Original Article

Laparoscopic Peritoneal Catheter Revisions Reduce the Rate of Subsequent Revisions in Pediatric Patients Operated for Hydrocephalus

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ABSTRACT

Keywords: *Children, distal shunt, laparoscopy, revision, ventriculoperitoneal shunt*

Background

The National Institute for Neurological Disorders and Stroke (NINDS) estimates that hydrocephalus (HC) occurs in approximately 1 out of 500 births. HC develops due to the blockage of cerebrospinal fluid (CSF) flow inside the head, failure of absorption, or, in rare cases, the overproduction of CSF.[1]

Ventriculoperitoneal (VP) shunt placement is the most common treatment for HC[2]; however, revisions are often required due to mechanical failure, infection, fracture, or disconnection of the catheter.[3] Obstruction can develop proximally to the shunt in the ventricle or distally in the abdominal cavity. If the ventricular catheter is plugged by the choroid plexus, it requires urgent surgery. In 25–30% of mechanical failures, the distal catheter is obstructed by peritoneal adhesions, CSF pseudocysts, kinking, migration, or, rarely, false passage of the distal catheter.[4-6]

Laparoscopy may be both diagnostic and therapeutic in distal catheter revisions. It helps the detection and release of adhesions and permits the fenestration of CSF pseudocysts. The fractured fragment is easily removable via the use of laparoscopic instruments, and the insertion of a new catheter to a lower point of the abdominal cavity is visually controlled.[7,8] The visual control of positioning the peritoneal catheter spares extraradiation exposure. If any complications, such as bowel injury, occur during laparoscopy, they can be seen and resolved immediately as part of the laparoscopic procedure.[9]

The aim of this study was to analyze and compare the results of open and laparoscopic shunt revisions.

Materials and Methods

In this study, we report our 10-year experience with VP shunt patients in a *tertiary* pediatric surgical center. A retrospective analysis of HC surgeries between January 2009 and December 2018 was performed. Subsequent revisions within 12 months, shunt infections, operative time, hospital stay, and shunt survival of laparoscopic versus open distal shunt revisions were compared in pediatric patients. In case of shunt obstruction, preoperative X-ray of the skull, neck, thorax, and abdomen and abdominal ultrasound were performed in all cases to locate the region and to determine the type of obstruction.

Operative Techniques

Open revision

The open procedure *entails* a 2–3 cm long skin incision, which *is* made on the epigastrium above the obstructed distal catheter. The obstructed catheter is removed. When the access through the muscles and peritoneum

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is free, the end of the catheter is directed into the pelvis with *a pair of* long forceps, blindly.

Laparoscopic revision

A camera port is inserted through an infraumbilical access with *the* open (Hasson) technique. Pneumoperitoneum is achieved by insufflating carbon dioxide until an intra-abdominal pressure of 8–12 mmHg is obtained. A 30º optic device is placed and abdominal exploration is performed. Any adhesions or pseudocysts found can be released with laparoscopic instruments. Afterwards, a 5 mm long epigastric incision is made, where the obstructed catheter is removed and the end of the new catheter is pulled into the abdomen and pushed into the pelvic cavity with laparoscopic forceps under direct visual control.

Statistical methods

The χ^2 test for independence was used. A *p*-value of less than 0.05 was regarded as statistically significant. Statistical software IBM SPSS version 25 was also used.

Results

A total of 140 HC surgeries were performed in 60 patients in our pediatric surgical department between January 2009 and December 2018. There were *n*= 28 (20%) laparoscopic revisions, *n*=27 (19%) open revisions, *n*=26 (19%) new VP shunt insertions, *n*= 23 (16%) central catheter revisions, *n*=10 (7%) externalizations, *n*=9 (7%) shunt fractures in the neck, *n*=7 (5%) ventriculo-subgaleal shunt insertions, *n*=7 (5%) VP shunt removal, and *n*=3 (2%) ventriculoatrial shunt insertions. The minimum follow-up period was at least 1 year (1–10 years).

Out of the 60 patients, 38 (63%) were boys and 22 (37%) were girls. The mean age *at the time of* surgery was 5.6 years (1 month to 21 years old).

