Pediatric laparoscopic procedures in special indications

Ph.D. THESIS

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University of Szeged

Doctoral School of Clinical Medicine

Szeged 2021

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LIST OF ABBREVIATIONS IN TEXT

MIS	Minimally invasive surgery
NOTES	Natural Orifice Transluminal Endoscopic Surgery
LIHR	Laparoscopic inguinal hernia repair
PEG	Percutaneous endoscopic gastrostomy
LAG	Laparoscopic assisted gastrostomy
L-PEG	Laparoscopic assisted percutaneous endoscopic gastrostomy
TAD	Thoracoabdominal deformity
HC	Hydrocephalus
CSF	Cerebrospinal fluid
VP	Ventriculoperitoneal
MRDS	Manual reduction and delayed surgery
MRGA	Manual reduction in general anesthesia
IOR	Intra-operative reduction
ESPGHAN	European Society for Paediatric Gastroenterology Hepatology and Nutrition
Sy	Syndrome

1. INTRODUCTION

1.1. Laparoscopy in pediatric surgery

In recent decades, minimally invasive surgical techniques have undergone enormous development. The advantages of laparoscopy over traditional operations are now unequivocal. Smaller incisions result in less postoperative pain and quicker recovery (1). The remaining scar is significantly smaller, and lifelong cosmetic satisfaction is much higher. Intraoperative visualization has become much better, and hidden parts of the abdominal cavity are more easily accessible. Exposure of the internal tissues to external contamination is less significant in laparoscopic surgery than in open surgery, which therefore decreases the risk of post-operative infections (1). The length of hospital stay is shorter and hospitalization costs are lower with minimally invasive surgery (MIS), because the healing process is much faster. Most patients and their parents can return to their normal everyday activities much more quickly than following an open surgical procedure (1).

Minimal invasive techniques have been gaining popularity in general surgery since Kurt Semm performed the first laparoscopic appendectomy in 1981 (2*).* Pediatric surgeons followed the adult surgical practice with a couple of years' delay.

Pediatric surgeons adopted MIS slowly because in infants and toddlers the relatively smaller traditional incisions and the good healing capacity of children usually lead to good cosmetic results. Also, the broad spectrum of pediatric surgical operations and the relatively small number of certain malformations result in a longer learning curve of technically challenging minimally invasive procedures (3).

Another reason for the slow spread of MIS in pediatric surgery was that surgical pain and perioperative stress associated with open procedures were underappreciated in children (3). Small-sized instruments were developing slowly because companies were focusing on adults, and instruments for children –the market of which is much smaller- were much more expensive (3). Pediatric surgeons had to familiarize themselves with new techniques, invent new instruments and facilitate their use in pediatric patients. These facts did not facilitate the spread of advanced MIS operations. However several pioneering pediatric surgeons began to perform basic surgical interventions demonstrating that children could also benefit from MIS

techniques. Nowadays, already evidence-based literature supports the effectiveness and benefit of MIS in pediatric patients.

In neonates and infants, carbon dioxide insufflation can cause decreased oxygen saturation and increased end tidal CO2, especially when used in the thoracic cavity (4). Children's need for decreased insufflation pressures increases the possibility of trauma during the entry of port sites. This can be prevented by the use of shorter length, blunt trocars or special trocar-introducing techniques (4). Infants have less physiologic reserve than children. The lower functional residual capacity of the lungs, lower blood pressures, and higher heart rates also increase the challenge of MIS in neonates (4). Laparoscopy has a lot of technical difficulties in infants and even in children, because the intraabdominal cavity is smaller, and the liver and spleen are relatively larger than in adults. On the other hand, in laparoscopic procedures the operative time is longer, which also makes anesthesia longer. According to recent publications, anesthetic drugs may have a negative impact on the neurocognitive development of the brain in neonates and infants, thus the length of operative time has to be considered when choosing the best therapeutic option, especially in the above mentioned groups (5).

The very first case of laparoscopy in pediatric surgery, referred to as peritoneoscopy, was reported by Stephen Gans in 1971, in the landmark publication, "Advances in Endoscopy of Infants and Children". The definition of peritoneoscopy was soon replaced by pediatric laparoscopy. Initially, laparoscopy in children was only applied for diagnostic purposes. In the early 1990s, laparoscopy was first used for confirming the diagnosis of intraabdominal testes; however some pioneers have performed advanced operations, too. Rothenberg reported laparoscopic anti-reflux procedures and gastrostomy tube insertions in infants and children in 1994 (6). Van der Zee performed laparoscopic repair of congenital diaphragmatic hernia in a 6-month-old child in 1995 (7). Over the next few years, several types of abdominal operations were performed and perfected by laparoscopic techniques. There is increasing enthusiasm about decreasing the number of ports in laparoscopic surgery. These techniques include single port, single access techniques, and Natural Orifice Transluminal Endoscopic Surgery (NOTES). The use of smaller (3 mm) instruments is getting wide spread. Experience with NOTES in children is limited at this time with only isolated reports (8).

In Hungary, Tibor Kiss performed the first adult laparoscopic surgery in 1990 (9). The first minimal invasive procedures at Hungarian pediatric surgical departments were performed at the end of the 1990's. The first operations to be performed were the same procedures as in

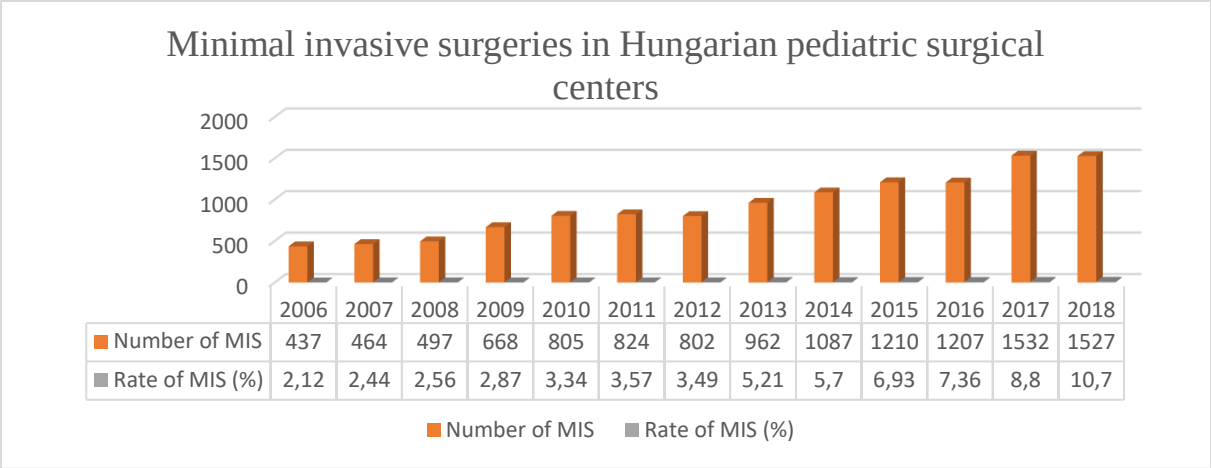
adults, for example cholecystectomies or varicocele ligations followed by appendectomies and ovarian procedures.

As the laparoscopic skill of pediatric surgeons developed, and pediatric instruments became available in Hungarian pediatric surgical centers, the repertoire of minimal invasive interventions became wider.

About fifteen years ago, most Hungarian centers started to perform MIS for urologic diseases: first for undescended, intraabdominal testes, later for hemi/nephrectomy, and nowadays laparoscopy is the gold standard even for pyeloplasty. Certainly, in abdominal pathologies, mainly in acute abdomen of unknown origin, MIS is not only a diagnostic but also a therapeutic option. The most common laparoscopic interventions are hernioplasty, appendectomy, cholecystectomy and pyloromyotomy; however, in several centers fundoplication, splenectomy, Meckel-diverticulectomy or even total colectomy are also performed laparoscopically. Thoracoscopic decortication and lobectomy are included in the repertoire of some centers as well.

Currently, the next step forward is the spread of MIS in newborn pathologies. In more and more cases of esophageal atresia, diaphragmatic hernia and duodenal atresia MIS has been successfully applied in some centers.

We studied the spread of laparoscopy in Hungarian pediatric surgery centers and its heterogeneity between hospitals and university centers. According to the statistical data of Hungarian pediatric surgical centers, the number of MIS-s is five times higher than it was ten years ago (Table 1).

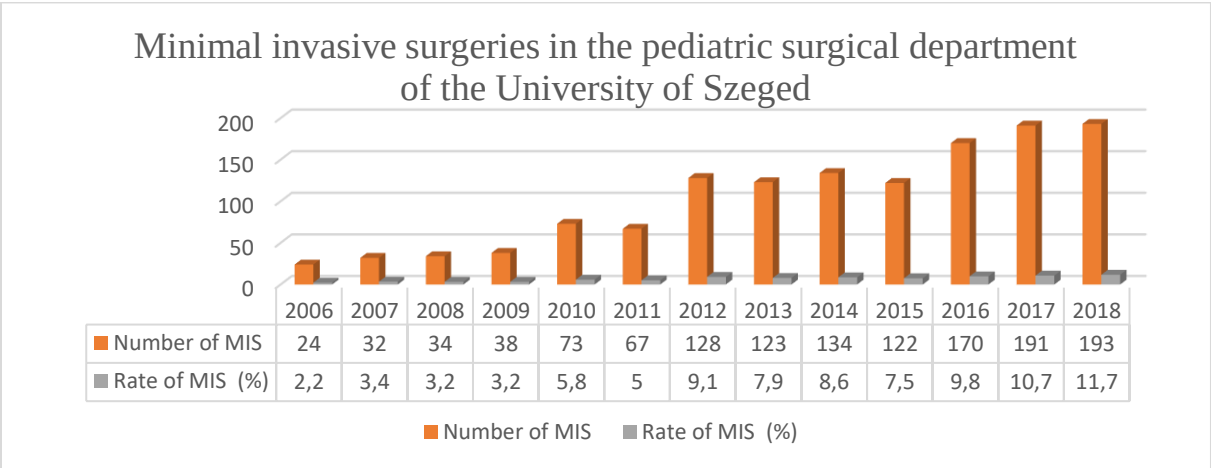


	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Number of MIS	437	464	497	668	805	824	802	962	1087	1210	1207	1532	1527
Rate of MIS (%)	2,12	2,44	2,56	2,87	3,34	3,57	3,49	5,21	5,7	6,93	7,36	8,8	10,7

Table 1: The number and rate of minimally invasive surgical procedures in Hungarian pediatric surgical centers

The rate of endoscopic surgeries is 15% in clinical centers without trauma service, and 2–10% in other training centers. Routine laparoscopies are performed in all centers, and in 40–60% of the centers advanced endoscopies are also applied.

In modern pediatric surgical management, the number and field of indications for MIS have broadened year by year. At the pediatric surgical department of the University of Szeged, we perform almost all of the above mentioned common MIS interventions as shown by the increasing number of MIS (Table 2).



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Number of MIS	24	32	34	38	73	67	128	123	134	122	170	191	193
Rate of MIS (%)	2,2	3,4	3,2	3,2	5,8	5	9,1	7,9	8,6	7,5	9,8	10,7	11,7

Table 2: The number and rate of minimally invasive surgical procedures in our pediatric surgical center

Also, as pediatric surgery involves all fields of surgery in childhood, cooperation with other subspecialties, like gastroenterology, pulmonology, nephrology and neurosurgery, is essential. As our minimally invasive skills have developed, we tried to use them in these frontiers. We share our experience in MIS in less frequent indications as well, where laparoscopy can offer several benefits and reduce the rate of intraoperative complications, as shown by the following dissertation.

1.2. Laparoscopy in incarcerated inguinal hernia

Indirect inguinal hernia repair is one of the most common surgical procedures in the pediatric population. Montupet was the first to perform intracorporeal laparoscopic pediatric hernia repair in 1993 (10). Laparoscopic hernioplasty has gradually gained popularity; however, its role in incarcerated cases is not well outlined. Incarceration is the severe complication of inguinal hernias, for which emergency treatment is necessary. The incidence of incarcerated inguinal hernias is estimated to be as high as 1/6 of the total pediatric population with inguinal hernia (11). If it is not treated in time, serious complications can develop, such as intestinal obstruction, strangulation and perforation, testicular atrophy or ovarian necrosis. If manual reduction maneuvers fail, urgent surgical treatment is necessary. The conventional open surgery may be difficult to perform in these patients due to inflammation and edema, which in turn may increase the risk of intraoperative injury of the vas deferens or testicular vessels (12, 13).

Laparoscopic inguinal hernia repair (LIHR) gives the advantage of excellent visualization, ability to evaluate the contralateral side, less iatrogenic trauma of the incarcerated structures, and decreased operative time (11,14). Even the pneumoperitoneum helps to widen the internal ring that can aid the reduction (15). After reducing the hernia content, the inguinal ring can be closed in the same session with a minimal access technique, such as purse string suture (intracorporeal) or the hook method (extracorporeal).

1.3. Laparoscopic-assisted percutaneous endoscopic gastrostomy

Childhood is a very dynamic period in growth and development during which the body needs a lot of different micro- and macronutrients. Long-term eating disorders, dysphagia, malabsorption or maldigestion can lead to severe malnutrition. According to the European Society for Clinical Nutrition and Metabolism guidelines, gastrostomy placement is indicated in all patients in need of supplementary feeding for more than 2 - 3 weeks (16). Enteral tube feeding helps to avoid further weight loss, correct nutritional deficiencies, promote growth in children, and improve patients' quality of life (16).

Percutaneous endoscopic gastrostomy (PEG) was first described in 1980 by Gauderer (17). Nowadays the procedure is widely used all over the world even though the rate of adverse effects is not low. In the past decades, various technical modifications have been described to reduce complications. Image guided-, introducer technique and single-stage PEG buttons or percutaneous gastrostomy tubes have the advantages of avoiding the oropharynx and esophagus to prevent the carriage of microorganism to the peristomal site. These variants of the push technique are useful in case of esophageal tumors or surgeries and can be performed even in smaller children when the internal fixation plate of the PEG is too big. With the push technique, there is no need for a second intervention and anesthesia to replace the tube.

Laparoscopic guidance is very useful in patients with severe thoracoabdominal deformities, hepatomegaly, or following abdominal surgeries, because the site of the puncture is under visual control and hepatic- or colon interposition, vascular injuries are avoidable, adhesions can easily be released (18). During *laparoscopic assisted gastrostomy (LAG)* a gastrostomy tube is inserted laparoscopically by a surgeon. This technique is very popular and can also be used during laparoscopic fundoplication. During *laparoscopic assisted PEG (L-PEG),* the original pull-through technique is performed under laparoscopic and endoscopic visual control. During this combined technique, the surgeon helps the gastroenterologist/endoscopist by providing an intraabdominal view, which is crucial in high-risk patients and even if transillumination of the abdominal wall is inappropriate.

1.4. Laparoscopic-assisted ventriculoperitoneal shunt revision

The National Institute for Neurological Disorders and Stroke (NINDS) estimates that hydrocephalus occurs in approximately one out of 500 births. Hydrocephalus (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 (19).

Ventriculoperitoneal (VP) shunt placement is the most common treatment for HC; however, revisions are often required due to mechanical failure, infection, fracture or disconnection of the catheter (20, 21). 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, cerebrospinal fluid pseudocysts, kinking, migration or, rarely, false passage of the distal catheter (22, 23, 24).

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 into the lowest point of the abdominal cavity is visually controlled (25, 26). The visual control of positioning the peritoneal catheter spares extra radiation exposure. If any complications, such as bowel injury, occur during laparoscopy, they can be seen and resolved immediately as part of the laparoscopic procedure (27).
The aim of this study was to analyze and compare the results of open and laparoscopic shunt revisions.

2. AIMS OF THE THESIS

1. One objective of our study was to prove the efficacy of laparoscopic treatment in irreducible incarcerated inguinal hernia in children by analyzing the literature.

2. We aimed to confirm that laparoscopic assistance during PEG insertions can reduce the rate of intraoperative complications in high-risk patients.

3. Furthermore, we aimed to prove that laparoscopic assistance during VP shunt revision in the abdominal cavity can prolong the postoperative symptom-free period.

3. PATIENTS AND METHODS

All of these studies were carried out in accordance with the recommendations of WHO 4015, Human Investigation Review Board, Albert Szent-Györgyi Clinical Centre, University of Szeged. The protocol was approved by the Human Investigation Review Board, Albert Szent-Györgyi Clinical Centre, University of Szeged. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

3.1. Laparoscopy in incarcerated inguinal hernia

We performed a PubMed® search using the terms “laparoscopic”, „incarcerated”, “inguinal”, “hernia” and “children” from 1998 to 2018. Data were extracted with regards to the age of the child, sex, side of the hernia, sac content, operative technique, follow-up period, complications, and recurrence rate. These data were analyzed in this study.

3.1.1. Manual reduction and delayed surgery (MRDS)

If incarceration of an inguinal hernia has been confirmed, the reduction of the hernia should be attempted manually. The patient is placed in the supine position and his or her pelvis is grasped gently, but firmly by an assistant to prevent any lateral movement of the buttocks. Depending on the side of the hernia, the ipsilateral leg can be externally rotated and flexed into the frog position. This position causes the external ring to ascend nearly to the internal inguinal ring. After a successful reduction, 24-48 hours later, the hernia should be closed (MRDS) during the day shift, when the patient’s general condition has improved. Hernia repair may be open or it can be performed using a minimally invasive intra- or extracorporeal technique.

3.1.2. Manual reduction in general anesthesia (MRGA)

Sometimes general anesthesia is essential for a successful manual reduction (MRGA). In such cases, it is advised to perform emergency laparoscopy immediately after the reduction, because it provides direct visualization of the reduced hernia content and serosal or deeper intestinal injury, Meckel’s diverticulum or ovarian necrosis. The hernia can be repaired easily with intra- or extracorporeal techniques, and the contralateral side can also be checked and repaired if necessary.

