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DEVELOPING A NEW LAPAROSCOPIC PAEDIATRIC SURGICAL SERVICE – PRELIMINARY RESULTS OF OUR EXPERIENCE

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INDEX

INTRODUCTION

History of Laparoscopic Surgery

The term laparoscopy derives from the Greek words ″λαπάρα″ that means abdomen and ″σκοπείν″ - to see, view or examine, indicating the endoscopic technique of observing the abdominal cavity through a small opening in the abdominal wall. The word λαπάρα may be traced back to the 17 to 13th century BC. Homer (8th century BC) repeatedly uses the word λαπάρα in his lyrics in the description of the Trojan War. Efforts to explore natural body orifices began as early as the classical period of ancient Greece, with the development of special instruments for the visualization of the rectum and the vagina. Hippocrates himself (460–377 BC) used a speculum to visualize and excise rectal condylomata. [1]

Laparoscopic surgery has been developed over many decades. It was initially introduced at the beginning of the 20th century by Dimitri Von Ott, a gynaecologist from St. Petersburg, when he performed his ″ventroscopy″ by transvaginally inserting, via a small colpotomy, a culdoscope to view the peritoneal cavity of a pregnant women in 1901.

At the same time Georg Kelling Photo 1, a General Surgeon from Dresden in Germany, was studying the problem of gastrointestinal bleeding into the abdominal cavity, which was often fatal. The only available method to provide treatment, at that time, was laparotomy. However, he observed that opening the abdomen could worsen the patient's condition. To stop blood loss, Kelling proposed a non-surgical treatment of insufflating high-pressure of air into the abdominal cavity, a technique he called luffttamponade (air-tamponade). Following this, in 1902, Georg Kelling performed a procedure, closer to the definition of modern laparoscopy, that he called "koelioscopie". To visualize the effects of the high-pressure lufttamponade on the abdominal organs, Kelling introduced a Nitze cystoscope directly through the abdominal wall of dogs and filtered air to create pneumoperitoneum and concluded it was perfectly harmless. [2]

The same year Hans Christian Jacobaeus (1879-1937), a Swedish internist from Stockholm, used a light source on the distal end of his endoscope to operate on a human and published the first report of a relatively large series of his ″laparothorakoskopie″ in humans in 1911 [2]. Jacobaeus entitled his first article on abdominal endoscopy ″Concerning the possibility of applying cystoscopy in the examination of serous cavities.″. The Stockholm internist worked on patients with ascites evacuating the fluid and creating air-pneumoperitoneum using a trocar with a trap-valve Photo 2

In the following years several authors in Europe and in the United States performed laparoscopic procedures mainly for diagnostic purposes. The use of CO_2 as insufflation gas was introduced by Richard Zollikofer in 1924 but It was only with the introduction of the cold light fiber-glass illumination by Max Fourestier, a French scientist and his colleagues (Fourestier et al. 1952) and the rod-lens optical system by the English physicist Harold Hopkins (Hopkins & Kapany 1954) that laparoscopy became more popular especially in the gynaecology departments in the 1960's and 1970's. The work of Hopkins set the basis for the modern flexible fiber-optic endoscopes and rigid laparoscopes.

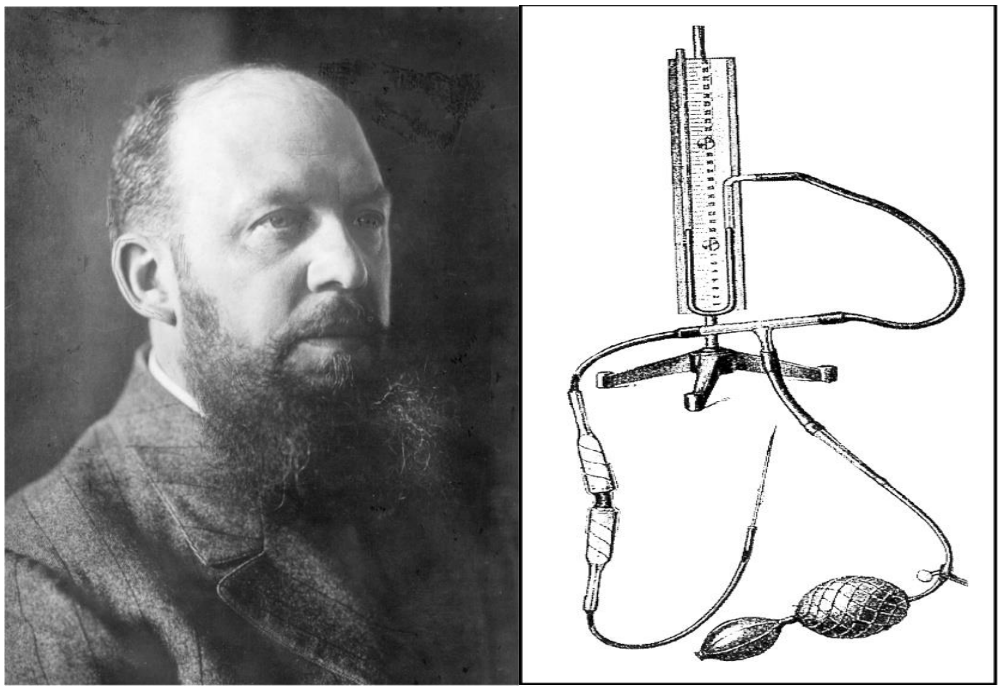


Photo 1 Georg Kelling (1866-1945) and his insufflator for the creation of pneumoperitoneum

