ΜΕΤΑΠΤΥΧΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΣΠΟΥΔΩΝ:
‘‘ΕΛΑΧΙΣΤΑ ΕΠΕΜΒΑΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ,
ΡΟΜΠΟΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ ΚΑΙ ΤΗΛΕΧΕΙΡΟΥΡΓΙΚΗ’’

ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
ΙΑΤΡΙΚΗ ΣΧΟΛΗ

ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ

ΘΕΜΑ:

Laparoscopic pancreatectomies in patients under 14 years old: A Review of the literature

ΜΕΤΑΠΤΥΧΙΑΚΟΣ ΦΟΙΤΗΤΗΣ:
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ΠΡΑΚΤΙΚΟ ΚΡΙΣΕΩΣ

ΤΗΣ ΣΥΝΕΔΡΙΑΣΗΣ ΤΗΣ ΤΡΙΜΕΛΟΥΣ ΕΞΕΤΑΣΤΙΚΗΣ ΕΠΙΤΡΟΠΗΣ ΓΙΑ ΤΗΝ ΑΞΙΟΛΟΓΗΣΗ ΤΗΣ ΔΙΠΛΩΜΑΤΙΚΗΣ ΕΡΓΑΣΙΑΣ
Του Μεταπτυχιακού Φοιτητή Πλαταρά Χρήστου

Εξεταστική Επιτροπή

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Η Τριμελής Εξεταστική Επιτροπή η οποία ορίσθηκε από την ΓΣΕΣ της Ιατρικής Σχολής του Παν. Αθηνών Συνεδρίαση της.....ης ..... 20.... για την αξιολόγηση και εξέταση του υποψηφίου κ. Πλαταρά Χρήστου, συνεδρίασε σήμερα .../.../....

Η Επιτροπή διαπίστωσε ότι η Διπλωματική Εργασία του κ. Πλαταρά Χρήστου με τίτλο: «Laparoscopic pancreatectomies in patients under 14 years old: A Review of the literature», είναι πρωτότυπη, επιστημονικά και τεχνικά άρτια και η βιβλιογραφική πληροφορία ολοκληρωμένη και εμπεριστατωμένη.

Η εξεταστική επιτροπή αφού έλαβε υπ' όψιν το περιεχόμενο της εργασίας και τη συμβολή της στην επιστήμη, με ψήφους ..... προτείνει την απονομή του Μεταπτυχιακού Διπλώματος Ειδίκευσης (Master's Degree), στον παραπάνω Μεταπτυχιακό Φοιτητή.

Στην ψηφοφορία για την βαθμολογία ο υποψήφιος έλαβε για τον βαθμό «ΑΡΙΣΤΑ» ψήφους ....., για τον βαθμό «ΛΙΑΝ ΚΑΛΩΣ» ψήφους ....., και για τον βαθμό «ΚΑΛΩΣ» ψήφους ..... Κατά συνέπεια, απονέμεται ο βαθμός «.....».

Τα Μέλη της Εξεταστικής Επιτροπής

- Χρήστος Π. Τσιγκρής, **Επιβλέπων** (Υπογραφή) _____
- Θεόδωρος Διαμαντής, (Υπογραφή) _____
- Νικόλαος Νικητέας, (Υπογραφή) _____

CONTENTS *page*

Abbreviations

CRP: C-Reactive Protein
CT: Computed Tomography
DP: Distal Pancreatectomy
ERCP: Endoscopic Retrograde Cholangio Pancreatography
IPMN: Intraductal Papillary Mucinous Neoplasm
LDP: Laparoscopic Distal Pancreatectomy
MCN: Mucinous Cystic Neoplasm
MRCP: Magnetic Resonance Cholangiopancreatography
MRI: Magentic Resonance Imaging
PHHI: Persistent Hyperinsulinemic Hypoglycemia of Infancy
SPT: Solid Pseudopapillary Tumor
TPN: Total Parenteral Nutrition
US: Ultrasound
WBC: White Blood Cells

Preface

Laparoscopic surgery has gradually become part of everyday training in many surgical subspecialties in Greece. Athens Medical School and Professor Tsigris have offered many young surgeons the opportunity to learn and improve skills in laparoscopic surgery over the last nine years. I feel very honoured to have been selected for this postgraduate program and would like to extend my deep appreciation to Professor Tsigris and all his team of assistant professors for the high standard of education and training we all received. I also owe many great thanks to his secretary Lamprini Konstantou for her assistance and problem solving role all these years of my training.

As most things in my life this study could never have been completed without the support and inspiration of my family, my wife, my daughter, my mother.

Introduction

Laparoscopic surgery has gained worldwide acceptance and is the preferred method of operation for several conditions in many surgical fields and in patients of all ages. Laparoscopy in paediatric surgery is nowadays a standard of treatment for a variety of surgical diseases and in certain cases seems to be the gold standard. There are published reports that show the feasibility of minimal invasive surgery for almost every case of abdominal or thoracic procedure in paediatric surgery. Laparoscopic appendectomy, hernia repair, bowel resection and re-anastomosis, pyloric stenosis, esophageal atresia, gastroesophageal reflux and many more, are already accepted and performed by an increasing number of paediatric surgeons all over the world.

Pancreatic surgery is a very demanding subspecialty in general as well as in paediatric surgery. Nevertheless laparoscopic techniques and procedures are also gaining acceptance in this field in general adult surgery as experience in laparoscopy from other more common procedures builds up. But can anyone say the same for paediatric surgery?

Pancreatic problems in children compared to adults are rarer. In addition the smaller pancreatic size and in general the more constricted anatomic space that leaves little freedom of movement to the surgeon makes an operation in this area a far more difficult and serious task in small patients. Moreover we already know that treatment of postoperative complications of pancreatic surgery present a challenge to general surgeons. This challenge is even harder to cope with in children. Finally the difference in anatomy and physiology compared to adult patients also add more difficulties before planning a pancreatic operation in children. Having in mind all the above it is interesting to find what is the current experience in laparoscopic surgery in children and more specifically the experience in laparoscopic distal pancreatectomy which is the most common procedure performed laparoscopically.

We present a retrospective study of all published cases of laparoscopic distal pancreatectomy in patients less than 14 years of age since the first such published case

in 2001. We have gathered all the details regarding patient history and diagnosis as well as the technique and postoperative course. We aim to present in a concise and organised way all the information that we managed to find regarding this specific laparoscopic procedure in children so as to help more paediatric surgeons make their own mind whether to accept it or not as an alternative to open laparoscopic pancreatectomy. Finally to help all surgeons who are keen to accept the challenge, in preoperative, intraoperative and postoperative planning.

PART 1:

ADULT LITERATURE REVIEW

1.1 Laparoscopic distal pancreatectomy in adults

The introduction of laparoscopic techniques was one of the most significant events in the evolution of surgery in the past century. This technique has been accepted and widely performed in several areas of general adult surgery also including pancreatic surgery. The first laparoscopic distal resection for insulinoma was reported 1996 and the first distal resection for malignancy was reported in 1999. However, laparoscopic pancreatic surgery is still slow in gaining popularity mainly due to technical difficulty **(1, 2, 3).** It is well known that pancreatic surgery represents one of the most challenging areas in digestive surgery in adults **(4, 5)**. The posterior position of the pancreas, its relation to surrounding vessels, and moreover the precarious pancreatic physiology can explain why surgery is historically associated with up to 50% morbidity and 5% mortality. Nevertheless following the increased experience in laparoscopic surgery of other districts and the availability of new technological devices, an increasing number of laparoscopic pancreatic procedures have been performed **(1, 6, 7).** Laparoscopic distal splenopancreatectomy and laparoscopic distal pancreatectomy with splenic preservation have been widely performed for benign diseases or endocrine neoplasms in the last decade **(8–22).**

LDP represents more than 70% of the laparoscopic pancreatic resections actually performed **(23).** The indications for LDP vary, depending on the study and mostly include benign islet cell tumors, chronic pancreatitis, and cystic neoplasm **(1, 24)**. However some cases of pancreatic adenocarcinoma have been reported **(25)** but its safety for long-term oncologic outcome is strongly debated. The ability to obtain clear surgical margins and an adequate lymphadenectomy has long been a concern **(8)**. This approach for the treatment of pancreatic carcinoma still requires prospective validation **(26).** LDP has also been performed in patients with chronic pancreatitis **(27)**; laparoscopic necrosectomy for acute necrotizing pancreatitis has been also described **(28)**. Steering wheel injury typically involves pancreatic parenchyma in front of the vertebra; LDP preferably with spleen preservation, has been indicated for patients with pancreatic trauma **(29-31)**.

