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Laparoscopic Management of Post Operative Obstructed Distal End of Ventriculoperitoneal Shunt Tube in Hydrocephalic Patients

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Abstract
Background: Hydrocephalus is a common condition in which there is an abnormal accumulation of cerebrospinal fluid in the brain. Ventriculoperitoneal (VP) shunt surgery is a standard treatment for hydrocephalus, but post-operative obstructed distal ends of VP shunt tubes can lead to complications. Laparoscopy has emerged as a potential diagnostic and therapeutic tool in managing such obstructions. This study aimed to comprehensively outline the role of laparoscopy in the diagnosis and management of obstructed distal ends of VP shunt tubes in hydrocephalic patients. **Methods:** The study was conducted at Benha University and Benha Children Hospitals between 2016 and 2021. A cohort of 40 hydrocephalic patients who had undergone VP shunt surgery and experienced abdominal obstruction at the distal end of their VP shunts were included. Diagnosis involved clinical abdominal examination, neurosurgical evaluation, and radiological examinations (abdominal X-ray, abdominal ultrasound, and brain CT scan). Laparoscopic procedures were performed to address the specific obstructions. **Results:** Among the 40 patients, laparoscopy successfully diagnosed and treated the obstructed distal ends of VP shunt tubes in 31 cases (77.5%). The laparoscopic interventions resulted in resolution of symptoms and signs of active hydrocephalus in these patients, as confirmed by radiological assessments. Out of the remaining 9 cases, 6 required additional laparoscopic revisions, while 3 patients were prepared for ventriculo-arterial shunts. No conversions to open surgery were needed, and there were no mortality cases. Mild post-operative complications were observed in 6 patients, which resolved with antibiotic and antipyretic therapy. **Conclusions:** Laparoscopy is a valuable diagnostic and therapeutic approach in the management of obstructed distal ends of VP shunt tubes in hydrocephalic patients.

Keywords: Hydrocephalus, Ventriculoperitoneal shunt, Laparoscopy, Obstruction, Diagnosis, Treatment.

1. Introduction

The VP shunting procedure involves the placement of a shunt system that diverts excess CSF from the cerebral ventricles to an extracranial location, usually the peritoneal cavity. While VP shunts have proven to be effective in controlling hydrocephalus, they are not without challenges [1].

Obstruction at the distal end of the shunt tube is one of the most common complications, leading to shunt malfunction, recurrence of symptoms, and the need for revision surgeries. The traditional approach to managing such obstructions has predominantly involved open laparotomy procedures. However, advances in minimally invasive techniques have led to the emergence of laparoscopy as a promising alternative [2].

Laparoscopy, a minimally invasive surgical procedure, involves the insertion of a small camera and specialized instruments through tiny incisions in the abdomen, allowing for visualization and treatment of the obstructed shunt without the need for large incisions. This approach offers several potential advantages, including reduced postoperative pain, shorter hospital stays, quicker recovery times, and improved cosmetic outcomes. Consequently, laparoscopy has gained increasing interest in the management of VP shunt complications [3, 4].

The objective of this study is to comprehensively outline the role of laparoscopy, whether diagnostic or therapeutic, in managing obstructed distal ends of VP shunt tubes in hydrocephalic patients.

2. Methods

This study was conducted at Benha University and Benha Children Hospitals between 2016 and 2021, involving a cohort of 40 patients diagnosed with hydrocephalus who had undergone ventriculoperitoneal (VP) shunt surgery. All of these patients experienced abdominal obstruction at the distal end of their VP shunts.

To diagnose the obstruction, a comprehensive approach was employed, combining full clinical abdominal examination, complete neurosurgical evaluation, and radiological examinations. The diagnostic process included abdominal X-ray, abdominal ultrasound, and brain CT scan.