Out of all distal shunt revisions, *n*=55 were intra-abdominal procedures due to obstruction. Intra-abdominal VP shunt revisions were divided into two groups: 28 *laparoscopic revisions* in 19 patients and 27 *open revisions* (20 open intra-abdominal revisions and 7 VP shunt exchanges) in 19 patients. In the first period of our study, all procedures were performed in the traditional open way. As our skills in laparoscopy developed, all the procedures were performed laparoscopically (in the second part of the study). There was no selection of patients for the different types of procedures.

The mean age was 11.2 years (3 months to 21 years) in the laparoscopic group, and 8.5 years (3 months to 16 years) in the open group [Table 1].

The causes of HC are shown in Figure 1 for patients with open shunt revisions and in Figure 2 for the laparoscopic group.

There was no misplacement of the peritoneal catheter in the two groups (0%).

The number of previous abdominal surgeries was not significantly different in the two groups. In the open group, the number of previous abdominal surgeries varied between 1 and 8 and in the laparoscopic group the number varied between 1 and 9.

Traditional open procedures through mini-laparotomy offer *only* limited access to the peritoneal cavity. During laparoscopic revisions, *n* = 7 extensive and *n* = 3 localized adhesions and *n* = 4 pseudocysts were found and released.

In three cases, laparoscopy was particularly helpful in choosing the proper surgical management via evaluating the peritoneal cavity. In one patient, a ventriculovesical shunt was replaced with a VP shunt. In one boy, a ventriculoatrial shunt was performed after the direct inspection of the abdominal cavity and in another child laparoscopy was used to explore the abdominal cavity since the insertion of a new VP shunt was preceded by bowel perforation.

Table 1: Comparison of open and laparoscopic distal shunt revisions

Intra-abdominal revisions, *N*=55	Open revisions, *N*=27	Laparoscopic assisted revisions, *N*=28
Number of patients	19	19
Mean age	8.5 years (3 months–16 years)	11.2 years (3 months–21 years)
Male: female ratio	11:8	13:6
Misplacement of peritoneal catheter	0	0
Number of previous abdominal surgeries	1–8	1–9
Shunt infection	2	1
Complications	0	0
Intraoperative time	28 min (13–86 min)	33 min (24–67 min).
Mean hospital stay	7.2 days (2–65 days)	6.6 days (2–46 days)
Subsequent abdominal revision within 12 months	13 cases (48.1%)	6 cases (21.4%)*

*The subsequent abdominal revisions within 12 months are significantly lower (p=0.037) with χ^2 test in the laparoscopic group

Shunt infection requiring externalization was detected in one patient in the laparoscopic group and in two patients in the open group.

The intraoperative time was not significantly different in the two groups. In the open group, the mean *operative* time was 28 min (13–86 min), and in the laparoscopic group it was 33 min (24–67 min).

Mean hospital stay was 7 days (2–65 days) in the open group and 6 days (2–46 days) in the laparoscopic group.

Subsequent abdominal revision within 12 months was necessary in 13 cases (48.1%) in the open group and in 6 cases (21.4%) in the laparoscopic group. The figures are significantly lower (p=0.037) with the χ^2 test in the laparoscopic group.

Discussion

VP shunt is the treatment of choice for HC of various origins; however, complication rates are considerably high in the literature. VP shunt dysfunction varies between 11% and 25% within the first year following the initial shunt placement.[9,10]

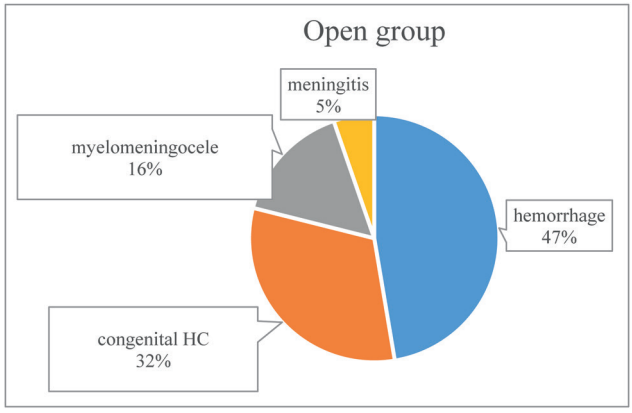

Figure 1: The origin of HC in patients operated with open revision for distal obstruction

