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Complications associated with Ventricle-Peritoneal Shunts: Experience at Carlos Van Buren Hospital (2020 –2023)

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ABSTRACT

Ventricle-peritoneal shunt (PVD) is one of the most commonly used surgical procedures for the management of symptomatic hydrocephalus. This surgical procedure is not without complications, both in the short and long term. The literature shows varied and dissimilar reports regarding the incidence of complications of these. The purpose of this work is to know the local reality of complications in the Neurosurgery service of the Carlos Van Buren Hospital during the period between March 2020 and April 2023, investigating the incidence and categorizing the complications of PVD and comparing it with that described in the literature. Likewise, as a second objective, to know the incidence and infectious etiology of these procedures. This is intended to provide information so that in the future protocols can be drafted and executed in order to reduce the incidence of complications.

1. INTRODUCTION

Hydrocephalus can be defined as a ventricular system with active distention, which may be associated with intracranial hypertension, caused by an imbalance between the production and reabsorption of cerebrospinal fluid (CSF). The installation of a ventricular bypass system remains an important long-term treatment option, which is not without multiple complications, especially if inserted early in an individual's life cycle. (1, 2) Currently an ideal system that works smoothly has not yet been found (3--4).

Hydrocephalus is diagnosed by clinical neurological evaluation. In addition to imaging techniques such as ultrasound, CT scans, magnetic resonance imaging or pressure monitoring techniques such as cerebrospinal fluid drainage. Clinicians choose diagnostic tools based on multiple variables, including the patient's age, clinical presentation, and the presence of other abnormalities (1 – 4).

Cerebrospinal fluid (CSF) shunts remain among the most failure-prone life-sustaining medical devices implanted in modern medical practice. Reported failure rates are 30% to 40% at one year and approximately 50% at two years in pediatric patients. With a 10-year failure rate of up to 70%. By the end of the first year, 40% of children may have problems related to referrals, and the numbers rise to 50% by the end of the second year. (5)

Ventricle-peritoneal shunts can present multiple and diverse types of complications. There are mechanical or infectious causes that can affect or be associated with its different components that constitute a dysfunction. The aforementioned complications can be due to multiple etiologies. These can be associated with the ventricular catheter, such as obstruction or migration; associated with the reservoir valve due to obstruction or an inappropriate pressure or flow regime for the patient; alterations associated with the peritoneal catheter, such as migrations, peritoneal insufficiency or rupture of viscera of the abdominal cavity.

As reported in the medical literature, the proportion of patients presenting with infection associated with the insertion of CSF diversion devices ranges from 5.3% to 29.3%, with a mean of 11.5%. (6-7-8).

Considering risk factors in the history of valvular dysfunction during the infection of a PVD, it is essential to evaluate the presence or absence of central nervous system infections prior to the placement of the PVD. It should also be considered whether the surgery was performed by a neurosurgeon who does not have specific experience in pediatric neurosurgery. In addition, the existence of concurrent systemic infection during shunt placement should be thoroughly examined and avoided

when possible. Choosing appropriate handwashing techniques also emerges as a critical factor to consider. In the field of surgical interventions, the relevance of atrial ventricular surgery to counteract previous infections in the abdominal system is highlighted, as well as the implementation of neuroendoscopy. (9).

DVP Complications

The causes of PVD dysfunction can be mechanical, infectious, or functional due to abnormal drainage of the CSF either by overdrainage or insufficient drainage. Unfortunately, the complication rate after insertion of a ventricular drainage system remains high, with 25-46% of failures occurring within the first year after implantation (10).

Approximately 56% to 80% of patients experience at least one failure within 10 years of inserting a DVP, with an estimated annual rate of system failure of 5%; Mortality due to failure of the peritoneal ventricle shunt system can be 1 to 2%. Patients with CSF shunt systems frequently present to the emergency department with common symptoms such as headache, fever, vomiting, lethargy, or irritability. These symptoms often coincide with common illnesses, so emergency medical personnel may have a hard time determining that a CSF bypass system is not working properly. Valvular dysfunction can be very dangerous if not diagnosed in time, which can lead to serious consequences and even death, which is why it is recommended to have a high index of suspicion in the emergency department (3).

Risk factors for surgery-related infections include a surgical time of more than 60 minutes and a procedure involving three surgeons, which is thought to increase the risk of infection (11).