Several comparative studies have shown that the average operative time, blood loss, morbidity, mortality and length of hospital stay after laparoscopic access might favourably compare with those after open surgery **(32-43)**. Open distal

pancreatectomy usually requires an extensive abdominal incision even if the pancreatic tumor is small, while the minimally invasive approach offers significant advantages: reducing the parietal damage to the abdomen, acceptable complication rate, reasonably short hospital stay, and early return of patients to previous activities **(44)**. However, the major part of the studies on LDP is represented by case series with a relatively small number of patients **(45, 46)** and a retrospective design. Subsequently, it is still difficult to trace any conclusion because of the insufficient level of evidence. The average reported conversion rate from laparoscopy to open operation is 14.1% (5–43%) **(16, 22).** The commonly described reasons for conversion in the literature are obesity, dense omental fat, intraoperative bleeding, malignant disease requiring lymph node dissection, inability to detect the tumor, bulky tumor, and peritoneal adhesions due to previous surgery **(13, 16**, **47, 48).**

An important concept for better results in major surgical procedures is that of centralization. Several studies have suggested a better outcome for complex surgical procedures when performed in high-volume centers. Centralization of pancreatic services has shown significant increase in surgeon workload and expertise, resulting in obvious benefits for both patients and institutions in terms of morbidity, mortality, operative time, conversion rate and blood loss **(49, 50)**.

1.2 Surgical techniques

The individual surgeon determines the technical conduction of LDP. It is usually performed in a supine, supine with a sand bag under the left side of the chest and a right lateral tilt or in a right lateral position. 10-mm 30-degree telescope is generally used for visualization.

The surgeon and camera surgeon stand to the right of the patient, the first assistant and the scrub nurse stand on the opposite side. Several technical variants may be used **(51)**. In general the main surgical steps of the procedure are as follows **(1, 2, 52)**:

- Inspection of peritoneal cavity
- Lesser sac and the gastrocolic ligament are opened to expose the tail of pancreas and the splenic artery.
- In case of en bloc distal pancreatectomy with splenectomy the short gastric vessels are divided
- Laparoscopic ultrasonography (LUS) is routinely performed. This information is essential to plan enucleation or distal resection in case of endocrine tumors.
- In case of en bloc distal pancreatectomy the splenic artery is identified and ligated
- Mobilization of the pancreas (inferior border of the body and tail)
- Mobilization of the splenic flexure
- Division of the splenocolic ligament
- In case of en bloc distal pancreatectomy the splenic vein is identified and doubly ligated
- When the spleen was conserved, the splenic artery and vein are conserved. Preservation of the spleen with distal pancreatectomy can be undertaken either with preservation or with sectioning of the splenic vessels by maintaining the blood flow to the spleen via short gastric vessels (technique of Warshaw) **(53).** The latter method is associated with a shorter operation time, less blood loss, and a shorter hospitalization. The subsequent appearance of gastric varices is a consequence of loss of the splenic

vein but no bleeding from these collaterals during long-term follow up, has been described. However, a splenic infarction after the laparoscopic procedure of Warshaw has been documented in several case reports **(54, 55).**

- The body and the tail are mobilized by dissecting the avascular plane between mesogastric fascia and Gerota fascia.
- The spleen is retracted
- The pancreatic tail is retracted (down and caudally) and communications between the pancreas and the main vessels sealed
- The pancreas is transected
- The specimen is placed in a large endobag and retrieved through the augmented umbilical port.
- A silicone drain is placed near the pancreatic remnant through the shorter route from the abdominal wall.

The main controversial aspects in LDP are: a) preservation of the spleen, b) the number and location of orifices needed for approaching the pancreas, c) the extent of the resection and d) the technique used for the parenchymal transection **(56)**.

Traditionally, distal pancreatectomy has been performed with splenectomy. However the spleen plays an important role in the immune system and spleen-preserving distal pancreatectomy is preferable, in patients with benign diseases or non-invasive neoplasms **(8, 57, 58, 59)**. The rate of splenic conservation of LDP is reported to be between 32% and 84% **(37, 40).** Some comparative studies have showed higher success rate of preservation in by laparoscopic compared to open approaches **(37, 40).** This is surely due to the better vision afforded by the magnification, used in laparoscopy.

Depending on underlying disease, four trocars were generally inserted into the following locations: the left side of the naval (12 mm); 5 cm caudal to the hypochondrium along the upper abdominal median line (5 mm); near the left mammillary line below the costal arch (12 mm); the anterior subcostal region–midaxillary line (12 mm) **(60).**

The extent of a resection in LDP is another controversial topic. It varies depending on the pathology. For example, when a non-invasive mucinous cystic neoplasm (MCN) is located in the tail of the pancreas, the gland can be divided to the right of the cystic lesion with a minimal margin and only the tail of the pancreas removed. For chronic pancreatitis, it is typically divided at the pancreatic neck anterior to the superior mesenteric vein **(7, 27).** Recently, pancreatic surgeons have performed parenchyma-sparing resections more frequently in order to decrease the rate of postoperative pancreatic insufficiency. Oncological radicality is essential and extended resections may be necessary in the setting of intraductal papillary mucinous neoplasms (IPMN) **(56)**.

With regard to pancreatic transection this can be performed either using harmonic scalpel or a linear stapler with polypropylene interrupted suture. It is also carried out by articulating linear cutter with green cartridge. Some surgeons also reinforce the staple line with sutures or fibrin glue application. All approaches, including fibrin glue, sealants, patches, stapler closure, electrocautery and suture have been tested in numerous studies **(61, 62)**. The appropriate usage of modern technologies (electro thermal bipolar vessel sealer, ultrasonic coagulating shears) can also achieve secure haemostasis of tributaries from splenic vessels **(63)**.

As experience in laparoscopic pancreatectomy increases several newer technical variants have been used:

a) Laparoscopic distal pancreatectomy can be performed using a hand-assisted technique in order to facilitate the splenic vessel preservation, because incidental bleeding can be immediately stopped by finger compression, and in large cystic tumors for a safe mobilization of the tumor and adjacent tissue. Hand ports for the insertion of operator's left hand are placed through an upper midline incision, right subcostal incision, or right lower-quadrant transverse incision according to the preference of surgeons **(64-67)**.

b) Single incision laparoscopic surgery has also recently been reported for LDP **(68)**. It may be effective as conventional laparoscopic pancreatectomy, when performed by expert hands although it is still a challenging procedure **(69)**. Further studies are

necessary to determine the advantages of this procedure in comparison with standard laparoscopy.

c) Finally some robot-assisted pancreatic resections have been reported **(70-72)**. Robotic surgery, can bridge the gap between minimally invasive surgery and complex pancreatic surgery, thus extending the indications for minimally invasive pancreatic surgery. This technique minimizes the risk of pancreatic capsule rupture as well as tumor cell dissemination, respecting oncological surgical standards and it could provide an increased chance for spleen preservation. However, robotic surgery has high costs especially concerning the installation and the operation time, which is longer than open surgery; at the same time, it also needs an adequate learning curve.

1.3 Morbidity

The most frequent complications after distal pancreatectomy are the fistula formation and collection **(8, 60, 73)**; they are usually related to pancreatic parenchymal transection techniques, that is another controversial topic. The incidence of pancreatic fistula is variable among various series, because of different definitions used in different pancreatic centers **(74, 75)**. In 2005 the International Study Group on Pancreatic Fistula Definition consensus paper defined a postoperative pancreatic fistula as the existence of any fluid output after postoperative day three with amylase content greater than three times the upper normal serum value **(76)**. With the same definition, pancreatic fistula rate of 19% was observed in a prospective open distal pancreatectomy series **(75)**. Pancreatic leak was observed in four patients (23%) in this series. Mabrut reviewed a total of 897 patients who underwent open distal pancreatectomy and reported the incidence of pancreatic fistula to be 3.5%-26% (average 13%) **(8)**. The incidence of pancreatic fistula with laparoscopy in studies that involved at least ten patients ranged from 0% to 27% **(60)** and at all institutions, a stapling technique was used when the pancreas was transacted **(8, 17, 18, 20, 21, 47, 48, 52)**. In three case series of laparoscopic resection for insulinomas, pancreatic leakage was reported for 3 of 6 (50%) **(77)**, 2 of 6 (33%) **(78)** and 2 of 9 (22%) **(79)** patients, an overall leakage value of 30% (7 of 21 patients).