3.1.3. Intraoperative reduction (IOR)

In case of severely incarcerated hernias, the reduction is successful only with the combination of inner retraction using laparoscopic instruments and external manual pressure. This method is called intra-operative reduction (IOR). Carbon dioxide insufflation and intra-abdominal pressure widen the internal inguinal ring, which helps the reduction of the hernia content (14). After successful reduction, the degree of intestinal injury or ovarian necrosis can be evaluated under direct vision and laparoscopic treatment can be performed (28). In case of incarcerated appendix or Meckel's diverticulum, both of these structures can be resected laparoscopically (29).

3.1.4. Intracorporeal repair of inguinal hernias

During intracorporeal repairs, such as the purse string suture, all suturing and knot tying around the inguinal ring are performed within the abdominal cavity with laparoscopic instruments, as was first described by Montupet and Esposito in 1999 (30) (Figure 1).

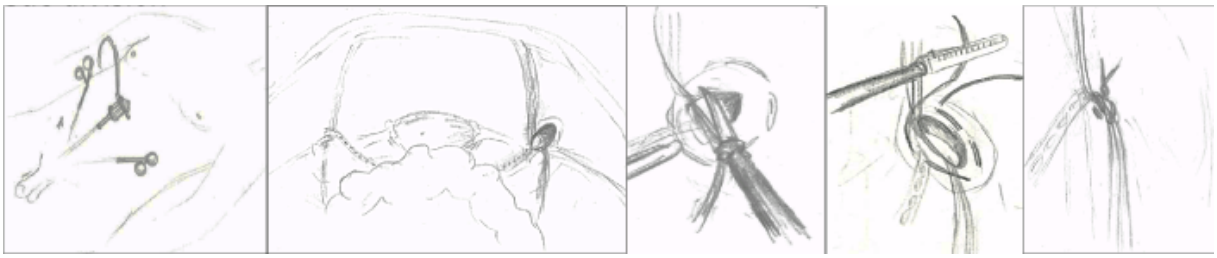


Figure 1: Intracorporeal repair of inguinal hernia in children

3.1.5. Extracorporeal repair of inguinal hernias

With the extracorporeal hook technique, a stab incision is performed above the inner ring, a needle is introduced medially into the preperitoneal space around the ring and when the needle is withdrawn, the suture loop is left intraabdominally (Figure 2). With the same technique, the suture is pulled outside and tied extracorporeally from the opposite side of the ring. The extracorporeal technique was published first by Prasad et al (31, 32).

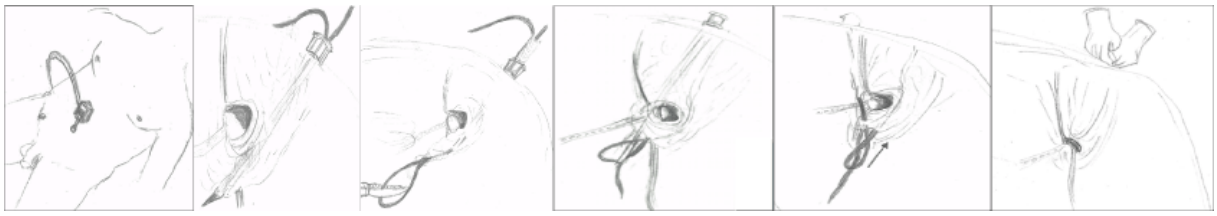


Figure 2: Extracorporeal repair of inguinal hernia in children

3.2. Laparoscopic-assisted percutaneous endoscopic gastrostomy

In this study, we report our 6-year experience in a pediatric surgical center with the cooperation of a pediatric gastroenterology unit. A retrospective analysis was performed on PEG surgeries between January 2014 and December 2019. The data of high-risk patients (with severe TAD, previous abdominal surgery or abdominal tumor and VP shunt) were analyzed retrospectively regarding patients' age, gender, diagnosis, indication for surgery, operative time, minor and major complications and mortality, and they were compared in the original PEG group and in the L-PEG group. Open gastrostomies, laparoscopic gastrostomies and one-step gastrostomy insertions were excluded from the study.

3.2.1. Original pull technique

All PEG procedures were performed under general anesthesia using a flexible Fujinon EG-530WR gastroscope with a standard 9.4 mm or with a nasal 5.9 mm outer diameter, respectively. The stomach was insufflated; after transillumination the surgeon performed a 5-mm skin incision at the proper site of the anterior abdominal wall. After puncture and air aspiration, a guidewire was passed through the cannula sheath into the stomach, then it was grasped and pulled out through the oropharynx together with the gastroscope. The loop of the gastrostomy tube was fixed to the guidewire and pulled back through the esophagus into the stomach and out through the puncture site until the internal fixation plate was adjacent to the anterior gastric wall.

3.2.2. Laparoscopic-assisted percutaneous endoscopic gastrostomy

Using an open (Hasson technique) infraumbilical access, pneumoperitoneum was achieved by insufflating carbon dioxide at 1 - 3 L/min until an intraabdominal pressure of 8 to

12 mm Hg was obtained. A 5-mm port and 30º optic device was placed and abdominal exploration was performed. If the abdominal cavity was adhesion-free, the original PEG procedure could be performed under gastroscopic and laparoscopic visual control. In case of adhesions, they were released with 3-mm instruments introduced through separate working ports and then the gastrostomy tube was inserted with the original pull technique.

3.3. Laparoscopic-assisted ventriculoperitoneal shunt revision

In this study, we report our 10-year experience with VP shunt patients in a tertiary pediatric surgical center. A retrospective analysis of hydrocephalus 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 determine the type of obstruction.

3.3.1. Open revision of distal catheter of VP shunts

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

3.3.2. Laparoscopic-assisted revision of distal catheter of VP shunts

A camera port is inserted through an infraumbilical access with the open (Hasson) technique. Pneumoperitoneum is achieved by insufflating carbon dioxide until an intraabdominal pressure of 8 to 12 mm Hg 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.

4. RESULTS

4.1. Laparoscopy in incarcerated inguinal hernia

In the English literature, 15 articles with n=689 incarcerated inguinal hernias were identified that met the inclusion criteria. The age distribution at the time of surgery was 2 weeks to 16 years with the median age being 22.4 months. The male to female ratio was 2.2:1. The affected side was reported in n=576 cases, with 69.1% (n=398) being right-sided and 30.9% (n=178) left-sided.

In n=355 cases (51.5%), manual reduction and delayed surgery (MRDS) was performed in 24-48 hours. In n=34 (4.9%) patients, manual reduction was possible only in general anesthesia (MRGA) followed by emergency LIHR. In n=300 cases (43.5%), the hernia content was reducible only intra-operatively (IOR) with laparoscopic instruments and external pressure (Table 3).

Surgical technique	Number of reductions (n)	%
Manual reduction and delayed surgery	355	51
Manual reduction in general anesthesia and emergency LIHR	34	5
Intraoperative reduction	300	44

Table 3: Treatment options for laparoscopic incarcerated inguinal hernias

During the intraoperative reduction, incarcerated contents were documented in 68 patients: intestine n=36 (52.9%), ovary n=14 (20.6%), omentum n=11 (16.2%), appendix n=5 (7.4%), and Meckel's diverticulum n=2 (2.9%). Among the 18 girls in the IOR group 14 (77.8%) had ovarian incarceration in the sac (Table 4).

Incarcerated contents	Number of cases (n)	%
Intestine	36	52.9
Ovary	14	20.6
Omentum	11	16.2
Appendix	5	7.4
Meckel's diverticulum	2	2.9

Table 4: Incarcerated contents found in the inguinal canal

Hernia repair was achieved with two different surgical techniques. The *hook method* (extracorporeal) was used in n=376 (54.6%) and the *purse string suture* (intracorporeal) in n=313 (45.4%) patients. Two conversions were found in the IOR group: in one patient the reduction required release of the external inguinal ring, and in the other patient LIHR was hampered by a friable internal ring. Mean follow–up time was 15 months (3-80 months). During the follow-up period, n=1 (0.15%) testicular atrophy was reported in the IOR group (10).

Recurrence was found in 4 (0.58%) patients in the MRDS group and in one (0.15%) in the IOR group. All 5 recurrences were found in the purse string technique group. The total recurrence rate was 0.73%. Recurrence was significantly higher (p=0.014) with Chi square test in the purse string group (n=5, 1.6%) than with the hook technique (n=0).

In the reviewed literature, 4 male patients required laparoscopic assisted bowel resections: n=2 small bowel gangrene, n=1 perforated Meckel's diverticulum and n=1 deep serosal tear of small bowel. Two partial omentectomies were performed laparoscopically and an oophorectomy in case of a necrotic ovary (32).

One testicular atrophy was mentioned after a late, difficult, instrument aided reduction (12). Umbilical granuloma was mentioned in 19 patients (4.8%) (42). Other minor complications were detected in less than 1%, such as hydrocele (n=6), port site hernia (n=6), and trocar infection (n=3) (12).

4.2. Laparoscopic-assisted percutaneous endoscopic gastrostomy

A total of 82 gastrostomy tubes were placed in our Institution in 80 patients between January 2014 and June 2019. Indications for gastrostomy in all cases were feeding difficulties or malnutrition due to the main diagnosis listed in Table 5.

Diagnosis	N	%
Neurologic disease (Epilepsy, Hydrocephalus, Hypoxic injury, Meningitis/encephalitis, Anencephaly, Microcephaly, Intracranial hemorrhage, Leukomalacia, Traumatic cerebral injury)	39	47.6
Malignancy (Leukemia, Lymphoma, Medulloblastoma, Ependymoma, Neuroblastoma, Rhabdomyosarcoma, Wilms-tumor)	16	19.5
Cardiac disease (Fallot tetralogy, Atrial/ ventricular septum defect, Patent ductus arteriosus, Coarctation of the aorta	12	14.6
Genetic disease (Spinal muscular atrophy, CASK mutation, Guillain-Barre syndrome (Sy), West Sy., Glycogenosis, Di-George Sy. , Down-Sy.)	8	9.8
Renal disease (Tubulointerstitial nephritis)	1	1.2
Pulmonary disease (Cystic fibrosis)	1	1.2
Gastrointestinal or metabolic disease (Crohn's disease, Congenital hyperinsulinism, Congenital disorders of glycosylation)	3	3.7
Pierre-Robin Sy.	1	1.2
Subglottic stenosis	1	1.2

Table 5. Main diagnosis of the patients of PEG insertions

The body weight percentile before PEG insertions is shown in the Diagram 1.

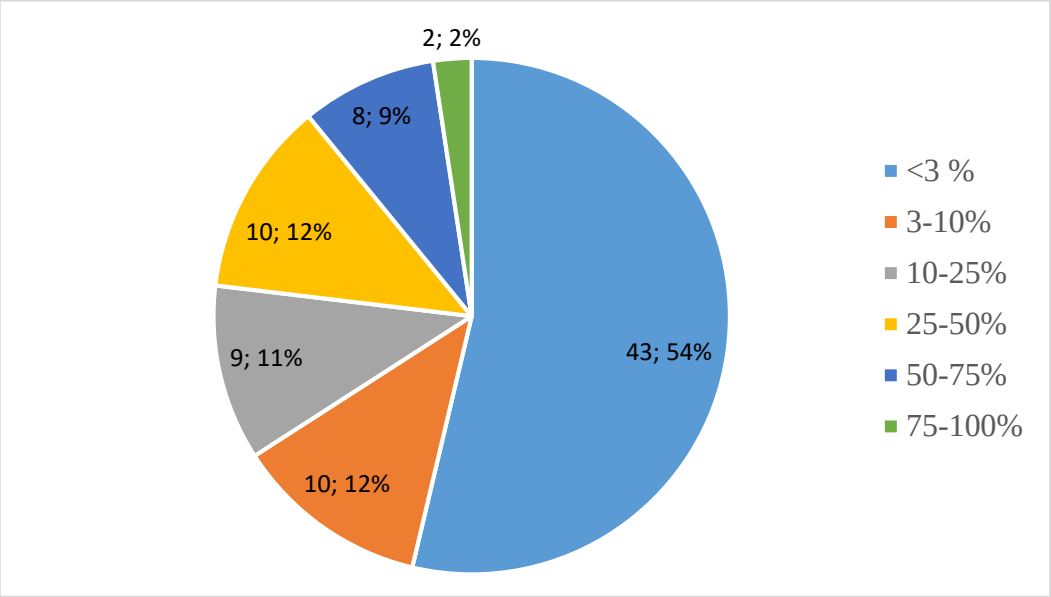


Diagram 1: The body weight percentile of patients before PEG insertion

From the 80 patients 25 high-risk patients received PEG tubes in this interval. This retrospective study included 15 (60%) boys and 10 (40%) girls with a mean age of 70 months (2 and a half months - 17.5 years).

These 25 interventions in high-risk patients were divided into 2 groups. The first group of purely endoscopic visualization was composed of 15 patients (60%), who underwent the original PEG insertion with the pull technique. The second group of both endoscopic and laparoscopic control included 10 patients (40%), who underwent L-PEG placement.

The mean age in the first group was 71 months (2 and a half months - 17.5 years), the boy: girl ratio was 9:6. In the second group, the median age was 57 months (10 months -14 years) with 6 boys and 4 girls (Table 6).

	Percutaneous endoscopic gastrostomy (n=15)	Laparoscopic assisted percutaneous endoscopic gastrostomy (n=10)
Mean age	71 months (2.5 months - 17.5 years)	57 months (10 months -14 years)
Boy: girl ratio	9:6	6:4
Risk factors	n=7 severe TAD n=6 abdominal tumor n=3 neuroblastoma n=3 Wilms tumor n=2 VP shunts	n=5 VP shunts n=4 previous abdominal surgeries n=1 duodenal atresia n=1 previous gastrostomy n=1 left nephrectomy (Wilms tumor) n=1 biopsy of rhabdomyosarcoma n=1 severe TAD
Mean operating time	23 minutes (14-35 minutes)	46 minutes (32-80 minutes)
Minor complications	n=1 unplanned removal of the tube (6.6%).	n=1 peristomal granuloma (10%)
Major complications	n=1 transverse colon perforation n=1 gastrocolic fistula n=1 pneumoperitoneum	n=0
Lethality	n=1	n=0

Table 6: Comparison of original and laparoscopic assisted percutaneous endoscopic gastrostomies

Indications for gastrostomy were feeding difficulties or malnutrition in all cases.

Risk factors in the first group were n=7 severe TAD, n=6 abdominal tumor (n=3 neuroblastoma, n=3 Wilms tumor) and n=2 VP shunts. Risk factors in the second group were n=5 VP shunts, n=4 previous abdominal surgeries (duodenal atresia, previous gastrostomy, left nephrectomy because of Wilms tumor, tumor biopsy of rhabdomyosarcoma), and n=1 severe TAD. Adhesions were found in n=3 (30%) patients, and they were released laparoscopically. There was no need for conversion.

The mean operating time of the PEG procedure was 23 minutes (14-35 minutes) in the first group compared to 46 minutes (32-80 minutes) necessary for the L-PEG procedure. Welch's two sample t-test found a significant difference between the length of the two procedures: L-PEG was significantly ($p=0.001$) longer than the original PEG, especially if adhesiolysis was necessary (60-80 minutes) (Figure 3).

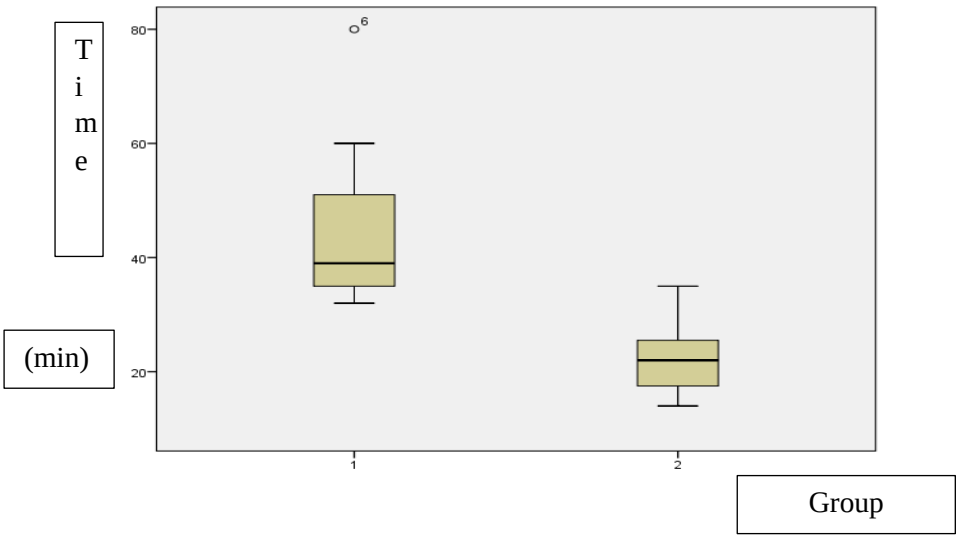


Figure 3: The main operating time of PEG procedure in L-PEG group (1.) and in original PEG group (2.)

Refeeding was started 8 hours later with water, and formula was started 24 hours after the insertion in both groups. There were no significant differences in refeeding time between the two groups. Hospital stay depended on refeeding time and underlying diseases, not on the operative technique.

Adverse effects were classified as minor or major based on the ESPGHAN guidelines (33). Minor complications occurred in 2 patients (8%). A total of one minor complication was observed in the first group (n=1), which was unplanned removal of the tube (6.6%). The opening of the skin closed spontaneously after the unplanned removal and the internal fixation plate was emptied with the stool. In the L-PEG group there was n=1 peristomal granuloma (10%)

A total of 3 major complications were observed: they all occurred in the first group (20%). One transverse colon perforation, one gastrocolic fistula and one pneumoperitoneum were found in the first group. No major complication (0%) was observed in the second group.