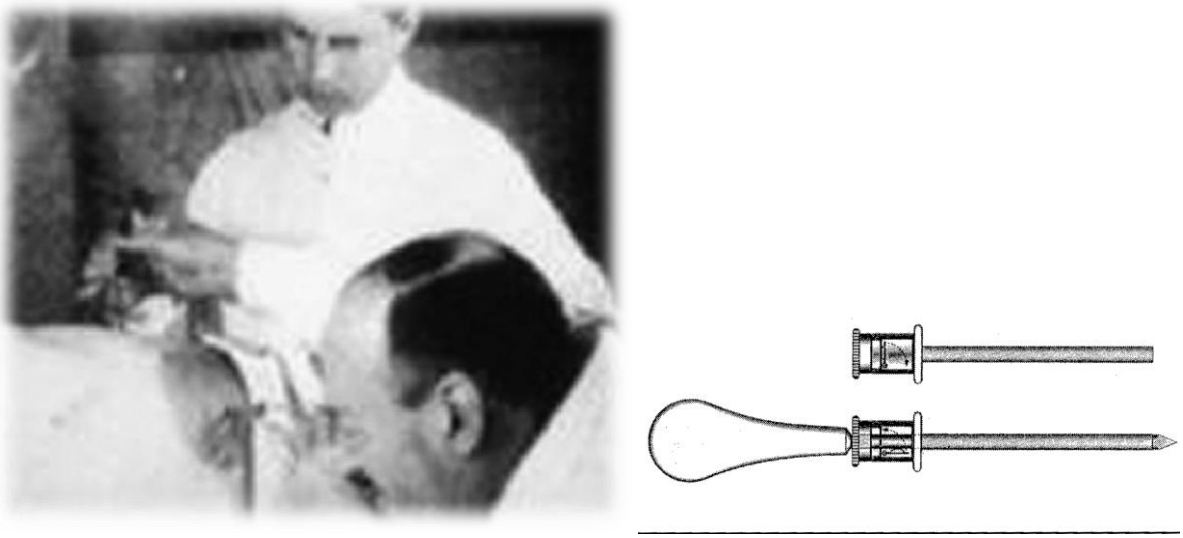


Photo2 Hans Christian Jacobaeus at work with his laparoscope and his "trocar"

It was it the 60's and 70's that Dr Kurt Semm, Photo 3 a gynaecologist from the Kiel University in Germany, an innovator and pioneer of the modern laparoscopy, invented his automatic insufflator, the thermoregulator for electrocautery, the ligating loop, techniques for extracorporeal knot tying and intracorporeal suturing but also laparoscopic instruments and procedures such as ovarian cystectomy, myomectomy etc. In 1980 he performed the first laparoscopic appendectomy, but his work received so much criticism that it wasn't published until three years later (1983). But it was not until the first laparoscopic cholecystectomy performed by Erich Mühe in 1985 and after the French gynaecologist Phillipe Mouret performed in 1987 the first acknowledged laparoscopic, four trocar, cholecystectomy that increasing interest in laparoscopy among general surgeons developed. The surprisingly fast recovery of patients undergoing laparoscopic cholecystectomy together with the development of computer chip television in 1986 set the basis for the growth of minimally invasive surgery in humans.

Photo 3 Kurt Summ (1927 – 2003)

With the advent of electronic videoscopes, small instruments and insufflators feasible for children, laparoscopy has also gained ground in paediatric surgery.

SCOPE OF THE STUDY

This paper reports our experience in our newly developed laparoscopic paediatric surgical service in ”Karamandaneion” Children’s Hospital, Patras – Greece, from January 2019 until September 2021. Our department is the only Paediatric Surgical Service in Western Greece & Ionian islands serving a population of 887.651 people (2011). We report the difficulties encountered in setting up the service but also how a careful case selection at the beginning and a growing experience and skills, as time passed, allowed introduction of this service with safety and good results.

MATERIALS AND METHODS

Patient records were retrospectively reviewed, and data were extracted from electronic and paper hospital patient records. All patients that had a laparoscopic surgery in our Unit from January 2019 till September 2021 were included in the study.

Patients were admitted under the care of three out of five Consultant Paediatric Surgeons, two of whom had undergone training in laparoscopic paediatric surgery as Specialist Registrars/Fellows and attended training courses in Paediatric Minimally Invasive Surgery in the UK and the Head of the Department that had undertaken training in Minimally Invasive Surgery at IRCAD Laparoscopic Training Center, France. Additional training and support were offered at the beginning by an experienced Laparoscopic General Surgeon, especially regarding cholecystectomies.