Various risk factors for fistula formation have been reported after distal pancreatectomy. Studies have reported that pancreatic fistula is likely to occur with a pancreas with a soft texture, and differences have been seen with respect to resection method **(8, 80-82)**. The distal pancreatectomy trial included 352 patients that were randomly assigned to stapler or hand-sewn closure of the pancreatic remnant: both groups showed equal fistula rates of 30% and 36% **(83)**. Studies on open-DP have reported the usefulness of ligation of the main pancreatic duct **(82)** or the necessity of ligating all peripheral narrow pancreatic ducts—not just the main pancreatic duct—using an ultrasonic dissector **(81)**. However, it was not possible to eliminate pancreatic fistula using any of these methods.

Some authors have suggested that the selective ligation may be more difficult during laparoscopy and may contribute to increased fistula rates **(8)**. Nevertheless, comparative studies showed that the laparoscopic approach results in a similar rate of

fistula formation than the open approach **(37, 38, 39)**. To prevent post-operative fistula, octreotide and its analogues, have also been used since 1990. However, despite twenty years of clinical use and performance in numerous studies, a recent Cochrane meta-analysis concluded that evidence is still lacking to give clear recommendations **(84)**. Intraabdominal drains are commonly used in most centres after pancreatic resections. There is no evidence that persisting drainage of postoperative wound fluid has a positive effect in avoiding fistulae; on the contrary, a recent study sustains that drains kept in situ for more than three days enhance fistula development **(85)**.

The management of postoperative fistula remains a therapeutic challenge. Depending on patient's clinical conditions, it ranges from persisting drainage without any further measures, up to revision surgery. However a conservative management of pancreatic fistula is usually described in literature, after LDP **(60, 76, 82)**.

1.4 Conclusion

In conclusion, LDP in adult patients is a feasible and safe procedure in patient with benign or low grade malignancies. The assets of laparoscopic pancreatectomy have been confirmed for benign diseases. Decreased blood loss and morbidity, early recovery and shorter hospital stay may be the main advantages. Still further studies are needed to advocate laparoscopic excision as a routine technique for malignancies located in the pancreatic body and tail **(2, 56).**

However, the benefits of minimally invasive surgery are mainly encountered in the absence of postoperative pancreas-related complications. Thus the successful management of the pancreatic stump remains the challenge of this procedure. As a high incidence of pancreas-related complications is associated with the use of laparoscopic staplers, further technical refinements are required for transecting the pancreas and treating the pancreatic surgical margin **(8).** The use of biodegradable Seamguard material seems to be promising in the perspective of preventing pancreatic leaks after distal resection **(2)**.

The introduction in particular of robotic surgery, can bridge the gap between minimally invasive surgery and complex pancreatic surgery. On the other hand, randomized multicentre trials involving centres with experience in advanced laparoscopic surgery are necessary to determine the best technique for minimizing pancreatic fistula formation and to improve the results of the procedure **(56)**.

All in all, laparoscopic pancreatic surgery must be considered an advanced laparoscopic procedure and should be performed only in institutions with expertise in pancreatic surgery by a team with advanced laparoscopic skills. Most published reports on laparoscopic pancreatic surgery resections are on single cases or limited series of patients. Moreover, the follow up is short, and therefore little is known about the long-term results. Three factors should be considered for the indications of this new procedure—the proper patient, the proper procedure, and the proper performance **(44).**

PART 2:

Laparoscopic Distal Pancreatectomy in Children

2.1 Aim of the study

The aim of this study is to present current evidence regarding laparoscopic distal pancreatectomy in children less than 14 years of age. We reviewed the most recent literature in order to offer an up-to-date regarding distal laparoscopic pancreatectomy in children. We gathered their data and attempted to present them in a concise and comprehensible way. Data regarding age and sex of the patients as well as medical indications for pancreatectomy, preoperative planning, technical details and methods, intraoperative and postoperative course and complications were all searched for, grouped together and presented in three all-inclusive tables. We then used these data to attempt to evaluate this technique using statistical analysis when possible. Unfortunately the number of published articles as well as that of the patients included is not sufficient to draw statistically significant conclusions. However we think that our presentation might help in preoperative, intraoperative and postoperative planning all those experienced paediatric laparoscopic surgeons who venture in an attempt to do a laparoscopic distal pancreatectomy. Our presentation might also offer information regarding feasibility and safety of this technique to all doctors in paediatric specialties who are involved with children in need for a distal pancreatectomy. Finally all information presented here, might help in a better understanding of the pros and cons of this technique and as a result give stronger evidence for a more informed patient consent.

2.2 Materials and Methods

Web search

At first a web search was performed in PubMed database. We used the key words “laparoscopic distal pancreatectomy” and used species filter for humans, language filter for English and age filter for child: birth-18 years. A total of 43 papers were found up to May 2014. Unfortunately there is no filter for child less than 14 years of age so we had to do that ourselves. By also using the information given in the title and abstract for each one of those papers we selected 34 of the above for further reading. The bibliographic research was further expanded considering the related references cited by the above-mentioned papers. We finally included 15 papers that were relevant to the subject we wanted to investigate and are the base of our presentation **(86-100).**

In order to include any paper possibly published in a journal not indexed in pubmed we also performed a Google search. We used the term “laparoscopic distal pancreatectomy and children” and “laparoscopic distal pancreatectomy and child”. We added one more paper with this search. This is a paper published in 2014 in a pubmed indexed journal but strangely enough it was not listed in pubmed with our previously mentioned filters **(101).** No other paper relevant to our research was found in any other journal or database.

These sixteen papers included 42 patients, 20 males and 22 females, less than 14 years of age that had a laparoscopic distal pancreatectomy. Most cases were case reports. We found five case series: The first included twelve patients with PHHI. The second one included two pancreatic trauma patients and one SPT. The third was a study from six large-volume pediatric trauma centers including seven pancreatic trauma patients that had laparoscopic distal pancreatectomy. The fourth one included another three patients with pancreatic trauma. Finally there was a case series with twelve cases of SPT tumours of who six were less than 14 years of age. Table 1 shows details of the 16 selected papers. All papers included retrospective series. Apart from the above mentioned multicentre study the rest derived from a single centre each time.

2.3 Results

2.3.1 Indications and epidemiology

Four were the main indications for distal laparoscopic pancreatectomy in children less than 14 years of age: 1) Pancreatic trauma, 2) PHHI (persistent hyperinsulinemic hypoglycemia of infancy), 3) Benign solid pseudopapillary tumours of the pancreas (SPT) and 4) Insulinoma. All data regarding indications for distal laparoscopic pancreatectomy, as well as epidemiological details of the patients are presented in Table 1. What follows is a more analytical presentation of these data.

1. Trauma to the pancreas is the most common indication of distal laparoscopic pancreatectomy in children. Blunt traumatic injury to the pancreas occurs infrequently in children and can be very difficult to diagnose. It is estimated that injuries to the pancreas compose 3% to 12% of intra-abdominal injuries in children sustaining blunt trauma. **(102).** The lack of surrounding fat planes and the small size of the retroperitoneal gland make it challenging to document even a major ductal injury by routine CT **(103).** A dynamic CT pancreatogram, with multiple thin slices while infusing a contrast medium, gives much more detail than routine abdominal CT. Magnetic resonance cholangiopancreatography also is a useful diagnostic modality but is not appropriate in the acute resuscitative phase of the child with multiple injurie **(104).**