There was n=1 lethal outcome in a patient with severe comorbidities, who died due to severe outcomes of his general condition long after the postoperative period. He was in the 1st group; however, there was no association between the fatal outcome and the operation.

4.3. Laparoscopic-assisted ventriculoperitoneal shunt revision

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%) ventriculosubgaleal shunt insertions, n=7 (5%) VP shunt removal and n=3 (2%) ventriculoatrial shunt insertions (Diagram 2). The minimum follow-up period was at least 1 year (1-10 years).

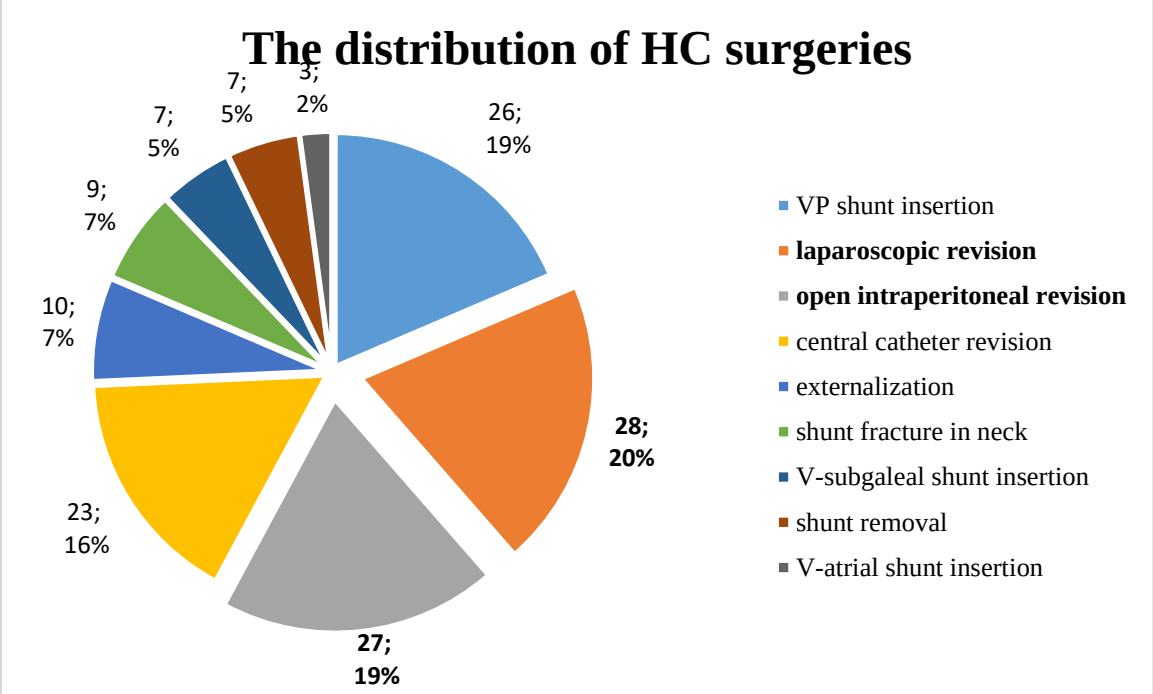


Diagram 2: Distribution of all operations due to hydrocephalus in our department between 2009 and 2019

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 - 21 years old).

Out of all distal shunt revisions, n=55 were intraabdominal procedures due to obstruction. Intraabdominal VP shunt revisions were divided into 2 groups: 28 laparoscopic revisions in 19 patients and 27 open revisions (20 open intraabdominal revisions, 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 - 21 years) in the laparoscopic group, and 8.5 years (3 months - 16 years) in the open group (Table 7).

Intraabdominal 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 minutes (13-86 minutes)	33 minutes (24-67minutes).
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 number of subsequent abdominal revisions within 12 months is significantly lower (p=0.037) with Chi-square test in the laparoscopic group.

Table 7: Comparison of open and laparoscopic distal shunt revisions

The causes of HC are shown in Diagram 3 for patients with open shunt revisions and in Diagram 4 for the laparoscopic group.

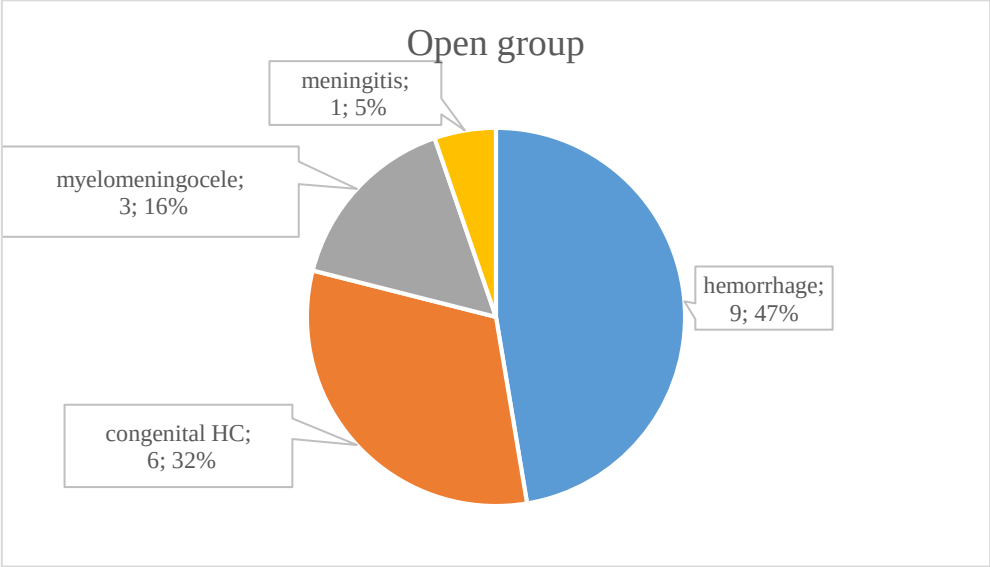


Diagram 3: The origin of hydrocephalus in patients operated with open revisions for distal obstruction

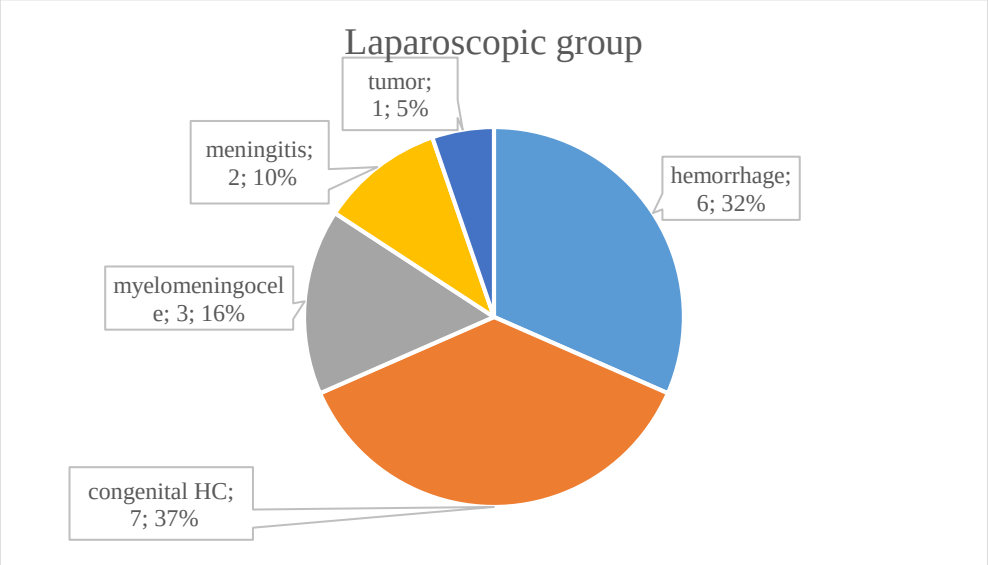


Diagram 4: The origin of hydrocephalus in patients operated with laparoscopic technique for shunt revision of distal obstruction

There was no misplacement of the peritoneal catheter in the 2 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 1-8, and in the laparoscopic group between 1-9.

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 3 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.

Shunt infection requiring externalization was detected in one patient in the laparoscopic group and in 2 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 minutes (13-86 minutes), and in the laparoscopic group it was 33 minutes (24-67 minutes).

Mean hospital stay was 7.2 days (2-65 days) in the open group and 6.6 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 Chi-square test in the laparoscopic group. Chi-square test for independence was used. A p-value of $p<0.05$ was regarded as statistically significant. Statistical software IBM SPSS version 25 was also used.

5. DISCUSSION

5.1. Laparoscopy in incarcerated inguinal hernia

LIHR is one of the most common minimal access surgical procedures performed in pediatric patients (34). Incarceration is the most severe complication of inguinal hernias, for which emergency treatment is necessary. Manual reduction of the hernia content should be performed with care. After successful reduction, as soon as the patient's general condition has improved, the hernia should be closed (MRDS). Hernias can be repaired open or using minimal access techniques after 24-48 hours, during the day shift, when the patient is in a good general condition and when the risk of anesthesia is lower. Laparoscopic closure has the advantage of avoiding the difficult dissection of an edematous sac in the groin even days following the reduction of incarceration, and it permits the repair of a contralateral patent processus vaginalis if present (13).

If general anesthesia is necessary for successful manual reduction (MRGA), it is recommended to perform emergency laparoscopy in the same session, because it allows inspection of the reduced hernia content and detection of serosal or deeper intestinal injury, Meckel's diverticulum or ovarian necrosis.

Reduction of severely incarcerated contents can be done by a combination of retraction using laparoscopic instruments together with external manual pressure – intra-operative reduction (IOR). A further advantage of using laparoscopic techniques is that carbon dioxide insufflation and intraabdominal pressure widen the internal inguinal ring, which helps the reduction (15). Furthermore, under direct visualization the degree of intestinal injury or gonad necrosis can be evaluated and laparoscopic treatment can be performed (28). If the incarcerated content is the appendix or Meckel's diverticulum, both of these structures can be resected laparoscopically (14, 29). Even the repair of the contralateral patent processus vaginalis can be performed with minimally invasive techniques in the same session. (15, 35).

Bowel necrosis due to strangulation or serosal tears resulting from the retraction force of laparoscopic instruments can be treated with intracorporeal suturing, or the damaged intestine could be exteriorized through the single-incision LIHR for repair (36). Omentectomy,

oophorectomy or Meckel's diverticulum resection can also be managed with the minimal access approach (32).

Only one testicular atrophy was documented in a male who underwent a late, difficult, instrumental reduction. It can be hypothesized that the development of testicular atrophy can be attributed more to the duration of incarceration and condition of the testis, rather than to the surgical technique employed.

Two conversions were documented: in the first case the release of the external inguinal ring was necessary, and in the other case the LIHR was hampered by a friable internal ring (34).

In girls with irreducible hernias, the content of the hernia is most commonly the ovary. Irreducible hernias with ovarian content should be treated by laparoscopy, as soon as possible once they are detected (36). Incarcerated hernias containing ovary can be corrected laparoscopically with or without cutting the external inguinal ring with a small skin incision (37).

The recurrence rate of LIHR after incarceration is as low as 0.78%, which is comparable to non-incarcerated hernias (38). However, the recurrence rate in case of incarcerated hernias following open closure can be 15-20% (39). The hook and purse string methods are equally popular in LIHR for pediatric incarcerated hernias; however, the recurrence is significantly higher with the purse string suture than with the hook technique (12, 15, 39). It can be hypothesized that the recurrence in the purse-string technique can be overcome if the edema in the area of the internal inguinal ring is recognized and an additional Z-suture is placed to reinforce the purse-string suture. Other factors that could play a role are (a) the type of suture material (thickness and braided vs. monofilament) used for these repairs, (b) the numbers of "crushes" to the suture material by the instruments, especially in case of monofilament sutures that could weaken the suture strength with multiple grasps and (c) the number of knots tied to hold the suture bearing in mind that unwinding can take place in monofilament sutures with 3 knots.

LIHR is highly recommended for incarcerated hernias because of its advantages in the reduction of irreducible hernias with pneumoperitoneum. Laparoscopic instruments can help with pulling the content of the sac during external manual pressure. Following successful

reduction, the content is still under direct vision so accidental injuries can be detected. Inguinal hernias can be closed easily with any LIHR technique, without the danger of injury to the vas or vessels, which may occur in the open way. If intestinal injuries, gonadal necrosis or Meckel's diverticulum are visible, they can be treated immediately with the laparoscopic instruments (40). Laparoscopic treatment is associated with a short postoperative stay and excellent esthetic outcomes (41, 42).

5.2. Laparoscopic-assisted percutaneous endoscopic gastrostomy

Tube feeding is the method of choice when enteral nutrition is recommended but oral intake is insufficient. Earlier, open gastrostomies were performed by surgeons through a few cm long upper abdominal incision. A Pezzer catheter was inserted into the stomach and fixed with a double layer purse string suture. Then the tube was brought out through a stab incision on the abdominal wall (17).

After Gauderer first described PEG in 1980, this minimally invasive technique became the gold standard (17). Its advantages are less scarring, shorter operative time, less infections, less postoperative pain and shorter hospital stay (17). In most cases, PEG tube insertion is a safe procedure when the esophagus is patent and transillumination of the stomach through the abdominal wall is well achievable.

According to our literature review on complications of PEG insertions, major complications developed in 10% of patients. Almost 50% of the major complications were infections. Systemic infections occurred in 3.5%, which were treated with intravenous antibiotics. Cellulitis, peritonitis, sepsis or wound dehiscence were noticed in 1.5%. Pneumoperitoneum was observed in 0.7% . Asymptomatic pneumoperitoneum can occur without intestinal perforation; however, in 0.3% of the cases esophageal or bowel perforations were noticed. Gastrocolic fistulas due to interposition of the splenic flexure between the anterior abdominal and gastric walls were found in 0.45% and buried bumper, intraabdominal bleeding and ileus were detected in 1%.

In our systematic review two articles compared the major complication rate after laparoscopic and original PEG insertion technique in high-risk patients. All these patients had at least one

severe comorbidity; the most important ones were neurologic disorders, previous abdominal surgeries, VP shunts and PD catheters. There were altogether 541 patients in the original pull technique group and 45 patients in the laparoscopic assisted group (43). In the first group the most common major complications were buried bumper, granulation, peritonitis and gastrocolic fistula. Altogether 12.6% of the high-risk patients had major complications in the first group. In the laparoscopic group only 4.4% of patients with severe comorbidities had major complications. One patient had peritonitis and one child had gastrocutaneous fistula after the removal of the PEG.

Impaired coagulation, severe ascites, peritonitis and local esophageal and general gastrointestinal obstructions are considered to be absolute contraindications of PEG insertion (44). Severe kyphoscoliosis with interposed organs and distorted anatomy are relative contraindications (44). Vervloessem et al. analyzed potential the risk factors of major complications in 449 patients and only VP shunts were found to be associated with a significantly higher major complication rate. Although PD catheters, hepatomegaly, esophageal stenosis and coagulopathy had higher complication rates, the difference between the two rates was not significant (43).

Laparoscopic guidance is recommended during PEG placement in patients with severe kyphoscoliosis, hepatomegaly, splenomegaly, extreme obesity or an intraabdominal tumor, as well as in patients with previous abdominal surgery (45).

In our institute, L-PEG was started in 2014 after a major complication in a patient with a VP shunt. Since then, all patients with a high risk of intestinal injury (VP shunts, PD catheters, previous abdominal surgery, severe TAD, hepatomegaly or intraabdominal masses) have been operated this way. Before this shift, the original PEG was performed in 15 high-risk patients: severe TAD (n=7), abdominal tumor (n=6) and VP shunts (n=2). There were 3 major complications: colon perforation (n=1), gastrocolic fistula (n=1) and pneumoperitoneum (n=1).

Colon perforation was found in a 2-year-old VP shunt patient. The patient developed peritonitis on the 1st postoperative day. Laparotomy was performed and two perforation openings were found on the transverse colon, which were closed in double layer. The distal catheter of the VP shunt was temporarily externalized. The PEG was exchanged to a gastrostomy tube.

Gastrocolic fistula was found in a 3-year-old boy with Fallot tetralogy, severe TAD and somato-mental retardation. The internal bumper was removed endoscopically and the chronic fistula was closed surgically.

One case of pneumoperitoneum was caused by early dislodgement of the tube, because it was moved in the early postoperative period by an autistic patient with severe TAD. Gastropexy was performed with laparoscopic exploration. This complication was independent from the surgical technique and even from the patient's high-risk status.

After the selection of high-risk patients was started, 10 L-PEGs were inserted; the indications for laparoscopic guidance were VP shunts (n=5), previous abdominal surgeries (n=4) (duodenal atresia, previous gastrostomy, left nephrectomy because of Wilms tumor, tumor biopsy of rhabdomyosarcoma), and severe TAD (n=1). Adhesions were found in three patients (30%); two of them had a VP shunt and one had previous gastrostomy.

The advantage of L-PEG is that surgeons and endoscopists perform the same procedure as usual and there is no need to learn a new technique. The endoscopist performs the original pull technique. The surgeon performs the umbilical access in the same way as in any laparoscopic procedure for a 5-mm camera port. We prefer the open, Hasson technique instead of the Veress needle to prevent vessel-, hepatic- or bowel injury. Any adhesions found can be released laparoscopically. When the stomach is free of adhesions, the original PEG procedure can be performed under double visual control. The laparoscopic procedure is longer but safer than the pure endoscopic insertion not only in high-risk but in all patients as well.

This study has limitations, including its retrospective nature and the small study size in both groups. However, L-PEG is not widespread in the literature.