The clinical examination encompassed both general and neurological assessments. In the general examination, the presence of fever,

headache, and vomiting was noted, which are common symptoms associated with elevated intracranial pressure (ICP). Additionally, specific neurological signs indicating increased ICP were observed in almost all patients. These signs included an increase in the size of head circumference, a tense anterior fontanelle, new onset seizures, and the Setting sun sign, which is characterized by downward deviation of the eyes due to the raised pressure in the brain.

Abdominal findings were also considered during the clinical examination. Patients with abdominal obstruction exhibited abdominal distension, a tense abdominal wall, abdominal pain, and tenderness.

Investigations:

Brain CT–scan in all cases revealed signs of active hydrocephalus, such as ventricular enlargement and trans ependymal absorption. Lateral ventricles were enlarged, with visible temporal horns and ballooning of the frontal horns. The third ventricle was also enlarged with periventricular hypodensity, which is a sign of trans ependymal absorption of CSF were also present. The proximal end of the ventricular catheter was located within the lateral ventricle and no signs of proximal obstruction of the shunt can be seen on brain CT–scan.

Abdominal ultrasonography revealed intrabdominal transonic cystic mass in six patients, suggesting gross amount of encysted fluid within, and ascites in five cases. Intraperitoneal fluid, which is a sign of good shunt function, was not noted, except for the cases with ascites.

Abdominal ultrasonography and Brain CT–scan helped establishing the diagnosis rapidly and noninvasively.

Surgical procedure:

1) Preoperative preparation:

Informed consent was obtained from all patients' parents before they were taken to the operating room. All patients received preoperative antibiotic prophylaxis.

Patients were placed in a supine position, the head turned to the left or right depending on the location of the shunt, General anesthesia is then induced, the head and abdomen are prepped and draped in the standard sterile surgical fashion.

2) Laparoscopic technique:

The peritoneum was then accessed with a 5-mm optical access trocar through a 5-mm incision in the umbilicus, this port was used for the position of the camera, pneumo peritoneum was established to a pressure of 10mm Hg to 15 mm Hg.

Intraoperative findings and Therapeutic intervention:

(I) Cases with abdominal pseudocyst:

Abdominal cerebrospinal fluid pseudo cyst is defined as a cyst surrounded by a non-epithelial lining and filled with the cerebrospinal fluid .

In cases with abdominal pseudo-cyst, the large CSF-filled pseudo-cyst was evacuated. A sample was sent for culture and cytological analysis, Adhesiolysis was performed by debridement and deroofing the cyst walls, excision of cyst wall as possible, and the VPS catheter was repositioned to a new area in the abdomen mostly in supra hepatic or in pelvis, then in vivo examination of shunt system functionality was done. **Figure 1**

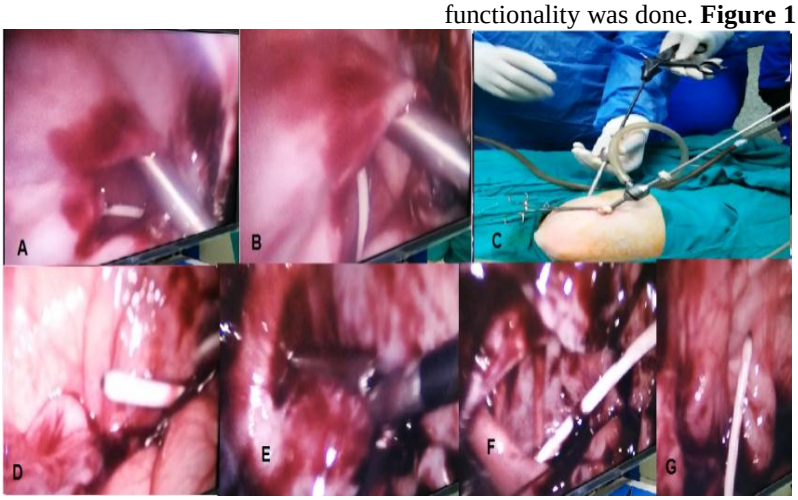

Fig. (1) intraoperative management in a patient of VPS distal obstruction with abdominal pseudo cyst. A: pseudo cyst with the tube inside B: the wall of the pseudo cyst, C: adding a grasper through the 2nd port D: catheter tip repositioning E & F: debridement and excision of cyst wall, G: in-vivo check of shunt function.