There is a difference in the pattern of injury and management of blunt pancreatic trauma for children and adults **(31, 105)**. Children are more likely to have isolated pancreatic injury compared with adults. In children, nonoperative management of pancreatic trauma has been found to be successful even if a major ductal injury has occurred **(31, 106, 107).** Nonoperative management of blunt injuries to the liver, spleen, and kidney in children is accepted as the standard of care in the majority of cases. Controversy exists when discussing management of the child with a significant pancreatic injury. Those with a pancreatic contusion without major ductal disruption will heal spontaneously. In the child with a major pancreatic ductal injury, early operative intervention has been reported to shorten hospitalization and lessen

dependence on total parenteral nutrition compared with those children who were initially managed nonoperatively **(108, 109).** Pseudocyst formation occurs in 45% to 100% of ductal injuries managed nonoperatively **(110, 111).** Of these, a significant number, up to 60%, may resolve with time. Percutaneous or cyst-enteric drainage procedures may be needed if resolution does not occur spontaneously. These children have an increased length of hospitalization as well as an increased dependence on total parenteral nutrition compared with those undergoing early distal pancreatectomy. ERCP as a diagnostic and therapeutic option has recently gained some favor in selected centers with pediatric ERCP expertise. Documentation of a ductal injury, sphincterotomy, and possible stenting of the injury are all maneuvers useful for healing **(112).**

So reports from major pediatric trauma centers are clearly in conflict. Some favor and document the efficacy and safety of observational care for virtually all pancreatic injuries, including duct disruption **(111)**; others advocate aggressive surgical management with debridement or resection **(108, 109)**. Because proponents supply compelling data for each of these treatments, algorithms reflecting individual hospital or surgeon preference will probably determine which treatment plan is selected. However, it is clear that with simple transection of the pancreas at or to the left of the spine, spleen-sparing distal pancreatectomy can provide definitive care for this isolated injury, with short hospitalization and acceptable morbidity. Laparoscopic techniques may limit perioperative morbidity **(113)**.

In conclusion the management of pancreatic injuries should be individualized depending on the site of injury, timing of referral, presence of associated injuries, and institutional expertise and logistics. Firm evidence-based conclusions are impossible because of the small number of patients in each series, the variable natural history of pancreatic duct trauma and the diversity of reported management strategies. However, children referred early with clearly defined grade III injuries probably benefit from an early spleen-sparing distal pancreatectomy. Those with grade IV injuries frequently require laparotomy when Roux-en-Y drainage of the fracture site is a useful technique. Most other children should initially be managed without surgery **(114)**.

There are eight published reports of laparoscopic distal pancreatectomy for pancreatic trauma in children. Most were case reports **(86, 91, 92, 95, 98)**. The first one is a case of a 10-year-old boy who sustained a distal transection of the pancreas due to blunt abdominal trauma **(86).** Unfortunately this is a case report that was

published only online and got lost when ownership of the journal changed and its old website was shut down. All information we have are those included in the summary. There are also three case series with two, three and seven cases respectively **(97, 99, 100)**. The last one was a multicentre study. All these reports include 17 patients. There are 12 male and 5 female patients. Age ranged from 7 to 14 years. All patients had a preoperative abdominal CT. One patient had an ERCP and another had MRCP in order to further investigate the extent of pancreatic injury. All patients had pancreatic duct injury. Transection was located in the distal pancreas in 4 patients. In three patients pancreatic body was injured. There are also two cases of pancreatic neck injury. There were no further details for the rest of the patients.

2. A second indication for laparoscopic distal pancreatectomy in children is persistent hyperinsulinemic hypoglycemia of infancy (PHHI). PHHI is a rare derangement of glucose metabolism. Molecular biologic studies have shown that abnormalities of the K ATP channel, which are encoded by the sulfonylurea receptor 1 (SUR1) and Kir6.2 genes, are responsible for altered control of insulin secretion. PHHI carries an estimated incidence of 1 to 1.4 in 50,000 live births, leading to about 80 to 120 new cases in the United States each year. Pancreatectomy for management of persistent infantile hypoglycemia was first performed at the Children's Hospital of Philadelphia (CHOP) in 1950. Inappropriate oversecretion of insulin is the hallmark of PHHI. The old term "nesidioblastosis" should be discarded. PHHI is the most common cause of persistent hypoglycemia in neonates and can lead to seizures and irreversible brain damage **(115).**

It can either be focal or diffuse. Because more than 50% of focal lesions involve the pancreatic head, subtotal (50% to 75%) distal pancreatectomy is inadequate therapy in many of these cases. 95% of babies with the focal form of PHHI are cured after limited pancreatectomy. The vast majority had a less than 50% pancreatectomy. For babies with diffuse PHHI treated with near-total pancreatectomy (95% to 98%), about one third require no glycemic medications, one third require insulin to treat diabetes, and one third require a glycemic medication (usually octreotide). Long-term follow-up is necessary for all of these children, particularly with regard to neurodevelopmental issues **(115).**

In our review we found two published reports of patients that had distal laparoscopic pancreatectomy for hyperinsulinism. The first is a case report of a 4 week old male infant with PHHI **(87).** Unfortunately this is a case report that was published only online and got lost when ownership of the journal changed and its old website was shut down. All information we have are those included in the summary. The second one is a study of 12 patients with PHHI **(93).** They all had distal laparoscopic pancreatectomy. There were 4 male and 8 female patients. Age ranged from 0.5 to 89 months. Median age was 11.5 months. Distal pancreatectomy for PHHI involves a younger age than all other indications.

3. The third most common indication for laparoscopic distal pancreatectomy in children is benign solid pseudopapillary tumour of the pancreas (SPT). The first cases of papillary-cystic endothelial tumors of the pancreas were reported by Franz in 1959 **(116).** Since these tumors were described as solid and cystic acinar cell tumors of the pancreas by Kloppel and colleagues **(117)** increasing numbers have been reported in children. They occur predominantly in girls and young women and are manifested as large, encapsulated masses, usually with extensive necrosis and varying amounts of cystic change. These tumors seem to be associated with a much better prognosis than the usual type of pancreatic carcinoma but still have malignant potential **(118).** The tumor follows a benign course after resection in most cases. Metastasis or recurrence has occurred in 5% of cases in Japan **(119).** Thus complete extirpation is necessary because of the slow tumor progression associated with metastatic disease. Liver metastases have been treated with resection and liver transplantation **(115).**

In our study we found 6 papers including 11 patients **(89, 90, 94, 96, 97, 101)**. There are 2 male and 9 female patients. Age ranged from 9 to 13 years of age. All patients had preoperative CT. Three out of them had a transabdominal US and one had an abdominal MRI. Four patients had the tumour localized in the pancreatic tail. One 12 year old female patient had the tumour located in the pancreatic body.

4. Finally there is an insulinoma case **(88).** Insulinomas are the most common tumor arising from islet cells and are usually benign (> 90%), solitary (80%) lesions

that occur in children older than 4 years. A plasma insulin-to-glucose ratio greater than 1 is diagnostic (< 0.4 is normal), and the ratio increases with fasting. Concomitant measurement of C peptide levels may be used to exclude factitious hypoglycaemia **(120, 121, 122)**. CT, US, arteriography, and transhepatic portal venous sampling can be used to localize an insulinoma. The tumor is usually discrete and well encapsulated, and most can be enucleated. The introduction of endoscopic and intraoperative US has allowed obscure lesions to be identified. If all methods of tumor localization are unsuccessful, distal pancreatectomy with careful sectioning of the gland is advisable. In that circumstance, measurement of intraoperative insulin levels is recommended to avoid missing lesions. Virtually all infants and children with insulinoma can be cured **(115).**

The case report inlcuded in our study is a case of a 13 year old male patient with an insulinoma in the tail of the pancreas. The patient had endoscopic ultrasound, CT and MRI preoperatively. Insulinoma was located in the tail of the pancreas **(88)**.

2.3.2 Operative details

We gathered information that included operative time, the time that passed in case of a pancreatic trauma to operation, the number of ports used, the method of pancreatic transection and dissection of the body and tail, whether the spleen and or the splenic vessels were preserved, the method of specimen retrieval, the need for intraoperative transfusion and estimated blood loss, the use of a drain and the day this was removed. We also found all information regarding postoperative course such as time of initial feeds, time to full feeds, ambulatory time, the length of hospital stay, time to restart full activity and the presence of any complication. All information is presented in Table 2.

Operative time ranged from 75 min to 540 min. Median operative time was 228 min. This wide range in time may be due to difference in experience of the surgeon, difficulty of individual case or difference in start and stop point measured in each case. For instance in the only insulinoma case we included in our study the surgical team performed laparoscopic ultrasonography to confirm the extent of resection and the operation also included splenectomy and morcellation of the spleen in order to remove the specimen. These manoeuvres resulted in a longer operative time 330 min **(88).** In another case an 8 year old female had a laparoscopic distal pancreatectomy after pancreatic trauma **(99)**. Because she was much smaller and her transection was closer to the superior mesenteric vessels, a stapler was not used for concerns of compromising more normal pancreas than necessary with the stapling device. Instead, after the pancreatic remnant was removed, the proximal pancreas was oversewn laparoscopically with several 5-0 PDS (RB-1) sutures to imbricate the transected surface and achieve closure. As a result operative time increased to 344 min.