L-PEG was first described by Stylianos et al. in 1995. They successfully inserted a primary PEG button with laparoscopic guidance in two children who had previously undergone multiple abdominal procedures (46). In 1995 Stringel et al. reported successful L-PEG in two children after attempts at original PEG had failed (47).

In cerebral palsy patients Takahashi et al. performed 34 L-PEG procedures, where the anterior wall of the stomach was anchored to the abdominal wall laparoscopically. Intraoperative or postoperative complications were not found (48).

Perger et al. performed PEG tube insertions at the time of laparoscopic Nissen fundoplication in 44 children. In 7% of the cases, laparoscopic supervision was found crucial in the prevention of major complications (49).

Köhler et al. reported 9 patients whose conventional PEG insertion failed because of inappropriate transillumination, gastric indention, or an abdominal tumor. All patients underwent L-PEG without major complications (50). Yu et al. recommend L-PEG if the abdominal wall is estimated to be thicker than 2 cm, or in children whose original PEG placement has failed. There were no postoperative complications and no revisions in 15 patients (51). Hermanowicz reported L-PEG without complications in 12 patients (6 children), in whom standard PEG was impossible because of distorted anatomy (45).

At least 60-70% of the children with feeding difficulties such as dysphagia or failure to thrive, that qualify for PEG insertions, have at least one comorbidity. Parents/caregivers report that the gastrostomy is a great help for themselves and their child. PEG is a safe operative technique for enteral feeding, with frequently observed minor complications and a low rate of major complications. According to our systematic review patients with VP shunt have higher risk of major complications. In case of high-risk patients laparoscopic assisted PEG is recommended.

5.3. Laparoscopic-assisted ventriculoperitoneal shunt revision

VP shunt is the treatment of choice for HC of various origin; however, complication rates are considerably high in the literature. VP shunt dysfunction varies between 11-25% within the first year following the initial shunt placement (52, 53).

Most authors report a significantly higher number of shunt revisions and replacements among pediatric patients compared to adults requiring VP shunts for hydrocephalus (54). 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. laparoscopic shunt placement significantly reduces the rate of distal shunt failure compared to mini-laparotomy (55). Even after revisions, laparoscopy can reduce the rate of distal shunt failures. Laparoscopic assistance can help not only with proper adhesiolysis and the excision of pseudocysts, but also with decision making concerning when to choose 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 (54). 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. reported a lower risk of wound infection, visceral injury, hernia and shunt complications after laparoscopic revision compared to open revisions (56).

In 3 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 (57). 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 2nd 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. stated that diagnostic laparoscopy eliminated the need for ventriculoatrial shunt placement in 85% of patients with a potentially hostile abdomen (58).

The benefit of laparoscopy in the treatment of HC has been well known for decades. Esposito et al. 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 was lost in the abdominal cavity and in two children with a malfunctioning peritoneal catheter (59).

In 1998 Rolle et al. 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 laparoscopic-assisted abdominal shunt revisions (60).

According to Carvalho et al., during laparoscopic revisions a 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 retrohepatic space or at any other retro-omental space where the free migration of the catheter with peristaltic movements can be ensured (61).

Laparoscopy allows not only for the accurate placement of the distal catheter in the peritoneal cavity, but it also enables the retrieval of fractured catheter segments, and allows confirmation of the patency of the shunt system (62).

During laparoscopic revision, visualization of CSF dripping out of the functioning shunt confirms that intracranial pressure exceeds our pneumoperitoneum. A pneumoperitoneum of 10 mm Hg using CO2 appears to be safe and effective for laparoscopic procedures in these patients with VP shunts (63).

Martin et al. recommend laparoscopic revisions in patients with multiple previous revisions, prior abdominal surgery, previous intraperitoneal infections, broken devices, or cerebrospinal fluid pseudocysts (64).

Laparoscopy can be beneficial not only in shunt revisions, but also in VP shunt insertions. Schukfeh et al. 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 shunts (65).

Open and laparoscopic insertion of VP shunts was compared in two systematic review and meta-analyses. Phan et al. demonstrated that the laparoscopic technique in VP shunt surgery is associated with reduced shunt failure and abdominal malposition compared to the open laparotomy technique, with no significant difference in the rates of infection or other

complications (66). He et al. found a lower distal failure rate and shorter operative time in the laparoscopic group (67).

There was only one cohort analysis of laparoscopic versus open VP shunt revisions in pediatric patients. Fahy et al. found that laparoscopic peritoneal VP shunt revision significantly reduces the rate of subsequent peritoneal revisions, without increasing shunt infections or operative time in pediatric patients (68).

6. CONCLUSIONS

6.1. Laparoscopy in incarcerated inguinal hernia

LIHR is highly recommended for incarcerated hernias because of its advantages in the reduction of irreducible hernias with pneumoperitoneum and in pulling the content of the sac with laparoscopic instruments. The inguinal hernia can be closed simultaneously with any LIHR technique (hook or purse string methods), with a much lower risk of injuring the vas or vessels compared to open procedures. If intestinal injuries, gonadal necrosis or Meckel's diverticulum are visible, they can be treated immediately with laparoscopic instruments.

Recurrence rate is low and comparable with that of non-incarcerated hernias; however, it is significantly higher with the purse string suture than with the hook technique.

6.2. Laparoscopic-assisted percutaneous endoscopic gastrostomy

Our results show that the rate of major complications in high-risk patients is lower with L-PEG; however, the operative time is significantly longer, especially if adhesiolysis is necessary.

Laparoscopic guidance provides a clear intraabdominal view, offers the possibility of releasing adhesions, thus adjacent bowel or hepatic injuries can be prevented. L-PEG is advised for children with distorted anatomy, VP shunts or previous abdominal surgeries. L-PEG can provide an immediate solution if transillumination of the gastric wall is inappropriate during gastroscopy. PEG insertion for high-risk patients is advised in centers with pediatric surgical departments, where laparoscopy is routinely used.

6.3. Laparoscopic-assisted ventriculoperitoneal shunt revision

VP shunts are the first line treatment of HC; however, revisions are frequently necessary. Distal shunt revisions can be performed both in an open and laparoscopic way. The most important advantages of laparoscopy are the possibility of releasing adhesions, fenestration of CSF pseudocysts and visually controlled insertion of the new catheter into the

abdominal cavity. Laparoscopy can facilitate the diagnostic evaluation of the peritoneum, thereby helping in decision making regarding surgical management. As a result, significantly fewer subsequent abdominal revisions are necessary postoperatively.

6.4. Summary of new findings

1. **Laparoscopic procedure is effective in the treatment of irreducible incarcerated inguinal hernias in children. Laparoscopy can help not only in the reduction, but also in the repair of the inguinal hernia in one session.**

2. **Laparoscopic assistance during PEG insertions can reduce the rate of intraoperative complications in high-risk patients with distorted anatomy or previous abdominal surgery.**

3. **Laparoscopic assistance during intraabdominal VP shunt revisions can significantly reduce the number of subsequent abdominal revisions, and in special cases, laparoscopic findings can help in the selection and timing of the most appropriate technique for VP shunt insertion.**

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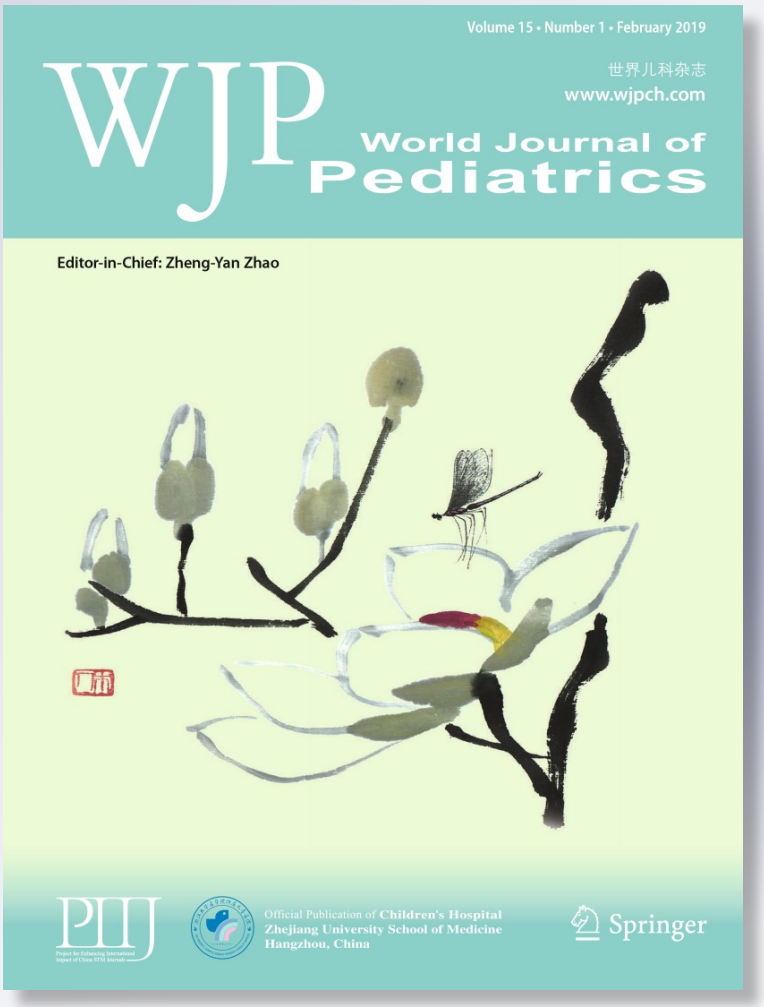

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REVIEW ARTICLE

Complications in children with percutaneous endoscopic gastrostomy (PEG) placement

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Abstract

Introduction The aim of this study was to analyze the complication rates and mortality in association with different operative techniques of percutaneous endoscopic gastrostomy (PEG), age, underlying diseases and other risk factors. Moreover, analysis of the indications of PEG insertion and the underlying comorbidities was also performed.

Methods This study performs a literature analysis of PEG-related complications in children. Literature was searched on PubMed® (1994–2017) using terms "percutaneous endoscopic gastrostomy", "complications", "mortality" and "children".

Results Eighteen articles with 4631 patients were analyzed. The mean age was 3 years (0–26 years). Operative techniques were: pull technique in 3507 (75.7%), 1 stage PEG insertion in 449 (9.7%), introducer technique in 435 (9.4%), image-guided technique in 195 (4.2%) and laparoscopic-assisted PEG in 45 (1.6%). Most frequent indications for PEG insertion were dysphagia ($n=859$, 32.6%), failure to thrive ($n=723$, 27.5%) and feeding difficulties ($n=459$,17.4%). Minor complications developed in n1518 patients (33%), including granulation ($n=478$, 10.3%), local infection ($n=384$, 8.3%) and leakage ($n=279$, 6%). In 464 (10%) patients, major complications occurred; the most common were systemic infection ($n=163$, 3.5%) and cellulitis ($n=47$, 1%). Severe complication like perforation occurred in less than 0.3%. Patients with lethal outcomes ($n=7$, 0.15%) had severe comorbidities; and the cause of mortality was sepsis in all cases. Prematurity or young age did not affect complication rate. Patients with ventriculoperitoneal (VP) shunt had higher risk of major complications. In high-risk patients, laparoscopic-assisted PEG insertion had less major and severe complication than traditional pull technique.

Conclusions PEG is a safe operative technique; although minor complications are relatively common and occur in up to 1/3 of patients, there is a fairly low rate of severe complications. Two-thirds of PEG patients have at least one comorbidity. Patients with VP shunt have higher risk of major complications. In high-risk patients, laparoscopic-assisted PEG is recommended.

Keywords Children · Complications · Percutaneous endoscopic gastrostomy

Introduction

Childhood is a very dynamic period in growth and development during which the body needs a lot of different micro- and macronutrients. Long-term eating disorders, dysphagia, malabsorption or maldigestion can lead to severe malnutrition. Long-term enteral access, such as gastrostomy, is indicated if nutritional supplement is needed for longer than 4–6 weeks. Percutaneous endoscopic gastrostomy (PEG) was first described in 1980 by Gauderer and this is the globally used technique for permanent enteral feeding in patients with eating disabilities [1]. Since then, various techniques for gastrostomy insertion have been developed.

In the last three decades, various variants of less invasive PEG techniques have evolved and different techniques have different spectrum of outcomes. The rate of complications

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of pediatric PEGs varies widely in the literature, ranging from 4 to 44% [2]. There is no recent study that analyzes the preoperative risk factors for postoperative short- and long-term complications. The aim of this study was to analyze the complication rates and mortality in association with different operative techniques of PEG, age, underlying diseases and other risk factors. Moreover, analysis of the indications of PEG insertion and the underlying comorbidities was also performed. According to the ESPGHAN (European Society for Pediatric Gastroenterology, Hepatology and Nutrition) guidelines, the complications were divided into early or late, and minor or major [3].

Methods

Literature was searched on PubMed® using terms "percutaneous endoscopic gastroscopy", "children", "complications" and "mortality". Eighteen articles were published between 1994 and 2017 about the complications of different PEG techniques. Altogether, data from 4631 patients were collected and analyzed in this study. Surgical techniques were divided into five different groups. Group-1 had the original pull technique, Group-2 had one-stage PEG insertion, Group-3 had introducer technique, Group-4 had image-guided technique and the last group Group-5 had laparoscopic-assisted PEG insertion.

Surgical techniques

Group-1, the original pull technique described by Gauderer was utilized [1]. In this technique, during gastroscopy a puncture site is determined above the inflated stomach. The correct insertion site is midway between the umbilicus and the junction of the costal margin and the left mid-clavicular line [3]. A needle is inserted followed by a trocar through the abdominal wall into the stomach. While the trocar is withdrawn, the sheath stays in situ. The guide wire is passed through the sheath and retrieved out through the mouth. The gastrostomy tube is looped to the end of the guide wire that is pulled back into and out of the stomach until the bumper comes to lie on the anterior gastric wall. If the tube is in the right position, it is cut down and the adapter plug is inserted [4].

Group-2, one-stage PEG button insertions are performed, which is a similar procedure to the pull technique described by Gauderer except for the final step. The design of the tube allows the button part of the PEG to be hidden inside the introducer part of the PEG. Once this sheath is peeled off, the flanges of the button are deployed and the cap is placed on it. The second anesthesia for PEG change to PEG button can be avoided with this technique [2, 5].

Group-3 uses the introducer technique, when gastric tube is inserted through a percutaneous puncture to avoid its passage through the mouth. Long curved needles are used for two parallel gastropexy stitches under gastroscopic assistance. These stitches provide the fixation of the anterior wall of the stomach. The metal trocar designed for PEG is inserted through a percutaneous incision. The sheath is removed and the balloon of the gastric tube is inflated. This technique prevents peristomal infections and pharyngoesophageal tumor implantations [5, 6].

Group-4 had image-guided PEG insertion using biplane fluoroscopy. Oral barium sulfate suspension is given to the patient the night before the procedure for localization of the colon. Ultrasonography is used for visualization of the liver. A snare is passed orally and a guide wire is inserted in the stomach under fluoroscopic guidance and withdrawn through the mouth. A snare catheter is pulled in a retrograde fashion from the abdominal wall to the mouth, and finally the PEG is pulled down through the esophagus [7].

Laparoscopic assistance is used in Group-5. A scope is introduced through an umbilical port site. If the stomach is visualized, a 5 mm port is placed in the left upper quadrant. The stomach is grasped with a Babcock forceps and pulled up directly to the abdominal wall. A full thickness gastric traction stitch is performed. After placing two anchoring fascial sutures and a purse-string suture, the balloon gastrostomy tube is inserted through a small incision and the sutures are tied [8, 9].

Results

PEG insertions were performed in 4631 patients (2441 males, 1945 females and 245 unknown). The median age of the patients was 3 years (newborns—26 years). Indications for PEG were reported in 2632 (56.8%) patients. Most common indications for gastrostomy were inability to swallow or dysphagia in 859 (32.6%), failure to thrive in 723 (27.5%), feeding difficulties in 459 (17.2%), aspiration in 201 (7.63%) and poor weight gain in $n = 158$ (6%). (Suppl. Table 1).

About 60–70% of the children had at least one comorbidity. A total of 1777 (38.4%) patients had impaired neurologic status and 704 (15.2%) had oncologic conditions. Metabolic, respiratory, cardiac and neuromuscular disorders were also common among these patients (Suppl. Table 2).

Prematurity, thoraco-abdominal deformity, previous abdominal surgery, peritoneal dialysis (PD) catheter and ventriculo-peritoneal (VP) shunt were the most frequently mentioned risk factors for complications during the PEG insertion procedure (Suppl. Table 3).

Complications

Several procedures of PEG insertion techniques exist to prevent the higher risk of complications. Among the examined 4631 patients, 1518 had minor complications. The most common minor complications were superficial and of infectious origin: granulation tissue ($n=478$,10.3%), local infection ($n=384$, 8.3%), external leakage ($n=279$, 6%) and skin erosion or erythema ($n=188$, 4.1%). Unplanned tube removal after postoperative period occurred in 65 cases, tube migration and obstruction developed in 2%. Less common complications are described in Suppl. Table 4.

Major complications developed in 464 (10%) patients. Almost 50% of the major complications were related to infections. Systemic infections occurred in 163 (3.5%) patients which were treated with intravenous antibiotics. Cellulitis, peritonitis, sepsis or wound dehiscence was noticed in 1.5%. Pneumoperitoneum was observed in 34 (0.7%) patients. Asymptomatic pneumoperitoneum can occur without intestinal perforation as a result of the procedure; however,esophagus or bowel perforations were noticed in 13 patients (0.3%). Gastrocolic fistulas were found in 21 patients (0.45%). Buried bumper, intraabdominal bleeding and ileus were detected in 1% (Suppl. Table 5).

Mortality

Literature was also searched for mortality within few weeks of insertion in different insertion techniques; however, all the patients with lethal outcomes ($n=7$) had severe comorbidities and died due to severe outcomes of general conditions such as sepsis ($n=6$) or cachexia ($n=1$). There was no association between mortality and the operative technique (Suppl. Table 6).