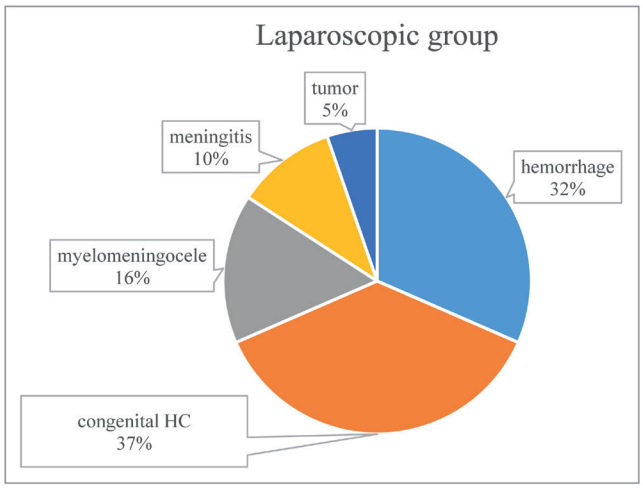

Figure 2: The origin of HC in patients operated with the laparoscopic technique for shunt revision of distal obstruction

Most authors report a significantly higher number of shunt revisions and replacements among pediatric patients compared with adults requiring VP shunts for HC.[11] Although there have been many developments to reduce shunt malfunctions, such as antibiotic impregnated catheters, sterile techniques, and programmable valves, HC patients still frequently require multiple shunt revisions throughout their life.

According to Schucht *et al.*,[12] laparoscopic shunt placement significantly reduces the rate of distal shunt failure compared with mini-laparotomy. Even after revisions, laparoscopy can reduce the rate of distal shunt failures. Laparoscopic assistance can help not only with proper adhesiolysis and excision of pseudocysts, but also with decision-making when choosing another therapeutic option. In VP shunt patients, our aim is to achieve the longest possible complication-free period.

The most common complication of VP shunts is obstruction.[11] Traditional open procedures through mini-laparotomy for distal revision offer limited access to the peritoneal cavity. In case of extensive abdominal adhesions, this procedure will result *in* only a short symptom-free period as we have experienced among our patients. The introduction of laparoscopic shunt revisions has resulted in longer symptom-free periods. Logghe *et al.*[13] reported a lower risk of wound infection, visceral injury, hernia, and shunt complications after laparoscopic revision when compared with open revisions.

In three patients, laparoscopy was performed to help decision-making, as evaluation of the abdominal cavity for sufficient absorbing surface or local inflammation can affect shunt function.

In a 16-year-old male patient with multiple previous revisions, a ventriculovesical shunt was performed due to extensive abdominal adhesions. After the patient developed bladder stones around the shunt, revision was necessary. Following laparoscopic evaluation of the abdominal cavity and extensive adhesiolysis, the VP shunt was re-formed successfully and no more distal revision has been necessary in the past 10 years.

A distal shunt catheter penetrated the colon and appeared in the anus of an asymptomatic 9-month-old girl. Spontaneous bowel perforation is a rare complication of VP shunt surgery occurring in only 0.01–0.07% of the cases.[14] After 2 weeks of externalization and antibiotic therapy, laparoscopy

found a healed perforation site on the colon and a new VP shunt was inserted into another part of the abdominal cavity under laparoscopic control. Five months later, the patient needed a distal revision due to adhesions; however, since that time she has been complication-free for 8 years.

During a laparoscopic revision, there was no free abdominal cavity in a 14-year-old boy due to dense adhesions in all parts of abdomen because of previous inflammation. In the second step, a ventriculoatrial shunt was inserted for a longer revision-free period. He was the only patient who received a ventriculoatrial shunt. The patient has been symptom-free for 6 years. Farach *et al.*[15] stated that diagnostic laparoscopy eliminated the need for ventriculoatrial shunt placement in 85% of the patients with a potentially hostile abdomen.