It is stated that the microorganisms isolated vary according to the pathogenesis of the infection. Skin microorganisms can be found in particular: Staphylococcus epidermidis and Staphylococcus aureus (60-80%, of which 50% are resistant to methicillin). Gram-negative bacilli (10-25% of cases) are usually nosocomial pathogens or isolated from shunts that have been draining cerebrospinal fluid into the peritoneal cavity. Polymicrobial isolation is common (10-15%), sometimes from enterobacteriaceae, and anaerobes (indicative of perforation of the small intestine due to impaction of a distal catheter) (11).

In recent years, an increase in CSF infections by gram-negative bacilli, especially Acinetobacter baumannii (often multidrug-resistant), and which could be associated with increased hospital stay, has been shown to be associated with the use of broad-spectrum antibiotics (12).

It is suggested that the infection may present as a syndrome of valve dysfunction at the level of the proximal ventricular catheter due to obstruction or dysfunction of the system in one of its components. The main symptoms include headache (21%), changes in mental status and language (30-70%), drowsiness, nausea (14%) and vomiting (11%) (10).

Exposure to the peritoneal cavity of the CSF or the distal catheter itself induces a variety of inflammatory and clinical responses. Abdominal symptoms may be observed during peritoneal bypass surgery (40% of cases), most commonly manifesting as pain in the right iliac fossa, with or without signs of peritoneal irritation, as well as fever and mild pain (13).

Exposure to the peritoneum allows the absorption of cerebrospinal fluid, which sometimes results in the presence of large fluids or even intra-abdominal abscesses. Catheter-related distal pressure ulcers and/or perforation of the intestinal loop frequently cause acute abdominal symptoms (symptoms of peritonitis, abdominal pleural effusion, and acute abdomen (11).

Intestinal perforation and catheter penetration into the intestine are very rare, accounting for 0.01 to 0.07% of abdominal complications. In the literature, 94 cases of intestinal perforation and catheter penetration have been reported, and only 2 cases of duodenal perforation. (14)

Given the above, abdominal symptoms in patients who have had a peritoneal shunt should alert them to the possibility of infection. Peritonitis after ileal perforation can occur weeks or months after surgery, where signs and symptoms such as fever, malaise, intense abdominal distension and/or abdominal pain are usually evident; Clinical findings such as meningeal signs, diffuse leukocytosis in the cerebrospinal fluid, elevated proteins, and low glucose levels may also occur. The mortality rate in this case is 10 to 20% and 30% of survivors suffer permanent damage to the central nervous system Infections are usually caused by structural gram-negative gut bacteria, with mixed flora

in 12-21% of cases (11).

2. METHODOLOGY

A quantitative, descriptive, observational study was carried out, which included all patients hospitalized in the Neurosurgery Service of the Carlos Van Buren Hospital during the period from March 2020 to April 2023, covering 160 patients. The main variables of interest were type of diagnosis, type of intervention, complications, causes of complications, infections, infectious agent, operative time. The information was obtained from the review of surgical protocols, clinical records and review of the computer system of laboratory tests (cultures), and was worked anonymously.

Once the data was cleaned, they were analyzed using descriptive and inferential statistics through the Excel program and SPSS v.25. The qualitative variables were expressed in frequencies and percentages, for the quantitative variables central tendency (mean and median), position (minimum, maximum and quartiles) and dispersion statistics (standard deviation and

interquartile range) were used. For the inferential analysis, the Student's t-test was used for independent samples, through which the means of the operative time were compared between users who had and did not have an infection, and between users who presented and did not present any complications.

3. RESULTS

The study population consisted of 160 patients hospitalized in the Neurosurgery Service of the Carlos Van Buren Hospital during the period from March 2020 to April 2023, of which 51.3% corresponded to men and the remaining 48.7% to women. The average age was 30.6 ± 26.6 years, with the minimum being 2 days of life and the maximum 83 years, with the majority being in the category of adult (35.8%) and child (21.4%). The general characteristics are shown in Table 1.

Table 1. General characteristics of the study population.

Sex	
Man	81 (51,3%)
Woman	77 (48,7%)
Age	30.6 ± 26.6
Age Category	
Baby	35 (22%)
Child	34 (21,4%)
Adult	57 (35,8%)
Older Adult	33 (20,8%)

The qualitative variables are expressed in frequency and percentage.