Laparoscopic versus original pull insertion

Two studies compared the major complications rate after laparoscopic and original PEG insertion technique in high-risk patients. All these patients had at least one severe comorbidity; the most important comorbidities were neurologic disorders, previous abdominal surgeries, VP shunts and PD catheters. There were 541 patients in the original pull technique group and 45 patients in the laparoscopic-assisted group [8]. In the first group, the most common major complications were buried bumper, granulation, peritonitis and gastrocolic fistula. Altogether, 12.6% of the high-risk patients had major complications in the first group. In the laparoscopic group, only 4.4% patients with severe comorbidities had major complications. One patient had peritonitis and one child had gastrocutaneous fistula after the removal of the PEG. According to this report [8], the complication rate is higher in patients with VP shunt, hepatomegaly, PD catheter, esophageal stenosis, coagulopathy and in infants weighing less than 2 kg. Age, mental retardation, scoliosis, previous abdominal surgery and severe constipation are not risk factors for major complications (Table 1).

Table 1 Comparison of original and laparoscopic-assisted percutaneous endoscopic gastrostomy (PEG)

Variables	Number of patients (*n*)	Comorbidities	Complications (*n*)	Conclusions
Pull technique	541	Neurologic Oncologic Gastrointestinal VP shunt Hepatomegaly PD catheter Coagulopathy	Buried bumper (11) Gastrocolic fistula (8) Granulation (8) Peritonitis (8) Gastrocutan fistula (5) Tube migration (4) Infection (4) Bleeding (3) Pneumonia (1) Esophagus perforation (1) Miscellaneous (15)	Higher risk of complications Significant: VP shunt Not significant, but higher: Hepatomegaly PD catheter Esophageal stenosis Coagulopathy Infant < 2 kg
Laparoscopic-assisted PEG	45	Neurologic VP shunt Previous abdominal surgery Hepatomegaly Extreme kyphoscoliosis Colon interposition Situs inversus	Peritonitis (1) Gastrocutan fistula (1)	No risks: Age < 1 y Mental retardation Scoliosis Previous surgery Constipation 0% conversion

PD peritoneal dialysis, *VP* ventriculo-peritoneal

Discussion

Percutaneous endoscopic gastrostomy is the most widespread technique for enteral feeding of patients with dysphagia, feeding difficulties or nutritional absence. The original technique described by Gauderer has many modifications [1]. This study analyzed the risk factors for different minor and major complications.

Age, weight and maturity

According to Szlagtys et al., PEG insertion is advisable as early as possible in patients with feeding disorders even in infancy if long-term enteral access is necessary, because better nourished children have less postoperative complications [10]. At the time of intervention, younger patients had lower prevalence of severe malnutrition than older children. Early nutritional supplementation is associated with better outcome [10].

Young age is often mentioned as risk factor; however, McSweeney et al. found that age younger than 6 months was significantly protective against major complications [11]. Children weighing < 4 kg had lower risk for major complications. In the same study, ASA (American Society of Anaesthesiologists) III class had lower complication rate than in ASAI-II and ASA IV–V groups. These patients were hospitalized before PEG placement and had more intense postoperative monitoring. Lalanne et al. reported higher rate of late complications in patients younger than 1 year. More than 60% of late complications were granulation tissue, local erythema or leakage [12]. Another study found that there was no difference in outcomes in patients < 1 year [11]. Forty infants with a mean gestational age of 29 weeks were treated with PEG. Premature infants had similar minor and major complication rates as older children [13]. According to an Italian multicentre study, age was not an independent variable influencing the factor of complications. However, patients older than 5 years had significantly higher incidence of intraoperative complications [14].

Operative techniques

Nah et al. reported a new technique called image-guided PEG with easy insertion and avoidance of laparotomy incision [7]. Ultrasonography and fluoroscopy were used as guidance in 331 patients. However, original PEG insertion had lower overall complication rate than the image-guided procedure.

One-step low-profile PEG insertion was used in 45 children. Almost all patients had an upper gastrointestinal study before the placement to evaluate anatomical abnormalities [15]. In this method, anesthesia is not required for change or removal [16]. The introducer technique had the advantage of avoiding the oral passage, so these patients had less peristomal infections. Campoli et al. reported 0.2% peristomal infection rate with the introducer technique even without using prophylactic antibiotics [6].

Two articles compared the outcomes after the original pull technique and laparoscopic-assisted PEG insertion in high-risk patients. Vervloessem et al. reported 467 patients (448 PEG, 19 laparoscopic-assisted PEG) with potential risk factors: age under 1 year, mental retardation, scoliosis, esophageal stenosis, hepatomegaly, upper abdominal surgery, VP shunt, peritoneal dialysis or coagulopathy [8]. Normal PEG procedure had 12.6% major complications; however, there were no major complications in the 19 laparoscopic-assisted PEG. Only VP shunt was a significant risk factor ($P = 0.002$) for major complications. Hepatomegaly, coagulopathy, esophageal stenosis and peritoneal dialysis were possible risk factors; however, the number of patients were low. Zamakhshary et al. compared 26 laparoscopic and 93 original PEG procedures in high-risk patients [9]. In the laparoscopic group, there was one major tube-specific complication, a formula drainage around the tube and a non-specific complication: a gastrocutaneous fistula. The overall complication rate was 7.7% in the laparoscopic group and 14% in the standard PEG group with more severe complications, for example transcolonic tube placement, peritonitis or disruption of the gastrocutaneous tract. Landish et al. reported that significant major complications included a 3.8% incidence of gastrocolic fistula among standard PEGs (3.8% vs 0%, $P = 0.04$) and 7.6% early tube dislodgements among the laparoscopic group (0 vs. 7.6%, $P = 0.01$) [17]. According to McSweeney et al., the frequency of complications decreased after the first year following PEG insertions [2].

Comorbidities and risk factors

McSweeney et al. found that patients with neurologic disorders had less major complications, because they are usually hospitalized and are under increased supervision [2]. However, patients with VP shunt have higher risk during PEG insertion [2]. Patients with VP shunt had a significantly higher risk ($p\ P = 0.07$) for major complications. Oncologic patients without neurologic disorders or with failure to thrive had greater risk for a major complication. According to Fortunato's data, neurologically impaired patients had elevated risk for wound infection; however, this population demonstrated greater weight gain after the PEG placement [18]. Respiratory diseases were association with fewer early complications according to Lalanne et al. [12]. Late complications were less frequent in patients with neurological disorders and more frequent with digestive diseases. Eleven

pediatric bone marrow-transplanted children were operated with PEG placement. Four patients were neutropenic during the procedure and all these patients had severe infection after the procedure. According to this study, significant neutropenia may be a contraindication for PEG placement [19].

Several risk factors were analyzed for major complications on 467 patients with PEG procedure. Only VP shunt was found to be a significant risk factor [8]. Hepatomegaly, coagulopathy, esophageal stenosis and peritoneal dialysis were described as possible risk factors; however, age under 1 year, mental retardation, scoliosis, constipation and upper abdominal surgery were not related to complication rate. Thoraco-abdominal deformity had a greater incidence of late complications such as decubitus or leakage [14].

Conclusions

At least 60–70% of the children with feeding difficulties such as dysphagia or failure to thrive that qualify for PEG insertions have at least one comorbidity. Parents/caregivers report that the gastrostomy is a great help for themselves and their child [20]. PEG is a safe operative technique for enteral feeding, with frequently observed minor complications and a low rate of major complications [21]. Patients with VP shunt have higher risk of major complications. In case of high-risk patients, laparoscopic-assisted PEG is recommended.

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Compliance with ethical standards

Ethical approval This article does not contain any studies with human participants performed by any of the authors.

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Review Article

Outcomes of laparoscopic incarcerated inguinal hernia repair in children

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Abstract

Aim: Laparoscopic inguinal hernia repair (LIHR) is gaining widespread acceptance, but its role in the management of incarcerated cases is not well outlined. This review analyses the outcomes of laparoscopic repair of incarcerated inguinal hernia in children.

Patients and Methods: Literature was searched on PubMed® using terms 'laparoscopic', 'incarcerated', 'inguinal', 'hernia' and 'children'. Age, sex, side, sac content, operative technique, follow-up period, complication and recurrence rate were analysed.

Results: Fifteen articles with 689 paediatric incarcerated inguinal hernias were identified between 1998 and 2018. Median age of patients was 22.4 months (2 weeks–16 years; M:F = 2.2:1). Side was mentioned in $n = 576$: $n = 398$ (69.1%) right and $n = 178$ (30.9%) left. In $n = 355$ (51.5%) manual reduction and delayed surgery (MRDS), in $n = 34$ (4.9%) manual reduction in general anaesthesia (MRGA) followed by emergency LHR and in $n = 300$ (43.5%) intraoperative reduction (IOR) was necessary. Incarcerated contents were documented in $n = 68$: intestine $n = 36$ (52.9%), ovary $n = 14$ (20.6%), omentum $n = 11$ (16.2%), appendix $n = 5$ (7.4%) and Meckel's diverticulum $n = 2$ (2.9%). Among the $n = 18$ girls in IOR group, $n = 14$ (77.8%) had ovaries incarcerated. For LHR, the hook method was used in 376 (54.6%) and purse-string suture in 313 (45.4%), with two conversions in IOR group. Mean followup was 15 months (3–80 months), with one (0.15%) testicular atrophy, and 4 (0.58%) recurrences in MRDS and 1 (0.15%) in IOR. All five cases were closed with pursestring technique. Total recurrence rate was 0.73%; significantly higher ($P = 0.014$) with pursestring ($n = 5$, 1.6%) than with the hook (none).

Conclusion: Hook and purse-string methods are equally popular in LHR for paediatric incarcerated hernias, with 50% hernia reductions possible at the time of surgery. Recurrence rate is low and comparable with non-incarcerated hernias; however, it is significantly higher in purse-string method than hook technique.

Keywords: Incarceration, inguinal hernia, laparoscopic, paediatric, repair

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INTRODUCTION

Indirect inguinal hernia repair is one of the most common surgical procedures in paediatric population. From 1995, laparoscopy was employed to repair the open internal inguinal ring and also to check the contralateral patent processus vaginalis.[1] Laparoscopic hernioplasty thereafter gained popularity; however, its role in incarcerated cases is not well outlined. The incidence of incarcerated inguinal hernia is estimated to be as high as one-sixth

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of the total population with inguinal hernia.[2] If it is not treated in time, serious complications can develop, such as intestinal obstruction, strangulation and perforation, testicular atrophy or ovarian necrosis. If manual reduction manoeuvres fail, urgent surgical treatment is necessary. Conventional open surgery in these patients may be difficult due to inflammation and oedema, which in turn may increase the risk of intraoperative injury of the vas deferens or testicular vessels.[3,4] Laparoscopic inguinal hernia repair (LIHR) gives the advantage of excellent visualisation, ability to evaluate contralateral side, less iatrogenic trauma of incarcerated structures and decreased operative time.[2,5,6] Even the pneumoperitoneum helps to widen the internal ring that can aid in the reduction.[7] After the reduction of hernia content, the inguinal ring can be closed in the same session with one of the minimal access technique such as purse-string suture or hook method.

This study performs a literature review to determine the outcomes after LIHR in children with incarcerated inguinal hernias.

PATIENTS AND METHODS

Literature was searched from 1998 to 2018 on PubMed® using the terms 'laparoscopic', 'incarcerated', 'inguinal', 'hernia' and 'children'. Data were extracted with regard to the age of the child, sex, side of the hernia, sac content, operative technique, follow-up period, complication and recurrence rate and were analysed in this study.

RESULTS

Fifteen articles with 689 incarcerated inguinal hernias were identified that met the inclusion criteria in the English literature. The age distribution at the time of surgery was 2 weeks to 16 years, with median age being 22.4 months. Male-to-female ratio was 2.2:1. The affected side was reported in 576 patients, with 69.1% (n = 398) being right-sided and 30.9% (n = 178) left-sided.

In 355 (51.5%) patients, manual reduction and delayed surgery (MRDS) was performed in 24–48 h. In 34 (4.9%) patients, manual reduction was achievable only in general anaesthesia (MRGA) followed by emergency LIHR. In 300 (43.5%) patients, the hernia content was reducible only intraoperatively (IOR) with laparoscopic instruments and external pressure [Table 1].

During the intraoperative reduction, incarcerated contents were documented in 68 patients: intestine n = 36 (52.9%), ovary n = 14 (20.6%), omentum n = 11 (16.2%), appendix n = 5 (7.4%) and Meckel's diverticulum n = 2 (2.9%). Among the 18 girls in IOR group, 14 (77.8%) had ovarian incarcerated in the sac [Table 2].

The hernia repair was achieved by two different surgical techniques. After the hernia contents are reduced, intracorporeal and extracorporeal techniques can be used for repairing the hernia. Laparoscopic repair of inguinal hernias in paediatric girl patients was first described in 1997 by El-Gohary.[8] During intracorporeal techniques such as purse-string suture, all suturing and knot tying around the inguinal ring is done within the abdominal cavity with laparoscopic instruments, which was first described by Montupet and Esposito in 1999.[9] During extracorporeal hook technique, a stab incision is performed above the inner ring, the needle is introduced medially around the ring in the preperitoneal space, the suture loop left intraabdominally when the needle is withdrawn. With the same technique from the opposite side of the ring, the suture is pulled outside and tied extracorporeally; extracorporeal technique was published first by Prasad *et al*.[10] Hook method was used in 376 (54.6%) and purse-string suture in 313 (45.4%) patients. Two conversions were found in IOR group; in one patient the reduction required release of the external inguinal ring and in the other patient LIHR was hampered by a friable internal ring. Mean follow-up time was 15 months (3–80 months). During the follow-up, 1 (0.15%) testicular atrophy was reported in the IOR group.[3] Recurrence was found in 4 (0.58%) patients in MRDS group and in one (0.15%) in IOR group.

All five recurrences were found in purse-string technique group. Total recurrence rate was 0.73%. Recurrence was significantly higher (P = 0.014) with Chi-square test in purse-string group (n = 5, 1.6%) than with the hook technique (n = 0).

Table 1: Treatment options for laparoscopic incarcerated inguinal hernia

Surgical technique	Number of reductions, *n* (%)
Manual reduction and delayed surgery	355 (51)
Manual reduction in general anaesthesia and emergency LIHR	34 (5)
Intraoperative reduction	300 (44)

LIHR: Laparoscopic inguinal hernia repair

Table 2: Incarcerated contents found in the inguinal canal

Incarcerated contents	Number of cases, *n* (%)
Intestine	36 (52.9)
Ovary	14 (20.6)
Omentum	11 (16.2)
Appendix	5 (7.4)
Meckel's diverticulum	2 (2.9)

In the reviewed literature, four male patients required laparoscopic assisted bowel resections: 2 small bowel gangrene, 1 perforated Meckel's diverticulum and 1 deep serosal tear of small bowel. Two partial omentectomies were performed laparoscopically and an oophorectomy in case of necrotic ovary.[11]

One testicular atrophy was mentioned after a late, difficult instrument aided reduction.[3] Umbilical granuloma was mentioned in 19 patients (4,8%).[5,11] Other minor complications were detected in <1% such as hydrocele (n = 6), port site hernia (n = 6) and trocar infection (n = 3).[3,5]

DISCUSSION

LIHR is one of the most common minimally access surgery procedures performed in paediatric patients.[12] Incarceration is the severe complication of inguinal hernias, for which emergency treatment is necessary. Manual reduction of the hernia content should be performed with care. After successful reduction, as soon as the patient's general condition improves, the hernia should be closed (MRDS). Hernia can be repaired open or using minimal access techniques, after 24–48 h, during the day shift, when the patient is in good general condition and when the risk of anaesthesia is lower. Laparoscopic closure has the advantage to avoid the difficult dissection of an oedematous sac in the groin even days following reduction of incarceration, and it permits the repair of a contralateral patent processus vaginalis if present.[4]

If general anaesthesia is necessary for successful manual reduction (MRGA), it is recommended to do emergency laparoscopy in the same session, because it allows inspection of the reduced hernia content and serosal or deeper intestinal injury, Meckel's diverticulum or ovarian necrosis.

Reduction of severely incarcerated contents can be done by a combination of retraction using laparoscopic instruments together with external manual pressure – intra-operative reduction (IOR). Further advantage of using the laparoscopic techniques is that carbon dioxide insufflation and intra-abdominal pressure widen the internal inguinal ring, which helps the reduction.[7] Furthermore, under direct vision, the degree of intestinal injury or gonad necrosis can be evaluated, and laparoscopic treatment can be performed.[13] If the incarcerated content is the appendix or the Meckel's diverticulum, both these structures can be resected laparoscopically.[5,14] Even the repair of the contralateral patent processus vaginalis can be performed with minimally invasive techniques in the same session.[6,15]

Bowel necrosis due to strangulation or serosal tears resulting from the retraction force of laparoscopic instruments can be treated with intracorporeal suturing,[8] or damaged intestine could be exteriorised through the single-incision LIHR for repair.[16] Omentectomy, oophorectomy or Meckel's diverticulum resection can also be managed with the minimal access approach.[11]

Only one testicular atrophy was documented in a male who underwent a late, difficult instrumental reduction. It can be hypothesised, that the development of testicular atrophy can be attributed more to the duration of incarceration and condition of the testis, rather than the surgical technique employed.

