderly, who presented with clinical and radiological evidence of hydrocephalus.

Inclusion Criteria: The study included patients diagnosed with hydrocephalus of any etiology who required CSF diversion, patients who were medically fit for surgery and those who provided informed consent

for the procedure and follow-up. Both emergency and elective cases were included in the study cohort.

Exclusion Criteria: Patients with active CSF infection at the time of presentation, those with severe coagulopathy, patients who were deemed medically unfit for surgery and cases where consent for surgery or follow-up was not obtained were excluded from the study. Additionally, patients who had undergone previous shunt surgery at other institutions were excluded to maintain homogeneity in the study population.

Surgical Technique: All surgeries were performed under standard general anesthesia following strict aseptic protocols. The Keen's point was consistently used as the entry point for shunt placement. The Chhabra's shunt system was employed in all cases, with medium pressure shunts being the standard choice. Low-pressure or programmable shunts were selectively used based on specific patient requirements and clinical indicators. The choice of shunt pressure was determined by factors including age, etiology of hydrocephalus and ventricular size.

Perioperative Management: All patients received prophylactic antibiotics according to the institutional protocol. Preoperative CT or MRI scans were performed to confirm hydrocephalus and determine ventricular size. Post-operative imaging was performed within 24 hours of surgery to confirm appropriate shunt placement and initial ventricular response.

Follow-up Protocol: Patients were followed up regularly in the outpatient department at 2 weeks, 1 month, 3 months and 6 months post-surgery, or earlier if complications developed. During each visit, detailed neurological examination was performed and imaging studies were conducted when clinically indicated. Any shunt-related complications were promptly identified and managed according to standard protocols.

Data Collection and Analysis: Detailed clinical data was collected using a standardized proforma. Variables recorded included demographic details, etiology of hydrocephalus, clinical presentation, radiological findings, operative details, type of Chhabra's shunt used, post-operative complications and outcomes. The timing and nature of complications were meticulously documented. All data was entered into a secure database and analyzed using appropriate statistical methods.

Outcome Assessment: Primary outcomes included shunt survival rates, complication rates and need for revision surgery. Secondary outcomes included improvement in clinical symptoms, changes in ventricular size and quality of life parameters. The Glasgow Outcome Scale was used to assess functional outcomes at follow-up visits.

RESULTS AND DISCUSSIONS

The study analyzed 245 patients who underwent ventriculoperitoneal shunt surgery during the 18-month period from June 2020 to November 2021. The mean age of the study population was 19.4±15.2 years, with a male predominance (58.4%, n=143) compared to females (41.6%, n=102). Age distribution analysis revealed that pediatric cases constituted the majority, with 27.3% (n=67) being infants under one year and 33.5% (n=82) between 1-18 years. Adults between 19-50 years comprised 23.7% (n=58) of cases, while elderly patients over 50 years represented 15.5% (n=38) of the study population. Analysis of hydrocephalus etiology demonstrated that congenital causes were most prevalent, accounting for 29.8% (n=73) of cases, followed by post-meningitic hydrocephalus at 21.2% (n=52). Tumor-related hydrocephalus constituted 18.4% (n=45) of cases, while post-hemorrhagic hydrocephalus represented 15.5% (n=38). Normal pressure hydrocephalus and post-traumatic hydrocephalus were less common, comprising 9.0% (n=22) and 6.1% (n=15) of cases, respectively. Regarding shunt characteristics, medium pressure Chhabra's shunts were predominantly used, accounting for 80.8% (n=198) of cases, which was statistically significant ($p<0.001$). Low-pressure shunts were utilized in 14.3% (n=35) of cases, while programmable shunts were employed in 4.9% (n=12) of patients. Initial outcome assessment at two weeks post-surgery showed a success rate of 90.2% (n=221), with only 9.8% (n=24) requiring early revision ($p<0.001$). Complications were observed in 32.7% (n=80) of cases during the follow-up period. Mechanical complications were most frequent, with proximal obstruction occurring in 7.3% (n=18) of cases at a mean of 45.2±12.3 days post-surgery, followed by distal obstruction in 4.9% (n=12) at 62.4±15.7 days and disconnection in 3.3% (n=8) at 78.6±18.2 days. Infectious complications included shunt infection in 6.1% (n=15) of cases, presenting at a mean of 21.3± 8.4 days and meningitis in 2.9% (n=7) at 15.7±5.2 days post-surgery. Functional complications comprised over drainage in 4.5% (n=11) and under drainage in 3.7% (n=9) of cases, presenting at 32.4±9.8 and 28.6±7.5 days respectively. The six-month follow-up outcomes, assessed using the Glasgow Outcome Scale, showed good recovery (GOS 5) in 68.6% (n=168) of patients, which was statistically significant ($p<0.001$). Moderate disability (GOS 4) was observed in 17.1% (n=42), severe disability (GOS 3) in 9.4% (n=23), vegetative state (GOS 2) in 3.3% (n=8) and mortality (GOS 1) in 1.6% (n=4) of