The quantitative variables are expressed in mean and standard deviation.

Regarding the associated diagnosis, most patients were hospitalized for Hydrocephalus plus Subarachnoid Hemorrhage, covering 21.3% of the population, followed by the diagnosis of Hydrocephalus plus Primary CNS Tumor and Hydrocephalus plus MMC, with 13.8% and 9.4% respectively. The specification of all diagnostics is available in Table 2.

Table 2. Distribution of the study population according to type of diagnosis.

Diagnosis	Frequency	Percentage
Hidrocefalia + HSA	34	21,3
Hydrocephalus + Primary CNS Tumor	22	13,8
Hidrocefalia + MMC	15	9,4
Congenital hydrocephalus	15	9,4
Post-infeccous hydrocephalus	8	5,0
Hydrocephalus + premature ICH	7	4,4
Normotensive hydrocephalus	7	4,4
Hydrocephalus in the Needy	7	4,4
Idiopathic Intracranial Hypertension	6	3,8
Hydrocephalus + Metastasis	5	3,1
Hydrocephalus + Hemorrhage of prematurity	4	2,5
Hidrocephalus + Chiari	3	1,9

Hydrocephalus + ECT	3	1,9
Congenital Hydrocephalus Dandy Walker	3	1,9
Hydrocephalus + Ruptured AVM	3	1,9
Hydrocephalus + Aqueductal Stenosis	3	1,9
Hydrocephalus + traumatic SAH	2	1,3
Hydrocephalus + Intraparenchymal hematoma	2	1,3
Hydrocephalus + Choroid plexus hyperplasia	2	1,3
Hidrocefalia + Toxoplasmosis	1	0,6
Hydrocephalus + Cranioplasty for ECT	1	0,6
Hydrocephalus + Lymphoma	1	0,6
Hydrocephalus + Pial fistula	1	0,6
Hydrocephalus + Goldenhar Syndrome	1	0,6
Hydrocephalus + Neurocysticerosis	1	0,6
Hydrocephalus + Syndromic craniosynostosis	1	0,6
Hemorrhage of prematurity	1	0,6
Ependymoma + CSF Fistula	1	0,6

With respect to the type of surgery performed, most patients underwent a ventricle-peritoneal drainage (PVD) facility, covering 76.9.4% of the total population, followed by PVD replacement with 14.4% (Table 3)(Figure 1).

Table 3. Distribution of the study population according to type of surgery.

Type of Surgery	Frequency	Percentage
Installing DVP	123	76,9
DVP Replacement	23	14,4
Programmable DVP Installation	4	2,5
Installing DVP Straight Connector	3	1,9
Replacement of DVP with adjustable valve	2	1,3
Ventricular catheter replacement	1	0,6
DVP Review	1	0,6
Abdominal catheter replacement	1	0,6
Posterior fossis decompression + DVP	1	0,6
DVP + Brain Endoscopy Installation	1	0,6