An initial contract with a company that provided us with a borrowed laparoscopic tower and the necessary instruments (single use) and one optical telescope made the service possible for a few months until additional funding was approved for the purchase of more multiple use instrument sets and telescopes.

Setting up a new service though was not uneventful as the lack of instruments at the beginning meant that for some time only one or two operations per day were allowed as the telescopes had to be washed and sterilised in between the operations. In addition, after about eight months of successful operation we had to interrupt our work for about two months due to a delay in funding.

Before surgery, a Foley catheter was routinely inserted to empty the bladder and allow assessment of urine output during the procedure. Open-entry technique was preferred for entering the abdominal cavity. Insufflation pressure was set between 10 and 12 mmHg, which can be well tolerated by children and young adolescents. An initial 10 mm port was placed at the upper umbilical skin crease and two 5 mm accessory ports were then placed in the left iliac fossa and suprapubic area Figure 1 for typical laparoscopic appendectomy and in the lower lateral quadrants Figure 2 for adnexal surgery. No abdominal drains were placed. A typical, 4 trocar, laparoscopic

cholecystectomy was performed for patients with cholelithiasis. Figure 3 A drain was left in the cholelithiasis bed and removed the 1st post-operative day.

RESULTS

Demographics and operative procedure

A total of 221 laparoscopic procedures were performed between January 2019 and September 2021. There were 135 males and 86 females, and the mean age was 11.3 years (range 3.8 - 19.4).
Out of these 221 patients, 187 were diagnosed with acute appendicitis with a male to female ratio of almost 2:1 (124 M/63 F) and a mean age of 11.1 years (range 3.8 - 15.10). All patients presented at the Emergency Department of our hospital or were referred/transferred to us from their local hospital due to abdominal pain. They all had blood tests and an ultrasound scan of the abdomen was performed from our three, very experienced, paediatric radiologists that confirmed the diagnosis of acute appendicitis or highlighted other pathologies such as adnexal pathology in female patients.

US is currently the recommended initial imaging study of choice for the diagnosis of acute appendicitis in paediatric and young adult patients. US has been shown to have high diagnostic accuracy for acute appendicitis as an initial imaging investigation and seems to reduce the need for further imaging and the number of negative appendectomies. Accuracy of appendix US varies widely, is operator dependent, and may be dependent on patient-specific factors, such as obesity [3]. The sensitivity and specificity of US for the diagnosis of paediatric acute appendicitis varies but in experienced hands can approach that of CT. In expert hands Cundy et al [4] showed 92% visualization of the appendix with 95.5% accuracy, 97% sensitivity, and 95% specificity for the diagnosis of acute appendicitis. Findings suggestive of appendicitis include a thickened wall, a non-compressible lumen, diameter greater than 6 mm, absence of gas in the lumen, appendicoliths, hyperechogenic peri appendicular

fat, fluid collection consistent with an abscess, local dilation and hypoperistalsis, free fluid, and lymphadenopathy. [5]

The gangrenous appendix is considered ruptured even if macroscopically it is not often visible. For this reason in our study, except for the early stages of catarrhal and suppurative appendix, other stages were classified as complicated forms of acute appendicitis.
In our study 150 patients (80,2%) had an appendectomy for non-complicated appendicitis and 37 patients (19,8%) for complicated appendicitis. The appendicitis was considered complicated once the appendix was gangrenous or perforated according to its visual appearance during laparoscopy as per the Gomes et al grading system: grade 0 - normal looking, 1 - redness and oedema, 2 - fibrin, 3A - segmental necrosis, 3B - base necrosis, 4A - abscess, 4B - regional peritonitis, and 5 - diffuse peritonitis. [6]

Besides most laparoscopic appendectomies, laparoscopy was also performed in 13 patients for adnexal pathologies. In our Region there is no Paediatric Gynaecology Service and most patients under the age of 16 with lower abdominal pain are referred to our Paediatric Surgical Unit for adnexal pathologies also.
The patients treated in our service were mostly girls in pubertal age with a mean age of 12.96 years (Range 4.7 – 16.7). There were six functional ovarian cysts (46%), one presented with ovarian torsion due to a large (12cm) cyst and one with perforation of the cyst. They all had a laparoscopic cystectomy with ovarian preservation.
Four patients had a para-tubal cyst (30.8%). Two of these patients had an excision of the cyst but in two of them a salpingectomy and salpingo-oophorectomy were performed respectively, due to tubal and tubo-ovarian torsion and necrosis; There were also two haemorrhagic corpus luteus (15.4%); and one oophorectomy (7.7%) due to ovarian torsion. All patients were symptomatic with symptoms suggestive of an adnexal torsion or ruptured cyst and persistent and symptomatic adnexal masses. In our study, a physical examination and ultrasonography with Colour Doppler for suspicion of adnexal torsion were enough for the initial evaluation and treatment plan for most cases.

In our service complex adnexal masses with a high suspicion for malignancy are considered an indication for laparotomy.