(II) Cases with CSF ascites:
In our cases CSF ascites was found in 3 patients. CSF ascites is a rare complication of VP shunts. Pathogenic factors are impaired absorption of the peritoneum, excessive production of CSF, increased protein level in CSF, subclinical shunt infection.

Therapeutic intervention:
After aspiration of the CSF and CSF sample was taken for chemical and cytological analysis plus culture and sensitivity, laparoscopic exploration and checking VPS functionality in vivo was done, then catheter tip repositioning in supra hepatic region.

(III) cases with adhesions: In cases with adhesions, adhesiolysis was done for the adhesions present around the distal catheter, exteriorization of the distal catheter to take CSF sample for chemical and cytological analysis, then reentering the distal catheter to the peritoneum was done, then catheter tip repositioning in pelvis or supra hepatic region was done after in-vivo checking of VPS function.

Closure: In all cases only two sutures were done, one suture for the umbilical incision and another one suture for the additional incision.

Follow Up: All patients were given antibiotic and analgesic for 1 week. Follow up was done after 1 week then after 2 weeks then become monthly for up to six months.

Outcome: We had no conversions to open surgery, there was no mortality in our cases. Only 6 cases develop fever and subsides within 1 week of antibiotic and antipyretic (paracetamol) therapy. In our study 31 case improved, their symptoms and signs of active hydrocephalus disappeared which is confirmed radiologically by brain CT scan and abdominal ultrasound, and they needed no revision until 6 months of follow up. In our study 9 cases not improved, 6 cases of them needed another laparoscopic revision and 3 cases was prepared for ventriculo arterial shunt.

Statistical analysis:
Statistical Analysis: Data collected for this study were carefully revised, coded, and entered into IBM SPSS version 20 (Statistical Package for Social Science). Qualitative data were presented as numbers and percentages, while quantitative data with parametric distribution were described using mean, standard deviations, and ranges. To compare two groups with qualitative data, the Chi-square test was utilized, and in cases where the expected count in any cell was less than 5, Fisher's exact test was used as a suitable alternative to the Chi-square test. For the comparison between two independent groups with quantitative data and parametric distribution, the independent t-test was employed. A 95% confidence interval and a margin of error of 5% were established for analysis, and significance levels were categorized as follows: $P>0.05$ denoted non-significant (NS), $P<0.05$ indicated significance (S), and $P<0.001$ represented high significance (HS).

3. Results
The studied cases consisted of a total of 40 individuals. Among them, 15 (37.5%) were female, while 25 (62.5%) were male. The age of the participants ranged from 2 to 72 months, with a mean age of 9.50 months and a standard deviation of 10.95 months.

The distribution of the studied cases is presented based on their association with myelomeningocele (M.M), previous revision of the shunt, and the type of hydrocephalus (HCP). Out of the total 40 cases, 6 cases (15.0%) were found to have an association with myelomeningocele, while in 34 cases (85.0%), no association with myelomeningocele was observed. Regarding the previous revision of the shunt, 12 cases (30.0%) had not undergone any previous revision, 13 cases (32.5%) had undergone one revision, 13 cases (32.5%) had undergone two revisions, and 2 cases (5.0%) had undergone three revisions. In terms of the type of hydrocephalus, 15 cases (37.5%) were categorized as acquired hydrocephalus, while 25 cases (62.5%) were classified as congenital hydrocephalus.

The distribution of the studied cases is presented based on the presence or absence of vomiting, fever, and fits. Out of the total 40 cases, 6 cases (15.0%) reported no vomiting, while 34 cases (85.0%) presented with vomiting. Regarding fever, 38 cases (95.0%) showed no signs of fever, while only 2 cases (5.0%) had a fever. Similarly, fits were absent in 38 cases (95.0%), but 2 cases (5.0%) did present with fits.