cases. Shunt status at six months revealed 82.0% (n=201) remained functional, while 16.3% (n=40) required revision and 1.7% (n=4) necessitated removal (p<0.001). Multi variate analysis identified several significant risk factors for shunt failure. Age >one year carried the highest risk (OR 2.34, 95% CI 1.45-3.78, p=0.001), followed by prior CNS infection (OR 2.15, 95% CI 1.34-3.45, p=0.002). Post-meningiticetiology showed significant association with shunt failure (OR 1.92, 95% CI 1.23-2.98, p=0.004), as did emergency surgery (OR 1.76, 95% CI 1.12-2.77, p=0.015). The use of low-pressure shunts showed a trend toward increased risk but did not reach statistical significance (OR 1.45, 95% CI 0.89-2.36, p=0.134).

Table 1: Demographic and Clinical Characteristics of Patients (N=245)

Characteristic	Number (%)
Age Distribution	
-0-1 year	67 (27.3%)
-1-18 years	82 (33.5%)
-19-50 years	58 (23.7%)
->50 years	38 (15.5%)
Gender	
-Male	143 (58.4%)
-Female	102 (41.6%)
Mean Age (years)±SD	19.4±15.2

Table 2: Etiology of Hydrocephalus (N=245)

Etiology	Number (%)
Congenital	73 (29.8%)
Post-meningitic	52 (21.2%)
Tumor-related	45 (18.4%)
Post-hemorrhagic	38 (15.5%)
Normal Pressure Hydrocephalus	22 (9.0%)
Post-traumatic	15 (6.1%)

Table 3: Type of Chhabra Shunt Used and Initial Outcomes (N=245)

Variable	Number (%)	p-value*
Shunt Type		
-Medium Pressure	198 (80.8%)	<0.001
-Low Pressure	35 (14.3%)	
-Programmable	12 (4.9%)	
Initial Outcome (2 weeks)		
-Successful	221 (90.2%)	<0.001
-Required Revision	24 (9.8%)	

*Chi-square test

Table 4: Complications During Follow-up Period (N=245)

Complication	Number (%)	Timing (Mean±SD days)
Mechanical		
-Proximal Obstruction	18 (7.3%)	45.2±12.3
-Distal Obstruction	12 (4.9%)	62.4±15.7
-Disconnection	8 (3.3%)	78.6±18.2
Infectious		
-Shunt Infection	15 (6.1%)	21.3±8.4
-Meningitis	7 (2.9%)	15.7±5.2
Functional		
-Over drainage	11 (4.5%)	32.4±9.8
-Under drainage	9 (3.7%)	28.6±7.5
Total Complications	80 (32.7%)	

Table 5: Outcome Analysis at 6-Month Follow-up (N=245)

Outcome Measure	Number (%)	p-value*
Glasgow Outcome Scale		
- Good Recovery (5)	168 (68.6%)	<0.001
- Moderate Disability (4)	42 (17.1%)	
- Severe Disability (3)	23 (9.4%)	
- Vegetative State (2)	8 (3.3%)	
- Death (1)	4 (1.6%)	
Shunt Status		
- Functional	201 (82.0%)	<0.001
- Revised	40 (16.3%)	
- Removed	4 (1.7%)	

*Chi-square test for categorical variables

Table 6: Risk Factors Associated with Shunt Failure (Multi Variate Analysis)

Risk Factor	Odds Ratio	95% CI	p-value
Age <1 year	2.34	1.45-3.78	0.001
Post-meningiticetiology	1.92	1.23-2.98	0.004
Emergency surgery	1.76	1.12-2.77	0.015
Low-pressure shunt	1.45	0.89-2.36	0.134
Prior CNS infection	2.15	1.34-3.45	0.002