Other operations performed were 10 cholecystectomies, mostly due to symptomatic cholelithiasis with mean age 12.78 (range 8.5 – 15.4), 5 omental torsions, 1 varicocele, 1 adhesiolysis, 1 one-stage orchidopexy, 1 diagnostic laparoscopy for non-palpable testes/anorchia, 1 lap-assisted Meckel's diverticulum resection and 1 torsion of Colo-epiploic fat appendix (Graph 1).

Conversion rates and causes

The risk of conversion is related to surgeon factors, patient factors, and even equipment factors. Of course, the surgeon's experience is very important. In our study, conversion meant abandoning the laparoscopic procedure in favour of an open surgery (via a McBurney, Lanz or Pfannenstiel incision). The overall conversion rate was 6,33% that was steady during the first two years (2019-7,5%; 2020-7,4%) and declining the third year (2021-4,6%), as the number and complexity of the cases but also our skills and expertise increased.

Conversion was most likely to happen in complicated appendicitis (21,6%) while for the non-complicated was very low (2,6%). Table 1 The most common cause for conversion in non-complicated appendicitis was difficult anatomy such as retrocaecal appendix and appendix in peritoneal pocket and this was gradually surpassed as the surgeons' experience and confidence increased. In the complicated ones, the most common causes of conversion were the presence of appendiceal mass/abscess and gangrenous/perforated base of the appendix. Other causes included severe peritonitis, malrotation and instruments' malfunction.

Regarding the other pathologies there was only one conversion of an omental torsion at the beginning of our service due to lack of instruments and of an oversized ovarian cyst (12cm) in 2021.

Complications and readmissions

A complication in medicine is an unfavourable process or event occurring during a disease, that is not essential part of that disease, although it may result from it or from independent causes. Complications may also arise as an adverse or undesired result of various treatments or operations. They may adversely affect the prognosis, or outcome of a disease and generally involve a worsening in severity of disease or the development of new signs, symptoms, or pathological changes (WIKIPEDIA)

In our study out of the 221 laparoscopic operations performed there were only 6 readmissions; two of the patients were readmitted within a month from discharge, due to abdominal pain and were investigated with blood tests, abdominal X-Ray, and ultrasonography but no pathology was revealed. One patient, a female that had a laparoscopic excision of an ovarian cyst was readmitted twice. The first time presented an umbilical fistula, that was reoperated and the second time an umbilical wound infection and necrosis of the umbilicus, treated conservatively with IV antibiotics. During the umbilical fistula repair pre-peritoneal fat was found stuck in the umbilical wound closure. Finally, another two patients were readmitted due to a peritoneal pus collection following laparoscopic appendectomy for a complicated appendicitis (peritonitis) and were managed conservatively with IV antibiotics.

Other complications presented in our series were: One patient that developed a pus peritoneal collection diagnosed during admission, following a laparoscopic complicated appendicitis with peritonitis, treated conservatively with IV antibiotics. A patient with umbilical wound infection that was treated with oral antibiotics; this was a female obese patient with a laparoscopic para-tubal cyst excision. And finally, a patient with an iatrogenic acute renal injury due to Amikacin. The patient responded immediately to interruption of the medicine and careful fluid balance management and his renal function recovered in full.

Two patients in our series developed an adhesional small bowel obstruction but they both had a converted laparoscopic procedure and a laborious appendectomy due to difficult anatomy. No patient that had a complete laparoscopic procedure has developed adhesional small bowel obstruction so far.

DISCUSSION

Worldwide dissemination and increasing popularity of minimally invasive surgery over the last thirty years, has made it possible for many laparoscopic procedures to have now evolved as the standard of care in many centres. Especially regarding appendectomy, it has increasingly been performed using a minimally invasive approach although some surgeons remain sceptical to replacing the conventional, safe, and relatively straightforward, open appendectomy.

Acute appendicitis is among the most common causes of lower abdominal pain leading patients to attend the emergency department and the most common diagnosis made in young patients admitted in hospital with an acute abdomen, and can progress to perforation and peritonitis, associated with morbidity and mortality. The incidence of acute appendicitis has been declining steadily since the late 1940s, with a peak between the ages of 10 and 30. Geographical differences are reported, with a lifetime risk of appendicitis of 9% in the USA, 8% in Europe, and 2% in Africa [7]. It occurs most often between the ages of 10 and 30, with a male: female ratio of approximately 1,4:1. One third of patients with acute appendicitis are under the age of 18, with a peak incidence in the paediatric population between the ages of 11 and 12 [8] One third of appendicitis cases present to hospital with a perforated appendix. The mortality risk of acute, not gangrenous appendicitis is less than 0.1%, but the risk rises to 0.6% in gangrenous and up to a high 5% in perforated cases [7].

In children the available literature is conflicting [9], therefore, the use of laparoscopy remains controversial still today. Criticism of laparoscopic appendectomy involves increased operative cost, increased operation time, and concerns about a higher incidence of intra-abdominal abscesses, particularly after perforated appendicitis.