The distribution of the studied cases is presented based on the presence or absence of specific clinical signs, including anterior fontanel bulging, increased head circumference, distal resistance, and reservoir swelling. Out of the total 40 cases, 33 cases (82.5%) exhibited anterior fontanel bulging, while 7 cases (17.5%) did not show any bulging. Concerning head circumference, 24 cases (60.0%) had an increased size, while 16 cases (40.0%) did not show any increase in head circumference. Distal resistance was found to be present in all 40 cases (100.0%). In terms of reservoir swelling, 14 cases (35.0%)

displayed swelling around the reservoir, whereas 26 cases (65.0%) had no swelling observed around the reservoir.
Out of the total 40 cases, 33 cases (82.5%) exhibited anterior fontanel bulging, while 7 cases (17.5%) did not show any bulging. Concerning head circumference, 24 cases (60.0%) had an increased size, while 16 cases (40.0%) did not show any increase in head circumference. Distal resistance was found to be present in all 40 cases (100.0%). In terms of reservoir swelling, 14 cases (35.0%) displayed swelling around the reservoir, whereas 26 cases (65.0%) had no swelling observed around the reservoir. **Table 1**

Table (1) Distribution of the studied cases according to presence of positive findings in Brain CT, Pelvi abdominal US, plain abdominal x ray and the correlation between Abd x ray & Abd US

		No.	%
Brain CT	Increased ICP	40	100.0%
Pelvi abdominal US	(+ve) findings Present	11	27.5%
	NAD	29	72.5%
Plain Abd X ray	CYST is present	7	17.5%
	NAD	33	82.5%
Abd X ray & Abd US correlation	Positive Correlation	7	17.5%
	Negative Correlation	33	82.5%

Out of the total 40 cases, 32 cases (80.0%) exhibited adhesions during the surgical procedure, while 8 cases (20.0%) did not show any adhesions. Regarding abdominal collections, 12 cases (30.0%) had collections present during the intraoperative assessment, while 23 cases (57.5%) had no collections observed.
Out of the total 40 cases, 9 cases (22.5%) were classified as "Failed," indicating that the treatment did not lead to the desired resolution of the obstruction or improvement in the patient's condition. On the other hand, 31 cases (77.5%) were categorized as "Improved," signifying that the intervention, likely including laparoscopic management, resulted in an improvement in the patient's condition and successful resolution of the obstruction. **Figure 2**

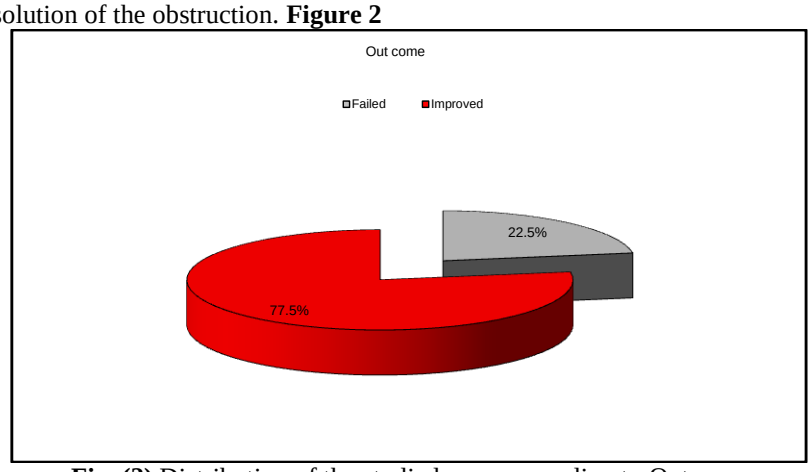

Fig. (2) Distribution of the studied cases according to Outcome

The mean age of the "Failed" group was 5.56 months with a standard deviation (SD) of 1.88 months. The mean age of the "Improved" group was 10.65 months with a higher standard deviation (SD) of 12.20 months. In the "Failed" group, there were 2 cases (22.2%) that were female and 7 cases (77.8%) that were male. In the "Improved" group, there were 13 cases (41.9%) that were female and 18 cases (58.1%) that were male. Age and sex were insignificantly different between the studied groups. **Table 2**