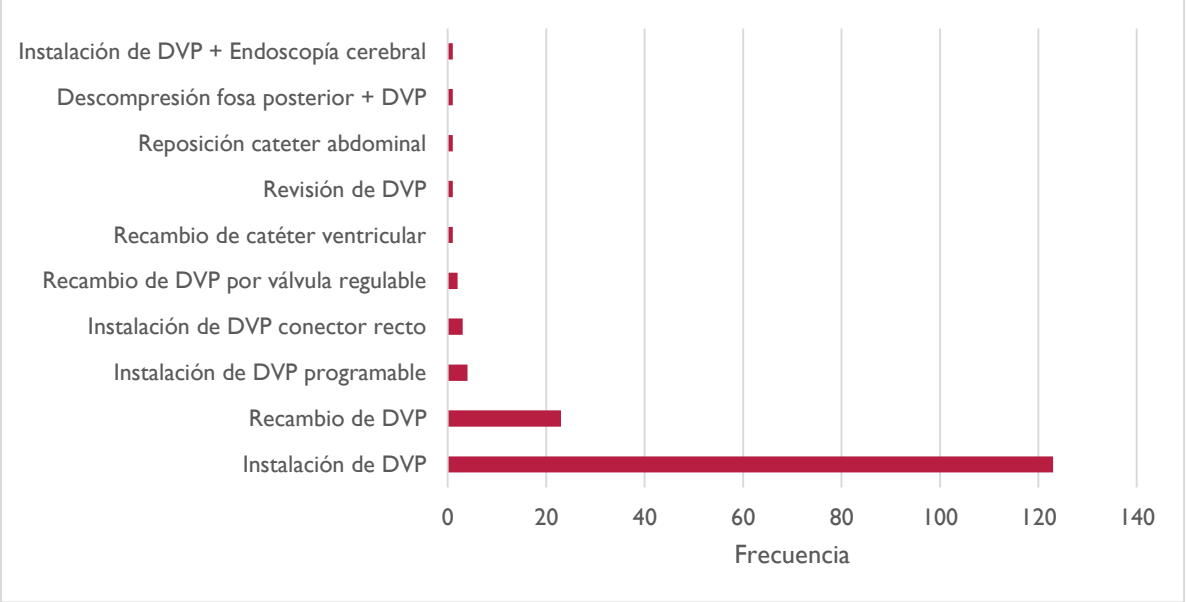

Figure 1. Distribution of the study population according to type of surgery. In original Spanish language

Of the total number of patients hospitalized during the period indicated, 38.1% presented some complication and 31.1% underwent removal of PVD, where the most common causes were ventriculis (42.9%) and valvular dysfunction (32.1%) (Table 4).

Table 4. Characteristics of complication and withdrawal of PVD in the study population.

	Frequency (percentage)
Complication	
Yes	61 (38,1%)
No	99 (61,9%)
DVP Withdrawal	
DVP Withdrawal	50 (31,3%)
DVP Replacement	3 (1,9%)
DVP Review	1 (0,6%)
Cause of Withdrawal	
Ventriculitis	24 (42,9%)
Valvular dysfunction	18 (32,1%)
Catheter displacement	4 (7,1%)
Overdrainage	3 (5,4%)
Subcutaneous distal catheter	2 (3,6%)
Colon perforation	1 (1,8%)
Ventricular catheter disconnection from valve	1 (1,8%)
Surgical wound infection	1 (1,8%)
Abdominal pseudocyst and ventriculitis	1 (1,8%)
Ventricular catheter migration and ventriculitis	1 (1,8%)

Installing New DVP	
Yes	44 (27,5%)
No	116 (72,5%)

Regarding catheter-associated complications, 6.9% of patients had a proximal catheter complication, most of which are not specified or correspond to a catheter displacement, 6.3% had a distal catheter complication, and 14.6% had a valve complication (Table 5).

Table 5. Catheter and valve complications in the study population.

	Frequency (percentage)
Proximal catheter complication	
Yes	11 (6,9%)
No	148 (93,1%)
Type of complication: proximal catheter	
Not specified	4 (36,4%)
Displaced catheter	3 (27,3%)
Migration to parenchyma	2 (18,2%)
Suboptimal drainage	1 (9,1%)
Bleeding from the path	1 (9,1%)
Distal catheter complication	
Yes	10 (6,25%)
No	150 (93,25%)
Type of complication: distal catheter	
Not specified	3 (30%)
Cateter extraperitoneal	2 (20%)
Abdominal quist	2 (20%)
Colon perforation	1 (10%)
SKIN	1 (10%)
Obstruction	1 (10%)
Valve complication	
Yes	23 (14,6%)
No	135 (85,4%)

On the other hand, of the total number of hospitalized patients, 16.9% had an infection, with the most prevalent germ being Staphylococcus epidermidis, accounting for 44.4% of the total number of patients with infection (n=27) (Table 6).

Table 6. Infections and types of germs in the study population.

	Frequency (percentage)
Infection	
Yes	27 (16,9%)
No	133 (83,1%)
Type of Germ	
Staphylococcus epidermidis	12 (44,4%)
SAMS	3 (11,1%)
Pseudomona aeruginosa	2 (7,4%)
No germ	2 (7,4%)
Escherichia coli	2 (7,4%)
SAMR	2 (7,4%)
Klebsiella pneumoniae	1 (3,7%)
Staphylococcus capitis	1 (3,7%)
Staphylococcus hemolyticus	1 (3,7%)
Acinetobacter	1 (3,7%)

Regarding the operative time, the average number of minutes of intervention was 45.4 ± 30.1 minutes, with the minimum being 13 minutes and the maximum being 300 minutes. When comparing the operative time between patients with and without infection, it was observed that patients who had an infection had an average of 41.5 ± 12 minutes, which was slightly less than the operative time of the group that did not have an infection, however, this difference was not statistically significant (p-value 0.461); The same phenomenon was observed when comparing the operative time between patients with and without complications, where no statistically significant differences were found (Table 7).