Two conversions were documented: in the first case the releasing of the external inguinal ring was necessary and in the other case, the LIHR was hampered by a friable internal ring.[12]

In girls with irreducible hernia, the content of hernia is most commonly the ovary. Irreducible hernias with ovarian content should be treated by laparoscopy, as soon as possible after they are detected.[16] Incarcerated hernias containing ovary can be corrected laparoscopically with or without cutting the external inguinal ring with a small skin incision.[17]

Recurrence rate of LIHR after incarceration is as low as 0.78%, which is comparable with non-incarcerated hernias.[18] However, recurrence rate in case of incarcerated hernia after open closure can be 15%–20%.[19] Hook and purse-string methods are equally popular in LIHR for paediatric incarcerated hernias; however, recurrence is significantly higher with purse-string suture than hook technique.[3,6,19] It can be hypothesised that the recurrence in the purse-string technique can be overcome if the oedema in the area of the internal inguinal ring is recognised and an additional Z-suture is placed to reinforce the purse-string suture. Other factors that could play a role is (a) the type of suture material (thickness and braided vs. monofilament) used for these repairs, (b) the numbers of 'crushes' to the suture material by the instruments, especially in case of monofilament sutures, which could weaken the suture strength with multiple grasps and (c) number of knots tied to hold the suture bearing in mind that unwinding can take place in monofilament sutures with three knots.

LIHR for incarcerated hernias is highly recommended, because of its advantages in reduction of irreducible hernias

with pneumoperitoneum. Laparoscopic instruments can help pulling the content of sac during external manual pressure. Even after successful reduction, the content is under direct vision to check if any injury occurred. Inguinal hernia can be easily closed with any LIHR technique, without the danger of injury of vas or vessels encountered in open way. If intestinal injuries or gonadal necrosis or Meckel's diverticulum is visible, it can be treated immediately by laparoscope.[20] Laparoscopic treatment has short post-operative stay and excellent aesthetic outcomes.[21,22]

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Conflicts of interest

There are no conflicts of interest.

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Gyermeksebészeti szakképzés kulcslyukon keresztül

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Bevezetés és célkitűzés: A minimálinvazív technikák a gyermeksebészetben is egyre nagyobb teret hódítanak, melyek elsajátítása fontos feladata a szakképzésnek. Felmérésünk a gyermeksebészek laparoszkópos tréningjét elemzi.
Módszer: E-mail formájában kerestük fel a szakorvosjelölteket, illetve a 2012 után szakvizsgázott gyermeksebészeket. A kérdőív a szakképzés alatti laparoszkópos lehetőségeket és a szubjektív véleményeket dolgozta fel.
Eredmények: E-mailben küldtünk ki 34 kérdőívet, melyre 17 szakorvosjelölt és 11 fiatal szakorvos válaszolt (összesen 82%). A traumatológiai ellátást nem végző képzőhelyeken 15%, a többi központban 2% és 10% közötti a minimálinvazív műtétek aránya. Minden gyermeksebészeten végeznek rutin laparoszkópos műtéteket, míg az osztályok 40–60%-án haladó laparoszkópos beavatkozások is elterjedtek. A rezidensidőszak első 2 évében a szakképzésben lévők fele jutott laparoszkópos műtéthez. A 3–6. képzési évben átlagosan 20 laparoszkópos műtét jutott a szakorvosjelölteknek. A képzésben lévők 50%-ának van lehetősége laparotrainer használatára, azonban az endoszkópos műtétekre való felkészüléshez az oktatóvideók megtekintése a legelterjedtebb (100%). A gyermeksebészek véleménye arról, hogy rendelkeznek-e elegendő laparoszkópos tapasztalattal a szakvizsgára: n = 6 (21%) igen, n = 12 (43%) elégséges és n = 10 (36%) nem. Véleményünk szerint a képzés javítható lenne az eszközpark bővítésével, laparotraineres és állatkísérletes ingyenes gyakorlatokkal és az oktatók türelmesebb és odaadóbb hozzáállásával.
Következtetés: A legtöbb képzőhelyen a laparoszkópia már a mindennapi gyakorlat része, a szakképzésben lévők azonban kevés lehetőséget kapnak a magabiztos jártasság megszerzéséhez. A laparotrainerek rendszeres használata és több műtéti lehetőség biztosítása lényegesen javíthatná a képzést. Szükség van a szakképzés műtéti követelményrendszerének revíziójára, a laparoszkópos műtéti szám emelésére.
Orv Hetil. 2018; 159(43): 1747–1753.

Kulcsszavak: gyermeksebészet, sebészet, szakképzés, laparoszkópia, tapasztalat

Training for pediatric surgeons through the keyhole

Introduction and aim: Minimally invasive techniques are gaining popularity in pediatric surgery, confident knowledge in endoscopies is one of the main purposes of the training. This survey analyzed the laparoscopic training for pediatric surgeons.
Method: We sent questionnaires to all trainees and pediatric surgeons specialized after 2012 by e-mail. The questionnaire focused on their opportunities for laparoscopy during the training and their subjective opinions.
Results: 34 questionnaires were sent by email. 17 trainees and 11 specialists responded (82%). The rate of endoscopic surgeries is 15% in the clinical centers without trauma surgery, and 2–10% in other training centers. Routine laparoscopies are performed in all centers, and in 40–60% of the centers, advanced endoscopies are also applied. Half of the surgeons performed laparoscopy in the first 2 years of training. An average of 20 laparoscopies were carried out by trainees in the 3–6th year. 50% of the trainees had the opportunity to use pelvitrainer, however, video-watching (100%) is the most common preparation before endoscopies. The surgeons' subjective opinion about having enough laparoscopic experience by the time of the specialty exam was yes: n = 6 (21%), sufficient: n = 12 (43%) and no: n = 10 (36%). The training could be more effective with more equipment, free courses on pelvitrainers or animal models, and with more patient and dedicated attitude of the instructors.
Conclusion: Laparoscopy is in everyday practice in major centers, however, trainees do not have enough experience in terms of its confident use. Endoscopic training could be better with the regular use of pelvitrainers and more surgical practice. Revision of the operation list and the rise in the number of laparoscopies are necessary.

Keywords: pediatric surgery, surgery, training, laparoscopy, experience

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Rövidítések

MIS = (minimally invasive surgery) minimálinvazív sebészet; UEMS = (Union of European Medical Specialists) Európai Szakorvosi Szövetség

A magyarországi gyermeksebészeti szakképzést évtizedek óta országosan egységes, szigorú követelményrendszer jellemzi. Az 1991-ben megalakult Gyermeksebész Szakmai Kollégium egyik legfontosabb feladatának tekintette a gyermeksebészi szakvizsga megszerzésének egységesítését, ezzel emelve a szakma színvonalát. E törekvés eredményeként a korábbi ráépített szakképesítés mellett lehetővé vált alap-szakképesítésként is specializálódni. Emellett a Kollégium megalkotta a Gyermeksebészeti Curriculumot, azaz leckekönyvet, melyben rögzítette a szakképzés követelményeit.

Az 1999-től életbe lépett szakképzési rendszerrel [1] a képzés ideje 6 évre hosszabbodott, illetve a gyermeksebészet alapszakképzésként került besorolásra. A régi rendszer szerint azonban gyermekgyógyászatra vagy általános sebészetre ráépített szakvizsgaként is megszerezhető a gyermeksebészi szakképesítés.

1. táblázat | Kötelező gyermeksebészeti műtéti teljesítmény a Curriculum alapján

	Végzett	Asszisztált	Látta
Általános gyermeksebészeti beavatkozások			
Inguinalis műtétek, hernia, hydrokele, kryptorchismus stb.	100	–	∅
Hasfali sérvek műtétei, umbilicalis, supraumbilicalis, epigastrialis	10	–	∅
Appendectomia	20	–	∅
Akut scrotum műtétei (testicularis torsio, Morgagni-hydatida stb.)	5	5	∅
Phimotomia	10	–	∅
Mélyvénás kanül behelyezése (percutan vagy feltárással végzett)	3	5	∅
Traumatológiai műtétek			
Fedett osteosynthesis	5	10	∅
ORIF (Open Reduction Internal Fixation, „véres osteosynthesis”)	2	5	∅
Ín-ideg varrat	2	3	∅
Transzplantáció (bőr)	5	5	∅
Plasticai műtétek			
Ajakplastica	2	2	
Szájpadzárás	2	2	
Nyaki fistula/cysta kiirtása, torticollis műtétje	2	3	
Z-lebeny-plastica	3	3	
Hasi műtétek			
Pyloromyotomia	5	5	
Ileus műtétje (stoma felhelyezése, stomazárás, adhesiolysis)	3	3	
Bélreszekció, anastomosis	3	5	
Fundoplicatio, anorectalis malformatio, Hirschsprung-betegség, colitis ulcerosa, Crohn-betegség, polyposis stb. definitív műtéte	2	5	
Tumorexstirpatio (hasi, retroperitonealis, mellkasi)	1	3	
Laparoszkópia (diagnosztikus vagy terápiás)	3	6	
Hydrostaticus desinvaginatio	3	5	
Újszülöttműtétek			
Oesophagusatresia, congenitalis lobalis emphysema, tüdő adenomatoid malformatio, rekeszsérv, rekeszrelaxáció	1	5	
Omphalokele, gastroschisis, Vitellinus-járat	2	5	
Vékonybél (duodenum is)-obstructio, stomafelhelyezés, újszülöttkori perinealis műtét (mini Pena)	2	5	
MMC-zárás, VP/VA shunt	1	2	
Urológiai beavatkozások			
Nephrectomia (zsugorvese, dysplasiás vese, multicystás vese, heminephroureterectomia)	3	6	
Pyelonplastica, ureterneoimplantáció, VUR endoszkópos kezelése	3	6	
Nephrostomiás katéter behelyezése, suprapubicus katéter behelyezése, vesicostomia, ureterocutaneostomia	2	5	
Ovarialis cysta, tumor, torsio műtéte	2	3	
Hypospadiasis, neourethra képzése	2	6	

MMC = nyitott gerinc; VA = agykamra–pitvar közötti; VP = agykamra–hashártya közötti; VUR = hólyagból a húgyvezeték felé visszaáramló vizelet

A Kollégium 2005-ben korszerűsítette a Gyermeksebészeti Curriculum képzési elemeit annak érdekében, hogy a magyar gyermeksebészképzés lépést tartson a szakma változásaival.

A képzés első két évében a rezidenseknek fél év sürgősségi gyakorlat mellett felnőtt-, illetve gyermeksebészeti osztályon kell alapjártasságot szerezniük. Az ezt követő négy év alatt koraszülött és gyermek intenzív osztályos gyakorlaton (3-3 hónap) és traumatológiai (6 hónap) képzésen is részt kell venni. A szakvizsga előtt még minimum 1 hónapi, külföldi gyermeksebészeti osztályon szerzett tapasztalat szükséges, illetve a hazai főbb képzőcentrumokban 1-1 hónapos forgás, melynek során a kollégákkal való személyes kapcsolat kialakítása mellett a műtéti listából hiányzó műtétek is pótolhatók.

A szakképzés során többször tanúbizonyságot kell adni a szerzett elméleti és gyakorlati tapasztalatról. A második év után rezidensvizsgát kell tenni a Gyermeksebészet Szakmai Kollégium Oktatási Bizottsága előtt, ahol az addig elvégzett műtétek jegyzékét is be kell mutatni [2] *(1. táblázat)*.

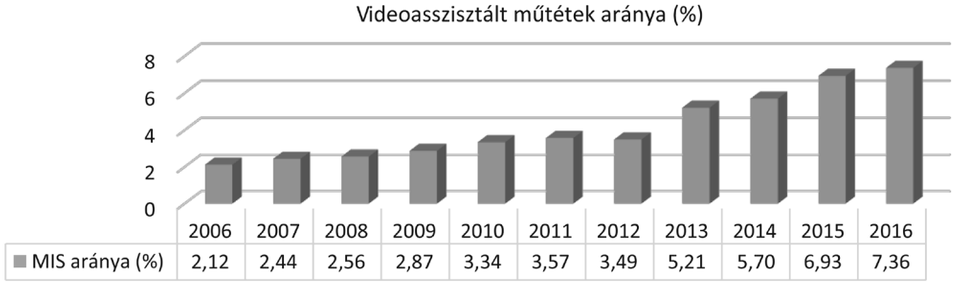
Ezt követően a szakorvosjelöltnek félévente a saját képzőhelyén, saját mentora és tutora előtt kell számot adnia elméleti tudásáról, az összegyűjtött kreditpontokról, illetve a hiányzó műtétekről. A képzés legkomolyabb megmérettetése talán az 5. év után következő előszakvizsga, melynek során az oktatási bizottság előtt kell megmutatni, hogy a sebész szaktudása megfelel az elvárásoknak. A vizsga kérdéseit műtéti, ultrahang-, illetve röntgenképek vezetik, nincs tételsor, a vizsgáztatók bármilyen témakörből kérdezhetnek. Ha a prezentált szaktudás vagy a műtéti repertoár nem elegendő, akár a szakvizsga halasztását javasolhatják. A 6. év végén szakvizsgára az bocsátható, aki a kötelező műtétek mellett legalább két előadást tartott országos vagy nemzetközi kongresszuson, egy tudományos cikke megjelent, és minimum 65 kreditpontot összegyűjtött. Kreditpontok az alapkövetelményen felül tartott előadásokkal, szakmai cikkekkel, nyelvvizsgával, külföldi kongresszusokkal, illetve tanfolyamokkal gyűjthetők.

A minimálinvazív technikák a gyermeksebészetben is egyre nagyobb teret hódítanak a laparoszkópia 1981. évi megjelenése, a *Kurt Semm* által végzett első laparoszkópos appendectomia óta [3]. Hazánkban az első laparoszkópos műtétet 1990-ben *Kiss Tibor* végezte [4]. A '90-es évek végétől a gyermeksebészeti osztályokon is megjelentek az első minimálinvazív beavatkozások, melyeket a felnőtteknél már bevált cholecystectomiák és va-

2. táblázat | Az éves statisztikai adatok az elmúlt évek minimálinvazív gyermeksebészeti műtéteiről, 2006–2016

	Éves műtéti szám (országos)	Éves videoasszisztált műtéti szám (országos)	A MIS aránya (%)
2006	20 640	437	2,12
2007	19 046	464	2,44
2008	19 395	497	2,56
2009	23 299	668	2,87
2010	24 126	805	3,34
2011	23 094	824	3,57
2012	22 977	802	3,49
2013	18 468	962	5,21
2014	19 067	1087	5,70
2015	17 458	1210	6,93
2016	16 397	1207	7,36

MIS = minimálinvazív sebészet



1. ábra | A videoasszisztált gyermeksebészeti műtétek aránya, 2006–2016

MIS = minimálinvazív sebészet

ricokeleműtétek során alkalmaztak, főként nagyobb gyermekeken. A későbbiekben az appendectomiák és a petefészekműtétek is laparoszkópos úton történtek egyre több centrumban. Ahogy a kisebb gyermekek számára kifejlesztett eszközök hozzáférhetővé váltak a centrumokban, úgy nőtt a beavatkozások repertoárja. Közel tíz éve már a legtöbb centrumban végeznek urológiai (hemi/nephrectomia, pyelonplastica, rejtett here), hasi (hernioplastica, fundoplicatio, pyloromyotomia, Meckel-diverticulectomia) és mellkasi műtéteket (lobectomia, decorticatio). Jelenleg az újszülöttsebészeti kórképek (nyelőcső-atresia, rekeszsérv, duodenumatresia) minimálinvazív ellátása az új mérföldkő, melyre már több képzőhelyen történtek sikeres próbálkozások. Míg a nagyobb centrumok folyamatosan bővítik a minimálinvazív műtétek (MIS) indikációs körét, addig néhány kisebb gyermeksebészeti osztályon a laparoszkópos technika elterjedése még lassabban halad, előfordul, hogy eszköz vagy megfelelő szaktudás hiánya miatt.

A Gyermeksebészeti Szakmai Kollégium éves statisztikájából kiderül, hogy hazánkban a MIS száma közel a háromszorosára emelkedett az utóbbi években *(2. táblázat, 1. ábra)* [5]. A modern gyermeksebészetben évről évre bővül a minimálinvazív műtétek száma és indikációs területe [6]. Napjainkban a laparoszkópos jártasság elengedhetetlen része a modern ellátásnak, így fontos eleme a szakképzésnek is.

Célkitűzés

A 2010-ben módosított Curriculum mindössze három laparoszkópos műtétet tartalmaz mint minimális műtéti követelményt, ez azonban napjainkban a magabiztos ellátáshoz igen csekély szám, ezért vizsgáltuk meg a jelenlegi képzés minőségét e tekintetben.

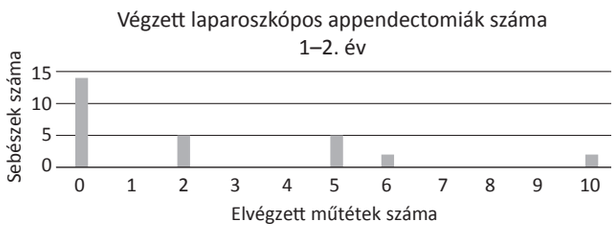
Felmérésünk célja a Magyarországon jelenleg gyermeksebészeti szakképzésben lévők és az utóbbi 5 évben szakvizsgázott sebészek laparoszkópos tréningjének elemzése és szubjektív véleményük feldolgozása a minimálinvazív képzés minőségéről.

Módszer

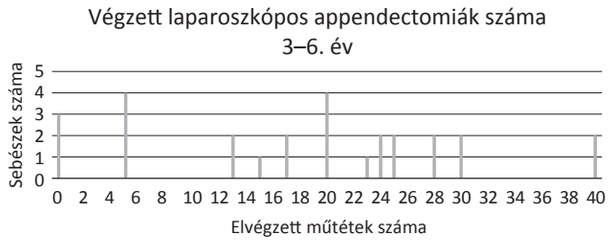
2017-ben összeállítottunk egy kérdőívet *(lásd a cikk végén)*, melyet 34 fiatal gyermeksebész számára küldtünk el e-mail-formátumban. A legfiatalabb megkérdezett is befejezte az alapképzést, azaz minimum a szakképzés 3. évében járt. A fiatal szakorvosok 2012 és 2016 között szereztek szakképesítést. A kérdőív a demográfiai adatokon kívül elemezte a rezidensidőszak és a speciális képzés alatt végzett laparoszkópos műtéteket, a műtétek körülményeit, a laparoszkópia elsajátításához és gyakorlásához szükséges feltételeket.