Table (2) Comparison between Failed (no.=9) and Improved (no.=31) regarding Age (months) and Sex

		Failed	Improved	P-value
		No. = 9	No. = 31	
Age (months)	Mean ± SD	5.56 ± 1.88	10.65 ± 12.20	0.224
	Range	2 – 8	2 – 72	
Sex	Female	2 (22.2%)	13 (41.9%)	0.282
	Male	7 (77.8%)	18 (58.1%)	

In the "Failed" group, none of the cases were associated with myelomeningocele (0.0%), while 19.4% (6 cases) of the "Improved" group were found to have an association with myelomeningocele (p=0.152). Regarding previous revisions of the shunt, the "Failed" group had 44.4% with no previous revisions, 22.2% with one revision, 33.3% with two revisions, and no cases with three revisions. In the "Improved" group, 25.8% had no previous revisions, 35.5% had one revision, 32.3% had two revisions, and 6.5% had three revisions (p=0.622). With respect to the type of hydrocephalus, the "Failed" group had 44.4% with acquired hydrocephalus and 55.6% with congenital hydrocephalus, while the "Improved" group had 35.5% with acquired hydrocephalus and 64.5% with congenital hydrocephalus (p=0.625). **Table 3**

Table (3) Comparison between Failed (no. =9) and Improved (no. =31) regarding association with MM, Previous revision and Type of HCP

		Failed		Improved		P-value
		No.	%	No.	%	
Association with MM	Associated with MM	0	0.0%	6	19.4%	0.152
	Not found	9	100.0%	25	80.6%	
Previous revision	No	4	44.4%	8	25.8%	0.622
	Once	2	22.2%	11	35.5%	
	Twice	3	33.3%	10	32.3%	
	Triple	0	0.0%	2	6.5%	
Type of HCP	Acquired	4	44.4%	11	35.5%	0.625
	Congenital	5	55.6%	20	64.5%	

In Failed Group, 77.8% of them had Vomiting, 0.0% had Fever and 0.0% had Fits, while the Improved Group; 87.1% of them had Vomiting, 6.5% had Fever and 6.5% had Fits. There was no statistically significant difference between Failed Group and Improved Group regarding Vomiting, Fever and Fits. **Table 4**

Table (4) Comparison between Failed (no.=9) and Improved (no.=31) regarding Vomiting, Fever and Fits

		Failed		Improved		P-value
		No.	%	No.	%	
Vomiting	No Vomiting	2	22.2%	4	12.9%	0.491
	Vomiting present	7	77.8%	27	87.1%	
Fever	Absent	9	100.0%	29	93.5%	0.434
	Present	0	0.0%	2	6.5%	
Fits	No Fits	9	100.0%	29	93.5%	0.434
	Present	0	0.0%	2	6.5%	

In Failed Group, 100.0% of them had Bulge ant fontanel, 55.6% had Increased Head circumference Size and 55.6% had Reservoir swelling, while the Improved Group; 77.4% of them had Bulging ant fontanel, 61.3% were Increase Head circumference Size and 29.0% had Reservoir swelling. There was no statistically significant difference between Failed Group and Improved Group regarding Anterior fontanel, Head circumference and Reservoir swelling. **Table 5**

Table (5) Comparison between Failed (no. =9) and Improved (no. =31) regarding Anterior fontanel, Head circumference and Reservoir swelling