Among the benefits of minimally invasive surgery is most commonly a shorter hospital stay, reflecting a reduced postoperative pain that enables earlier mobilization and subsequent discharge from the hospital, with an earlier return to normal activity. Other common advantages are a lower rate of wound infection and a lower rate of bowel obstruction [10, 11, 12, 13].

On the other hand, the most common disadvantages are a longer operation duration and a higher risk of intra-abdominal collection in complicated appendicitis [12, 13], although this effect seems decreased in the last decade, being probably related to surgical expertise.

The unmeasured benefit of laparoscopy is that it provides both a diagnostic and therapeutic modality in the setting of acute abdomen, which is of particular benefit in females, which is also reflected in our series. Through direct visualization of the abdominal and pelvic contents, patients with equivocal signs can be diagnosed and treated accordingly. In young females especially, lower abdominal pain is less attributable to abnormalities in pelvic female organs than in adults. Although all patients in our study had an ultrasound scan of the abdomen prior to surgery it was with the aid of laparoscopy that equivocal cases were correctly diagnosed and treated, such as early ovarian, salpingeal and omental torsions.
Therefore, laparoscopic appendectomy should represent the first choice where laparoscopic equipment and skills are available, since it offers clear advantages in terms of less pain, lower incidence of complications, decreased length of stay and overall costs [7].

In adult females, it has been shown that 3% of acute abdominal pain is the result of ovarian torsion, which if promptly treated surgically has a successful outcome in terms of follicular development or normal macroscopic appearance of the ovary at follow-up. Although in young females, lower abdominal pain is less attributable to abnormalities in female reproductive organs, Guthrie et al reported an ovarian torsion annual incidence of 4.9 per 100 000 females aged 1 to 20 years, similar to that reported by Michelotti et al. [14, 15] This is quite similar to the estimated incidence of testicular torsion. Ovarian torsion is uncommon but occurs in all ages and is typically associated with normal ovaries or benign lesions. In fact, the incidence of malignant tumours in paediatric patients ranges from 1.4 – 4.5%. [14, 16, 17]
Simple cysts of the ovary, the majority functional ovarian cysts, are the most commonly encountered adnexal lesions in pubertal age and can be the cause of ovarian torsion.

Although torsion is usually seen between ages 11-14.5 years [14, 16, 17], it can also be encountered in the premenarchal girls. Adnexal torsion should therefore be kept in mind in the differential diagnosis of all paediatric patients including those of prepubertal age who present with acute abdominal pain. Laparoscopy is currently the accepted approach to many pathologies. One reason is that postoperative adhesions are usually rare after laparoscopic surgery. Especially regarding presumed benign adnexal lesions in children and adolescents, this increases their chances for future fertility. Also, the cosmetic advantages of laparoscopic surgery are more profound in paediatric and adolescent patients. Increasing data suggest that laparoscopic surgery is safe and effective for the management and treatment of benign adnexal pathologies in paediatric patients.

CONCLUSION

Since the advert of laparoscopic surgery in the beginning of the 20th century there has been a great progress. Especially over the last thirty years, increasing popularity of minimally invasive surgery has made it possible for many laparoscopic procedures to have now evolved as the standard of care in many centres. Increasing data suggest that laparoscopic surgery is safe and effective for the management and treatment of many pathologies of the paediatric population such as acute appendicitis, cholelithiasis and adnexal lesions.
As shown in our study, adopting new technologies and minimally invasive techniques is feasible and safe with adequate training and careful case selection.

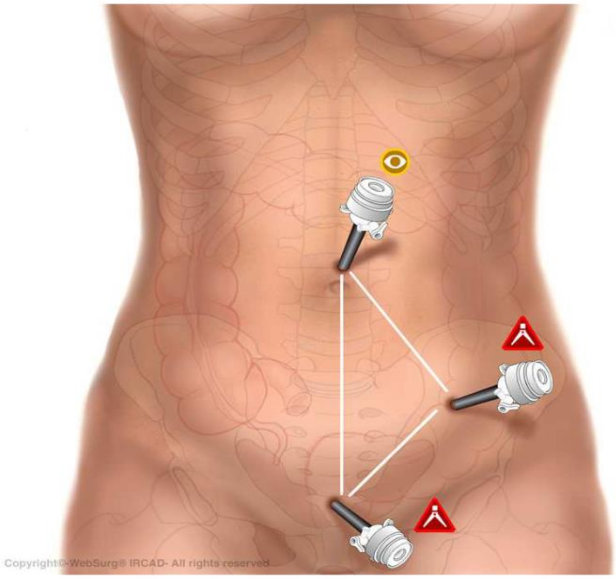


Figure 1 Typical port position for appendectomy (Hurng-Sheng W, et al. Current Evidence and Recommendations for Laparoscopic Appendectomy)