Table 7. Comparison of operative time between patients with and without infection or complication.

	Minimal	Maximum	Mediana [RIC]	Average ± OF	p-value
With infection	25	70	40 [30 - 47,5]	41,5 ± 12	0,461
No infection	13	300	40 [30 - 53]	46,2 ± 32,6	
With complication	13	120	40 [30 - 50]	41,3 ± 17,5	0,181
No complication	15	300	40 [30 - 55]	47,9 ± 35,6	

RIC: Interquartile Range

SD: Standard Deviation

4. DISCUSSION

This study offers a comprehensive assessment of complications arising from the installation of ventriculoperitoneal shunts (PVDs) in a sample of 160 patients hospitalized at Carlos Van Buren Hospital between March 2020 and April 2023. The results obtained reveal a complication rate of 38.1%, among which ventriculitis and valve dysfunction are positioned as the main causes of withdrawal of PVD, with 42.9% and 32.1% respectively. These data are consistent with the literature, which points to infection and mechanical problems as the most common complications in these procedures. However, the observed incidence is remarkably high, which underscores the need to implement more effective prevention and management strategies

in this type of intervention.

A relevant aspect of the analysis is the rate of postoperative infections, which reached 16.9%. Staphylococcus epidermidis was the most prevalent microorganism, responsible for 44.4% of infections. This finding coincides with previous studies that identify skin bacteria as the most common pathogens associated with these complications. However, the high rate of infections by this germ reinforces the importance of strictly reviewing asepsis and antisepsis protocols, especially in the perioperative phases. Despite concerns about infections, no significant relationship was found between operative time and the occurrence of infections, suggesting that other factors, such as patient conditions or postoperative management, may be influencing this outcome.

Regarding mechanical complications, 14.6% of patients had valve dysfunction. Since valve dysfunction can lead to serious complications, such as over- or under-drainage of cerebrospinal fluid, this finding highlights the need for more rigorous evaluation of the choice of devices and monitoring of their postoperative functioning. In addition, a small percentage of patients (1.8%) suffered severe complications, such as colon perforation, which, although infrequent, highlights the severity of some failures associated with PVD systems.

The distribution of diagnoses associated with hydrocephalus in this group is also remarkable, with a preponderance of cases of hydrocephalus accompanied by subarachnoid hemorrhage (21.3%) and primary tumors of the central nervous system (13.8%). This profile could influence the evolution of complications, given that some underlying diagnoses, such as tumours or haemorrhages, predispose to greater difficulties in the management of referrals.

In light of these results, it is imperative to strengthen infection control measures and develop protocols tailored to the particularities of this group of patients. In addition, the high frequency of mechanical dysfunctions calls into question the durability and efficacy of some bypass systems, suggesting the need for further research into technological improvements to reduce complication rates.

5. CONCLUSION

This study provides a clear perspective of the complications associated with ventriculoperitoneal shunts in a sample of Chilean patients. The high rate of mechanical and infectious complications highlights the urgent need to improve both surgical techniques and postoperative management protocols to reduce the risk of valve dysfunction and infections. Although the results obtained are largely in line with previous studies, the local incidence of infections and mechanical failures is high enough to warrant the development of new preventive procedures.

It is crucial that future studies focus on identifying the predisposing factors to these complications, considering variables such as the baseline health status of the patients, the experience of the surgical team and the characteristics of the devices used. The implementation of advanced technologies, such as programmable valves or shunts with lower failure rates, could also contribute to improved long-term outcomes in this group of patients.

Finally, the findings of this study will serve as a basis for optimizing local clinical guidelines, with the aim of improving the safety and functional outcomes of patients undergoing ventriculoperitoneal shunts, thus increasing their postoperative quality of life. Close monitoring and stricter infection prevention protocols are recommended as essential measures to reduce morbidity associated with these interventions.

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