Understandably pancreatectomy is a very delicate and demanding operation especially when trying to preserve the spleen and its blood supply. Duration of about 4 hours or even less seems reasonable and anticipated even in an open surgery case.

An operation of almost six hours also is justified especially when at the start of the learning curve and still has the potential postoperative advantages of minimal invasive surgery. If more time than six hours is needed to complete the operation then the surgeon should start making plans for conversion to open surgery.

As already reported we found seventeen patients that had distal laparoscopic pancreatectomy due to pancreatic trauma. The timing of the operation is still under debate. In 15 of the patients the timing from trauma to operation ranged from 6 hours to three days. Median 24 hours. One patient was operated in 3 months and another in 45 days. The first one was a 7 year old boy that sustained a blunt trauma following a fall into bicycle handlebar **(91)**. At first he was managed conservatively because he was stable. But after three months of conservative treatment the situation failed to resolve. To prevent the formation of pancreatic abscess a laparoscopic distal pancreatectomy was decided. This was owing to the fact that levels of pancreatic function were indicative for the progression of chronic pancreatitis. The increase of sepsis markers (e.g. WBC and CRP) and intermittent abdominal pain in the epigastrium were evaluated as a possible evolution to acute pancreatitis. The second one was a 13 year old female with persistent pancreatic fistula after blunt trauma s/p failure of drainage, ERCP, TPN **(97).**

Blood loss was minimal in most cases. When reported it ranged from 50ml to 1040ml. One study reported preoperative and postoperative transfusion rates of 17% for both **(100)**. All in all it seems that meticulous operative technique and modern technology have made blood loss not a major concern in this demanding operation.

In terms of port number and placement most surgeons used 4. Most used a 5mm camera, a 10 or 12mm port for stapler and two 5mm or 3.5mm ports for the instruments. When ultracision or endoloop was used then the 10-12mm port could be replaced with a smaller one. Some surgeons used only three trocars in the operation without a 5 mm trocar for the assistant when the surgical field of view was good enough and there was no further traction needed **(101)**. In one report surgeons used an 8 cm periumbilical hand port instead of the stapler port **(92)**.

The most common way to transect the pancreas was by linear endostapler. In 6 patients the stump was over sewn with suture to reinforce stapling line and avoid complications such as pancreatic leak. One surgeon used the Harmonic scalpel (ultracision) **(91)**. Fibrin glue was used for the same reason in 5 patients. Another surgical team that reported operating on 12 infants with PHHI used only endoloop 2-0 vicryl **(93).** This most likely is justified by the smaller and more delicate anatomy of the pancreas in an infant. A simple endoloop seems enough whereas on the other hand the 12 mm endostapler poses a threat for intraoperative injury by its size in small babies.

A very important part of laparoscopic distal pancreatectomy is spleen preservation with or without splenic vessel preservation. In our study we found four cases of spleen removal. Two were SPT cases and were removed because of encasement of the splenic vein by the tumour **(101).** One case of spleen removal was the only insulinoma case in our study. Authors claim that spleen preservation was infeasible because of the proximity of the tumour to the splenic hilum **(88)**. This practice seems to be more common and accepted compared to adults. Spleen has an important function for the immune system of a child and as a result every attempt should be made to preserve it.

The last case of spleen removal was a 12 year old male with persistent pancreatic fistula after blunt pancreatic trauma **(97)**. Due to the associated chronic inflammation, the splenic vessels could not be dissected away from the distal pancreas, so the spleen was resected. The only one case of spleen preservation but with ligation of splenic vessels was a 14 year old boy that suffered blunt pancreatic trauma **(92)**. There was significant peripancreatic fat necrosis adjacent to the splenic vessels, and no attempt was made to preserve them.

As for pancreas removal the most common way is by endobag through the umbilical incision. In two cases a pfannestiel incision was used **(90, 96).** There was one case that a hand port was used as already mentioned before **(92).**

A drain was used in most cases where this detail was reported. All surgeons that reported the type of drain, used a closed suction drain. In two cases a drain was not used **(101).** No further details are given to explain this decision. In all other cases the use or not of a drain was not reported. The drain stayed between 3 and less than 9 days.

Postoperative course was uneventful in all cases. Time for initial feeds ranged from 24 hours to 13 days. Time to full feeds ranged from 3 days to 25 days. Information regarding time to full activities was reported in only one study and this was 6 weeks **(99)**.

Finally length of hospital stay ranged from 3 days to 20 days. Median 6 days. One case with long hospital stay was the insulinoma patient. Authors had a concern about leakage and so there was a delay in removal of the abdominal drain. Moreover they admit that early experience and caution and the lack of pressure to send patients home with their present health care system are additional reasons for longer hospital stay **(88).**

2.3.3 Complications

Pancreatic surgery can be the cause of serious complications that are notoriously difficult to cope with and often affect patient's postoperative quality of life. In our study we thoroughly searched all selected publications of children less than 14 years of age that had a distal laparoscopic pancreatectomy for any reported complication. We specifically searched for any case of pancreatic leak, conversion to open surgery, postoperative ileus, wound infection, pleural effusion, bleeding, pancreatic fistulae, abdominal wall hematoma, pancreatitis, abscess, and pseudocyst. It seems that complications are not often in children. Most reported cases were completed without any incidents. This might be explained by the fact that only very experienced laparoscopic surgeons tend to undertake pancreatic surgery in children. Moreover the fact that they deal with children is in itself a factor for better preoperative planning and caution during surgery.

We found 10 cases with 13 complications out of 42 patients that had a laparoscopic distal pancreatectomy. Two were in patients with PHHI and three in SPT patients. The rest were pancreatic trauma patients.

Three patients had a pancreatic leak. All three of them encountered in cases of pancreatic trauma patients **(92, 100)**. Two pancreatic fistulas were reported in SPT cases **(101)**. Pancreatic leak and/or fistula indeed has always been the Achilles heel for any type of partial pancreatic resection **(100)**. The two first patients came from a multicenter study comparing laparoscopic and open surgery results. Authors observed that pancreatic leak rate was higher in the laparoscopic group even though there was no difference in how the pancreatic stump was managed. The lack of adhesion formation has been implicated as a reason for higher pancreatic leaks in laparoscopic pancreatic resections compared with open procedures **(100).** However, the published data do not support higher pancreatic leak rates with laparoscopy **(123, 124).** Furthermore, those series involved patients undergoing resection for pancreatic neoplasms and not patients with traumatic transection where a localized inflammatory

process has been initiated that would incite adhesion formation regardless of an open or laparoscopic approach **(100).** One of the three was a 14-year-old boy with complete transaction of the pancreatic neck following fall off his bicycle onto the handlebars. A low-volume pancreatic leak was noted for the first few days post-operatively, which spontaneously sealed after 3 days. In this case a hand port was used and the pancreas had retracted while the surgeons tried unsuccessfully to suture the transected stump **(92)**. In the case of the two SPT patients no additional procedure was performed to treat the fistulas. Patients had to fast for 5 days, and their pancreatic fistulas resolved through the maintenance of drainage at 3 weeks after surgery **(101)**.

The two complicated cases of PHHI patients needed conversion to open surgery **(93).** One was converted early in the series because of difficulties in dissecting the pancreatic tail of the splenic hilum. The other was converted because of difficulties in visualizing the head of the pancreas within the C-loop of the duodenum. A transverse mini-laparotomy was performed for the second patient over the area of the head of the pancreas, and minimal pancreatic tissue was removed to achieve 95% pancreatectomy.