Eredmények

A kérdőívre 17 szakorvosjelölt és 11 szakorvos válaszolt, a válaszadási arány 82%. A videoasszisztált műtétek aránya a képzőcentrumokban 1,4% és 15,5% között változik, ahogyan a 2016-os statisztikai adatok mutatják *(3. táblázat)*. Mivel a gyermeksebészeti osztályoknak csak egy része végez gyermektraumatológiai műtéteket is – amelyek között a videoasszisztált műtétek előfordulása elenyésző (artroszkópia) –, ezen osztályok összesített műtéti számában a laparoszkópos beavatkozások aránya lényegesen alacsonyabb. A különböző képzőhelyek eltérő arányban látnak el speciális szakterületeket, így a számadatok nem vethetők össze egyenesen arányosan egymással vagy egyéb külföldi centrumok eredményeivel.



2. ábra | A szakorvosjelöltek által az első két évben elvégzett laparoszkópos appendectomiák száma



3. ábra | A szakorvosjelöltek által a 3–6. évben elvégzett laparoszkópos appendectomiák száma

3. táblázat | A 2016-os adatok a képzőcentrumokból

2016	Éves műtéti szám	Éves videoasszisztált műtétek száma	A MIS aránya (%)
Országos összesítés	16 397	1207	7,36
Debreceni Egyetem	1 203	186	15,5
Pécsi Tudományegyetem	2 005	104	5,2
Semmelweis Egyetem I.	1 720	251	14,6
Semmelweis Egyetem II.	1 067	98	9,2
Szegedi Tudományegyetem	1 728	170	9,8
Miskolci Kórház	1 758	163	9,3
Heim Pál Kórház	2 492	147	5,9
Madarász Utcai Gyermekkórház	734	10	1,4
Szent János Kórház	1 323	25	1,9

MIS = minimálinvazív sebészet

A szakképzésben lévő jelöltek megoszlása a klinikák és kórházak között (rezidens 7 : 10; szakorvos 5 : 6), illetve a főváros és vidék között (rezidens 8 : 9; szakorvos 6 : 5) arányos. Egy-egy képzőcentrumban 1 és 4 közötti a párhuzamosan szakképzésben lévő jelöltek száma.

Az összes hazai centrumban végeznek laparoszkópos technikával appendectomiát, cholecystectomiát, varicokele- és ovariumműtéteket. A képzésben lévők több mint felének van lehetősége saját képzőhelyén laparoszkópos orchidopexiában, splenectomiában, nephrectomiában, pylorus- vagy lágyéksérvműtétben részt venni. Újszülött haladó endoszkópos műtéteket (például oesophagusatresia, duodenumatresia, rekeszsérv) egyelőre még csak néhány egyetemi centrumban végeznek, kis esetszámban. Természetesen a centrumok közötti forgás a többség számára lehetővé teszi a ritkább beavatkozásokban való asszisztálást.

A jelöltek felének (n = 14) nem volt lehetősége a képzés első két évében laparoszkópos műtétet végezni, azonban 14 rezidens (50%) már ez időszakban is végezhetett minimálinvazív beavatkozást, főként appendectomiát. Mivel laparoszkópos appendectomiát minden centrumban végeznek, és ez a leggyakoribb minimálinvazív műtét gyermekkorban, ezt vettük összehasonlítási alapul. A *2. ábrán* jól látható, hogy 2 rezidensnek volt szerencséje 10 laparoszkópos appendectomiát is végezni. 8 rezidensnek (29%) lehetősége volt egyéb MIS-t végezni, például cholecystectomiát, varicokeleműtétet, pyloromyotomiát, orchidopexiát vagy hernioplasticát.

A szakképzés 3. és 6. éve között a jelöltek átlagosan 18 (0–40) appendectomiát végeztek *(3. ábra)*. A gyakornokok ez időszakban már átlagosan egy (0–6) cholecystectomiát és két (0–10) varicokeleműtétet is végeztek, illetve a jelöltek közel 80%-a 1–2 egyéb laparoszkópos műtétet is végrehajtott, mint például orchidopexia, ovariumcysta-eltávolítás, fundoplicatio vagy pyloromyotomia. Van azonban 3 olyan jelölt, ugyanazon képzőhelyről, akinek a 4. évig egyetlen laparoszkópos műtétre sem volt lehetősége.

A képzésben lévők 72%-ának leginkább az ügyeleti időben van alkalma laparoszkopizálni, hiszen a szakorvosjelöltek által végzett minimálinvazív beavatkozások nagyobb részét az ügyeletben végzett appendectomiák teszik ki. A műtétekben való részvétel aránya operatőrként, illetve asszisztensként átlagosan 1 : 2.

A szakképzés keretében kötelező laparoszkópos tanfolyam sajnos nem minden egyetemi központban része a rezidensi tematikának, így csak a képzésben lévők 71%-ának (20/28) volt lehetősége részt venni ingyenes hazai tanfolyamon. A többi gyakornok ezt térítés ellenében végezte el. Ezenfelül a sebészek csaknem egyharmadának (8/28) – főként önköltségen vagy támogatások segítségével – külföldi haladó kurzusra is lehetősége volt eljutni.

Laparotrainer a jelöltek 50%-ának rendelkezésre áll a saját osztályán, azonban ennek rendszeres használata mégsem része a mindennapi gyakorlatnak. Sajnos az elérhető laparotrainerek nagyrészt pénzügyi okokból házilag készített dobozból és a leselejtezett eszközökből állnak, illetve a kamera minősége is kifogásolható. Hiányzik a tapasztalt sebészek szervezte oktatás és a szabadidő a gyakorlásra. Egy műtétre a fiatalok 100%-a (28/28) inkább oktatóvideókkal készül, ezenfelül 54% tankönyv (15/28), 46% internet (13/28) vagy 32% cikkek (9/28) segítségét is igénybe veszi. Mindössze a fiatal sebészek 21%-a (6/28) gyakorol a műtét előtt laparotrainerrel.

A legtöbben alap- vagy közepes szintűnek értékelték laparoszkópos tapasztalatukat, mindössze egy sebész vélte jónak saját tudását, illetve két–három sebész bizakodó a jövőt illetően. Arra a kérdésre, hogy *„Úgy érzed, a szakvizsga idejére rendelkezel elég laparoszkópos tapasztalattal?”*, mindössze 6 fő válaszolt *igen*nel (21%). További 12 fő (43%) *elégséges*nek értékelte tapasztalatát, és 10 sebész nyilatkozta, hogy *nem* (36%). Természetesen azokon a képzőhelyeken, ahol kevesebb minimálinvazív beavatkozást végeznek, a szakorvosjelöltek kevésbé érzik megfelelőnek laparoszkópos tapasztalatukat.

Fontosnak tartottuk a képzésben lévők és a friss szakvizsgások véleményét arról, hogy a hazai körülmények között hogyan javítható a képzésnek ez a területe. A válaszok alapján 3 csoportot különíthetünk el. Az egyik lehetőség az eszközök hozzáférhetőségét, az anyagi oldalt célozza: legyen ingyenes, bármikor elérhető laparoszkópos oktatóközpont a képzőhelyeken; legyenek laparotrainerek a centrumokban, jó minőségű eszközökkel; szimulációs számítógépes játékok, illetve rendszeres állatmodelles műtétek. A válaszok következő csoportja a gyakorláshoz szükséges szabadidőt hiányolja a fiatalok ügyeleti leterheltsége miatt. A válaszok harmadik csoportja a mentorok általi oktatással kapcsolatos. A sebészek tapasztalata a legjobban a saját műtétekkel csiszolható, amihez szükség van a MIS számának további emelkedésére, műtéteket átengedő vezetőkre és türelmesen, tanító szándékkal asszisztáló oktatókra.

Következtetés

A magyarországi gyermeksebészeti szakképzés jól kidolgozott, a szakma minden területét lefedő képzést nyújt. Három egyetemi centrum (Budapest, Pécs, Szeged) alkotta konzorcium az UEMS (Union of European Medical Specialists) által akkreditált képzőhely. A szakorvosjelöltek képzése végig jól követett, nemcsak a mentor és a tutor által, hanem a Szakmai Kollégium Oktatási Bizottsága előtti szóbeli beszámolók során is. A fentiekből is látható azonban, hogy a képzés követelményrendszere nem tart lépést a modern minimálinvazív technikák térhódításával.

A hazai gyermeksebészetben az utóbbi másfél évtizedben egyre gyorsabban terjed a laparoszkópia, ám nagyfokú heterogenitást mutat. Míg az egyetemi centrumokban a naprakész elvárásokhoz közelítve a haladó laparoszkópos műtétek széles repertoárja megtalálható,

néhány kisebb osztályon a laparoszkópia még nem a napi gyakorlat része.

A műtéti lista fontos része a képzésnek, mivel ezáltal jól követhető a szakorvosjelölt manuális teljesítése. Míg a műtéti lista részletes, és a gyermeksebészet egész spektrumát lefedi – hasi, mellkasi sebészet, újszülöttsebészet, urológia, traumatológia, plastica –, a minimálinvazív műtétek teljesítése nagyon csekély arányban része a követelményeknek. Felmérésünk adatait ismertettük a Gyermeksebész Szakmai Kollégium Oktatási Bizottságával, és részben ennek hatására a műtéti lista revíziója folyamatban van. Várhatóan többféle minimálinvazív műtéti típust fog tartalmazni, magasabb követelményszámmal. Természetesen a készség elsajátítása a szakvizsgát követően is folytatódik, hiszen a megfelelő rutin eléréséhez több gyakorlatra van szükség.

A szakorvosjelöltek tapasztalatszerzésének minden alappillére nehézségekkel tarkított. Az egyes centrumokban elérhető laparotrainerek kihasználása nagy lehetőséget rejt magában, azonban még sincs mindennapos gyakorlatban. A gyermeksebészetben is észlelhető létszámhiány nem teszi lehetővé, hogy munkaidőben a laparotraineres gyakorlás a napi rutin része lehessen. Így többnyire a szabadidő feláldozásával lehetséges ez a gyakorlási mód. Sajnos a házi laparotrainerek nem adják vissza tökéletesen a műtéti körülményeket, ezért is gyakran mellőzötté válnak [7]. Az is fontos lenne azonban, hogy az endoszkópos tapasztalattal bíró vezetők szaktudásukkal segítsék ezeket a gyakorlatokat, hogy a jelöltek a praktikákat már a műtét előtt elsajátíthassák. Modernebb képzőhelyeken csak megfelelő laparotraineres vagy „virtuális valóság” gyakorlat után kezdhetnek asszisztálni a sebészek állatmodelles műtétekben, majd a kórházakban valódi műtétekben, végül operálni [8–10]. Otthoni gyakorlásra sajnos a manuális szakmákban igen csekély lehetőség van, ám több kutatás is példázza, hogy a videojátékok igen jó hatással vannak a sebészek endoszkópos készségeire [11]. Több elérhető laparoszkópos alap- és állatmodelles tanfolyam szervezése, illetve külföldi workshopokon való részvétel támogatása segítheti a színvonalasabb képzést [12].

A képzőhelyeknek a gyakorlati időből kell lehetőséget biztosítaniuk a különböző tréningeken, továbbképzéseken való részvételre. Ahogy az utóbbi évek növekedő tendenciája is mutatja, egyre több műtét kivitelezhető minimálinvazív technikával. Az emelkedő műtéti szám további lehetőséget kínál a fiatal sebészek számára. Fontos, hogy a mentorok műtétek átengedésével és türelmes tanítással támogassák a szakorvosjelöltek fejlődését.

A jelöltek nagy része kellő gyakorlattal rendelkezik az alapvető műtéti típusokból, a legtöbben még haladó műtétekhez is hozzájuthatnak, ennek ellenére még több műtéti tapasztalat szükséges a megfelelő magabiztosság megszerzéséhez.

Bár európai ajánlás létezik a laparoszkópos képzésről [13], a nemzetközi szakirodalomban nem találtunk hasonló felmérést, mely a gyermeksebészeti szakképzés alatt végzett minimálinvazív műtétek követelményszámát és a fiatal sebészeknek a MIS területén szerzett szubjektív elégedettségét vizsgálta. Egy angol közleményben 2010-es és 2015-ös adatokat hasonlítottak össze a gyermeksebészek képzéséről és elégedettségéről. Annak ellenére, hogy a képzési rendszer folyamatosan fejlődött, a válaszadók „jó” vagy „kiváló” minősítése mindössze 50% körüli volt mindkét időszakban [14].

Véleményünk szerint fontos a szakképzést irányítóknak és a szakorvosjelölteknek is egy átfogó ’feed-back’ rendszer a képzés minőségéről. A visszajelzések alapján javítható az oktatási rendszer, felismerhetővé válik egy-egy centrum erőssége és hiányossága, segítséget kaphatnak azok a jelöltek, akik számára nehezen teljesíthetők bizonyos műtéttípusok. A szakorvosjelölteknek is pozitív visszacsatolás, hogy véleményüknek súlya van, mellyel segíthetik a következő gyermeksebész-generáció még színvonalasabb képzését.

Felmérésünk megmutatta, hogy van igény a szakképzési rendszer kiterjedtebb felülvizsgálatára, még egy ilyen precízen kidolgozott képzési terv mellett is.

Anyagi támogatás: A közlemény megírása, illetve a kapcsolódó kutatómunka anyagi támogatásban nem részesült.

Szerzői munkamegosztás: B. B. és K. T. a feldolgozott kérdéseket közösen fogalmazta meg. B. B. kiküldte a kérdőíveket, összegyűjtötte a válaszokat, majd feldolgozta az adatokat. A cikk megírását követően K. T. a cikket átolvasta, kiegészítette. A cikk végleges változatát mindkét szerző elolvasta és jóváhagyta.

Érdekeltségek: A szerzőknek nincsenek érdekeltségeik.

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Kérdőív | Gyermeksebészeti laparoscopos training

1. Rezidens/szakorvos adatai:
   - o Név: (nem kötelező)
   - o Kor:
   - o Szakképzés hányadik évében vagy:
   - o Egyéb szakvizsga:
   - o Munkahely: (húzd alá)
     klinika vagy kórház
     főváros vagy vidék
   - o Hány rezidens/szakorvosjelölt van jelenleg a képzőhelyeden?

2. Műtéti szám a képzőhelyeden évente: ……
3. Minimálinvazív műtétek száma évente: …….
4. Milyen laparoscopos műtéteket végeztek az osztályon? (húzd alá)
   appendicitis
   varicokele
   lágyéksérv
   cholecystectomia
   hasüregi here
   splenectomia
   fundoplicatio
   ovariumcysta
   nephrectomia/heminephrectomia
   pyelonplastica
   pyloromyotomia
   újszülöttsebészet: oesophagusatresia
   rekeszsérv
   duodenumatresia
   egyéb: ……
   ……
5. Nem szakorvosként milyen laparoscopos műtétek elvégzésére jutott lehetőséged? Sorold fel miből, hány!
   Appendectomia:
   Cholecystectomia:
   Varicokele:
   Lágyéksérv:
   Hasüregi here:
   Egyéb: .....
   .....
6. Rezidensként végzett laparoscopos műtéteid milyen arányban történtek elektíven és ügyeleti időben?

7. Rezidensidőszak első 2 évében végzett laparoscopos műtétek száma és fajtái?
   Appendectomia: …
   Cholecystectomia: …
   Varicokele: …
   Lágyéksérv: ….
   Hasüregi here: …..
   Egyéb: ……..

8. Rezidensidőszak 3–6. évében végzett laparoscopos műtétek száma és fajtái?
   Appendectomia: …..
   Cholecystectomia: …..
   Varicokele: …..
   Lágyéksérv: …..
   Hasüregi here: …..
   Egyéb: ……..

9. Laparoscopos műtétben való részvétel aránya: operatőrként vs. asszisztensként? (kb.)

10. Laparotrainer elérhetősége az osztályon? Van Nincs
11. Milyen laparoscopos tréningen vettél részt a rezidensképzés alatt?
    Kötelező, ingyenes: Fizetős:
    Belföldi: Külföldi:
12. Hogyan értékeled saját laparoscopos tapasztalatodat? (szöveges válasz)
    ……
    ……
13. Hogyan készülsz fel laparoscopos műtétre?
    – Tankönyv
    – Cikk
    – Internet
    – Videó
    – Laparotrainer

14. Hogyan érzed: a szakvizsga idejére rendelkezel elég laparoscopos tapasztalattal?
    Igen
    Elégséges
    Nem

15. Véleményed szerint mivel lehetne javítani a laparoscopos képzést? (szöveges válasz)
    ……
    ……

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Original Article

Check for updates

Laparoscopic-Assisted Percutaneous Endoscopic Gastrostomy Reduces Major Complications in High-Risk Pediatric Patients

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Conflict of Interest
The authors have no financial conflicts of interest.