		Failed		Improved		P-value
		No.	%	No.	%	
Anterior fontanel	Bulge	9	100.0%	24	77.4%	0.117
	Not Bulge	0	0.0%	7	22.6%	
Head circumference	Increase Size	5	55.6%	19	61.3%	0.757
	No Increase Size	4	44.4%	12	38.7%	
Reservoir swelling	Swelling present	5	55.6%	9	29.0%	0.142
	No Swelling around the	4	44.4%	22	71.0%	

reservoir

In Failed Group, no positive findings present in Pelvi abdominal U/S nor in Plain Abd X ray, while the Improved Group; 35.5% of them had positive findings in Pelvi abdominal U/S, 22.6% had positive findings in Plain Abd X ray and 71.0% had Abd X ray & Abd u/s Positive correlation. **Table 6**

Table (6) Comparison between Failed (no. =9) and Improved (no. =31) regarding Pelvi abdominal US, Plain abd x ray and Abd x ray & abd u/s correlation

		Failed		Improved		P-value
		No.	%	No.	%	
Pelvi abdominal US	Present	0	0.0%	11	35.5%	0.066
	NAD	9	100.0%	20	64.5%	
Plain Abd X ray	CYST is present	0	0.0%	7	22.6%	0.117
	NAD	9	100.0%	24	77.4%	
Abd X ray & Abd US correlation	Positive Correlation	7	77.8%	22	71.0%	0.687
	Negative Correlation	2	22.2%	9	29.0%	

In Failed Group, 77.8% of them had Adhesion and 11.1% had Abd collection, while the Improved Group; 80.6% of them had Adhesion and 35.5% had Abd collection. There was no statistically significant difference between Failed Group and Improved Group regarding Adhesion and Abd collection. **Table 7**

Table (7) Comparison between Failed (no. =9) and Improved (no. =31) regarding Adhesion and Abd collection as an intra operative finding

		Failed		Improved		P-value
		No.	%	No.	%	
Adhesion	Adhesions Present	7	77.8%	25	80.6%	0.850
	No Adhesions	2	22.2%	6	19.4%	
Abd collection	Collection Present	1	11.1%	11	35.5%	0.160
	No Collection	8	88.9%	20	64.5%	

4. Discussion

In the current study, a total of 40 hydrocephalic patients were included, with 25 being male and 15 being female, and their ages ranged from 2 to 72 months (mean 9.5 months). Similar age and sex distributions have been reported in previous studies on postoperative shunt complications by Ebrahim et al. (2019) [7], Ghritlaharey et al. (2012) [8], Hamdan et al. (2018) [9], and Orrego González et al. (2019) [10]. Vomiting was the most common symptom observed in 85.0% of cases in our study, which is in agreement with the findings of Gündeşlioğlu et al. (2018) [11] and Ebrahim et al. (2019) [7]. All cases in our study showed increased intracranial pressure (ICP), which was also seen in the study by Popa et al. (2009) [12], who observed acute hydrocephalus in their patients. Intraoperative ICP monitoring was used by Uzzo et al. (1997) [13] and resulted in a sudden increase in ICP along with an increase in CSF flow rate from the shunt, without any postoperative adverse neurological effects. These findings collectively contribute to a better understanding of the presentation and management of postoperative shunt complications in hydrocephalic patients, with vomiting and increased ICP being prominent clinical features.

Regarding the type of hydrocephalus, our study included 15 cases (37.5%) with acquired hydrocephalus and 25 cases (62.5%) with congenital hydrocephalus. These findings are consistent with Ebrahim et al. (2019) [7] and Hamdan et al. (2018) [9], who also reported a higher prevalence of VP shunt complications in patients with congenital hydrocephalus. However, Orrego-González et al. (2019) [10] found brain tumor to be the most common indication for initial VP shunt insertion in their study, highlighting the influence of the study population's age and etiology on the reported prevalence of complications. In our study, 6 cases (15.0%) were associated with myelomeningocele (M.M), and we observed various numbers of previous revisions, with 13 cases (32.5%) having one previous revision, 13 cases (32.5%) with two previous revisions, and two cases with triple previous revisions. Anterior fontanel bulging was present in 33 cases (82.5%), increased head circumference in 24 cases (60.0%), and reservoir swelling in 14 cases (35.0%). Distal resistance was noted in all the studied cases. The incidence of intra-abdominal

pseudocysts was 20%, with an extra peritoneal catheter reported in 2.5% of patients, and one infant presented with scrotal swelling due to a patent processus vaginalis. Pseudocysts are considered an uncommon complication for VP shunts, and their development's exact pathophysiology remains unclear, with various predisposing factors as mentioned by Popa et al. (2009) [12] and Rainov et al. (1994) [14].