There were also three cases of postoperative ileus. One case is reported but not further analyzed in the laparoscopic group of the multicenter study mentioned before **(100).** The second was an SPT case **(101).** The other one was a 10-year-old boy (31.4 kg) who sustained blunt trauma to the epigastrium during a football game from another players' knee **(99)**. Surgery was uneventful, EndoGIA stapler (Covidien,Norwalk, Conn) was used to divide the pancreas avoiding the splenic vein and artery. Operative time was 150 minutes, and intense fat saponification and colonic distension were notable at laparoscopy. He had a prolonged ileus postoperatively and this accounted for his longer hospital course of 15 days. This patient also was the one that presented mild pancreatitis as evidenced by slowly declining amylase and lipase levels. This episode of pancreatitis was treated conservatively. His drain was removed after 7 days, his diet was slowly advanced, and he required TPN for 13 days. He was discharged on postoperative day 15 and has done well for over 35 months after LDP.

One patient developed a right upper quadrant hematoma from a trocar **(99).** This was a 13-year-old boy (40.1 kg) that sustained a handle bar injury to the upper abdomen while riding a motorized dirt bike. CT scan revealed transected distal pancreas in addition to a grade 2 splenic laceration and left pleural effusion. Laparoscopic distal pancreatectomy (LDP) performed 72 hours after injury. EndoGIA stapler (Covidien,Norwalk, Conn) was used to divide the pancreas avoiding the splenic vein and artery. The pancreatic remnant was removed via a 10-mm Endobag (Covidien). Operative time was 146 minutes with a drain left in the pancreatic bed and removed on postoperative day 7. He remained on TPN for 7 days and was discharged on that day. The trocar site hematoma resolved with expectant management.

Finally a case with wound infection is also reported but not further analyzed in Iqbal et al **(100).**

No case of pseudocyst after LDP was reported in any of the selected papers.

2.4 Tables

TABLE 1: Journal Details

A/A	AUTHOR	JOURNAL	YEAR	NUMBER OF PATIENTS	PERIOD OF TIME	AGE	SEX	INDICATION	LOCATION OF TUMOUR/INJURY	PREOP IMAGING
1	Sayad et al	Surg Endosc	2001	1	-	10y	Male	Pancreatic Trauma	Distal transection of the pancreas	-
2	Blakely et al	Surg Endosc	2001	1	-	4w	Male	Persistent Hyperinsulinemic Hypoglycemia of Infancy (PHHI)	Lap Distal Pancreatectomy (from splenic hilum to mesenteric vessels) to control hypoglycemia	-
3	C.Y. Lo and P.K.H. Tam	Asian Journal of Surgery	2003	1	-	13y	Male	Insulinoma	Tail of pancreas	CT, MRI and endoscopic US
4	Carricaburu E et al	Surgical Endoscopy and Other Interventional Techniques	2003	1	-	9y	Male	Frantz's Tumour, (SPT)	Tail of the pancreas	CT
5	Melotti G et al	Annals of Surgical Oncology	2006	1	-	11y	Female	Benign neoplasm, solid pseudopapillary tumor (SPT)	Tail of the pancreas	Transabdominal US, CT
6	Leva E et al	Journal of Laparoendoscopic and Advanced Surgical Techniques	2008	1	-	7y	Male	Grade 4 pancreatic trauma	Body of the pancreas, interruption of the duct at the level between head and body	US, CT and ERP
7	Nikfarjam M et al	Journal of Pediatric Surgery	2009	1	-	14y	Male	Pancreatic Trauma	Complete disruption of the pancreatic duct at the level of pancreatic neck(imaging finding) / Pancreas transected entirely along its neck (operative finding)	CT and ERCP
8	Al-Shanafey, Al-Shanafey et al	Journal of Pediatric Surgery	2009	12	4y	11.5mo (median) (0.5-89mo)	4M-8F	Persistent Hyperinsulinemic Hypoglycemia of Infancy (PHHI)	Pancreatectomy to control hypoglycemia	None
9	Sokolov YY et al	European Journal of Pediatric Surgery	2009	1	-	13y	Female	SPT	Pancreatic Tail	US, CT
10	Malek et al	Surg Endosc (video)	2010	1	-	13y	Male	Pancreatic Trauma	Transected distal pancreas	CT
11	Uchida H et al	Journal of Pediatric Surgery	2010	1	-	12y	Female	Benign neoplasm, solid pseudopapillary tumor (SPT)	Body of the pancreas	US, CT, MRI
12a	Mukherjee et al	Journal of Laparoendoscopic and Advanced Surgical Techniques	2010	3	-	12y	Female	Benign neoplasm, solid pseudopapillary tumor (SPT)	Pancreatic Tail	CT, MRI
12b	Mukherjee et al	Journal of Laparoendoscopic and Advanced Surgical Techniques	2010	3	-	13y	Female	Pancreatic Trauma	Transected distal pancreas	CT, MRI
12c	Mukherjee et al	Journal of Laparoendoscopic and Advanced Surgical Techniques	2010	3	-	12y	Male	Pancreatic Trauma	Transected distal pancreas	CT, MRI
13	Gow K	The American Surgeon	2010	1	-	10y	Male	Pancreatic Trauma	Fracture through the midbody	CT
14a	Rutkoski J et al	Journal of Pediatric Surgery	2011	3	2y	13y	Male	Pancreatic Trauma	Transected distal pancreas	CT
14b	Rutkoski J et al	Journal of Pediatric Surgery	2011	3	2y	10y	Male	Pancreatic Trauma	Transected distal pancreas	CT
14c	Rutkoski J et al	Journal of Pediatric Surgery	2011	3	2y	8y	Female	Pancreatic Trauma	Midpancreatic transection	CT
15	Iqbal et al	Journal of Laparoendoscopic and Advanced Surgical Techniques	2012	7	2006-2010	9.1±4.2 (mean age less than 14)	57% Male	Pancreatic Trauma	Grade III pancreatic injury, transected main pancreatic duct	CT (7/7), MRCP(1/7)
16	Namgoong et al	Pediatr Surg Int	2014	6	6y	<14y	5F-1M	SPT	LPD	US, CT