CI=Confidence Interval

The management of hydrocephalus through ventriculoperitoneal shunting remains a cornerstone of neuro surgical practice, yet continues to present significant challenges in terms of complications and outcomes. The present study's findings contribute to the existing body of knowledge while highlighting several important aspects of VP shunt surgery in a tertiary care setting. The demographic distribution in our study, with 60.8% pediatric cases (including 27.3% infants), aligns with the findings of Reddy[11], who reported 65.2% pediatric cases in their series of 910 patients. The male predominance (58.4%) observed in our cohort is consistent with several large-scale studies, including Wu[12], who reported a male prevalence of 54.8% in their analysis of 1,376 cases. The etiological pattern in our study showed congenital hydrocephalus as the leading cause (29.8%), followed by post-meningitis (21.2%) and tumor-related (18.4%) hydrocephalus. This distribution differs somewhat from Western literature, where Korinek[13] reported tumor-related hydrocephalus as the predominant cause (31.5%) in their series of 844 patients. The higher proportion of post-meningitic cases in our study may reflect the regional disease burden in developing nations, as similarly noted by Warf[14] in his Ugandan series, where infectious causes accounted for 23.4% of cases. Our overall complication rate of 32.7% falls within the range reported in contemporary literature. Simon[15] documented a 31.3% complication rate in their prospective study of 1,015 patients, while Khan[16] reported a higher rate of 38.2% in their series from another developing nation. The timing of complications in our study, particularly shunt infections presenting at a mean of 21.3 days, corresponds closely with findings by Kulkarni[17], who reported a median time to infection of 19 days in their multicenter study of 1,173 patients. The predominant use of medium-pressure Chhabra shunts (80.8%) in our series yielded favorable outcomes, with an initial success rate of 90.2%. This compares favorably with international literature, where Steinbok[18] reported an 87.5% initial success rate using various shunt systems. The infection rate in our series (6.1%) is notably lower than some reported rates in developing countries (8-12%), possibly reflecting strict adherence to antiseptic protocols and the use of prophylactic antibiotics. Risk factor analysis revealed age >one year as a significant predictor of shunt failure (OR 2.34, p=0.001), consistent with findings by Drake[19], who reported an odds ratio of 2.6

(p<0.001) for infant age in their prospective cohort of 1,184 patients. The association of prior CNS infection with shunt failure (OR 2.15, p=0.002) aligns with McGirt[20]'s findings, where previous infection carried an odds ratio of 2.3 for subsequent shunt failure. The six-month outcome assessment using the Glasgow Outcome Scale showed good recovery (GOS 5) in 68.6% of cases, comparable to Jindal[21] reported 70.2% favorable outcomes in their series of 552 patients. Our revision rate of 16.3% at six months is lower than some reported figures, such as Patwardhan and Nanda[22] 22.4% revision rate, possibly due to our strict patient selection criteria and standardized surgical technique.

CONCLUSION

This prospective study of 245 VP shunt surgeries provides valuable insights into the contemporary management of hydrocephalus in a tertiary care setting. The findings demonstrate that with proper patient selection and standardized surgical technique using Chhabra's shunt system, favorable outcomes can be achieved with acceptable complication rates. The overall success rate of 90.2% at initial follow-up and 82.0% functional shunts at six months validates the effectiveness of the current protocol. The identification of significant risk factors, particularly age less than one year (OR 2.34, p=0.001) and prior CNS infection (OR 2.15, p=0.002), provides crucial information for preoperative risk stratification and patient counseling. The study highlights the continuing challenges in shunt surgery, with a 32.7% overall complication rate, emphasizing the need for vigilant post-operative monitoring and prompt intervention when complications arise. The relatively low infection rate of 6.1% demonstrates the effectiveness of strict antiseptic protocols. The predominance of mechanical complications (15.5%) over infectious (9.0%) and functional (8.2%) complications suggests areas for potential technological improvement in shunt design. These findings contribute to the existing literature on VP shunt surgery and provide evidence-based guidance for neurosurgical practice in similar healthcare settings. Future studies should focus on long-term follow-up and the development of strategies to reduce mechanical complications, particularly in high-risk populations.

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