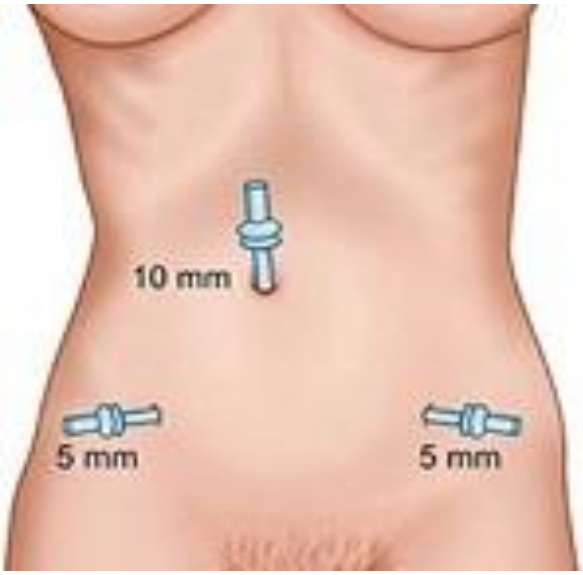


Figure 2 Typical port position for adnexal surgery (Nutan Jain, State-of-the-Art Atlas and Textbook of Laparoscopic Suturing in Gynaecology)

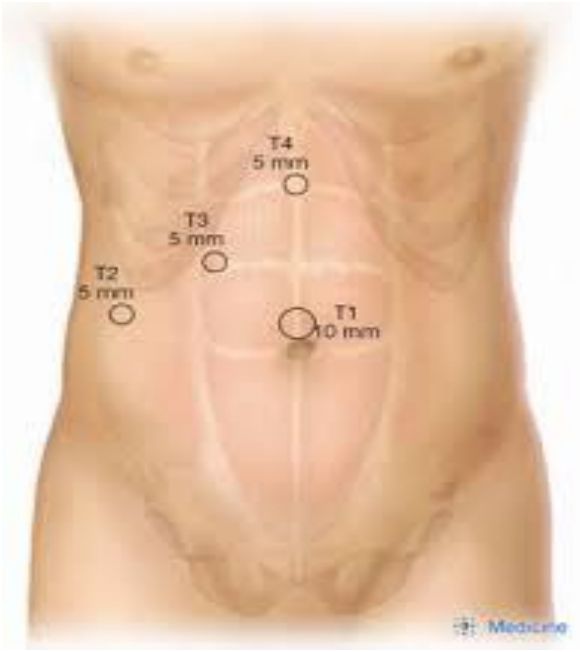
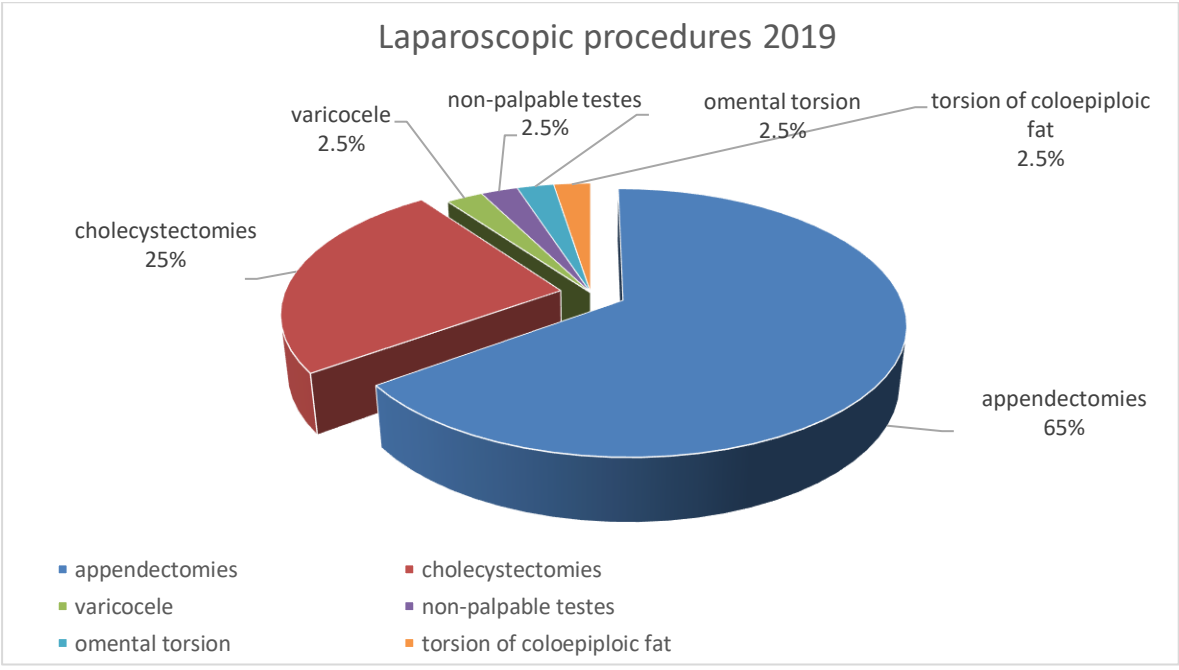
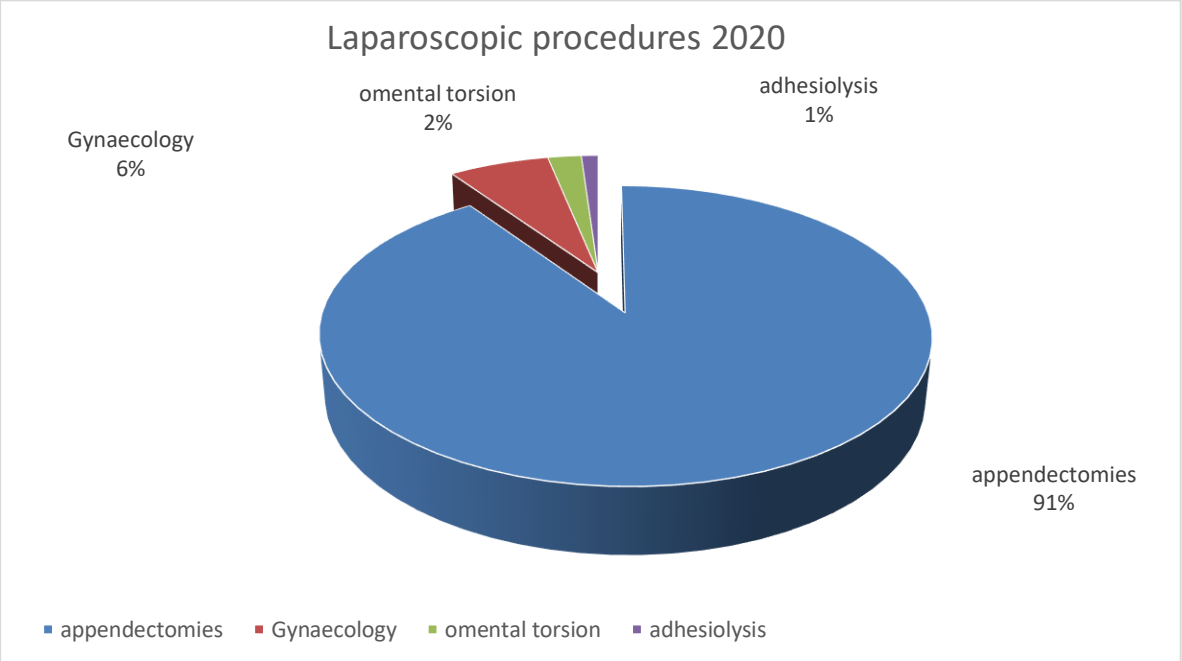