TABLE 2: Operative details

A/A	OPERATIVE TIME	BLOOD LOSS	DRAIN USED/REMOVED	SPLENIC PRESERVATION	SPLENIC VESSEL PRESERVATION	TIMING OF OPERATION (TRAUMA)	PANCREATIC STUMP (STAPLER / ULTRACISION /ENDOLOOP/ GLUE / SUTURES)	TIME OF INITIAL FEEDS	TIME TO FULL FEEDS	AMBULATORY TIME	LENGTH OF HOSPITAL STAY	COMPLICATIONS	RESTART FULL ACTIVITY	TRANSFUSION (PRE-INTRAOPERATIVE)	METHOD OF RETRIEVAL	PORTS
1	-	-	-	-	-	-	-	-	-	-	3d	None	-	-	-	-
2	75min	Minimal		Yes	Yes	-						None				4 {5mm camera(umbilicus), 3x3.5mm}
3	330min	400ml	Closed suction drain/8d	No	No	-	Stapler, no suture	Not known	5d	7d	11d	None	Not known	Not known	Sterile plastic bag	5 (10mm and 4x11mm)
4	240m	Not known	Yes/ Not known, <6d	Yes	Yes	-	Endoscopic linear stapler	2d	Not known	Not known	6d	None	Not known	Not known	Endobag, nlarge umbilical trocar incision	4 (1x10mm camera, 2x5mm, 1x12mm stapler)
5	120m	minimal	Yes/ Not known, <5d	Yes	Yes	-	Linear 45mm endostapler	2d	Not known	Not known	5d	None	Not known	Not known	Endobag, Pfannenstiel incision to avoid breaking the mass	4 (1x10mm camera, 2x5mm, 1x12mmstapler)
6	Not known	Not known	Not known	Yes	Yes	3mo	Harmonic scalpel (Ultracision)	4d	25d	Not known	6d	None	Not known	Not known	Endobag	4 (5mm)
7	Not known	50ml	Closed suction/unknown(<9d)	Yes	No	24h ?(the nlargeg day)	Completely transected, not oversewn because it had retracted to the right of the portal vein with concerns of inadvertent bile duct injury with suturing in this region	Not known	9d	Not known	9d	Yes	Not known	Not known	Hand port?	3x5mm and an 8cm periumbilical hand port
8	(117-305min)	Not known	Closed suction drain 3/12, removed on day3	Yes	Yes	-	Endoloop 2-0 vicryl	24-26h	Not known	Not known	Whenever blood glucose levels were stable/12.3 d mean*	Yes	Not known	Not known	Not known	3x3.5mm
9	150m	-	Closed suction drain/7d	Yes	Yes	-	Bipolar electrocautery, Oversewn 5-0 PDS	5d	-	-	-	None	Not known	Not known	Endobag	4 (1x10mm camera 2x5mm, 1x3mm)
10	Not known	Not known	Not known	Yes	Yes	Not known	Not known	4d	Not known	Not known	7d	None	Not known	Not known	Not known	Not known
11	340min	Little blood loss	Closed suction drain/	Yes	Yes	-	60mm endostapler reinforced with fibrin glue	3d	Not known	Not known	15d for viral illness	None	Not known	Not known	Endobag, 5cm Pfannenstiel incision	4 (1x5mmcamera, 2x5mm,1x12mm)
12a	228min	minimal	-	Yes	-	-	45mm linear stapling device	1d	-	-	4d	None	Not known	Not known	Endobag	4 (1x12mm camera, 3x5mm)
12b	285min	Minimal	-	No	-	45d	45mm linear stapling device, oversewn duct, 2-0 Ethibond	4d	-	-	12d	None	Not known	Not known	Endobag	4 (1x12mm camera, 3x5mm)
12c	206min	50ml	-	Yes	-	3d	45mm linear stapling device, oversewn duct, 2-0 Ethibond	2d	-	-	5d	None	Not known	Not known	Endobag	4 (1x12mm camera, 3x5mm)
13	Not known	Not known	Not known	Yes	Yes	6h	Oversewn 2-0 silk	Not known	Not known	Not known	5d	None	Not known	Not known	Not known	Not known
14a	344 min	< 100ml	Yes/6d	Yes	Yes	23h	Oversewn 5-0 PDS horizontal mattress sutures, Coseal sealant	0d TPN	unknown	unknown	6d	None	6w(average)	Not known	Endobag	5 (4x5mm, 1x4mm)
14b	150 min	< 100ml	Yes/7d	Yes	Yes	48h	Endostapler	13d TPN	unknown	unknown	15d	Yes	6w (average)	Not known	Endobag	4 (12 mm, 3x5mm)
14c	146 min	50ml	Yes/7d	Yes	Yes	72h	Endostapler	7d TPN	unknown	unknown	7d	Yes	6w(average)	Not known	Endobag	4 (10 mm, 3x5 mm)
15	218±101min	Not known	Yes/	Yes	Not known	1.1±1.2d	Stapled 57% / Oversewn 57% / Fibrin seal 43%	4.3±2.2	7.6±4.1	Not known	9.6±5.0	Yes, 4/7	Not known	17%/17%	Not known	Not known
16	175 (120-540min)	140 (50-1040ml)	Yes	4/6	4/6	-	Endoscopic stapler	2.0 (1-7)	3.5 (3-9)		7 (5-20)	4/7	Not known	Not known	Endobag	4 or 3(2x10mm, 2or1x5mm)

TABLE 3: Complications

A/A	CONVERSION TO OPEN	PANCREATIC LEAK	POST OP ILEUS	WOUND INFECTION	PLEURAL EFFUSION	BLEEDING	PANCREATIC FISTULAE	ABDOMINAL WALL HEMATOMA	PANCREATITIS	ABSCESS	PSEUDO CYST
1	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-
3		-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-
6		-	-	-	-	-	-	-	-	-	-
7	-	Yes, Low volume, resolved spontaneously after 3d	-	-	-	-	-	-	-	-	-
8	Yes, 2/12	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-
12a	-	-	-	-	-	-	-	-	-	-	-
12b	-	-	-	-	-	-	-	-	-	-	-
12c	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-
14a	-	-	-	-	-	-	No	Yes	-	-	-
14b	-	-	Yes	-	-	-	No	-	Yes (mild)	-	-
14c	-	-	-	-	-	-	No	-	-	-	-
15	-	Yes, 2/7	Yes, 1/7	Yes, 1/7	-	-	-	-	-	-	-
16	-	-	1/6	-	-	-	2/6	-	-	-	-

2.5 Discussion

The advantages of the laparoscopic approach over the open approach are well documented in the adult literature **(87,125).** It includes superb magnification and visualization that allow delicate dissection, shorter hospitalization, less postoperative pain, shorter interval between surgery and full recovery, and superior cosmetic results. Still laparoscopic pancreatectomy requires advanced laparoscopic skills, especially with dissection of the head of the pancreas. The dissection involves many vital structures and the extent of the resection to the right side of the superior mesenteric/portal vein may be limited by experience **(93).**

In a paediatric case this dissection needs to be done in a significantly more limited space compared to adults. Moreover paediatric cases in need of pancreatectomy are limited and rare. This is probably why laparoscopic distal pancreatectomy in children is still reported mainly in isolated case reports and small case series.

Laparoscopic pancreatic surgery in children has developed slowly due to several issues. A principal cause of this is the limited number of such cases and thus the insufficient opportunities for pediatric surgeons to master the surgical procedures required. The second cause of a delay in the advancement of laparoscopic pancreatic surgery techniques has been the development of instruments. The small patient size relative to the laparoscopic instruments being used has delayed progress. Adequately advanced laparoscopic instruments, such as vessel-sealing devices, have become obtainable only in the last decade, and are now available in sizes that are appropriate for use in children **(97)**. At the present time, pediatric surgeons can perform laparoscopic and thoracoscopic surgery even in neonates, thanks to the availability of 2 and 3 mm trocars and their matching laparoscopic instruments **(101).**

Having that in mind it is quite difficult to make any definite conclusions as to its role in children. Its more common indication is pancreatic trauma in children. It seems that the seriousness of the injury as well as the fact that surgery can be delayed for few days, gives the possibility to transfer patients to major centres and surgeons with better laparoscopic skills able to make such an operation. Moreover patients of

this group are bigger and have larger intrabdominal space and pancreatic dissection is easier and quicker.

Pancreatic injury is a relatively rare entity in the pediatric blunt abdominal trauma patient but can lead to severe morbidity. Most centres prefer conservative management and surgeons seldom have the necessary experience to perform an operation laparoscopically. The space restriction, the increased chance of bleeding and altered anatomy in a trauma patient and the use of cumbersome endostapler to transect the pancreas restrains many surgeons even experienced endoscopic ones from a laparoscopic approach. Contusions and minor pancreatic injuries should indeed be managed nonoperatively. However in children demonstrated to have a major pancreatic duct injury by CT or endoscopic retrograde cholangiopancreatography, splenic-preserving distal pancreatectomy has been documented to have the best outcomes when performed within 72 hours of injury. With a hemodynamically stable patient and an appropriately skilled surgeon, we advocate a laparoscopic approach to avoid pancreatic-associated complications, minimize length of stay, and enhance return to function **(99).** A driving force behind the claim that major pancreatic duct injury alone is not an indication for emergency pancreatectomy is the desire to preserve the function of abdominal organs. Yet, as demonstrated in our study and others of patients undergoing distal pancreatectomy for trauma, there were no instances of endocrine or exocrine deficiency **(99).**

PHHI is another common indication. It includes smaller infants and even though abdominal space is smaller, pancreatic transection on the other hand can be accomplished with simple tissue cut and endoloop ligation. So a laparoscopic procedure can possibly offer all the above mentioned advantages. Moreover early feeding as this is achieved in laparoscopicaly treated patients with PHHI is advantageous because of its physiologic effect to control hypoglycaemia **(93).**

Published data suggest that laparoscopic pancreatectomy for medically unresponsive PHHI is feasible and safe. It seems to be an ideal option as the initial resection for PHHI patients in general. For the focal type, the lesion may be identified and removed at the same time **(125).** Moreover, the advancement of the noninvasive techniques for identifying focal lesions **(126)** makes the laparoscopic approach more

practical regarding confirmation of the disease and selective resection. For the diffuse type, the initial resection may be curative or render the patient responsive to medical treatment and avoid the more extensive resection that could cause diabetes mellitus early. Even if the procedure was not effective initially, a redo-operation is possible with minimal surgical field scarring. Unfortunately there is a scarcity of reports in the literature regarding laparoscopic pancreatectomy for PHHI **(93).** As a result and even though preliminary data suggest its effectiveness, longer follow-up is warranted to ascertain that **(93).**