ABSTRACT

Purpose: Percutaneous endoscopic gastrostomy (PEG) is a safe method to feed patients with feeding difficulty. This study aimed to compare the outcomes of conventional PEG and laparoscopic-assisted PEG (L-PEG) placement in high-risk pediatric patients.
Methods: In our tertiary pediatric department, 90 PEG insertions were performed between 2014 and 2019. Children with severe thoracoabdominal deformity (TAD), previous abdominal surgery, ventriculoperitoneal (VP) shunt, and abdominal tumors were considered as high-risk patients. Age, sex, diagnosis, operative time, complications, and mortality were compared among patients who underwent conventional PEG placement (first group) and those who underwent L-PEG placement (second group).
Results: We analyzed the outcomes of conventional PEG placement (first group, n=15; patients with severe TAD [n=7], abdominal tumor [n=6], and VP shunts [n=2]) and L-PEG placement (second group, n=10; patients with VP shunts [n=5], previous abdominal surgery [n=4], and severe TAD [n=1]). Regarding minor complications, 1 (6.6%) patient in the first group underwent unplanned PEG removal and 1 (10%) patient in the second group had peristomal granuloma. We observed three major complications: colon perforation (6.6%) in a patient with VP shunt, gastrocolic fistula (6.6%) in a patient with Fallot-tetralogy and severe TAD, and pneumoperitoneum (6.6%) caused by early tube dislodgement in an autistic patient with severe TAD. All the three complications occurred in the first group (20%). No major complications occurred in the second group.
Conclusion: In high-risk patients, L-PEG may be safer than conventional PEG. Thus, L-PEG is recommended for high-risk patients.

Keywords: Percutaneous; Gastrostomy; Laparoscopy; Child; Complications

INTRODUCTION

According to the European Society for Clinical Nutrition and Metabolism guidelines, gastrostomy placement is indicated in all patients requiring supplementary feeding for >2–3 weeks. Enteral tube feeding aids in avoiding further body weight loss, correcting nutritional deficiencies, promoting growth in children, and improving patients' quality of life [1].

Percutaneous endoscopic gastrostomy (PEG) was first described in 1980 by Gauderer [2]. Currently, PEG is widely used worldwide; however, the rate of adverse effects is not low [3]. In the past decades, various technical modifications have been proposed to reduce complications. Techniques such as image-guided gastrostomy, introducer PEG, and single-stage PEG buttons or tubes have the advantage of avoiding the oropharynx and esophagus and thus, prevent the carriage of microorganisms to the peristomal site [3]. These variants of the push technique are useful in the case of esophageal tumors or surgery and can be performed even in smaller children when the internal fixation plate of the PEG is extremely large. A second intervention or anesthesia is not required to replace the tube in the push technique.

Laparoscopic guidance is useful in patients with severe TAD, hepatomegaly, or previous abdominal surgery, because the site of the puncture is under visuall control, and thus hepatic or colonic interposition, and vascular injuries are avoidable and adhesions can be released easily [4]. In laparoscopic-assisted gastrostomy (LAG), a gastrostomy tube is inserted laparoscopically by a surgeon. This technique is popular and can be used during laparoscopic fundoplication. In laparoscopic-assisted PEG (L-PEG), the original pull-through technique is performed under laparoscopic and endoscopic guidance. In L-PEG the laparoscopy provides an intra-abdominal view to the endoscopist. This help is crucial in high-risk patients, although transillumination of the abdominal wall is inappropriate.

This study aimed to analyze the outcomes of conventional PEG and L-PEG in high-risk patients in our tertiary pediatric center.

MATERIALS AND METHODS

A total of 90 PEG insertions were performed between January 2014 and December 2019 in our tertiary pediatric gastroenterological and surgical centers. Patients who underwent open, LAG, and one-step gastrostomy placements were excluded from the study. We retrospectively analyzed 25 of 85 high-risk patients (patients with severe thoracoabdominal deformity [TAD], previous abdominal surgery or abdominal tumor, and ventriculoperitoneal [VP] shunt) with respect to age, sex, diagnosis, indication for surgery, operative time, minor and major complications (intraoperative/postoperative), and mortality.

This study was conducted in accordance with the Declaration of Helsinki and the recommendations of the 2015 World Health Organization (WHO) guidelines. The study protocol was approved by the Human Investigation Review Board of the University of Szeged, Albert Szent-Györgyi Clinical Center (Approval No. WHO 4015). Written informed consent was obtained from all patients.

Operative techniques

1. Original pull technique

All PEG procedures were performed under general anesthesia using a flexible gastroscope (Fujinon EG-530WR [outer diameter: 9.4 mm] or Fujinon EG-530N [outer diameter: 5.9 mm]; Fujinon, Wayne, NJ, USA). The stomach was insufflated. After transillumination, a 5-mm skin incision was made by the surgeon at the appropriate site of the anterior abdominal wall. After puncture and air aspiration, a guidewire was passed through the cannula sheath into the stomach and was grasped and pulled out through the oropharynx along with the gastroscope. The loop of the gastrostomy tube was fixed to the guidewire and pulled back

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through the esophagus into the stomach and out through the puncture site until the internal fixation plate was adjacent to the anterior gastric wall.

2. L-PEG

An open (Hasson) technique was used to gain infraumbilical access to establish pneumoperitoneum by insufflating carbon dioxide at 1–3 L/min until an intra-abdominal pressure of 8–12 mmHg was achieved. A 5-mm port and 30° optic device were placed and abdominal exploration was performed. If the abdominal cavity was adhesion-free, the conventional PEG procedure was performed under gastroscopic and laparoscopic visual control. However, in the case of adhesions, adhesions were released using 3-mm instruments introduced through separate working ports and thereafter, the gastrostomy tube was inserted using the original pull technique.

RESULTS

A total of 25 high-risk patients underwent PEG tube placement between January 2014 and December 2019. Patients who underwent open, one-step, and LAG were not included in the analysis. This retrospective study included 15 (60%) boys and 10 (40%) girls with a mean age of 70 months (range: 2.5 months to 17.5 years).

These 25 high-risk patients were divided into two groups. The first group comprised 15 (60%) patients who underwent conventional PEG placement with the pull technique only under endoscopic guidance. The second group comprised 10 (40%) patients who underwent L-PEG placement under both endoscopic and laparoscopic guidance.

In the first group, the mean age of the patients was 71 months (range: 2.5 months to 17.5 years) and the boy:girl ratio was 9:6. In the second group, the mean age of the patients was 57 months (range: 10 months to 14 years) and the boy:girl ratio was 6:4 (**Table 1**).

Indications for gastrostomy in all cases were feeding difficulties or malnutrition.

Risk factors in the first group were severe TAD (n=7), abdominal tumor (n=6; neuroblastoma [n=3] and Wilms tumor [n=3]), and VP shunts (n=2), and those in the second group were VP

Table 1. Comparison of conventional and laparoscopic-assisted percutaneous endoscopic gastrostomies

Variable	Percutaneous endoscopic gastrostomy (n=15)	Laparoscopic assisted percutaneous endoscopic gastrostomy (n=10)
Mean age	71 mo (2.5 mo to 17.5 y)	57 mo (10 mo to 14 y)
Boy:girl ratio	9:6	6:4
Risk factors	Severe TAD (n=7) Abdominal tumor (n=6) Neuroblastoma (n=3) Wilms tumor (n=3) VP shunts (n=2)	VP shunts (n=5) Previous abdominal surgeries (n=4) Duodenal atresia (n=1) Previous gastrostomy (n=1) Left nephrectomy (Wilms tumor; n=1) Biopsy of rhabdomyosarcoma (n=1) Severe TAD (n=1)
Mean operative time	23 min (14–35 min)	46 min (32–80 min)
Minor complications	Unplanned removal of the tube (n=1, 6.6%)	Peristomal granuloma (n=1, 10%)
Major complications	Transverse colon perforation (n=1) Gastrocolic fistula (n=1) Pneumoperitoneum (n=1)	n=0
Lethality	n=1	n=0

TAD: thoracoabdominal deformity, VP: ventriculoperitoneal.

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shunts (n=5), previous abdominal surgeries (n=4; duodenal atresia, previous gastrostomy, left nephrectomy because of Wilms tumor, and tumor biopsy of rhabdomyosarcoma), and severe TAD (n=1). Adhesions were found in three (30%) patients, and they were released laparoscopically. There was no need for a conversion.

The mean operative time for the PEG procedure was 23 minutes (range: 14–35 minutes), whereas that for the L-PEG procedure was 46 minutes (range: 32–80 minutes) in the first group. The Welch's two-sample t-test revealed a significant difference between the length of the two procedures. The mean operative time of L-PEG was significantly (p=0.001) longer than that of the conventional PEG, especially if adhesiolysis was required (60–80 minutes).

After PEG placement, refeeding was started with water at 8 hours followed by formula at 24 hours in both the groups. The refeeding time did not significantly differ between the two groups. Hospital stay depended on refeeding time and underlying diseases and not on the operative technique.

Adverse effects were classified as minor or major according to the European Society for Pediatric Gastroenterology, Hepatic and Nutrition guidelines [5]. Minor complications occurred in two (8%) patients. In the first group, one (6.6%) patient underwent unplanned removal of the tube. The skin opening was closed immediately after unplanned removal and the internal fixation plate was emptied with a stool. In the second group, the occurrence of peristomal granuloma was noted in one (10%) patient.

We observed three major complications: transverse colon perforation, gastrocolic fistula, and pneumoperitoneum. All the three complications occurred in the first group (20%). No major complications (0%) were observed in the second group.

Regarding lethal outcome, one patient in the first group with severe comorbidities died because of severe outcomes of his general condition long after the postoperative period. However, no association was found between the fatal outcome and the operation.

DISCUSSION

Tube feeding is the method of choice when enteral nutrition is recommended and oral intake is insufficient. Previously, open gastrostomies were performed by surgeons through laparotomy. A Pezzer catheter was inserted into the stomach and fixed with a double-layer purse-string suture. Thereafter, the tube was brought out through a stab incision in the abdominal wall [2].

After PEG was first described by Gauderer [2] in 1980, this minimally invasive technique became the gold standard. The advantages of PEG are less scarring, shorter operative time, fewer infections, less postoperative pain, and shorter hospital stay [2]. In most cases, when the esophagus is patent and transillumination of the stomach through the abdominal wall is achievable, PEG tube placement is safe. The three principles of safe PEG placement are endoscopic gastric distension, endoscopically visible focal finger invagination, and transillumination [3,4]. However, these criteria are not considered in children with distorted anatomy because of severe scoliosis or intra-abdominal adhesions due to VP shunts, peritoneal dialysis, or previous operations. In these patients, a high risk of bowel or hepatic

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injury exists. Laparoscopy offers better and direct visualization of the stomach, and any adhesions can be released with this minimally invasive method.

According to a literature review on the complications of PEG insertions, the most common major complications after the conventional PEG procedure are systemic infections (3.5%) and peritonitis, sepsis, or wound dehiscence (1.5%). Pneumoperitoneum occurs in 0.7% of the patients. Asymptomatic pneumoperitoneum can occur without intestinal perforation because of the procedure; however, esophagus or bowel perforations occur in 0.3% of the patients. Gastrocolic fistulas because of the interposition of the splenic flexure between the anterior abdominal and gastric walls occurs in 0.45% of the patients. Buried bumper, intra-abdominal bleeding, and ileus are detected in 1% of the patients [3]. Impaired coagulation, severe ascites, peritonitis, and local esophageal and general gastrointestinal obstructions are considered absolute contraindications for PEG placement [6]. Severe kyphoscoliosis with interposed organs and distorted anatomy are relative contraindications [6]. Vervloessem et al. [7] analyzed the potential risk factors for major complications in 449 patients and found that only VP shunts were associated with a significantly high major complication rate. Although PD catheters, hepatomegaly, esophageal stenosis, and coagulopathy had high complication rates, the difference between the two rates was not significant.

In our institute, L-PEG was started in 2014 after a major complication in a patient with a VP shunt. Thereafter, all patients at high risk for intestinal injury (patients with VP shunt, PD catheter, previous abdominal surgery, severe thoracoabdominal deformities, hepatomegaly, or intra-abdominal masses) underwent L-PEG placement. Before selection of patients, conventional PEG placement was performed in 15 high-risk patients, that is patients with severe TAD (n=7), abdominal tumor (n=6), and VP shunts (n=2). Three major complications, namely colon perforation (n=1), gastrocolic fistula (n=1), and pneumoperitoneum (n=1), occurred.

Colonic perforation was found in a patient with a 2-year-old VP-shunt. The patient developed peritonitis on the first postoperative day. Laparotomy was performed, and two perforation openings were found in the transverse colon, which were closed with a double-layer suture. The distal catheter of the VP shunt was temporarily externalized. The PEG was transferred to a gastrostomy tube. A gastrocolic fistula was observed in a 3-year-old boy with Fallot-tetralogy, severe TAD, and somatomental retardation. The internal bumper was removed endoscopically and the chronic fistula was planned to be closed; however, the patient was lost to follow-up and the chronic fistula was closed surgically. Pneumoperitoneum because of early dislodgement of the tube in the early postoperative period by an autistic patient with severe TAD was observed. Gastropexy was performed laparoscopically. This complication was independent of the surgical technique as well as patient's high-risk status.

After selection of high-risk patients, 10 L-PEG placements were performed and the indications for laparoscopic guidance were VP shunts (n=5), previous abdominal surgeries (n=4; duodenal atresia, previous gastrostomy, left nephrectomy because of Wilms tumor, and tumor biopsy from rhabdomyosarcoma), and severe TAD (n=1). Adhesions were found in three (30%) patients, of which two had a VP shunt and one had a previous gastrostomy. The advantage of L-PEG is that surgeons and endoscopists perform the same procedures, and therefore, there is no requirement for learning a new technique. The endoscopist performs the original pull technique and the surgeon attains umbilical access as in any laparoscopic procedure for a 5-mm camera port. We recommend the open (Hasson) technique over the Veress needle technique to prevent vessel, hepatic, or bowel injury. Any adhesions can be

released laparoscopically. In the case of no adhesions in the stomach, the conventional PEG procedure can be performed under double visual control. Although the laparoscopic procedure is longer, it is safer than the endoscopic procedure not only for high-risk patients but also for all patients.

This study has limitations owing to its retrospective nature and small sample size. However, L-PEG is not widespread in the literature.

Our results revealed that the major complication rate of L-PEG was lower than that of conventional PEG in high-risk patients; however, the operative time of L-PEG was significantly longer, especially if adhesiolysis was required.

Laparoscopic guidance provides a clear intra-abdominal view and offers the possibility to release adhesions and therefore, adjacent bowel or hepatic injuries can be avoided. L-PEG is recommended for children with distorted anatomy, VP shunts, or previous abdominal surgeries. L-PEG can be an emergency aid if transillumination of the gastric wall is inappropriate during gastroscopy. PEG placement in high-risk patients is advised in centers with pediatric surgical departments, where laparoscopy is in everyday use.

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PUBMED | CROSSREF

Original Article

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

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Abstract

Background: Ventriculoperitoneal shunt placement is the first line treatment of hydrocephalus, however revisions are often necessary. This study compares the efficacy of open vs. laparoscopic distal shunt revisions in pediatric patients. **Materials and Methods:** Data were analyzed in a single center between 2009 and 2019. Age, cause of hydrocephalus, outcomes including subsequent distal revisions, shunt infections, operative time, and hospital stay were compared between the open and laparoscopic groups. **Results:** A total 140 surgeries in 60 patients were performed due to hydrocephalus during the 10-year period. Out of the 140 interventions, 55 intraabdominal distal shunt revisions (28 laparoscopic and 27 open) were analyzed. Operative time, length of hospital stay, and shunt infection rates were similar in the laparoscopic vs. open groups. Significantly fewer subsequent peritoneal revisions were necessary in the laparoscopic group in the first 12 postoperative months ($P = 0.037$). **Conclusions:** Laparoscopic distal shunt revision may reduce the rate of subsequent peritoneal revisions due to the direct visualization of peritoneal catheter positioning, release of adhesions, and excision of cysts. In addition, the direct visualization of the abdominal cavity enables surgeons to choose the best surgical management.

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 lowest point of the abdominal cavity is visually controlled.[7,8] The visual control of positioning the peritoneal catheter spares extra radiation 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]

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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 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 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].

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

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.

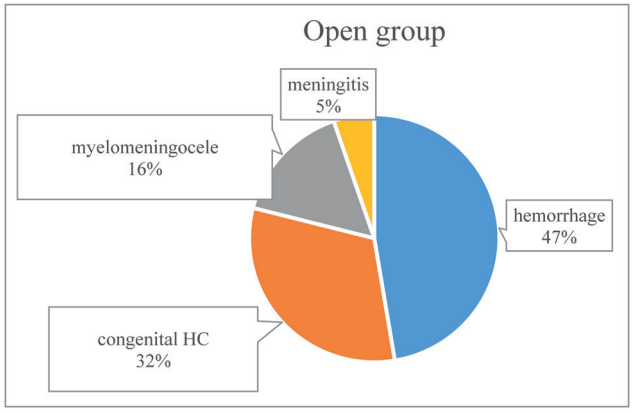

Figure 1: The origin of HC in patients operated with open revision for distal obstruction

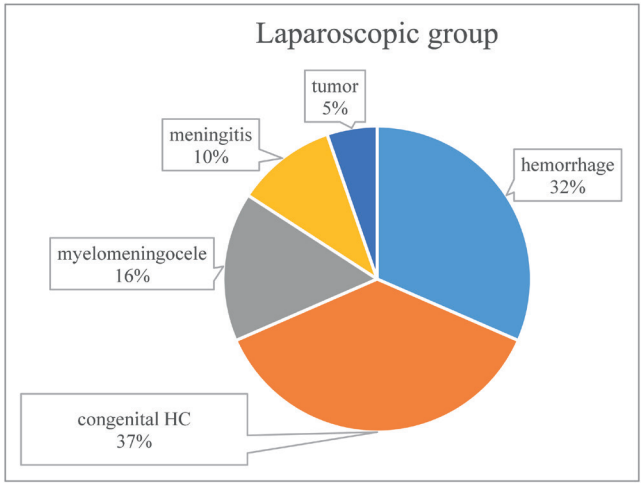

Figure 2: The origin of HC in patients operated with the laparoscopic technique for shunt revision of distal obstruction

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]

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 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 the free migration of the catheter 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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