Figure 3 Port position for Laparoscopic Cholecystectomy

Graph 1 Type of Laparoscopic procedures/year performed January 2019 – September 2021




Laparoscopic procedures 2020
omental torsion
2%
adhesiolysis
1%
Gynaecology
6%
appendectomies
91%
appendectomies
Gynaecology
omental torsion
adhesiolysis

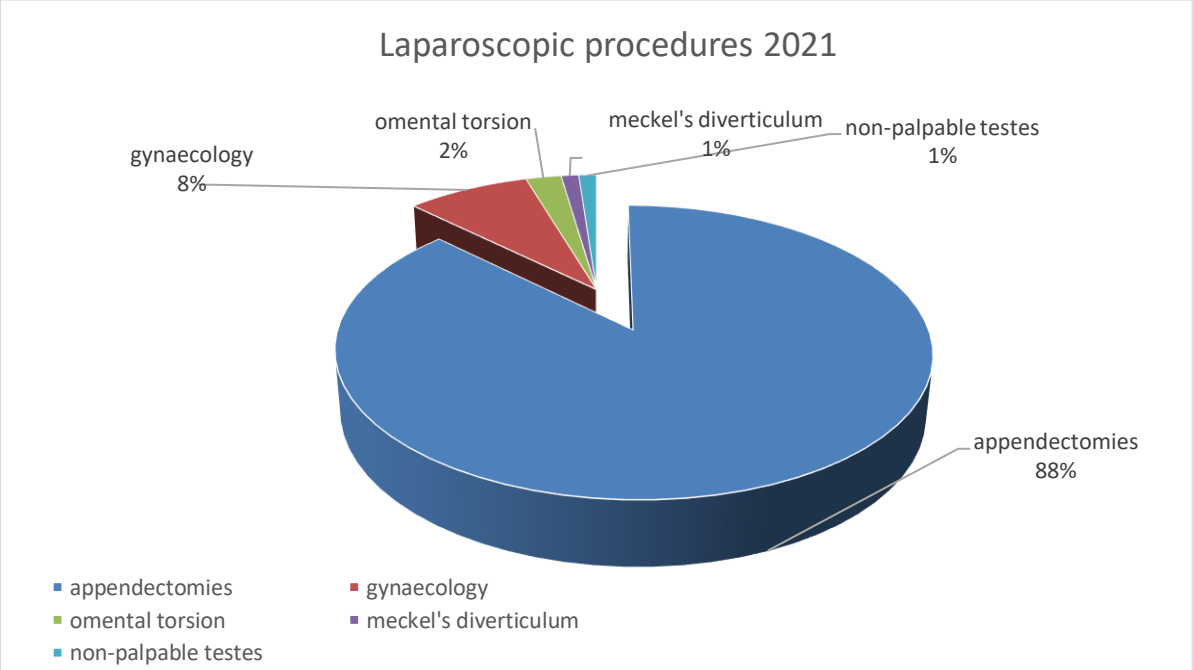

Laparoscopic procedures 2021
omental torsion
2%
meckel's diverticulum
1%
non-palpable testes
1%
gynaecology
8%
appendectomies
88%
appendectomies
gynaecology
omental torsion
meckel's diverticulum
non-palpable testes