The technique used for LDP in cases of SPT of the pancreas is reproducible, can be completed safely within a reasonable operative time, and yielded good results. However, it should be considered an advanced laparoscopic procedure, and its application in children is still being developed. Only surgical teams with advanced laparoscopic skills should attempt it. As experience with this technique continues to grow, laparoscopic distal pancreatectomy may well become the approach of choice in selected patients for benign tumors, and it would seem ideal for treatment of SPT in children, with the recommendation that breaking the mass be avoided **(90).**

In one of our selected papers the authors prefer to perform a Pfannenstiel incision to avoid breaking the mass **(96).** This fact is important because the same authors reported a recurrence in a 12-year-old girl with SPT that was initially approached by laparoscopic biopsy because it was thought that she had a lymphoma; disease was eventually treated by open pancreatic resection. Two years later, the child developed a recurrence in the form of a peritoneal carcinomatosis. The authors could not exclude the possibility that the laparoscopic biopsy had contributed to the disease's evolution; consequently, they stopped using the laparoscopic approach for solid tumors of the pancreas. Nowadays, on the basis of several reported experiences, they believe that the laparoscopic approach is feasible, provided that the tumor is not broken open, as is done in an open technique **(90).**

Laparoscopic enucleation and distal pancreatectomy have been shown to be safe and are associated with improved postoperative recovery in patients with insulinoma **(9, 74)**. Although the role of laparoscopic surgery in children has been

accepted into the modern paediatric surgical armamentarium, the potential of applying laparoscopic surgery in children for the treatment of insulinoma cases should be explored and investigated in appropriate settings **(127).** In the only published such case the authors documented the safety and feasibility of applying this technique to pancreatic resection for benign insulinoma located in the pancreatic tail in children **(88).**

2.6 Conclusions-Proposals

Our study helped gather all the available information regarding laparoscopic distal pancreatectomy in children less than 14 years of age. All available information so far points to the fact that laparoscopic distal pancreatectomy is a feasible and safe operation with few minor complications reported in children under 14 years of age. Nevertheless its superiority compared to open surgery cannot be proven in children. This is due to the fact that there are very few published papers with regard to the subject and the fact that most of them are case reports and case studies and there are no prospective randomized trials. Still one can reasonably anticipate all the advantages well established for laparoscopic surgery.

From operating point of view it seems that there are no major technical differences from adult pancreatic surgery. It is a very demanding operation, needs advanced laparoscopic skills and equipment and ideally should be performed in large tertiary paediatric surgery centres from well-trained laparoscopic surgeons. However, it is a general admittance that the magnification of the laparoscopic technique allowed the surgeon to identify the structures much better than open surgery. Vessels such as the splenic artery and vein could be easily identified and isolated. If the experience of the team allows, laparoscopic management can be superior to open surgery owing to the magnification of the structures, return to normal activities and start of adequate diet.

So in selected patients with specific indications, in large tertiary centres and in the hands of surgeons with advanced laparoscopic skills, laparoscopic distal pancreatectomy can become an ideal alternative to open surgery. The tendency is that LDP has at least similar if not better results than open surgery. If planned well has minimal complications and in addition all the advantages reported for laparoscopy give the patient the possibility to recover to a normal life promptly.

Nevertheless randomized multicentre trials with large patient numbers and prospective study design, involving centres with experience in advanced laparoscopic surgery are necessary to establish statistical significance and change current treatment algorithms. Only in that way will laparoscopic distal pancreatectomy become the modern gold standard in the treatment of paediatric patients.

ΠΕΡΙΛΗΨΗ

Πρόκειται για μια αναδρομική ανασκόπηση της πιο πρόσφατης βιβλιογραφίας προκειμένου να παρουσιάσουμε ότι πιο σύγχρονο υπάρχει σχετικά με την λαπαροσκοπική περιφερική παγκρεατεκτομή σε παιδιά μικρότερα των 14 ετών. Βρέθηκαν και αναλύθηκαν διεξοδικά δεκαέξι άρθρα που περιλαμβάνουν 42 ασθενείς. Αναζητήθηκαν πληροφορίες που αφορούσαν την ηλικία, το φύλο των ασθενών καθώς και τις ιατρικές ενδείξεις για παγκρεατεκτομή, την προεγχειρητική προετοιμασία, διεγχειρητικές τεχνικές λεπτομέρειες και μεθόδους, την διεγχειρητική και μετεγχειρητική πορεία και τέλος τις επιπλοκές. Όλα τα στοιχεία ομαδοποιήθηκαν και παρουσιάζονται αναλυτικά. Οι κύριες ενδείξεις ΛΠΠ σε παιδιά είναι: 1) Τράυμα παγκρέατος, 2) Εμμένουσα υπερινσουλιναιμική υπογλυκαιμία της βρεφικής ηλικίας, 3) Ψευτοθηλώδη νεοπλάσματα παγκρέατος, 4) Ινσουλίνομα. Από εγχειρητική πλευρά φαίνεται ότι δεν υπάρχουν σημαντικές διαφορές από την χειρουργική ενηλίκων. Παρόλ'αυτά ο περιορισμένος ενδοκοιλιακός χώρος και το μικρότερο μέγεθος όλων των δομών ειδικά σε μικρά βρέφη αποτελούν πρόκληση για το χειρουργό. Επιπλοκές βρέθηκαν σε 10 ασθενείς και η πλειοψηφία αντιμετωπίστηκε συντηρητικά. Μόνο δύο μετατροπές σε ανοιχτή επέμβαση αναφέρονται. Φαίνεται λοιπόν ότι σε επιλεγμένους ασθενείς, με συγκεκριμένες ενδείξεις, σε μεγάλα τριτοβάθμια κέντρα και από χειρουργούς με προχωρημένες λαπαροσκοπικές δεξιότητες η λαπαροσκοπική περιφερική παγκρεατεκτομή μπορεί να αποτελέσει μια ιδανική εναλλακτική επιλογή έναντι της ανοιχτής χειρουργικής. Φαίνεται επίσης να υπάρχει μια τάση για τουλάχιστον παρόμοια αν όχι καλύτερα αποτελέσματα για την λαπαροσκοπική έναντι της ανοιχτής τεχνικής. Συμπερασματικά με καλή οργάνωση έχει ελάχιστες επιπλοκές και απεναντίας παρουσιάζει όλα τα πλεονεκτήματα της λαπαροσκοπικής χειρουργικής που προσφέρουν καλύτερη και ταχύτερη ανάρρωση στον ασθενή. Δυστυχώς ο αριθμός τόσο των δημοσιεύσεων όσο και των ασθενών δεν αρκεί για να βγάλουμε στατιστικά σημαντικά συμπεράσματα. Επισημαίνουμε ακόμα μια φορά τη σημασία του να γίνουν μεγαλύτερες προοπτικές πολυκεντρικές μελέτες στο μέλλον ώστε να είναι δυνατό να αποκτήσουμε μεγαλύτερη βεβαιότητα σχετικά με το ρόλο της μεθόδου στην αντιμετώπιση παιδιών με παθήσεις του παγκρέατος.

SUMMARY

This is a retrospective review of the most recent literature in order to offer an up-to-date regarding distal laparoscopic pancreatectomy in children less than 14 years of age. Sixteen papers including 42 patients were found and thoroughly analysed. Data regarding age and sex of the patients as well as medical indications for pancreatectomy, preoperative planning, technical details and methods, intraoperative and postoperative course and complications were all searched for, grouped together and presented. Four were the main indications for LDP in children: 1) Pancreatic trauma, 2) Persistent Hyperinsulinemic Hypoglycemia of Infancy (PHHI), 3) Solid Pseudopapillary Tumor (SPT) and 4) Insulinoma. From operating point of view it seems that there are no major technical differences from adult pancreatic surgery. However the limited intrabdominal space and the smaller size of all structures especially in small infants present a unique challenge to the surgeon. Complications were seen in 10 patients and the majority were treated conservatively. There were only two conversions to open surgery. It seems that in selected patients with specific indications, in large tertiary centres and in the hands of surgeons with advanced laparoscopic skills, laparoscopic distal pancreatectomy can become an ideal alternative to open surgery. The tendency is that LDP has at least similar if not better results than open surgery. If planned well has minimal complications and in addition all the advantages reported for laparoscopy give the patient the possibility to recover to a normal life promptly. Unfortunately the number of published articles as well as that of the patients included is not sufficient to draw statistically significant conclusions. We highlight once more the importance to make larger prospective randomized multicentre studies in the future in order to draw more conclusive evidence as to its role in the management of children with pancreatic problems.

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