The benefit of laparoscopy in the treatment of HC is well known for decades. Esposito *et al.*[16] used laparoscopic VP shunt revisions in 10 cases between 1985 and 1995 to avoid conventional laparotomy: in four infants with CSF pseudocysts, in one case of abdominal wall perforation by the tip of the catheter, in two bowel obstructions, one case when the catheter lost in the abdominal cavity, and in two children with malfunctioning peritoneal catheter.

In 1998, Rolle *et al.*[17] reported 20 abdominal shunt revisions without complications. He found good intra-abdominal view, short operation times, and good cosmetic results to be the advantages of laparoscopy-assisted abdominal shunt revision.

According to Carvalho *et al.*,[18] during laparoscopic revision, suitable intraperitoneal place is selected and the distal tip of the peritoneal catheter is hence positioned: either at a newly created bundle-free spot, at the retro hepatic space or at any other retro-omental space where catheter-free migration with peristaltic movements can be ensured.

Laparoscopy not only allows the accurate placement of the distal catheter in the peritoneal cavity, but also enables retrieval of fractured catheter segments and allows confirmation of the patency of the shunt system.[19]

During laparoscopic revision, the visualization of CSF dripping out of the functioning shunt confirms that the intracranial pressure exceeds our pneumoperitoneum. A pneumoperitoneum of 10 mmHg using CO_2 appears to be safe and effective for laparoscopic procedures in these patients with VP shunts.[20]

Martin *et al.*[21] recommend laparoscopic revisions in patients with multiple previous revisions, prior abdominal surgery, previous intraperitoneal infections, broken devices, or CSF pseudocysts.

Laparoscopy can benefit not only in shunt revisions, but also in VP shunt insertions. Schukfeh *et al.*[22] recommend laparoscopically assisted VP shunt insertion in small infants with previous multiple abdominal operations to avoid the complications of alternative techniques, such as open techniques or ventriculoatrial shunt.

Open and laparoscopic insertions of VP shunt were compared in two systematic reviews and meta-analyses. Phan *et al.*[23] demonstrated that the laparoscopic technique in VP shunt surgery in adult patients is associated with reduced shunt failure and abdominal malposition when compared with the open laparotomy technique, with no significant difference in rates of infection or other complications. He *et al.*[24] found lower distal failure rate and shorter operative time in the laparoscopic group in adult patients.

There was only one cohort analysis of laparoscopic versus open VP shunt revisions in pediatric patients. Fahy *et al.*[25] found that laparoscopic peritoneal VP shunt revisions reduce significantly the rate of subsequent peritoneal revisions, without increasing shunt infections or operative time in pediatric patients.

Our study confirms that laparoscopy reduces the rate of subsequent peritoneal revisions, and in special cases laparoscopic findings can help in choosing and timing of the most suitable technique for VP shunt insertion, as our mentioned examples showed.

Conclusions

VP shunts are the first-line treatment of HC; however, revisions are frequently needed. Distal shunt revisions can be performed both in an open and laparoscopic way. The most important advantages of laparoscopy are the ability to release adhesions, fenestration of CSF pseudocysts, and visually controlled insertion of the new catheter into the proper part of the abdominal cavity. Laparoscopy can facilitate the diagnostic evaluation of the peritoneum, thereby assisting with decision-making regarding surgical management. As a result, significantly fewer subsequent abdominal revisions are necessary in the first postoperative year. We recommend the use of laparoscopy in all distal shunt revisions. If any pathology is found (adhesions and pseudocyst), it can be treated this way, and proper positioning of the end of the distal catheter can be performed under direct visual control.

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Conflicts of interest

There are no conflicts of interest.

Authors'contributions

Concept and design: B. Balogh, T. Kovács;
Acquisition, analysis, and interpretation of data: B. Balogh. F. Rárosi, T. Kovács;
Drafting the article and revising it critically for important intellectual content: B. Balogh, T. Kovács;
Final approval of the version to be published: B. Balogh, F. Rárosi, T. Kovács.

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