In our study, we encountered several complications related to ventriculoperitoneal (VP) shunts. CSF ascites was observed in 4 cases, which is a rare complication in VP shunts (Ghritlaharey et al., 2006; Popa et al., 2009). The pathogenic factors contributing to CSF ascites include impaired peritoneal absorption, excessive CSF production, hyperproteinuria, shunt infections, and tumoral seeding [15]. Histological examination of peritoneal biopsy samples from children with CSF ascites revealed granulation tissue infiltrated with various immune cells and vascular congestion [15]. Shunt blockage was found in 20% of patients in the series by Peacock and Currer (1984) [16], and Lee et al. (1995) [17] reported a shunt blockage rate of 12.2% in their study. Shunt blockage was often associated with shunt infections, suggesting a potential causal relationship between infection and malfunction [17]. In our study, pelvic abdominal ultrasound showed positive findings in 27.5% of cases, and plain abdominal x-ray revealed positive findings in 17.5% of cases. Adhesion was a common finding in 80.0% of cases, consistent with Abouhashem et al. [5], who reported peritoneal adhesion in most cases of distal mechanical failure. Shunt obstruction, either proximal or distal, was the most common postoperative complication [7], and infection was also a significant cause of shunt failure [10]. Various studies have reported on the prevalence of shunt-related complications, and careful assessment and management are essential to improve outcomes and reduce morbidity in patients with VP shunts.

Bowel obstruction is a distressing complication associated with abandoned intraperitoneal distal catheters in VP shunt patients. Factors contributing to ileus development include bowel volvulus around the catheter and adhesions between the catheter and intestines due to a local inflammatory response to a foreign body [18]. It is crucial not to mistake ileus secondary to an abandoned catheter with other causes of bowel obstruction specific to infants and toddlers, such as intussusception and volvulus. In our study, 17.64% of patients developed intraperitoneal abscess, abscess of the lesser omentum, hepatic abscess, peripancreatic abscess, and 5.88% experienced peritonitis [12]. Pseudocysts were observed in 12 patients, with 16% having a history of acute shunt infections and 41.6% with a history of shunt infections [19].

Inguinal hernias without hydrocele occurred in one patient, with a frequency of 3.8 - 16.8% in VP shunt patients [12]. Patient age plays a significant role in the occurrence of inguinal hernias, with 30% occurring in infants aged 0-3 months and 10% in children aged 1 year. Predisposing factors include persistent processus vaginalis, increased abdominal pressure, impaired peritoneal absorption, and tumoral seeding [20]. The study's overall outcome showed 9 cases (22.5%) failed and 31 cases (77.5%) improved. Removal of shunt hardware with CSF involvement and external ventricular drain (EVD) drainage achieved success rates varying between 60% and 85% in different studies [21]. In our study, there were no conversions to open surgery, and no mortality was observed in our cases. Popa et al. [12] also reported no conversions to open surgery but noted an overall mortality rate of 5.88% and postoperative morbidity of 11.76% in their series.

5. Conclusion

In conclusion, laparoscopic management of abdominal complications in VP shunt patients is highly successful, offering a minimally invasive alternative to traditional laparotomy. It enables accurate diagnosis, effective catheter repositioning, and treatment of associated lesions, reducing the risk of complications and adhesion formation. Laparoscopy provides comprehensive inspection of the abdominal cavity, allowing successful detection and treatment of pathologies. For pediatric patients with VPS obstruction, laparoscopically assisted shunt revision is the most effective approach.

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