Table 1 Conversion rates / year

	2019	2020	2021	TOTAL
Appendicectomies:				
Non-complicated	2/24 (8,3%)	2/66 (3%)	0/60 (0%)	4/150 (2,6%)
Complicated	0/2 (0%)	5/19 (26,3%)	3/16 (18,75%)	8/37 (21,6%)
Gynecology procedures	-	0/6 (0%)	1/7 (14,2%)	1/13 (7,6%)
Omental torsion	1/1 (100%)	0/2 (0%)	0/2 (0%)	1/5 (20%)

REFERENCES

[1] Antoniou SA, Antoniou GA, Koutras C, Antoniou AI. Endoscopy and laparoscopy: a historical aspect of medical terminology. Surg Endosc. 2012;26(12):3650-3654.

[2] Grzegorz S. Litynski. Laparoscopy - The Early Attempts: Spotlighting Georg Kelling and Hans Christian Jacobaeus.

[3] Abo A, Shannon M, Taylor G, Bachur R. The influence of body mass index on the accuracy of ultrasound and computed tomography in diagnosing appendicitis in children. Pediatr Emerg Care 2011; 27:731-6.

[4] Cundy TP, Gent R, Frauenfelder C, Lukic L, Linke RJ, Goh DW. Benchmarking the value of ultrasound for acute appendicitis in children. J Pediatr Surg 2016; 51:1939-43.

[5] Nielsen JW, et al. Reducing computed tomography scans for appendicitis by introduction of a standardized and validated ultrasonography report template. J Pediatr Surg. 2015;50(1):144–8.

[6] Gomes CA, Nunes TA. Acute appendicitis laparoscopic classification. Correlation between disease grade and intraoperative variables. Rev Col Bras Cir. 2006; 33:289–293.

[7] Di Saverio S et al. Diagnosis and treatment of acute appendicitis: 2020 update of the WSES Jerusalem guidelines. World J Emerg Surg. 2020 Apr 15;15(1):27. doi: 10.1186/s13017-020-00306-3.

[8] Grosfeld Jay L, O'Neil JA Jr, Goran AG, Fonkalsrud EW, *Pediatric Surgery (6th ed), Appendicitis*, vol.2, ch. 98

[9] Liping Dai , Jian Shuai. Laparoscopic versus open appendectomy in adults and children: A meta-analysis of randomized controlled trials. United European Gastroenterol J. 2017 Jun;5(4):542-553.

[10] Jaschinski T, Mosch CG, Eikermann M, Neugebauer EAM, Sauerland S. Laparoscopic versus open surgery for suspected appendicitis. Cochrane Database of Systematic Reviews 2018, Issue 11. Art. No.: CD001546. DOI: 10.1002/14651858.CD001546.pub4

[11] Thirty Years of Minimally Invasive Surgery in Children: Analysis of Meta-Analyses. Schukfeh N, et al. Eur J Pediatr Surg. 2020 Oct;30(5):420-428

[12] Zhang et al. Laparoscopic Appendectomy in Children with Perforated Appendicitis: A Meta-Analysis. Surg Laparosc Endosc Percutan Tech. 2017 Aug;27(4):262-266.

[13] Markar et al. Laparoscopic Versus Open Appendectomy for Complicated and Uncomplicated Appendicitis in Children. J Gastrointest Surg (2012) 16:1993–2004

[14] Guthrie BD, Adler MD, Powell EC. Incidence and Trends of Pediatric Ovarian Torsion Hospitalizations in the United States, 2000–2006. Pediatrics 125:532-538, 2010

[15] Brett Michelotti , Bradley J Segura, Indranil Sau, Sonia Perez-Bertolez, Jose M Prince, Timothy D Kane. Surgical management of ovarian disease in infants, children, and adolescents: a 15-year review. J Laparoendosc Adv Surg Tech A. 2010 Apr;20(3):261-4.

[16] Berna Seckin [1], Tulin Ozdener, Omer Lutfi Tapisiz, Sertac Batioğlu. Laparoscopic treatment of ovarian cysts in adolescents and young adults. J Pediatr Adolesc Gynecol. 2011 Oct;24(5):300-3.

[17] Brooke V Rossi , Elisabeth H Ference , David Zurakowski , Stefan Scholz , Neil R Feins , Jeanne S Chow , Marc R Laufer. The clinical presentation and surgical management of adnexal torsion in the pediatric and adolescent population. J Pediatr Adolesc Gynecol. 2012 Apr;25(2):109-113.